D. A. TSENOV ACADEMY OF ECONOMICS

Faculty of Finance

Department of Finance and Credit

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ABSTRACT

of a dissertation for the award of the educational and scientific degree ‘doctor’ in the doctoral programme „Finance, Money Circulation, Credit and Insurance (Finance)” on the topic:

"INVESTMENTS IN PHOTOVOLTAIC POWER PLANTS – FINANCIAL AND ENVIRONMENTAL ASPECTS"

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Description of the dissertation paper:

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All materials related to the defence shall be available upon request at the Department of Academic Studies and Academic Staff Development.

CONTENTS OF THE ABSTRACT

I. General characteristics of the dissertation paper

1. Relevance of the topic

The energy system of the Republic of Bulgaria is an economic sector that directly influences all other systems and economic entities. The price of energy is a key component of the price of practically all goods and services. The variety of energy-generating capacities, however, includes such in which the fuel component is a renewable natural resource. Among these capacities, photovoltaic power plants stand out with their global impact and continuous expansion. Their construction, commissioning, and subsequent operational function with the supply of solar electricity to the grid, are of vital importance for the state and the prospects of ensuring the power balance of the Republic of Bulgaria. Therefore, the analysis of the current situation and the prospects for investment and development of photovoltaic power plants in the energy balance of our country should be perceived as a priority in both the energy strategy and the European Green Deal.

The EU's targets for achieving a share of 27% energy from renewable resources from the total energy consumption require significant investments. This goal is attainable for Bulgaria only under conditions of supportive government policies, viable technological solutions, and a good regulatory framework. However, the EU's Green Deal also demands a precise balance and a smooth transition because the greatest risk in the electricity system is the shortage or absence of capacity in the electricity transmission network.

This allows arguments to be developed in support of the assertion that climatic conditions, geographical location, degree of urbanization, population density, and the capacity of the electricity transmission network are factors that support and motivate investments in photovoltaic power plants.

2. Object and subject of research in the dissertation

On this basis, **the object** of research in the dissertation is formulated as the

investments in photovoltaic power plants in Bulgaria. Energy is a fundamental sector of our national economy. Its development over the years, significant private and public investments, the influence of the Green Deal in the EU, the favourable geographical location with a moderate climate in the European continent, and a significant number of days with intense sunlight are strategic advantages for justifying investments in photovoltaic power plants.

The subject of the dissertation is defined as the financial and environmental aspects in deciding for investments in photovoltaic power plants, based on the price levels and supply and demand volumes in the national and international electricity markets.

Investments in photovoltaic power plants require a precise analysis of all financial and environmental aspects, in accordance with the regulatory framework in the country and the EU, with a precise assessment of the impact of the EU Green Deal and the strategic advantages of the geographical locations of solar renewable energy systems.

3. Research thesis statement

The thesis of the dissertation work is based on the assertion that the EU Green Deal shapes increasing demand for low-carbon electricity production. This, in turn, presents a favourable prospect for investments in photovoltaic power plants, supported by financial models ensuring returns while adhering to environmental regulations in both the country and the EU.

4. Research purpose

The research purpose is to conduct a financial-economic analysis and propose well-founded decisions for investment in low-carbon electricity production, highlighting the benefits of photovoltaic power plants and in conformity with the environmental regulations in Bulgaria and the EU, price

levels, demand on independent energy exchanges, and the strategic advantages of the geographic location of the country in South-eastern Europe.

5. Tasks and methodology of research

The defined purpose, object, subject, and thesis allow for setting the **tasks** to be achieved in the dissertation work and development of a relevant **structure**.

The specific **tasks** set for the dissertation are:

First. To analyse the theoretical research in the sector and the empirical evidence regarding the development of the "Electric Power Sector" in Bulgaria in the context of the European Green Deal and the trend towards increasing the share of renewable energy sources in the electricity mix of the country.

Second. To conduct an econometric analysis for the period 2019–2023 of the day-ahead segment of the independent energy exchange, focusing on Bulgaria and economies from Central and South-eastern Europe. This analysis aims to determine the characteristics of the price (in Euro/MWh) as a leading indicator in investment models for photovoltaic power plants.

Third. To justify an investment proposal for the establishment of a network of photovoltaic power plants in Bulgaria, combining the best technological performance indicators for solar panels and to explore the options for project company financing through credit mechanisms.

In a **methodological aspect**, the study relies on the use and application of comparative analysis, deductive and inductive methods, the graphical method, statistical methods for analysis, descriptive statistics, regression and correlation analysis, and others.

6. Research scope

The research inquiries in the dissertation work, both in their theoretical and empirical aspects, are limited in scope to precisely specified aspects of investments in Photovoltaic Power Plants (PVPPs). This includes an assessment

of the price dynamics in the day-ahead segment of the energy exchange as a key factor for the return on these investments and the formation of net cash flow. The environmental aspect of the research is addressed as a supportive factor for the expansion of these investments and the setting of ambitious quantity targets for building a network of solar parks in the country and the EU. **Outside the scope** of the research are the issues related to investments in batteries for storing excess electricity generated by PVPPs, considering the competitive demand for basic materials and elements in the electric vehicle manufacturing sector, versus the possibilities for integrating high-efficiency batteries. Also, questions regarding other renewable energy sources and technologies related to solar parks, which could be subjects of additional independent scientific research, are set aside. Potential environmental challenges for decommissioning PVPPs after their useful lifespan are considered topics for future studies. In this regard, the operational lifespan of modern solar panels determines a low-risk profile for these investments, but also raises the question of technologies for their recycling when the time comes.

7. Structure of the dissertation

The dissertation consists of a total of 239 standard pages, structured into three chapters as follows:

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8. Applicability of the research findings

The theoretical discussions and conclusions presented in the dissertation, alongside the empirical findings, aim to support the understanding that transitioning to a low-carbon economy requires investments in the cornerstone of the economy – electricity production. On this basis, the conducted research and the developed model for investment in Photovoltaic Power Plants (PVPPs) through a project company serve as a useful guide and tool for any entity wishing to contribute to the transformation of Bulgaria's energy sector. The perspective is for a predominant share of renewable energy sources and a shift away from heavily polluting energy technologies to parameters and indicators in the country's energy balance that meet the goals of the EU Green Deal.

Last but not least, the literature and information sources used in the dissertation work, the econometric models developed and adapted, the approaches to the study and presentation of knowledge explored and adopted, are extremely useful for the author in his work as a manager of companies investing in PVPPs, thereby improving his skills and efficacy in the field.

II. Resume of the dissertation paper

Chapter One. Theoretical, market and environmental aspects of investments in the electric power sector

The research hypothesis to be tested in Chapter One is formulated as follows: In the context of environmental regulations and outlined objectives in the European Green Deal, the development of capacity for electricity generation from renewable energy sources in Bulgaria and the EU requires accelerated growth, an increasing share in the energy mix, and heightened demand for efficient engineering solutions.

The **task** is to address the analysis of theoretical research within the sector and empirical evidence on the development of the electric power sector in Bulgaria, in the light of the European Green Deal and the tendency towards an increased share of renewable energy sources in both the country's and the EU's energy mix.

Given the formulated hypothesis, Chapter One is structured and focused as follows: firstly, a historical analysis and evaluation of the technological features and impacts of investments in photovoltaic power plants; secondly, an investigation into the position and significance of renewable energy in Bulgaria's energy balance; thirdly, the European Green Deal as a framework for prioritizing investments in renewable energy sources, particularly in photovoltaic power plants.

Within the framework of Chapter One, the following key results, conclusions, and observations can be summarized:

Photovoltic panel modules are usually made of semi-conducting materials like multicrystalline silicon, which provides an energy efficiency of 33% for electricity generated from solar energy (EC, 2022). This is in comparison to electricity from geothermal sources with an efficiency of 10%, resp. heat obtained from geothermal sources with 50% efficiency, or heat obtained from solar thermal

energy with 100% efficiency, and for electricity and heat obtained from nuclear sources with an efficiency of 33%. Since its engineering inception in 1954 until 2020, a solar panel module with an area of 1.7 square meters has had a 22 times jump in power rating (from 20W to 440W) with a corresponding increase in efficiency from 6% to over 22%.

Secondly, the introduction of a regulatory approach to balancing energy systems in the EU, aims to ensure energy security for the GDP growth of the EU and its member states. During the crisis with interrupted supply corridors for natural gas, it was confirmed that the gas-intensive economic operators in the EU are able to swiftly switch to the use of diversified sources and market instruments. In the electricity sector, market evidence confirms that the "green transition" is an ambitious goal, directing significant investments towards renewable energy sources mainly wind and solar, which forms nature-dependent sinusoids in the supply of "green" electricity. The phenomenon of zero electricity market prices emerges as a consequence of peaks in quantities of cheap electricity (generated by offshore wind parks in the North and Baltic Seas), significantly impacting investment efficiency indicators.

Thirdly, the implementation of the European Green Deal has its key objective - the European Union to reduce its net greenhouse gas emissions by 55% by the end of 2030 compared to 1990 levels. This goal requires the enactment of specific supporting policies in climate, energy, transportation, and taxation. Part of these policies pertains to renewable energy sources, including photovoltaic power plants.

Fourthly, at the national level, national energy and climate plans (NECPs) have been developed, adopted, and subsequently updated. The "Integrated Energy and Climate Plan of the Republic of Bulgaria 2021-2030," envisages that by 2030, installed capacities for energy from renewable sources will reach 10.9 GW, with a leading share of photovoltaic power plants of 5.5 GW, reaching a maximum installed capacity of 6.2 GW by 2035. The gradual increase in cumulative capacity

of photovoltaic power plants, based on the 2020 baseline of 1.1 GW, is projected to be 345% by 2025 (or 3.8 GW) and 564% by 2030 (or 5.5 GW). Therefore, the period from 2020 to 2030 will witness the most significant sectoral investments in the energy sector, with solar power plants taking the lead role.

Fifthly, the primary objective of EU policies for development of single market coupling is to achieve social welfare. Coupling and collaboration provide for a more secure electricity supply, foster competition, and support the EU's decarbonization efforts. The fundamental premise behind the development of single day-ahead coupling (SDAC) is to establish a single pan-European electricity market, where trading transactions are concluded today for delivery the next day. The single day-ahead coupling significantly improves trading efficiency by promoting effective competition. An objective constraint on the system is the capacity for cross-border transmission. The combination of the two factors allows for welfare maximization. The findings are based on the analysis for 2019 evidence aligning of average hourly prices in the segment and positive economic aspect of coupling.

Sixth. The Independent Bulgarian Energy Exchange (IBEX) was established in January 2014. Initially, it was 100% owned by Bulgarian Energy Holding (BEH) EAD, and since 2018, it has been 100% owned by Bulgarian Stock Exchange (BSE) EAD. The segment with the highest trading volume on the energy exchange is the day-ahead segment, followed by the within-day segment and the bilateral-contracts segment.

Seventh. Statistical testing of the correlation of energy markets in six selected Central and Eastern European (CEE) countries in the day-ahead segment during force majeure circumstances in 2022 revealed an international transmission of economic disturbances, the energy market in the examined CEE countries having amplified external pressure and become a pro-inflationary factor. The record inflation rates calculated by Eurostat for 2022, averaging 9.2% for the EU (based on a 2021 baseline of 2.9%) and the six surveyed countries (Bulgaria

at 8.2%, Romania at 5.7%, Hungary at 17.2%, Slovakia at 11.9%, Czech Republic at 8.1%, and Slovenia at 14%), clearly demonstrate that CEE countries can easily absorb negative external economic shocks.

Eighth. A study of Slovenia's energy exchange (branded as the "Southern Pool") yields valuable analytical insights into the effects of European electricity regulations on national prices in the most dynamic price segment - the day-ahead market. The study tests the hypothesis of the positive correlation within the relatively small electricity market of Slovenia. The strategic location of the country, coupled with the presence of a nuclear power plant, makes it a transit electricity hub between the economy of Italy, which is system for the EU, and the neighboring countries to the north and east: Austria, Croatia, Hungary, Czech Republic, and Slovakia.

Ninth. Electric power generation in Bulgaria in 2022 marked a historic high for the past decade at 50,570 million MWh, an increase by 5.8% compared to 2021 and by a notable 23.7% compared to 2020. This record is supported by a 38.5% surge in production capacity from Photovoltaic Power Plants (PVPPs), reaching a share of 12.8% of the total installed capacity by generation type. Total capacity peaked in 2022 at 13,505 MW, with a peak load of 7,150 MW for the year. Annual cross-border electricity exchanges for 2022 maintain a positive balance, totalling 12,244,830 MWh, an increase of 38.8% compared to 2021. Upon analysing hourly data for all days of 2022, comprising 8,760 price records and the similar size of sample for quantity, a coefficient of variation for prices in the day-ahead segment stands at 51.8%, resp. for quantities at 16.3%. Price changes range from 0.17 Euro/MWh to a historic for the Bulgarian energy market peak of 936.33 Euro/MWh.

Chapter Two. The day-ahead price segment as a determining factor for the return on investment in solar power plants

The research hypothesis to be tested in this chapter is formulated as follows: By conducting econometric analysis on the day-ahead segment of the independent energy exchanges in twelve economies from Central and South-eastern Europe, it is possible to develop models for forecasting the price (in Euro/MWh) of electricity as a key indicator in investment models for photovoltaic power plants and to identify trends for an increase (by years) of the correlation of price levels in the sector for countries with highly interconnected electricity transmission systems.

The task at hand involves conducting econometric analysis for the period spanning 2019–2023 on the day-ahead segment of the independent energy exchange by the example of Bulgaria and economies from Central and South-eastern Europe to determine the characteristics of the price (in Euro/MWh) as a primary indicator in investment models for photovoltaic power plants.

Given the formulated hypothesis, Chapter Two is structured into the following distinct parts. The first paragraph introduces the topic. Paragraphs two through six present multifactor modeling of day-ahead electricity price from 2019 to 2023.

All analyses are conducted using the IBM SPSS software.

Within the exposition of Chapter Two, the following key results, conclusions, and observations are derived and synthesised:

Firstly, it is specific of electricity trading that inter-system exchange is limited while the energy cannot be stored. This leads to the formation of clusters of countries with electricity systems permitting inter-system transfer of metered electricity, but this also exposes them to risks of price shocks, particularly in the markets of smaller absorptive capacity. Bulgaria's geographic location logically links its electricity market trading with larger economies and electricity exchanges in Greece and Romania. Despite having twice the capacity to cover peak national

electricity consumption levels, Bulgaria's economic operators suffered severe price shocks in 2022 specifically due to record-high electricity prices (in Euro/MWh).

Secondly, in examining the variation in the electricity price on the Bulgarian day-ahead market (P_BG), the influence of the following factors is explored: Day (Day), Hour (Hour), the day-ahead market price in Czechia (P_CZ), the day-ahead market price in Slovakia (P_SK), the day-ahead market price in Hungary (P_HU), the day-ahead market price in Romania (P_RO), the day-ahead market price in Slovenia (P_SL), the day-ahead market price in Greece (P_GR), the day-ahead market price in Poland (P_PL), the day-ahead market price in Germany (P_DE), the day-ahead market price in Austria (P_AT), the day-ahead market price in Italy (P_IT), the day-ahead market price in Croatia (P_HR), and the sold quantity on the Bulgarian market (BGv). Energy prices are expressed in EUR/MWh, while the sold quantity is in MWh. For the year 2019, it is observed that the lowest average electricity price on the day-ahead market is in Germany (37.67 EUR/MWh), while the highest is in Greece (63.82 EUR/MWh).

Thirdly, for the year 2019, the Pearson correlation coefficients from the generated correlogram indicate a very high positive correlation (*in the range of* $0.70 < r <= 1.00$) at a significance level of 0.01 between: P_BG and P_HU (0.757); P_BG and P_RO (0.748); P_CZ and P_SK (0.945); P_CZ and P_HU (0.757); P_CZ and P_DE (0.841); P_CZ and P_AT (0.894); P_SK and P_HU (0.761); P_SK and P_RO (0.721); P_SK and P_SL (0.716); P_SK and P_DE (0.780); P_SK and P_AT (0.857); P_HU and P_RO (0.939); P_HU and P_SL (0.876); P_HU and P_IT (0.728); P_HU and P_HR (0.883); P_RO and P_SL (0.824); P_RO and P_HR (0.833); P_SL and P_IT (0.724); P_SL and P_HR (0.968); P_DE and P_AT (0.859).

Fourthly, the multiple linear regression model for IBEX in the day-ahead segment for 2019 demonstrates a multivariate correlation coefficient indicating the strength of the dependence between the combination of independent variables

and the price of the Bulgarian day-ahead market R of 0.767 and a coefficient of determination R^2= 0.588. The adjusted coefficient of determination (Adjusted R^2) is also equal to this value. The F-ratio (between the variation explained by the model (mean square) and the residual variation) is equal to 1787.176, with a statistical significance of the F-ratio at 0.000, which is less than 0.05, indicating that the result is statistically significant, and the regression model fits the data, demonstrating a linear relationship between the independent and dependent variables. The Durbin-Watson coefficient from the regression model is 0.364, a value significantly lower than 2, indicating the presence of positive autocorrelation. Therefore, the linear model is transformed into a first-order autoregressive model using the Cochrane-Orcutt procedure. Based on the standardized beta coefficients, it can be stated that the greatest contribution comes from the price of the Italian day-ahead market, followed by the price of the Romanian market, the quantities sold on the Bulgarian market, while the price of the Greek market has the smallest contribution.

Fifth. The average day-ahead electricity price for 2020 for the examined price variables ranged from 33.62 EUR/MWh to 46.66 EUR/MWh. From the descriptive statistics for the price variables, it is observed that the lowest average day-ahead electricity price is in the Czech market (33.62 EUR/MWh), while the highest is in the Polish market (46.66 EUR/MWh). For the traded volumes on the Bulgarian market, the average quantity is 1759 MWh, which is higher than the quantity sold in 2019 (957.85 MWh). The skewness coefficients for most variables fall within the range of -1 to +1, indicating a normal distribution. Some positive (right) skewness is observed in the data for the prices in Romania, Slovenia, Greece, Croatia, and Hungary.

Sixth. The Pearson correlation coefficients for 2020 from the generated correlogram show a very high positive correlation *(in the range 0.70 < r <= 1.00)* at a significance level of 0.01 between: P_CZ and P_SK (0.990); P_CZ and P_HU (0.878); P_CZ and P_RO (0.860); P_CZ and P_SL (0.872); P_CZ and P_PL

(0.750); P_ CZ and P_DE (0.861); P_CZ and P_AT (0.941); P_CZ and P_HR (0.852); P_CZ and P_BG (0.820); P_SK and P_HU (0.886); P_ SK and P_RO (0.868); P_SK and P_SL (0.878); P_SK and P_PL (0.746); P_ SK and P_DE (0.847); P_SK and P_AT (0.932); P_SK and P_HR (0.858); P_SK and P_BG (0.829); P_HU and P_RO (0.975); P_ HU and P_SL (0.921); P_ HU and P_GR (0.742); P_ HU and P_DE (0.712); P_ HU and P_AT (0.825); P_ HU and P_HR (0.917); P_HU and P_BG (0.888); P_RO and P_SL (0.903); P_RO and P_GR (0.737); P_RO and P_AT (0.805); P_RO and P_HR (0.901); P_RO and P_BG (0.897); P_SL and P_DE (0.735); P_SL and P_AT (0.861); P_SL and P_HR (0.978); P_SL and P_BG (0.844); P_GR and P_BG (0.707); P_PL and P_AT (0.725); P_DE and P_AT (0.909); P_DE and P_HR (0.711); P_AT and P_HR (0.836); P_AT and P_BG (0.733); P_HR and P_BG (0.842).

Seventh. The multivariate correlation coefficient R for 2020, indicating the strength of the relationship between the combination of independent variables and the day-ahead price of the Bulgarian market is 0.904, with a coefficient of determination $R^2 = 0.816$. The F-ratio is 5575.73, with a statistical significance of 0.000, indicating a statistically significant result, and the regression model fitting the data with a linear relationship between the independent and dependent variables. The Durbin-Watson coefficient from the regression model is 0.479, indicating the presence of positive autocorrelation. Therefore, the linear model is transformed into a first-order autoregressive model using the Cochrane-Orcutt procedure.

Eighth. After eight iterations, the optimal autocorrelation coefficient is found to be 0.853. Based on this value, the new parameters of the model are obtained. From them, it can be seen that the multivariate correlation coefficient R, indicating the strength of the relationship between the combination of selected predictors and the price on the Bulgarian day-ahead market has decreased from 0.904 to 0.625, the coefficient of determination R^2 being equal to 0.391. The adjusted coefficient of determination (Adjusted R^2) is 0.390, indicating that only

39% of the changes in the day-ahead electricity price on the Bulgarian market are determined by the total influence of the included independent factors. The Durbin-Watson coefficient is now 2.024, indicating no autocorrelation. The new coefficients of the regression model are positive, indicating that with their increase, the day-ahead electricity price on the Bulgarian market will also increase, and vice versa. Based on these coefficients, a new regression equation for 2020 can be derived. Based on the standardized beta coefficients, it can be said that the largest contribution comes from the day-ahead price of the Romanian market, followed by the sold quantities on the Bulgarian market, the price of the Italian day-ahead market, and the smallest contribution comes from the day-ahead price on the Greek market.

Ninth. The average day-ahead electricity price for 2021 for the investigated price variables ranges from 87.03 EUR/MWh to 129.02 EUR/MWh, which is significantly higher compared to the previous year. From the descriptive statistics for the price variables, it can be seen that the lowest average day-ahead electricity price is on the Polish market (87.03 EUR/MWh), while the highest is on the Italian market (129.02 EUR/MWh). On the Bulgarian market, the average day-ahead energy price is 108.69 EUR/MWh. For the traded volumes on the Bulgarian market, the average quantity is 2888.8 MWh, which is higher than that in 2020 (1759 MWh). The skewness coefficients for most variables are above +1, indicating positive skewness, with the highest skewness observed for Poland, the Czech Republic, Slovakia, and Germany. The kurtosis coefficients for all variables are different from 0, mostly positive for almost all variables. The highest excess kurtosis is observed for Poland, the Czech Republic, Slovakia, Germany, and Austria. For BGv, the coefficient value is close to 0. The kurtosis coefficients have negative values for the Day and Hour variables. From the price data, it can be observed that negative day-ahead prices are achieved for most markets, with maximum prices reaching up to 620 EUR/MWh. The minimum traded quantities

on the Bulgarian market are 1592.7 MWh, and the maximum is 4251.4 MWh, significantly exceeding those in 2020.

Tenth. Pearson correlation coefficients for the year 2021 from the generated correlogram show a very high positive correlation *(in the range 0.70 < r <= 1.00)* at a significance level of 0.01 between: P_CZ and P_SK (0.983); P_CZ and P_HU (0.928); P_CZ and P_RO (0.897); P_CZ and P_SL (0.922); P_CZ and P_GR (0.861); P_CZ and P_PL (0.885); P_CZ and P_DE (0.974); P_CZ and P_AT (0.959); P_CZ and P_IT (0.838); P_CZ and P_HR (0.918) P_CZ and P_BG (0.878); P_SK and P_HU (0.941); P_SK and P_RO (0.912); P_SK and P_SL (0.928); P_SL and P_GR (0.871); P_SL and P_PL (0.872); P_SK and P_DE (0.955); P_SK and P_AT (0.957); P_SK and P_IT (0.845); P_SK and P_HR (0.924); P_SK and P_BG (0.889); P_HU and P_RO (0.977); P_HU and P_SL (0.971); P_HU and P_GR (0.941); P_HU and P_PL (0.827); P_HU and P_DE (0.902); P_HU and P_AT (0.960); P_HU and P_IT (0.906); P_HU and P_HR (0.967); P_HU and P_BG (0.949); P_RO and P_SL (0.948); P_RO and P_GR (0.940); P_RO and P_PL (0.808); P_RO and P_DE (0.871); P_RO and P_AT (0.929); P_RO and P_IT (0.885); P_RO and P_HR (0.945); P_RO and P_BG (0.964); P_SL and P_GR (0.838); P_SL and P_PL (0.823); P_SL and P_DE (0.900); P_SL and P_AT (0.965); P_SL and P_IT (0.919); P_SL and P_HR (0.996); P_SL and P_BG (0.938); P_GR and P_PL (0.763); P_GR and P_DE (0.838); P_GR and P_AT (0.908); P_GR and P_IT (0.926); P_GR and P_HR (0.937); P_GR and P_BG (0.956); P_PL and P_DE (0.868); P_PL and P_AT (0.851); P_DE and P_IT (0.744); P_PL and P_HR (0.820); P_PL and P_BG (0.788); P_DE and P_AT (0.946); P_DE and P_IT (0.823); P_DE and P_HR (0.986); P_DE and P_BG (0.853); P_AT and P_IT (0.891); P_AT and P_HR (0.961); P_AT and P_BG (0.913); P_IT and P_HR (0.917); P_IT and P_BG (0.882); P_HR and P_BG (0.935); P_SK and Day (0.703); P_HU and Day (0.772); P_RO and Day (0.750); P_SL and Day (0.790); P_GR and Day (0.822);

P_AT and Day (0.749); P_IT and Day (0.855); P_HR and Day (0.791); P_BG and Day (0.764).

Eleventh. The multivariate correlation coefficient R for the year 2021, indicating the strength of the relationship between the combination of independent variables and the price on the Bulgarian day-ahead market is 0.964, with a coefficient of determination $R^2 = 0.930$. The adjusted coefficient of determination (Adjusted R^2) is also equal to this value. The F-ratio is 28918.565, with a statistical significance of 0.000, which is less than 0.05. This indicates that the result is statistically significant, and the regression model fits the data, showing a linear relationship between the independent and dependent variables.

Twelfth. The Durbin-Watson coefficient from the regression model is 0.479, a value significantly lower than 2, indicating the presence of positive autocorrelation. This is the basis for transforming the linear model into a first-order autoregressive model using the Cochrane-Orcutt procedure. Based on the value of the autoregressive coefficient, which is 0.876, the new parameters of the model are obtained. From them, it can be seen that the multivariate correlation coefficient R, indicating the strength of the relationship between the selected predictors and the price on the day-ahead Bulgarian market has decreased from 0.964 to 0.748, while the coefficient of determination R^2 is equal to 0.559. The adjusted coefficient of determination (Adjusted R^2) is also 0.559, meaning that 55.9% of the changes in the day-ahead energy price on the Bulgarian market are determined by the combined influence of the included independent factors. The Durbin-Watson coefficient is now 1.879, which is relatively close to 2. Based on the standardized beta coefficients, it can be said that the largest contribution comes from the price of the Romanian day-ahead market followed by the day-ahead price on the Polish market, the traded day-ahead quantities on the Bulgarian market, and the “Hour” variable.

Thirteenth. The average day-ahead electricity price for 2022 for the examined price variables ranges from 166.72 EUR/MWh to 295.07 EUR/MWh,

which is significantly higher compared to the previous three years. From the descriptive statistics of the price variables, it can be seen that once again the lowest average day-ahead electricity price is in the Polish market (166.72 EUR/MWh), while the highest is in the Italian market (295.07 EUR/MWh). In the Bulgarian market, the average day-ahead energy price is 253.24 EUR/MWh, which is twice the price for 2021 of 108.69 EUR/MWh. For the traded volumes in the Bulgarian market, the average quantity is 3187.82 MWh, which is higher than in 2020 (2888.8 MWh). From the data on the mode of the price factors, it can be observed that for the Bulgarian market, the most transactions are concluded at prices of 138.41 EUR/MWh, which is slightly higher compared to 2020. The values of the skewness coefficients for most variables exceed +1, except for Italy, indicating moderate positive skewness, with the highest observed in Poland. The coefficient has a negative value only for the traded quantity in the Bulgarian day-ahead market. The excess coefficients for all variables are different from 0, mostly positive. The sharpest excess is observed for Poland. For BGv, the value of the coefficient is close to 0, but negative.

Fourteenth. The Pearson correlation coefficients from the generated correlogram for the year 2022 show very high positive correlation *(in the range 0.70 < r <= 1.00)* at a significance level of 0.01 between: P_CZ and P_SK (0.960); P_CZ and P_HU (0.948); P_CZ and P_RO (0.909); P_CZ and P_SL (0.946); P_CZ and P_GR (0.780); P_CZ and P_PL (0.720); P_CZ and P_DE (0.974); P_CZ and P_AT (0.963); P_CZ and P_IT (0.831); P_CZ and P_HR (0.940); P_CZ and P_BG (0.851); P_SK and P_HU (0.989); P_SK and P_RO (0.953); P_SK and P_SL (0.975); P_SL and P_GR (0.807); P_SK and P_DE (0.916); P_SK and P_AT (0.967); P_SK and P_IT (0.852); P_SK and P_HR (0.973); P_SK and P_BG (0.975); P_HU and P_RO (0.965); P_HU and P_SL (0.979); P_HU and P_GR (0.819); P_HU and P_DE (0.904); P_HU and P_AT (0.964); P_HU and P_IT (0.857); P_HU and P_HR (0.979); P_HU and P_BG (0.886); P_RO and P_SL (0.946); P_RO and P_GR (0.838); P_RO and P_DE

(0.861); P_RO and P_AT (0.924); P_RO and P_IT (0.836); P_RO and P_HR (0.955); P_RO and P_BG (0.913); P_SL and P_GR (0.809); P_SL and P_DE (0.906); P_SL and P_AT (0.974); P_SL and P_IT (0.865); P_SL and P_HR (0.989); P_SL and P_BG (0.871); P_GR and P_DE (0.741); P_GR and P_AT (0.790); P_GR and P_IT (0.798); P_GR and P_HR (0.822); P_GR and P_BG (0.864); P_PL and P_DE (0.723); P_DE and P_AT (0.938); P_DE and P_IT (0.806); P_DE and P_HR (0.895); P_DE and P_BG (0.811); P_AT and P_IT (0.860); P_AT and P_HR (0.964); P_AT and P_BG (0.854); P_IT and P_HR (0.862); P_IT and P_BG (0.781); P_HR and P_BG (0.879).

Fifteenth. Using the stepwise method, the optimal regression model for 2022 has been obtained, which includes the independent variables: BGv, Hour, P_DE, P_PL, P_GR, P_IT, P_RO. With these predictors, the method "Inclusion" to obtain the model parameters" was applied. The multivariate correlation coefficient R, indicating the strength of the relationship between the combination of independent variables and the price of the day-ahead Bulgarian market is 0.934, with a coefficient of determination R^2 = 0.872. The adjusted coefficient of determination (Adjusted R^2) is also equal to 0.872. The F-ratio is 8537.637, with statistical significance of 0.000, which is less than 0.05. This means that the result is statistically significant, and the regression model fits the data, indicating a linear relationship between the independent and dependent variables. All coefficients, except the constant, are statistically significant, as all values are less than 0.01. The Durbin-Watson coefficient from the regression model is 0.881, a value significantly lower than 2, indicating the presence of positive autocorrelation.

Sixteenth. Through the Cochran-Orcutt procedure, the multiple linear regression model is transformed into a first-order autoregressive model for 2022. In line with the specified criteria, 12 iterations were generated, with the optimal autocorrelation coefficient obtained being 0.764. It is evident that the multidimensional correlation coefficient R, reflecting the strength of the dependence between the combination of selected predictors and the price in the

Bulgarian day-ahead market, decreased compared to the initial regression. After the transformation, R=0.685, and the coefficient of determination R^2 equals 0.469. The adjusted coefficient of determination (Adjusted R^2) is also 0.469, indicating that 46.9% of the changes in the energy price in the Bulgarian day-ahead market are determined by the combined influence of the included independent factors. The Durbin-Watson coefficient is now 2.118, which is relatively close to 2. Based on the standardized beta coefficients, it can be stated that the largest contribution comes from the price of the Romanian day-ahead market, followed by the German market, the price of the Italian market, followed by the Polish market, the day-ahead quantity traded in the Bulgarian market, and the smallest contribution comes from the "Hour" variable.

Seventeenth. The average electricity price in the day-ahead market for 2023 for the examined price variables ranges from 99.53 EUR/MWh to 127.04 EUR/MWh, a level significantly lower than the previous year. Descriptive statistics for the price variables show that the lowest average electricity price in the day-ahead market is in the German market (99.53 EUR/MWh), while the highest is in the Italian market (127.04 EUR/MWh). In the Bulgarian market, the average energy price in the day-ahead market is 106.14 EUR/MWh, which is almost at the level of the price for 2021 of 108.69 EUR/MWh. For the traded volumes on the Bulgarian market, the average quantity is 3139.94 MWh, very close to the average level in 2022. The skewness coefficients for all variables fall in the range from -1 to +1, indicating a rather normal distribution. Positive coefficients are observed for Slovakia, Hungary, Romania, Greece, Italy, Bulgaria, and the traded quantity. Negative coefficients are observed for the Czech Republic, Slovenia, Poland, Germany, Austria, and Croatia. The skewness coefficients for the "Day" and "Hour" variables are zero.

Eighteenth. The correlation coefficients for 2023 show a very high positive correlation *(in the range 0.70 < r <= 1.00)* at a significance level of 0.01 between: P_CZ and P_SK (0.955); P_CZ and P_HU (0.8958); P_CZ and P_RO (0.757);

P_CZ and P_SL (0.942); P_CZ and P_PL (0.771); P_CZ and P_DE (0.828); P_CZ and P_AT (0.899); P_CZ and P_HR (0.869) P_CZ and P_BG (0.759); P_SK and P_HU (0.959); P_SK and P_RO (0.819); P_SK and P_SL (0.967); P_SK and P_PL (0.759); P_SK and P_DE (0.770); P_SK and P_AT (0.899); P_SK and P_HR (0.908); P_SK and P_BG (0.821); P_HU and P_RO (0.840); P_HU and P_SL (0.963); P_HU and P_PL (0.740); P_HU and P_DE (0.733); P_HU and P_AT (0.862); P_HU and P_HR (0.901); P_HU and P_BG (0.840); P_RO and P_SL (0.806); P_RO and P_GR (0.705); P_RO and P_AT (0.802); P_RO and P_HR (0.905); P_RO and P_BG (0.996); P_SL and P_PL (0.761); P_SL and P_DE (0.797); P_SL and P_AT (0.911); P_SL and P_HR (0.892); P_SL and P_BG (0.807); P_GR and P_BG (0.711); P_PL and P_DE (0.753); P_PL and P_AT (0.766); P_PL and P_HR (0.758); P_DE and P_AT (0.885); P_DE and P_HR (0.808); P_AT and P_HR (0.934); P_AT and P_BG (0.803); P_HR and P_BG (0.903).

Nineteenth. The multivariate correlation coefficient R for 2023, which indicates the strength of the relationship between the combination of independent variables and the price on the Bulgarian day-ahead market, is 0.996, and the coefficient of determination $R^2 = 0.992$. The adjusted coefficient of determination (Adjusted R^2) is also equal to 0.992. The F-ratio is 200875.278, with a statistical significance of 0.000, which is less than 0.05. This means that the result is statistically significant, the regression model fits the data, and there is a linear relationship between the independent and dependent variables. The Durbin-Watson coefficient from the regression model is 0.715, which is significantly less than 2 and therefore indicates the presence of positive autocorrelation. That is why, the linear model is transformed into a first-order autoregressive model using the Cochrane-Orcutt procedure. The transformation is performed using the AREG Algorithms in IBM SPSS Statistics.

Twentieth. Based on the value of the autoregressive coefficient, which is equal to 0.648, the new parameters of the model for 2023 are obtained. From them,

it is observed that the multivariate correlation coefficient R, indicating the strength of the relationship between the combination of selected predictors and the price on the Bulgarian day-ahead market, is 0.991. The coefficient of determination R^2 is equal to 0.982. The adjusted coefficient of determination (Adjusted R^2) is also 0.982, meaning that only 98.2% of the changes in the day-ahead energy price on the Bulgarian market are determined by the total influence of the included independent factors. The Durbin-Watson coefficient is now 1.998, indicating the absence of autocorrelation. Based on the standardized beta coefficients, it can be said that in 2023, the largest contribution in forecasting the price in the same segment of IBEX comes from the price of the Romanian day-ahead market.

Chapter Three. Financial Analysis and Evaluation of a Project Company for Investment in the Construction of a Photovoltaic Plant

The research hypothesis to be tested in this Chapter Three is formulated as follows: The growing demand for investments in renewable energy sources in conditions of a free electricity market provides the basis for profitable business models of project photovoltaic companies, utilizing financial leverage techniques, combined with the best technological performance indicators for solar panels.

The task is set to justify an investment proposal for the establishment of a network of photovoltaic plants in Bulgaria, combining the best technological performance indicators for solar panels with options for project company financing through credit mechanisms.

In view of the formulated hypothesis, Chapter Three is structured into the following distinct parts. In paragraph 1, the focus is on the prospects for the establishment of a decentralized network of photovoltaic plants using the example of "Smart Energy Group." Paragraph 2 outlines the engineering-technological challenges facing the construction and commissioning of photovoltaic plants with

capacities up to 1 MW. Paragraph 3 presents a business plan for the construction and commissioning of a photovoltaic plant with a capacity exceeding 1 MW by a project company.

Within the exposition of Chapter Three, the following key results, conclusions, and observations are derived and synthesised:

First. The capacity of the national energy grid to accommodate new RES installations is an objective limiting factor for the implementation of projects for new WPPs and PVPPs, regardless of the favourable geographical location of the country, which provides high duration of sunshine indicators compared to the EU average. To maintain the high-voltage energy grid of the country and the interconnection with neighboring countries, Bulgaria operates 3032 km of 400 kV power lines, 2710 km of 220 kV power lines, and 10066 km of 110 kV power lines (or a total length of high-voltage power lines of 15808 km).

Second. To provide for the safe operation of facilities and installations at PVPPs, a specific regulatory framework is enforced. This framework entails ensuring compliance of solar park projects with five laws, five regulations, and twenty ordinances. By adhering to the regulatory framework and following technological timelines and logistical expertise, the building of new solar power plants is based on a timeline comprising 14 stages for solar parks with a capacity of 1 MW. With strict adherence to these defined stages under the current regulatory landscape, professional firms engaged in project execution for solar power plant construction can successfully implement projects with capacities up to 1 MW within an average timeframe of 6 months.

Third. In view of the geographical location of Bulgaria, the optimal tilt angle for the positioning of solar panels is 34%. The panels have a standardized area of 2.187m^2. The bill of quantity for implementing a project for a photovoltaic power plant (PVPP) with a capacity of 1 MW comprises 34 individual indicators.

Fourth. For investments in photovoltaic power plants with a capacity exceeding 1 MW, the project company approach is recommended. Such a project

pursues two fundamental objectives: (1) **constructing a photovoltaic power plant with optimal installed capacity and production parameters;** (2) **achieving projected levels of sales and profits.**

Fifth. From an engineering perspective, various metrics are evaluated, including azimuthal orientation of the solar park, geographic alignment of solar panels, perspectives of the PV field and surrounding shading, seasonally adjusted shading diagrams, and capacity loss due to seasonal changes in the position of the sun. Monthly forecasts for losses resulting from seasonal shifts in the sun's position relative to panel position at the photovoltaic power plant, as well as monthly coefficients of panel performance at the plant, are required.

Sixth. The investment in a photovoltaic power plant (PVPP) with a capacity exceeding 1 MW through a project company requires valuation of six key parameters:1) Acquisition of land and designs; 2) Project development and construction for the PVPP; 3) Calculation of expenses, taxes (John & Williams, 1985) and fees for the notarial transfer of title to property, of an area tailored to the specific municipality; 4) Production and delivery of a transformer substation with corresponding capacity; 5) External connections and installation of a transformer substation; 6) Construction supervision.

Seventh. The financial plan of the project company (DePamphilis, 2009) for the PVPP includes calculations for loan repayment based on income structure and capital cost, engineering efficiency metrics for solar panels by month, and anticipated losses up to the grid connection point. Forecasts for eight basic indicators determining solar park panel efficiency and the loss of electricity during the transmission from the solar panels to the grid connection point are explored.

Eighth. The time frame of the validated business plan spans from 2024 to 2035. The developed forecast "incoming" and "outgoing" cash flows illustrate possible profit generation and net cash flow accumulation after the coverage of the operating expenses and bank loan repayment. Sales revenue projections per annum are as follows: in 2024 - 161,354 BGN VAT not included, in 2025 -

314,697 BGN, in 2026 - 313,043 BGN, and in 2027 - 311,388 BGN. Total sales revenues from July 2024 to December 2035 amount to 3,402,859 BGN. These projections stem from three probabilistic scenarios for generation of solar electric power and its injection into the grid. The first scenario, with a 50% probability, forecasts sales of 1824.6 MWh, the second, with a 75% probability, forecasts sales of 1802.4 MWh, and the third, the most conservative, with a 95% probability, forecasts sales of 1770.5 MWh.

Ninth. After accounting for the projected revenues, expenses, and the repayment of the principal on a loan to the size of 80% of the amount of the investment, the net cash flow (excluding depreciation and taxes) is calculated as 28,753 BGN for the year 2024, based on a forecasted price of 180 BGN/MW. For 2025, it reaches 59,979 BGN, followed by 65,153 BGN in 2026, and 70,000 BGN in 2027. Over the entire period from July 2024 to December 2035, the accumulated net cash flow totals 1,000,258 BGN. Additionally, the effect of positive and negative deviations from the forecasted price is examined. In the modeled net cash flow, the impact of forecasting models for prices in the day-ahead market segment (during the period 2019-2023) provides grounds for applying five price levels, with an increment of 20 BGN/MW (ranging from 160 BGN to 240 BGN) under an annual sales scenario of 1802 MW at the connection point.

Tenth. Investments in PVPPs entail two groups of risks – systematic and unsystematic. In all cases, it is imperative to mind the dynamics in electricity market price levels. Contracts for purchasing electricity at preferential fixed prices are now obsolete. All new PVPP investments adhere to market rules, ensuring equilibrium between demand and supply. As a result, the issue of long-term electricity price levels remains subject to ongoing discussion. There is a noticeable trend among consumers and major economic entities – including governments, corporations, and households – to develop their own solar energy capacities. Whether and to what extent this will lead to a permanent reduction in

market electricity demand requires further examination. Based on this, there is a heightened likelihood of maintaining sustainable and consumer-friendly electricity price levels in the long term, particularly within the framework of the European Green Deal.

Conclusion

The focus of the dissertation topic on investments in photovoltaic power plants allowed for the development of a study that addressed several key areas:

First. A critical review of the evolution of the Energy sector incorporating comparative analyses at both national and international levels.

Second. An exhaustive econometric analysis of market trends in the day-ahead segment across twelve Central and Southeastern European countries for the period 2019–2023 was conducted. The aim was to establish the degree of correlation among national markets and address the price shocks from 2021. The analysis covered the day-ahead market segments in the Czech Republic, Slovakia, Hungary, Romania, Slovenia, Greece, Poland, Germany, Austria, Italy, Croatia, and Bulgaria.

Third. Justification and financial-economic argumentation of investments in photovoltaic power plants with capacities up to and above 1 MW (aggregate capacity of solar panels), including through a project company.

The presented exposition confirms, methodologically and deductively, the validity of the research thesis, namely: the EU Green Deal shapes increasing demand for low-carbon electricity production. This, in turn, presents a favourable prospect for investments in photovoltaic power plants, supported by financial models ensuring returns while adhering to environmental regulations in both the country and the EU. The established trend of progressively increasing cumulative capacity of photovoltaic power plants in Bulgaria, at a baseline of 1.1 GW for the year 2020, is projected to be 345% (or 3.8 GW) by 2025 and 564% (or 5.5 GW) by 2030. Therefore, the period from 2020 to 2030 will witness the most significant

sectoral investments in the energy sector, with solar power plants taking the lead role.

The econometric study for the period 2019–2023, based on14 predictors, confirms a clear trend of coupling of energy markets, where the influence on electricity prices in the day-ahead segment for Bulgaria in 2023 is limited to equivalent market segments in Romania, Greece, and the Czech Republic, supplemented by the traded quantities of electricity in MWh.

The analysis, conclusions, and summaries allow for the assertion that the core research hypotheses have been validated, and the following relevant scientific and applied results can be formulated:

First. The accelerated rate of investment and the growing share of renewable energy sources in Bulgaria and the EU's energy mix stem logically from new environmental regulations, set targets, and timelines within the European Green Deal, alongside the gradual shift from polluting to low-carbon energy production.

Second. The econometric analysis of the day-ahead segment of the independent energy exchange in twelve economies from Central and South-eastern Europe serves as the basis for developing models to forecast the price (in Euro/MWh) of electricity. These forecasts are pivotal in determining the most crucial indicator in business plans for investments in photovoltaic plants. The overarching conclusion drawn from the study of the day-ahead segment of the twelve national electricity markets indicates a trend towards increased correlation (from 2019 to 2023) of price levels in the sector for countries with highly interconnected electricity transmission systems.

Third. The profitable business models of project photovoltaic companies use financial leverage techniques, combined with the best technological performance indicators for solar panels. However, these investments also entail corresponding risks, the hedging of which requires managerial evaluation and professional analysis.

Irrespective of the ideas and viewpoints presented, the subject of investments in photovoltaic plants can be deemed consistently relevant given the anticipated rates of replacing coal-powered capacities with renewable energy sources. Alongside the rehabilitation of nuclear energy, the European Green Deal is poised to revolutionize the structure of electricity production capacities in the EU. It aims to achieve the ambitious environmental target of reducing net greenhouse gas emissions by 55% by the end of 2030 compared to 1990 levels. The challenges posed by climate change and the deteriorating state of the environment threaten the future of both the European continent and the world at large. The Green Deal offers a comprehensive political, engineering, and financial response to adapt the economy to new environmental standards.

III. Directions for future research on the dissertation topic

While the primary research directions outlined in the dissertation work shed light on investments in Photovoltaic Power Plants (PVPPs), the topic remains relevant, and the following research directions could be identified for future investigation:

1. Exploration of Coal-fired Power Plant Conversion within the European Green Deal Framework.
2. Determining the optimal capacity of pumped-storage hydroelectric power plants (PSHPPs) that can function as batteries, balancing the overall system capacity.
3. Inclusion all EU countries in the study of the day-ahead segment to establish trends and results from the European Target Model for electricity market price formation.

IV. List of the scientific and applied contributions of the dissertation paper

First. The significance of issues related to the European Green Deal as an environmental regulatory standard in the energy sector and a powerful driver for investments in photovoltaic power plants, is thoroughly justified. Projections and justified expectations of an accelerated pace and an increasing share of renewable energy sources in the energy mix of the country, with a priority of the energy generated by photovoltaic plants, are confirmed through the evaluation of target metrics in national strategic documents.

Second. By conducting econometric analysis of the day-ahead segment of independent energy exchanges across twelve economies in Central and Southeastern Europe, regression models have been developed to forecast the annual price (in Euro/MWh) of electricity as a key indicator in business plans for investments in photovoltaic power plants.

Third. Trends indicating a heightened correlation of price levels in the day-ahead segment of energy exchanges have been identified, particularly in countries with closely interconnected electric power transmission systems. For Bulgaria, using stepwise multifactor regression modeling, a regression equation has been derived illustrating the dependence of electricity prices on Romania's price (the leading factor), as well as prices in Greece and the Czech Republic as of the year 2023.

Fourth. The increasing demand for investments in renewable energy sources in a liberalized electricity market sets the foundation for profitable business models for project-based photovoltaic companies. These companies leverage financial techniques along with the best technological performance indicators for solar panels.

V. Publications on the topic of the dissertation paper

I. Articles: 2

Georgiev, Todor. (2022). Fotovoltaichnite centrali v energijnija balans na Bulgarija – sustojanie i perspektivi. Godishen almanah „Nauchni izsledvanija na doktoranti“, 2022 g. Broj XV, kniga 18 – Studii i statii, s. 492-501, ISSN: 1313-6542.
https://doi.org/10.13140/RG.2.2.28810.59841
URL: https://almanahnid.uni-svishtov.bg/title.asp?title=2959

1) **Zahariev**, A., Georgiev, T. (2023). The day-ahead energy market: correlation analysis and trends for selected CEE countries, Economic and Social Development. Book of Procieedings, (100), pp. 178-192, ISSN: 1849-7535.
URL: https://nsarhiv.uni-svishtov.bg/title.asp?title=2803

II. Scientific reports: 3

1) **Georgiev,** Todor. (2023). Logistichni predizvikatelstva pri izgrazhdaneto na fotovoltaichni centrali v Bulgarija, Nauchna konferencija „Logistikata i obshtestvenite sistemi”, 16-17 mart 2023 godina, NVU "Vasil Levski", V. Tarnovo, s. 713-722, ISSN 2738-8042.
URL: https://www.researchgate.net/publication/371082049

2) Zahariev, A., **Georgiev**, T. (2023) Ikonometrichen analiz na borsovite ceni na elektroenergijata v segment „den napred“ v Chehija, Slovenija, Slovakija i Ungarija za 2023 godina, Sbornik s dokladi ot Krugla masa na tema „Globalna ikonomika i biznes“, posvetena na 30-godishninata ot osnovavaneto na katedra „Mezhdunarodni ikonomicheski otnoshenija“, Svishtov, 29 septemvri 2023 g., str. 131-141, ISBN 978-954-23-2421-8.
URL: https://www.researchgate.net/publication/375330040

3) **Georgiev**, Todor (2023). Bulgarskoto elektroproizvodstvo i cenovata dinamika v segment „den napred“ prez 2022 godina, Sbornik s dokladi ot jubilejna mezhdunarodna nauchnoprakticheska konferencija „Predizvikatelstva pred finansite i stopanskata otchetnost v uslovijata na mnozhestveni krizi“, Svishtov, 9-10 noemvri 2023 g., str.147-152, ISBN 978-954-23-2426-3.
URL: https://www.researchgate.net/publication/378475416
DOI: https://doi.org/10.58861/tae.cf.cfeacmc.2023.21

VI. Reference for the participation of the doctoral student in scientific forums

1) XV Doctoral Scientific Session, December 2, 2022, "D. A. Tsenov" Academy, Svishtov.

2) Scientific Conference "Logistics and Public Systems", March 16-17, 2023,Vasil Levski National Military University, V. Tarnovo.

3) Round Table on the topic "Global Economy and Business", dedicated to the 30th anniversary of the establishment of the Department of International Economic Relations, September 29, 2023.

4) 100th International Scientific Conference on Economic and Social Development – "Economics, Management, Entrepreneurship and Innovations" (4-6 October 2023, Svishtov).

5) Jubilee International Scientific and Practical Conference "Challenges for Finance and Economic Accounting in Conditions of Multiple Crises", Svishtov, November 9-10, 2023.

VII. Reference for the compliance with the national requirements under the Rules for the Implementation of the Law on the Development of Academic Staff in the Republic of Bulgaria

Articles: 2 (1 in authorship and 1 in co-authorship)
Scientific reports: 2 in authorship and 1 in co-authorship
Required minimum number of points: 30.

The requirement for minimum number of points for Indicator 7 (Articles and reports published in non-refereed journals with scientific review or published in edited collective volumes), according to the Appendix to Article 1a, Paragraph 1 of the Rules for the Implementation of the Law on the Development of Academic Staff in the Republic of Bulgaria with Minimum National Requirements for Scientific, Teaching, and/or Artistic or Sports Activities of Candidates for Obtaining a Scientific Degree and for Occupying Academic Positions of "Chief Assistant," "Associate Professor," and "Professor" in Scientific Fields and/or Professional Directions in Field 3. Social, Economic, and Legal Sciences, Professional Direction 3.1 Sociology, Anthropology, and Cultural Sciences, 3.2 Psychology, 3.3 Political Sciences, 3.4 Social Activities, 3.5 Public Communications and Information Sciences, 3.6 Law, 3.7 Administration and Management, 3.8 Economics, 3.9 Tourism **is fulfilled**.

(3 + 2x50%) articles and scientific reports x 10 p. = 40 p. > 30 p.

VIII. Scientometric indicators of the dissertation work

№	Indicator	Reported
1	Number of tables	122
2	Number of figures	55
3	Number of standard pages	239
4	Software used	MS Excel, IBM SPSS Statistics
5	References	151
5.1.	incl. in a foreign language	115
5.2.	incl. in Bulgarian	36
6	Author's publications on the topic of the dissertation	5
7	Number of points according to the Regulations for the Implementation of the Law on the Development of Academic Staff in the Republic of Bulgaria	40,00
8	Number of participations in scientific forums	5
9	Order number for enrolment in the doctoral program	Order number № 142 dated 15.03.2021
10	Date of enrolment in the doctoral program.	01.03.2021
11	Duration of the doctoral program	3 years
13	Annual assessment grades	positive
14	Date of decision by the DC ouncil to grant permission for defence	15.04.2024
15	Date of decision by the FC to open a defence procedure	15.04.2024
16	Time, date, and location of the public defence	12.00 hrs., 13.06.2024 (Thursday), the Rectorate Conference Hall of D. A. Tsenov Academy of Economics – Svishtov
17	URL address for online access to the public defence, BBB room 'SA-KFK-Nauchni jurita'	https://bbb.uni-svishtov.bg/b/yc7-x2c-dtm

IX. Statement of originality of the dissertation paper

The dissertation paper in volume 239 pp., titled: *"**Investments in Photovoltaic Power Plants – Financial and Environmental Aspects**"* is own research work of the author. It presents own ideas, text, and graphic presentation in strict compliance with the requirements of the of the Copyright and Related Rights Act, including by properly citing and referencing the sources of information used, including:

1. The results achieved and contributions made in the dissertation are original and have not been borrowed from research and publications in which the author has not participated.
2. The information provided by the author in the form of copies of documents and publications, personally compiled references, etc. corresponds to the objective truth.
3. The scientific results obtained, described and/or published by other authors are duly and extensively cited in the text and in the bibliography.

The signature has been removed based on EU Regulation /EU/2016/679

Date: ……..

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Doctoral student Todor Georgiev