



BULGARIAN ACADEMY OF SCIENCES

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**Final investment decision for construction of nuclear
power plant in the context of a liberalized electricity
market in Bulgaria**

/methodological and applied aspects/

ABSTRACT

of the dissertation

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I. GENERAL CHARACTERISTICS OF THE DISSERTATION

1. Relevance of the dissertation topic

Applied energy sources at different historical stages are conditioned by the development of technologies, but the demand for energy is inextricably linked to population growth and improvement of living conditions. The addition of new energy sources stimulates the development of industry and expands consumption to satisfy increasingly diverse activities and services. Therefore, the role of various energy sources is not only a fundamental issue of the development of humanity, but also a subject of scientific research in the technological and economic fields. The socially and politically sensitive topic of energy provision arouses the interest of a number of theoretical economic schools, but it is precisely the clash of economic rationality with political and social factors that still does not allow for the construction of a clear methodology for substantiating decisions to achieve energy security. This is particularly pronounced in the assessment of the role of nuclear energy and its future, in the context of sustainable socio-economic development and requires consistent development of a theoretical and methodological basis that would serve to make rational and acceptable decisions.

The relevance of the study in terms of the conditions under which investments in a nuclear power plant are made is dictated by the fact that the investment decision to continue activities after the study phase leads to the assumption of contractual commitments with significant financial implications, as in the case of Bulgaria, such a decision commits national resources for the implementation of a structurally significant investment.

In Bulgaria, there are two specific project proposals for the construction of a new nuclear power plant and expressed interest in additional nuclear power plants by applying technologies for small modular reactors. This is a prerequisite for an in-depth discussion of the future use of nuclear energy based on the accumulated production experience, established regulatory environment, and developed scientific and technical infrastructure.

2. Thesis of the dissertation

The main thesis of the dissertation is that the application of a methodological approach for a complex analysis of the impact factors when making the Final Investment Decision (FID) for the construction of a new nuclear power plant through a multi-criteria analysis for comparing alternatives is the most effective assessment tool, through which the sustainability of the initiative is reliably guaranteed during its implementation. This approach has an advantage over target technical and economic models in the conditions of a

high degree of uncertainty arising from the preliminary nature of the presented planning, environmental, technical and financial reports, on the basis of which the intention to implement a specific project is confirmed or rejected.

3. Purpose and tasks of the dissertation

Formulation of alternatives and selection of a sustainable final investment decision for the construction of a nuclear power plant in Bulgaria, taking into account the new circumstances in the conditions of a liberalized electricity market in Europe.

The tasks of the dissertation, following from this goal, are as follows:

- development of a methodological approach applicable to justifying an investment decision for a new nuclear power plant based on a critical analysis of the aspects of the liberalization of the electricity market in Europe and the dynamics of the Bulgarian electricity sector;
- analysis of the specifics of the ownership of nuclear power plants and the place of public-private partnership for the implementation of such projects;
- derivation and assessment of a complex of influencing factors (financial, economic, technological, environmental, political and social) that determine the sustainability of the investment plan for the construction of a nuclear power plant;
- analysis of key indicators (criteria) for the assessment of an investment project for the construction of a nuclear power plant;
- application of the methodological approach for making an investment decision on the example of the development of new nuclear capacities at the Kozloduy NPP site and the Belene NPP site.

4. Object and subject of the dissertation

The object of the dissertation is the electricity sector in Bulgaria and the role of nuclear energy in the context of the liberalization of the electricity market.

The subject of the study is the complex influence of factors on the sustainability of an investment initiative applicable to the construction of new nuclear facilities in the conditions of a liberalized electricity market, based on the example of the development of new nuclear capacity in Bulgaria.

5. Methodology of the dissertation

The research methods include traditional scientific methods, such as methodological procedures for ranking investment projects and selecting the best project, within the framework of a multi-

criteria decision-making process. Expert analysis is applied in view of the subject of the study, and in particular nuclear technologies for the production of electricity in a competitive electricity market.

For the purposes of the study, an approach combining macro-analysis and micro-analysis is applied, using PEST/SWOT analysis to assess a project initiative for the construction of a nuclear power plant within a liberalized European market.

6. Information security and limitations of the study

The research in the dissertation is based on data on the two specific project proposals for the construction of a new nuclear power plant in Bulgaria, as well as available literature data on the nuclear technologies under consideration. A study of the ownership structure of nuclear power plants in the European Union (EU) and other countries was conducted. IAEA data were used. Statistical data on the production and consumption of energy and electricity were used.

The study is limited to an analysis of the market environment in the EU and applicable practices for the development of nuclear projects in the EU. The main emphasis of the study is a comparison of three alternatives for new nuclear power in Bulgaria.

7. Approbation

Four articles have been published on the topic of the dissertation.

II. STRUCTURE OF THE DISSERTATION

1. Contents

The dissertation has a volume of 212 standard pages and is structured as follows: introduction, three chapters with relevant sections, conclusions, list of literature used (141 sources) and appendices (30 pages). The text contains a list of abbreviations used, 16 tables, 26 figures and an index of concepts.

The contents of the dissertation include

Abbreviations used

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2. Main contents of the dissertation

CHAPTER ONE. DEVELOPMENT OF THE ELECTRIC POWER INDUSTRY. CURRENT CONDITIONS AND SOLUTIONS IN THE PRODUCTION OF ELECTRIC POWER

Chapter one is of a prescriptive nature. It first of all traces the trends in the demand for energy and electric power, as well as the effects of growing electrification of consumption, with a view to choosing alternatives for development, with an emphasis on basic energy sources, such as nuclear energy. **The dissertation seeks an answer to the question under what conditions projects for new nuclear power plants can be implemented, taking into account market and general restrictions.** In this sense, studies of the market environment and general aspects are the subject of in-depth analysis in search of factors of impact on the investment process.

Investments in nuclear power have a specific nature, arising from the high value of the assets, the long term of their use, the presence of sectoral regulations and restrictions on technological absorption. The investment process for the construction of a nuclear power plant, taking into account the conditions for operation in a liberalized electricity market, covers the preparation and justification of the investment proposal, as well as taking into account the subsequent phases of project implementation, asset acquisition, and their realization for commercial activity.

The Final Investment Decision (FID) is the last and most important step before entering the project implementation phase, ending with a conclusion on the continuation of the project or its abandonment. The FID for the construction of a nuclear power plant is related to the award of complex engineering, procurement and construction (EPC) contracts. At this stage, the management body discusses and accepts the proposed justification for the usefulness of the investment in the project, assessing whether all requirements for the implementation of the project are provided and it can be implemented according to schedule and within budget, after which it gives consent to sign binding supply and implementation contracts.

The dissertation is based on the understanding that **the sustainability of an investment initiative is achieved by taking into account all areas that influence the processes of implementing the initiative**, and by applying a methodological approach to comparing alternatives for a complex analysis of factors based on multi-criteria analysis, comparability of assumptions is achieved.

The implementation of a large-scale infrastructure transformation in the EU creates uncertainty that should be taken into account in the investment process, and the actions of external forces have a diverse nature of impact. In the case of nuclear power, the uncertainty factors are associated with technological features, but also with more general economic and social aspects, which requires taking into account the strategic national goals, which include requirements for the competitiveness of the economy, environmental protection, improving the well-being of people, and the functioning of society as a whole, by ensuring the safety and security of energy supplies at affordable prices.

Access to modern energy services is essential for meeting basic social needs, stimulating economic growth and fostering human development. This is because energy services have an impact on productivity, health, education, drinking water and communication services. Energy has both positive and negative impacts on societies. Access to abundant, affordable, secure, safe and clean energy benefits people. However, the extraction, transportation and use of primary energy resources can have negative impacts on health and the environment in a regional context. Increasing public attention to these aspects is increasingly influencing the decision-making process for investments in the sector.

Energy consumption is relevant to a wide range of human activities, but is differentiated within the demand by sectors, including: industry; transport; construction; agriculture; services, and households. There are also significant differences at the national and regional levels, which arise both from the availability of energy sources and access to new technologies, as well as from the dominant systems for implementing energy projects: centralized or market-based.

The review of empirical historical data and literary sources allows us to agree with the assessments of the high importance of energy production for economic development. Gradually, the energy input for the production of final products becomes a complementary factor to the main production factors – labour, land and capital, and the transition to more efficient and concentrated energy production is part of the ascending phases of cyclical economic development. The role of energy in general, as well as of electricity in more specific terms, is considered as an element of industrial and social development, without which society loses the potential necessary for the realization of its goals. The expansion of the scope of application of electricity as a basic resource for production and satisfaction of various needs is the basis of the high social significance of this industrial product.

A significant challenge in managing the investment process for large energy projects is taking into account the changing external environment, which determines the demand, but also the

currently available technologies for the production of electricity. Also, state support policies and the market model applied specifically in the EU should be taken into account, as they are the basis of the economic transformation of the Union. The dissertation provides an overview of the concepts for reforming the energy sector, emphasizing the role of green transition policies and promoting economic recovery, which are necessarily considered in the integrated energy and climate planning of the Member States within the EU. Specific environmental requirements and the introduction of changes in the conditions for the provision of energy services in Europe began to gain momentum after 1985, and currently the comprehensiveness of the regulations introduced and the targeting of public financial resources change the conditions for market competition in the supply of goods and services, which is already reflected in the divergence of basic ratios in the electricity sector. These aspects are important when considering nuclear energy as an alternative for the production of electricity.

The dissertation examines issues of competition, but with the expectation of security of supply, when operating different electricity sources in the conditions of a centralized or liberalized European market. It is emphasized that nuclear energy is part of the evolution of the technological development of energy sources, which ensures a constant supply of electricity, and the implementation of project initiatives for new nuclear capacities is carried out in the real market environment.

When making a decision to introduce new production capacities, the analysis of the factors influencing price formation is of great importance. The law of supply and demand is applicable to changes in the price of electricity, and in the general case, supply increases while demand decreases with increasing price. For the electricity sector, the application of the principles of supply and demand must take into account the still limited possibilities for storing the produced goods and the need for their placement practically immediately after their production.

As a result of the complex nature of the final product and its high importance for end customers, the market mechanism of price regulation with respect to electricity has limited effect.

For the purposes of this study, the quality of electricity is considered as a commodity supplied under general market principles, but taking into account its increasingly high socio-economic importance as a basic resource, and the first chapter provides an overview of statistical data on the consumption of energy resources and the consumption and production of electricity.

For the purposes of the analysis, this study is based on the specific features of electricity as a commodity:

- The demand for electricity is generated by the diverse needs of people, which are satisfied through its use, i.e. the supply of the commodity "*kilowatt-hour*" has no independent significance as a final product for consumption.
- Electricity has limitations in terms of its storage, which is why it is mainly produced simultaneously with its use.
- Electricity satisfies part of people's energy needs, but when high prices have been established on the market, electricity can be replaced with other energy sources only in some cases - for example, to satisfy the need for heating, but its use for lighting and powering electrical appliances still has no alternative.
- Electricity is often defined as a commodity of primary necessity, in which demand is relatively inelastic in terms of price, since people cannot easily do without it, so demand changes less in relation to price changes.

Electricity is supplied to end users as a general package, which includes additional services for end users, such as metering, billing, provision of mandatory information, etc. The supply of electricity is also associated with other mandatory services, such as renovation and maintenance. Some of these functions can be provided on a competitive basis, for example, a wider provision of system services by independent producers or by users, while other services are more difficult to liberalize.

Within the framework of the dissertation, a critical analysis of the market environment has been carried out in the light of liberalization and the establishment of a single European electricity market, taking into account the dynamics of production and discussing the factors in pricing for the main groups of electricity producers. As a result of the analysis, the conclusion has been drawn that the production of electricity is related to national and supranational policies that shape trends in demand and supply, but also in the choice of different technological solutions for ensuring supplies. These policies are formed in response to long-term goals in the process of developing new energy sources and technologies along the supply chain, but also as a reflection of changes in demand and emerging external crises.

The trends to limit the use of coal and oil for electricity generation are sustainable, as well as an increase in the share of new technologies for wind and solar generation, and when using natural gas, strong volatility is noticeable due to price factors. Nuclear energy has been losing ground in the last thirty years due to political decisions to close down capacities. On the other

hand, the trend for growth in electricity demand is maintained, thanks to the electrification of consumption and the introduction of a number of new technologies among end users.

In the modern world of rapid development of information systems (microelectronics, computers and telecommunications), electricity is gaining even greater importance, and the issue of its provision is directly related to the topic of national security or the issue of access to basic goods. For example, electricity and heat are part of the small consumer basket and are recognized as part of the goods and services without which normal physical and social existence is impossible. **When discussing the need for a higher level of security in the EU, nuclear energy is already considered with priority.**

In parallel with the establishment of a pan-European climate and energy policy framework, the choice of specific solutions for the development of the electricity mix belongs to the Member States, in accordance with their sovereignty for the use of primary energy sources. **With the increase in the share of renewable energy sources (RES) and the displacement of traditional capacities from the market, which have so far provided system reserves, a number of questions arise regarding the model of electricity industry dominated by green technologies.**

The recommendations for priority financing of renewable energy projects are subject to critical analysis, as they should take into account the realities of the established decentralized electricity supply systems and the technological possibilities for diversifying energy sources at an acceptable price.

A major problem is that any effort to design an appropriate energy future is riddled with uncertainty and divergent trends, due to the high diversity of national and sectoral conditions. However, the analysis of supply and demand factors and forecasts is essential because it helps investors, entrepreneurs and economists to understand and predict market conditions for the supply of electricity. This is especially true for nuclear power plant projects, which are characterized by high investment.

Although the free electricity market is often equated with a pure form of market economy, this is not correct, because a number of regulations are necessary for its functioning and government intervention is permissible in order to avoid supply shortages. The key difference between a liberalized and a centralized market is the scope, and especially the manner of such interventions. The acceptable scope and type of government intervention that would define it as permissible remains controversial, especially with regard to the role of the state in giving a

certain direction to energy development and dealing with the economic, social and resource issues arising from such impacts. **In the ideal concept of a free market, the role of the state is limited to providing security and protection from coercion and fraud in the performance of market exchange.**

But even in the general case, it is impossible for a market to function without any regulation, and in the case of the electricity market, regulatory mechanisms play a dominant role in the security of supply. State regulatory mechanisms include both monitoring and enforcement of rules established by primary and/or delegated legislation.

Competition policy brings to the fore short-term markets, focused on trading “*only for energy*”, which clearly supports the development of installations with low capital costs. In such conditions, in fact, the possibilities for building new or even modernizing conventional power plants are increasingly limited, as they are deprived of financial support and cannot rely on long-term contracts.

The conclusion is that the considered leading EU policies rely on a significant price effect **in the long term**, when the cumulative impact of investment projects in low-emission industries and energy efficiency measures will realize a large-scale change.

In the short term, the politically supported growth of RES in the grid leads to an increase in costs for end users, and price signals through the electricity market direct investor interest towards solutions with the shortest possible payback period. However, as their shares increase, their system costs also increase.

The conclusions on the existence of market failures that cast doubt on the ability of the “*energy-only*” market to provide the necessary investments are discussed and attention has been paid on the fact that the return on investment in long-term projects depends on the degree of impact of policies regarding environmental constraints and cross-border issues, whereby investors also take the risk that their projects will have a limited life as a result of external factors.

Based on an in-depth analysis of the policies and functioning of the European electricity market and the assessments made in the economic literature, this study identifies the main imperfections of this market in the short and long term.

The wide range of information sections that should be assessed when making a decision directs us to factor analyses as a tool for decision-making. In developing this approach, the main factors for forming an investment decision are sought. Technological parameters arise from the chosen technology and are a mandatory part of the justifications for compliance with the country's

regulatory framework. Financial and economic analyses have quantitative measures that arise from the financial proposals of the suppliers, the market environment, and the capital raising model.

The dissertation substantiates the claim that at the stage of making an investment decision, a wide range of cost-determining factors should be taken into account, based on forecasting and assessments of circumstances in a long horizon. Moreover, with regard to a number of project indicators (technical, market, financial), there is no reliable information in the entire range of influence, **which necessitates decision-making under conditions of uncertainty.** Under these conditions, deriving a categorical quantitative assessment for an individual project is inapplicable, **which is why the dissertation proposes an approach for comparing alternatives.**

The review of applicable models for justifying an investment project shows that the main attention is paid to financial analysis and forecasts, but it should be noted that the results of such models are strongly dependent on changes in the external environment.

The first chapter shows the presence of a positive market environment for new energy capacities, but emphasizes the wide range of circumstances that influence the successful implementation of a specific investment intention. With regard to nuclear power plant construction projects, it is concluded that the assessment of various risk factors can significantly change the conditions for project implementation. Based on the literature review, the need to apply factor analysis in justifying investment projects is justified, by systematizing the influence of the external environment within the political, economic, technological and social aspects of influence:

- **The political environment** is determined by the legal framework and regulatory mechanisms, but also by the presence of a supported strategic vision and sustainable management.
- **The economic environment** covers a broad scientific subject area, which includes topics related to the supply and use of energy in societies, accounting for the price of energy services and their associated value, but also the efficiency with which electricity can be produced. The economic environment also covers the forms of ownership of major assets and the instruments for implementing state economic policies.
- **The socio-cultural environment** covers both issues of satisfying basic needs for society and factors of public support, and in a number of countries the attitude towards environmental challenges enjoys high public attention. It also includes the topic of

corporate social responsibility, which is part of the policies of companies developing large energy projects.

- **The technological environment** covers the comparison of developed technologies and forecasts for the introduction of new technologies in the field of electricity production. The efficiency of energy services depends on the engineering technology used to produce and supply energy while complying with regulatory and environmental restrictions.

Due to the different nature of the influencing factors, some of which can be determined by quantitative indicators, while others use qualitative assessments, this paper proposes the application of a strategic analysis approach, comparing Strengths, Weaknesses, Opportunities and Threats in alternatives for developing an investment project. **The dissertation has developed a tool for substantiating a final investment decision for a new nuclear power plant, based on strategic analysis, namely PEST/SWOT analysis.**

Based on the complex nature of the risks and the resulting uncertainty in investments in nuclear power plants, the dissertation proposes a methodological approach based on a wide range of academic research and own experience in working on projects in the field of nuclear energy.

CHAPTER TWO. METHODOLOGICAL APPROACH TO JUSTIFY A SUSTAINABLE INVESTMENT DECISION IN A NUCLEAR POWER PLANT UNDER THE CONDITIONS OF A LIBERALIZED MARKET IN BULGARIA.

The proposed approach is developed in chapter two of the dissertation, in parallel with the analysis of the specifics of the development of nuclear projects in modern conditions. In the dissertation, the study of external impacts on a global and European scale, presented in chapter one, is distinguished from the analysis of external and internal impacts typical for Bulgaria. In this regard, the applied methodological issues, the choice of impact factors and the related literature review are considered in parallel with the analysis of the national context for choosing an alternative solution.

The final investment decision (FID) marks the transition from the phase of studies and conceptual volume-structural technical solutions to the phase of project implementation. The methodological approach to justifying investment decisions proposed in the dissertation aims to ensure sustainability in the long term by comparing alternatives, which may be specific

proposals or similar projects implemented abroad. **The study is based on the understanding that sustainability¹ of an investment initiative is achieved by taking into account all areas that influence the processes of implementing the initiative and by applying an approach to comparing competing alternatives to achieve comparability of assumptions.**

In the second chapter, attention is again paid to the market environment, but with a strong focus on nuclear projects implemented in a liberalized market. From this perspective, common approaches to modelling the market environment and preparing financial and economic assessments for nuclear projects are examined.

In the reviewed literature, decisions within the investment process are not highlighted as key moments of transition between different phases of the project and the need for a comprehensive approach to preparing an FID is not emphasized. **The methodological approach proposed in the second chapter reflects the complexity of the factors in the preparation of the FID, increasing the sustainability of a decision to build a nuclear power plant, thereby filling the theoretical and applied gap in this area.**

In the literature, there are developed methodologies for financial analysis, containing risk assessments, and serving to derive quantitative assessments, which are the basis of the decision-making process. In this dissertation, financial analysis methodologies have been partially used, and they have been upgraded with quantitative and qualitative assessments, both in relation to the project and in relation to the environment in which it will be implemented.

Based on the understanding that the justification of an investment decision to build a new nuclear power plant has a distinct national context, both from a systemic and market perspective, the methodological approach proposed here fully takes into account the influences of the external environment. The approach makes an independent contribution by introducing a clear sequence of steps to achieve sustainability of the conclusions with respect to the main influencing factors.

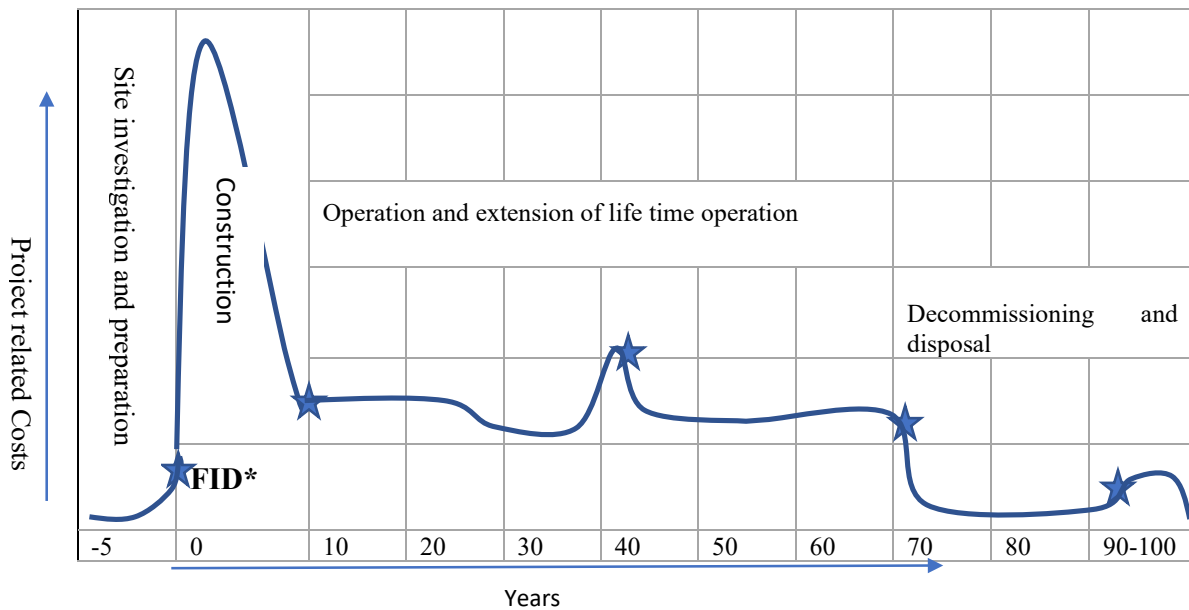
Making a decision to build nuclear power is not a single act, but a cycle of studies, assessments and interim decisions.

For this type of energy facilities, the regulatory framework requires that deductions be made during the operation of the facility for activities after its completion, thus the financial framework should take into account all costs within the life cycle, including after the end of the

¹ This investment decision is sustainable, as it supports sustainable corporate growth but places it within the framework of overall socially just and environmentally friendly development.

operation of the nuclear facility, even when making the FID. These costs are presented in Figure 1.

Figure 1. Costs within the life cycle of a nuclear power plant



*FID – final investment decision

Source: author's content

The adoption of the FID for the construction of a new nuclear power plant is based on an analysis of the sources of uncertainty and a developed strategy for minimizing risks, with the corresponding financial reserves provided for a response to the occurrence of unplanned events.

Within the framework of the preparatory phase of the project, the owner (the initiator of the investment intention) performs at his own expense a number of technical and organizational actions in compliance with regulatory requirements and in order to justify the soundness of the investment intention. The results of these actions are related to the success of the next phase of construction, but also have a significant contribution to the formation of the financial assessment of the project. In the preparatory phase, significant data is collected on the selected technology and site, but the impact of the external environment is also assessed through the prism of national policies, market characteristics and public support.

To justify investment intentions for the construction of a new energy facility, it is necessary to develop forecasts, both in terms of the life cycle of the new facility and in terms of the environment in which it will operate. The construction of new nuclear facilities is difficult due to the high initial investment costs and the associated financial and political risks that arise

during the long periods of study before obtaining construction permits. In addition, countries planning new nuclear power plants will have to make politically sensitive decisions regarding geological disposal and long-term management of radioactive waste.

These challenges, combined with the uncertainty of long-term forecasts of consumption and price levels, as well as competition from other energy sources, lead to the need to redistribute risk among a wide range of participants in the process of implementing a nuclear power plant project.

For nuclear power plants, the financial justification is part of the feasibility study, which takes into account both the technical adequacy of the project and the economic feasibility of its implementation, but should also take into account the overall environment in which the facility will be implemented and operated. Financial flow models and assessments of the financial viability of a new project are often discussed in comparison with a reference market price of electricity, which is compared with the project's revenues and costs.

In a liberalized market, ensuring energy supplies at minimal costs is not a functional goal, but is expected to be achieved due to the operation of the general economic principles of supply and demand. As the forecast period increases, determining the total production cost based on the detailed cost nomenclature becomes more difficult due to the increasing dependence on assumptions and dependence on changing external factors.

Financial and economic analysis takes into account a number of external factors, but they are focused on a specific object and cover medium-term forecasting, within a period of capital recovery. To avoid this limitation, this study proposes an upgrade of the accepted analysis methodologies.

In conditions of uncertainty regarding key market parameters, investors turn away from opportunities that are related to long-term capital commitment. The lack of sustainable market signals gives rise to the phenomenon of "*missing money*" and the need for the state to create prerequisites and encourage corporate decisions for investments in the sector.

Appendix 2 to the dissertation presents detailed data on ownership in nuclear power plants, which show that in them the ultimate owner is most often the state, and the nuclear power plant is managed by a licensed legal entity subject to specialized control.

In the case of the development of the electricity sector and in order to limit the risk component in financing large energy projects, centralized systems were based on dominant state support. At first glance, state support contradicts the idea of achieving a high degree of competitive

environment by introducing a free electricity market in Europe, and the gradual reduction of regulations and elimination of vertical integration of companies in the sector. In centralized national systems, the presence of monopolies in the production of electricity is also typical, in relation to which efforts were directed for reform.

But centralized systems for the production and supply of electricity also have a number of advantages:

- the provision of the necessary amounts of energy is largely decided by planning on an annual basis, drawing up a power balance and a forecast electricity balance;
- the participation of individual power plants is planned on an annual and seasonal basis, which allows planning both fuel requests and their production programs in the medium and long term;
- they are characterized by a high degree of redundancy, due to limited cross-border connections;
- the unified system of production, transit and distribution allows for the formation of an aggregate price for electricity "*price per kilowatt hour*", which provides predictability for consumers.

The transition from centralized systems to a system with market competition is associated with limiting monopolies, but the establishment of oligopolistic competition is observed.

The study concludes that the conditions for the implementation of mega-projects, such as nuclear power plant projects, presuppose their development being carried out by companies with monopoly or oligopolistic positions in the electricity market. Balancing public and private interest is achieved through state regulation and through voluntary implementation of policies for corporate social responsibility.

At the same time, electricity is of great importance both for the competitiveness of the economy and for the needs of the mass consumer, which is why states continue to play a significant role in the entire chain of electricity production and transformation. European and national legislation (for example, in the Bulgarian Energy Act) has introduced a definition of a "service of public interest", which is the transportation, delivery or supply of energy or natural gas of a certain quality, a regulated price or a price determined by a methodology approved by the commission and other contractual conditions, which cannot be refused for reasons not specified in the law.

The treatment of resources as publicly available or as publicly necessary is an important aspect that determines both state intervention in their allocation and the degree of their coverage by the market.

The variety of applicable concepts for the implementation of nuclear projects is limited due to the high capital costs, the requirements for a high level of competence and the conditions for licensing technological solutions for a nuclear reactor. The presented review of the practice of providing state aid for nuclear projects aims to highlight the importance of political commitment to this type of investment.

In addition to the combination of an **operator** (a person who is contracting for the construction of a new nuclear power plant) and a **technological supplier** of nuclear equipment, a key issue for the implementation of these projects is their **financing**. This study substantiates the claim that **the establishment of sustainable financial models for the implementation of nuclear projects in a competitive market requires the provision of state support. This claim is supported by empirical data for 170 contemporary projects**, and detailed information on the ownership and applicable technologies for nuclear projects is presented, including the market implementation of dominant suppliers. It is concluded that the grouping by specific characteristics of the ownership and the financing model may vary in different analyses, but the common denominator is the presence of state participation or participation of companies with high revenues. The dissertation indicates that all three attempts to implement a nuclear project in Bulgaria, with limited state participation or without such, failed mainly due to a change in the positions for providing state support. **The successful implementation of nuclear projects in recent years has been associated either with dominant state participation or with initiatives by monopolies in the sector, which can provide the necessary financial resources and guarantees.** A change in this aspect can be expected after the widespread introduction of small-power reactors, which a number of private investors have targeted, but overcoming current technological, resource and legal problems postpone their development for the next decade.

In conclusion, it can be stated that the development of nuclear technologies requires a concentration of resources, which limits corporate participants in this area. The concentration of resources makes nuclear projects significant at the state level and is associated with the implementation of policies with a broad economic and social effect.

The widespread use of direct state participation or state support for nuclear projects requires the development of a justification for the development of an investment project,

taking into account the effects of its implementation not only at the corporate level, but also by applying a strategic analysis of the macro environment, which is determined by current and foreseeable political, economic, social and technological factors. The transparency and provision of information for wide public discussion is key for taking of FID for nuclear power with direct state participation or state support.

The assessment of the factors that determine the successful implementation of the investment process for the construction of a new nuclear power plant, in the context of planning the long-term development of the power industry, should cover financial, economic, technological, environmental, political and social aspects that form internal and external conditions for the development of a specific project.

To support the process of substantiating a strategic choice at the stage of the Final Investment Decision, the dissertation proposes a methodological approach based on the analysis of factors for assessing the aggregate potential of the project initiative by comparing competitive alternatives.

The proposed methodological approach for a complex analysis of factors through multi-criteria analysis, in which key indicators are applied as a criterion for assessing the factors of influence when ranking an investment alternative in competition with other alternatives.

To support the process of analysing the factors of influence and deriving key indicators, the dissertation applies PEST/SWOT analysis as part of the approach for conducting an analysis of nuclear power relations.

PEST/SWOT analysis is an empirical approach based on facts and data, and is applied to study the internal and external environment in which the organization or a separate project of it will develop. PEST/SWOT analysis are two tools that offer summarized information about companies and their position in the market. These analyses aim to provide an objective view for making informed decisions. PEST environmental analysis focuses on external factors and takes into account their impact on companies. In contrast, SWOT analysis considers the investor's point of view regarding the immediate environment.

In this dissertation, strategic analysis in the development of an investment project is applied with a view to limiting and controlling risks at the relevant stage of implementation of the initiative.

The study is based on the assumption that covering the technical and economic characteristics for the needs of a systemic or economic analysis requires the development

of models of different scope, and the summary formats of analysis offered by the PEST/SWOT approach correspond to such a need.

PEST analysis covers influencing factors that are not directly related to the investor's short-term activities, but can influence its long-term decisions. The main directions that are taken into account when grouping trends/events beyond the control of the enterprise, which can affect the potential effectiveness of its strategy, are: political-legal, economic, social, technological.

A number of examples of the application of SWOT analysis and key indicators in relation to a nuclear power plant can be found in the literature. They apply both to a plant in operation and to preliminary analyses to justify or reject an investment initiative for the construction of a new nuclear power plant. The application of SWOT analysis by a number of researchers in the field of nuclear project evaluation supports the methodological approach proposed in the dissertation, as the proposed methodological approach takes into account the factors of influence derived from the literature review.

PEST/SWOT analysis is supplemented by substantiation of a set of key indicators that allow to compare alternatives, based on assigned values. Accordingly, the values of key indicators and the range of their change should be justified for each specific application case.

The system of PEST/SWOT analysis and key indicators in relation to a nuclear power plant allows to jointly consider indicators that are often used independently for project evaluation, such as financial indicators based on LCOE or economic indicators NPR/IRR, technological production indicators and others.

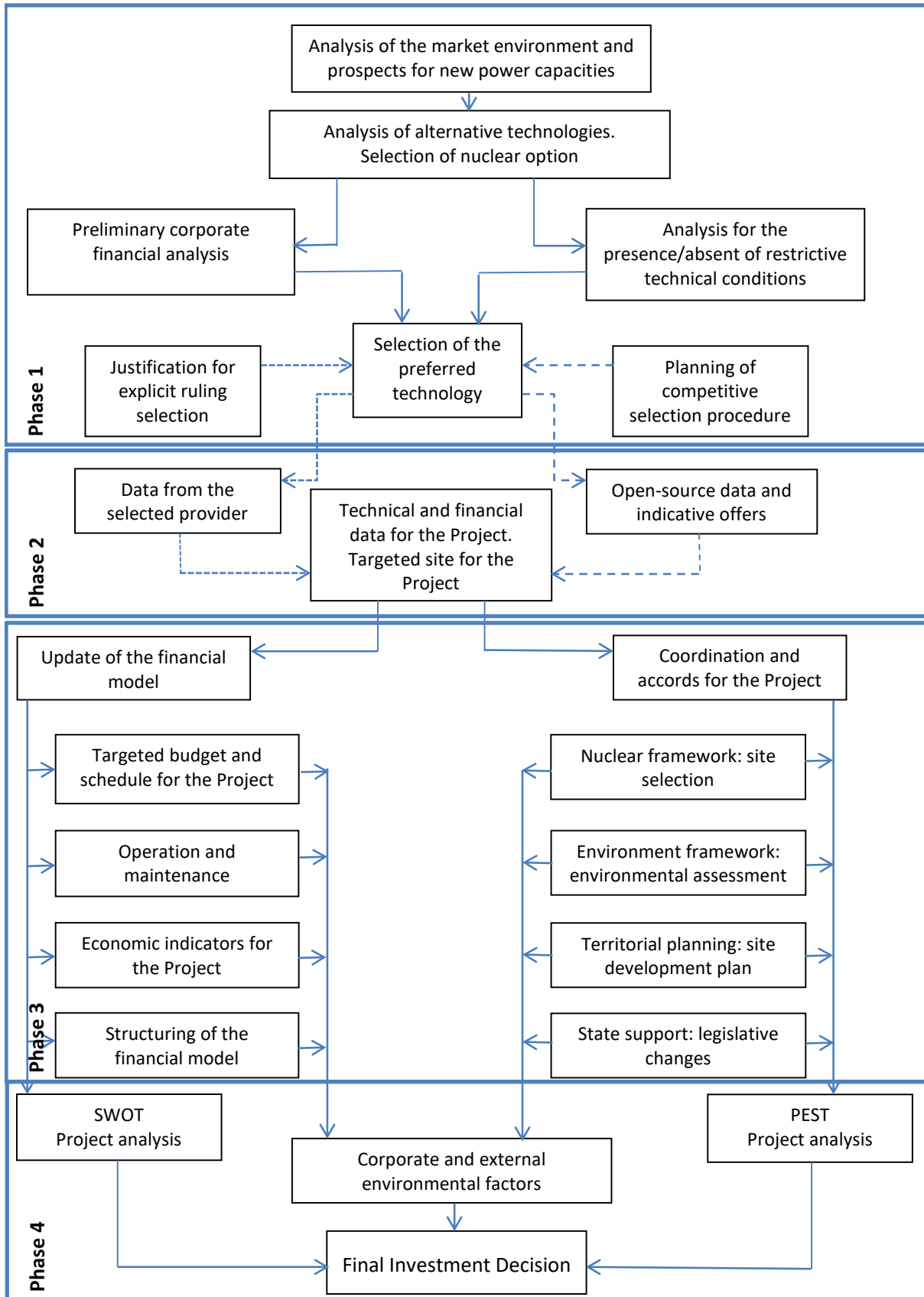
Key indicators are related to the main elements of the external environment, allowing to form assessments for comparison of different alternatives in relation to the same influencing factors when forming a final conclusion.

The process of forming influencing factors and key indicators is an iterative process of analysis of the external environment and assessment of the corporate environment and goes through the various phases of internal corporate analysis, making preliminary decisions, including the implementation of regulatory requirements. As data is accumulated, an extended analysis is conducted based on detailed site surveys and communication with the technology supplier.

The methodological approach proposed in the dissertation builds on common methodologies for financial and economic analyses and technical analyses at the initial exploratory stage.

The methodological approach is summarized in Figure 2.

Figure 2. Summary of the methodological approach for factor analysis



Source: author's analysis

The approach proposed in the dissertation links various analytical assessments into a single sequence and forms an FID based on a set of key indicators to achieve sustainability of the decision made. Key indicators measure various aspects of the implementation of a nuclear power plant construction project, such as quality, delivery and implementation time, production capacity, as well as quantitative financial and economic indicators. Due to the different nature of the quantitative and qualitative indicators, and in view of the goal of obtaining an aggregate assessment, the methodology suggests scaling both groups of indicators (quantitative and qualitative) on a scale from 1 (poor assessment) to 10 (positive assessment), as the approach to forming assessments for the various key indicators is demonstrated in the third chapter.

An advantage of these indicators is the ability to assess the effects of large-scale projects under potential development scenarios. This information is useful for planning and analyzing projects, which allows for optimal decision-making. In the third chapter, this usefulness will be demonstrated through our analysis of alternatives for the implementation of a nuclear project in Bulgaria, taking into account many different levels and aspects.

In developing the applied analysis in this work, the assessments and discussions within the framework of previous specialized studies are taken into account, making a critical selection of the factors that are significant in the case of the Bulgarian nuclear program, and in view of the stage of making a final investment decision.

CHAPTER THREE. TESTING A METHODOLOGICAL APPROACH FOR OIR CONSTRUCTION ON THE EXAMPLE OF NUCLEAR POWER PLANT CONSTRUCTION IN BULGARIA

The methodological approach developed in the dissertation for factor analysis in the preparation of a final investment decision is suitable for assessing the collected evidence for the validity of a proposed investment initiative for the construction of a new nuclear power plant. **In the third chapter, the methodological approach is put to the test by comparing three possible alternatives for the development of nuclear power in Bulgaria.** The comparison of alternatives allows for the refinement of the grounds for determining the impact factors, targeted selection of key indicators and avoidance of generating positive expectations for a pre-selected option.

The proposed alternatives have found a place in various strategic plans and visions of the Ministry of Energy in Bulgaria, and to varying degrees the arguments in favour of each of them

have been discussed in the public space. Despite the existence of public interest and stated program intentions, the proposed alternatives have so far been considered separately and in different time periods, which limits the possibilities for a justified comparison. A significant challenge in the analysis of the alternatives for the construction of new nuclear capacity is the scarcity of available financial data or statistics for implemented projects. By applying a methodological approach to the analysis of factors with the inclusion of quantitative and qualitative indicators applicable to each of the evaluated alternatives, a balanced result is achieved and a basis for making a rational investment decision that is sustainable over time.

The proposed methodological approach does not rely on the derivation of a single determining factor, such as a financial criterion for profitability, but uses a set of determining factors, which allows for achieving a result with higher stability when the external environment changes.

The use of a wide range of determining factors and the associated key indicators allows for the assessment of uncertainty and the derivation of the possibilities for achieving successful implementation for the individual alternatives. **The results of the application of the methodological approach make it possible to justify the need for state support for a new nuclear project in our country, in light of its systemic significance in a long period of exploitation.**

In continuation of the discussed factors of the external environment in the first and second chapters, in this third chapter the leading factors of the external and close environment applicable to the three alternatives are deduced and the key indicators are specified, which allows an assessment of the proposals to be made.

The methodological approach proposed in the dissertation, which builds on the common assessment methods, allows for the comparison of alternatives, by deducing at an early stage their advantages and the grounds for directing efforts towards some of them.

The generalized presentation of the result of the PEST analysis for the external environment is presented in the dissertation work, and the factors of influence when considering alternatives for the development of new nuclear capacities in Bulgaria are deduced:

- Political environment:
 - attractive investment environment,
 - energy security,
 - achievement of climate goals.

- Economic environment:
 - competitive market product,
 - accelerator for macroeconomic development.
- Sociocultural environment:
 - raising the standard of living,
 - public support.
- Technological environment:
 - operational reliability,
 - environmental impact,
 - application of proven technologies.

The factors of the immediate environment address issues typical for Bulgaria, **analysed on the basis of personal participation in the planning and discussion processes of the Belene NPP project in the period 2005-2009, which are supported by a discussion of specific risks that are taken into account in the study when assessing nuclear projects.**

The results of the assessment of the immediate environment through SWOT analysis are presented in the dissertation.

Some of the factors affecting the immediate environment are assessed after accumulating data from the feasibility studies and specific modelling, which is why the methodological approach implies the application of an iterative assessment process. In the first iteration of the assessment, some of the key indicators do not have quantitative assessments, and they are expected to be given in the next iteration.

This dissertation is based on comparative analyses of alternatives, which allow a conclusion to be drawn about a preferred strategy for the development of nuclear energy with the implementation of a nuclear power plant project, by choosing a specific technology and location on a specific site.

The possible alternatives for the development of a new nuclear project in our country are associated with the water-cooled reactor technology, regardless of where it will be chosen to be implemented - at the Belene site or at the Kozloduy site.

Taking into account the available generating capacities and the accumulated operating experience, this dissertation proposes the strategic choices that cover the following alternatives:

- **Alternative I** - Construction of two high-power nuclear units at the Kozloduy NPP site while maintaining state ownership of the plant. The target technology for this alternative

is Westinghouse's AP1000 taking into account a signed contract and a decision of the National Assembly;

- **Alternative II** - Construction of two high-power nuclear units at the Belene NPP site in the conditions of attracting a strategic partner. The target technology for this alternative is Rosatom's VVER1000/B466 taking into account delivered equipment that can be integrated into a successful Generation III+ project;
- **Alternative III** – Implementation of an innovative project with MMP in the conditions of attracting a strategic partner. The target technology for this alternative is NuScale Power’s VOYGR, taking into account the signed memorandum with “Kozloduy NPP – New capacities” and the advanced stage of project development.

It is emphasized that the lack of a solution for new nuclear capacity will lead to the need to preserve coal-fired power plants and high dependence on the regional market environment, taking into account that currently coal-fired units cannot cover their operating costs and need increasingly significant support in the long term, due to EU policies leading to high prices of CO₂ emission quotas.

Based on the identified leading factors of the external environment, the analysis of the corporate environment and the widely used indicators, the dissertation work has identified the applicable key indicators related to the relevant influence factor, as presented in Table 1.

Table 1. Formation of key indicators

Analysed environment	Impact factor	Key indicator	Dimension
Technological environment	Operational reliability	Average annual capacity utilization	%
		Burndown depth	MW.d/kg
		Severe accident frequency	1/ reactor-year
		Seismic resistance	G
		Load variation range	%
	Environmental impact	Used area for 1 nuclear unit	daa
		CO ₂ emissions	g/MWh
		Nominal cooling water flow rate	t/MWh
	Application of proven technologies	Construction period	months
		Duration of operation	years
Economic environment	Competitive market product	Direct capital costs	€/MW
		Price for financing	€/MW
		Operational costs	€/MWh
		LCOE	€/MWh
		NPV	value
		IRR	value
	Macroeconomic development	Impact on GDP	%
		Contribution to scientific and research development	by scale

Table 1 – continuation

Political environment	Attractive investment environment	National strategy for targeted technological development	<i>by scale</i>
		Uses state support mechanisms	<i>by scale</i>
		Practice with environmental impact assessment	<i>by scale</i>
		Established regulatory framework for technology	<i>by scale</i>
	Energy security	Dependence on supplies for production from third countries	<i>by scale</i>
		Part of critical energy infrastructure	<i>by scale</i>
	Achievement of climate goals	Reduction of CO2 emissions	t/y
Sociocultural environment	Raising the standard of living	New jobs in construction	number
		New jobs in operation	number
		National participation in supply chains	%
		Affordable prices	<i>by scale</i>
	Public support	Implemented ESG policy	<i>by scale</i>
		Public support for new capacity	<i>by scale</i>
		Public support for waste disposal by scale	<i>by scale</i>

Source: author's analysis

It can be seen that some of the key indicators are determined “on a scale”, in which case it is necessary to determine in advance the limit values and the conditions under which they are awarded. **In order to limit the subjectivity in these assessments, it is recommended that they be prepared based on the opinions of a wide range of respondents from within the organization and outside it.** On the other hand, to achieve a uniform assessment of the alternatives, it is also necessary for the quantitative key indicators to be presented in dimensionless values, corresponding to the scale for qualitative indicators. In this dissertation, targeted approaches are applied for scaling the quantitative and qualitative indicators.

The results of summing the assessments of the key indicators allow for deriving a cumulative assessment for each alternative and comparing the alternatives. The application of an approach based on the comparison of a complex of indicators also allows for tracking in which areas the respective alternative has advantages and in which disadvantages.

In the main analysis, LCOE estimates were obtained based on the maximum values of literature data, and subsequently, in the sensitivity analysis, the minimum estimates were adopted for LCOE. Accordingly, in the assessment of supply dependence in the main analysis, the current high-risk situation for supplies of fresh nuclear fuel and specialized maintenance for Russian reactors is reflected.

Table 2 shows the results of applying the scaling for the relevant key indicators.

Table 2. Results of applying scaled estimates for quantitative and qualitative key indicators

Key indicator	Min/Max difference	VVER 466	AP1000	SMR-300MW
Average annual capacity utilization	>15%	8	9	10
Burnup depth	<50%	7	10	1
Severe accident frequency	<50%	1	4	10
Seismic resistance	>50%	5	7	10
Load variation range	>50%	8	10	5
Used area for 1 nuclear unit	<50%	1	10	2
CO ₂ emissions				
Nominal cooling water flow rate	>50%	7	5	10
Construction period	<50%	3	1	10
Duration of operation	>50%	9	10	5
Direct capital costs	>15%	10	5	7
Price for financing				
Operational costs	<50%	10	8	1
LCOE	>50%	10	7	5
NPV				
IRR				
Impact on GDP, 55,7 bill€-22	<50%	5	10	2
Contribution to scientific and research development		10	5	1
National strategy for targeted technological development		1	1	1
Uses state support mechanisms		1	5	1
Practice with environmental impact assessment		10	10	1
Established regulatory framework for technology		10	5	1
Dependence on supplies for production from third countries		1	5	5
Part of critical energy infrastructure		10	10	5
Reduction of CO ₂ emissions		9	10	3
New jobs in construction	<50%	10	7	1
New jobs in operation	<50%	10	5	1
Total		178	180	115

Source: author's analysis

The results give a certain advantage to the AP1000 technology over the VVER technology, despite the lower capital costs and the existing experience in the country of operating similar units. The main reason is the assumption of the presence of state support for the implementation of a project with the AP1000 technology, as well as the presence of high risks in the supply chains of the VVER technology in the current geopolitical environment. The new technology with MMP has not yet been proven in practice, as there is no reference unit, which is why the estimates reflect the presence of significant uncertainties at this stage.

If the technologies are compared only by technological parameters, it is seen that the newer projects with the AP1000 have a significant advantage. According to these indicators, the SMR

also shows advantages even at this early stage of development, but the high imbalance in terms of external factors does not support this alternative at this stage.

Two key indicators were selected for sensitivity analysis - quantitative (LCOE estimate) and qualitative (dependence of supplies for the production process from third parties).

The result of the sensitivity analysis is presented in Table 3.

Table 3. Result of sensitivity assessment with respect to two indicators

Key indicator	Min/Max difference	VVER 466	AP1000	SMR-300MW
Average annual capacity utilization	>15%	8	9	10
Burnup depth	<50%	7	10	1
Severe accident frequency	<50%	1	4	10
Seismic resistance	>50%	5	7	10
Load variation range	>50%	8	10	5
Used area for 1 nuclear unit	<50%	1	10	2
CO ₂ emissions				
Nominal cooling water flow rate	>50%	7	5	10
Construction period	<50%	3	1	10
Duration of operation	>50%	9	10	5
Direct capital costs	>15%	10	5	7
Price for financing				
Operational costs	<50%	10	8	1
LCOE	>50%	10	5	8
NPV				
IRR				
Impact on GDP, 55,7 bill€-22	<50%	5	10	2
Contribution to scientific and research development		10	5	1
National strategy for targeted technological development		1	1	1
Uses state support mechanisms		1	5	1
Practice with environmental impact assessment		10	10	1
Established regulatory framework for technology		10	5	1
Dependence on supplies for production from third countries		5	5	5
Part of critical energy infrastructure		10	10	5
Reduction of CO ₂ emissions		9	10	3
New jobs in construction	<50%	10	7	1
New jobs in operation	<50%	10	5	1
Total		164	157	105

Source: author's score

The sensitivity analysis shows the possible changes in the overall assessment caused by the impacts of the external environment. In the absence of geopolitical opposition, an advantage for the VVER technology can be expected due to the advantage of economic indicators. **The sensitivity analysis once again emphasizes that the availability of state support, which**

leads to a reduction in the financial burden and the limitation of risks in the supply chains, is key to achieving a positive result.

CONCLUSION

The study supports the forecasts regarding the demand for electricity, which highlight the characteristic trend of its increase, while the ways of satisfying this demand are changing, under the strong influence of political factors and the possibilities for technological choice. In recent years, environmental aspects have shaped policies to shift from conventional methods of electricity production and supply, **but this study emphasizes the preservation of nuclear energy as part of low-emission production.**

The role of competition is preserved in the electricity market, both in production and in the provision of services, and opportunities are also sought to stimulate innovation. Within the European Union, a high level of equal market participation of producers and traders in the wholesale market has been achieved, but national powers have been preserved in the areas of supplies to end users (especially households), as well as in planning the national complex of electricity production capacities, **which is achieved by preserving the instruments of regulation and state intervention. At the same time, the desire to maintain favourable conditions on national markets leads to regional market imbalances resulting from the delayed development of interconnection.**

The dissertation work develops and evaluates the aspects that determine the participation of generating capacities in ensuring electricity supplies to consumers in Bulgaria, including:

- The dynamic growth of capacities with a variable nature of production;
- The growing role of balancing capacities in maintaining security of supply;
- The possibilities for cross-border supplies in a dynamic order.

The market mechanisms introduced to build a competitive environment in the EU require the transfer of additional investment costs and services into the price for end users, including commercial services and network development costs.

The transition from a vertically integrated electricity supply management system to a liberalized market changes the conditions for the implementation of energy projects in a dynamic environment. **The dissertation examines the complex nature of electricity supply and related services in a liberalized market**, as well as the presence of uncertainty in planning long-term investments. **Although the liberalization of the electricity market is justified by**

the desire to ensure a competitive environment, in a national context, when planning the development of the system, the high importance of issues of security of supply, provision of reserves for crisis response, as well as the issue of social tolerability of final prices should be taken into account.

The concept of "anticipatory investments" is discussed, which is recommended by the EC in relation to infrastructure energy projects that proactively ensure systematic development in anticipation of future increased demand for electricity, emphasizing the applicability of this concept to nuclear projects as long-term sources of energy with a basic nature and high reliability.

Within the framework of the dissertation, the main prerequisites for maintaining the role of the state through complementary and corrective regulatory functions in relation to market mechanisms, but also as a commercial participant in the market, which is a result of the identified features of the production, transit and supply of electricity in Europe, have been identified.

The presence of regulated state intervention, as well as the existence of natural monopoly activities (in network services) or of monopolistic and oligopolistic market participants, limit the operation of the free electricity market, but allow the allocation of resources for the development of new technologies.

Protecting the interests of society, the modern state encourages and even creates monopolistic enterprises in the production and supply of certain services that the entire population benefits from, for example, the supply of electricity.

The dissertation supports the conclusions that in the sector of production and supply of electricity, monopoly may have advantages over perfect competition, since it is economically profitable for the activity to be carried out by a large integrated enterprise, and the owner of such enterprises may be the state itself.

The dissertation justifies the high importance of the final investment decision for continuing the activities after the study phase and providing support for its financial provision. Investment decisions for the development of new capacities are made both at the state level, with a view to the general systemic electricity planning and provision of adequate transmission and distribution infrastructure, and at the corporate level, with a view to company development and achieving profits for the owners.

The analysis of the national environment in which the development of electricity production in Bulgaria is planned, **emphasizes the strong influence of the transition from a centralized to a decentralized system of supplies and services.** Decentralization in the sector leads to a limitation of the role of the state in the supply of electricity and introduces high complexity into the supply and service chain, **while maintaining and increasing the need for the centralized service for balancing and reserving supplies.**

Within the framework of the justification for a new investment project, the main uncertainty factors that form the risk assessments in a decision to build a new nuclear power plant should be assessed. In the literature, particular attention is paid to financial risk, due to the high capital costs typical of nuclear power plants, which is reflected in typical qualitative assessments of projects. The dissertation recommends that the analysis be upgraded with additional analyses of qualitative risk factors.

The dissertation substantiates the thesis that in conditions of uncertainty in long-term development forecasts, it is necessary to apply holistic methods for substantiating investment decisions at an early stage of project development. These methods should take into account a wide range of factors, relying on common approaches for quantitative assessments and are enriched with qualitative assessments of the external environment.

Based on this conclusion, a methodological approach to factor analysis is reasonably proposed to assist in the process of preparing a strategic choice at the stage of a final investment decision. This approach assesses the aggregate potential of the project initiative by comparing competing alternatives.

The achievement of the main goal of the dissertation is based on a large-scale review of empirical data for 170 nuclear projects that have been implemented or are in the process of implementation after 2000, paying attention to the specifics of corporate governance in the ownership of nuclear power plants and the place of public-private partnership for the implementation of such projects. **At the same time, the leading role of the state in planning nuclear projects, which are placed in the context of national strategies, clearly stands out.**

The dissertation shows that the implementation of national priorities, such as security of electricity supply, independence from short-term market impacts, low-emission production and opportunities for centralized price regulation, leads to the dominant choice of state participation in nuclear projects.

The dissertation compares the assumptions for the implementation of a nuclear project with the attraction of a possible strategic partner or with the preservation of state ownership. **It is pointed that despite attempts to implement such projects with leading participation of private capital, such an alternative has not yet yielded positive results in Bulgaria, and the advantage of state participation remains.**

The review of the potential of Bulgarian nuclear energy shows that Bulgaria can take steps to implement a nuclear project, while maintaining its leading role in this sector: the established specialized national infrastructure and the successful experience of operating nuclear units predetermine the natural choice of this alternative in support of achieving national strategic goals. The confirmation of this choice, however, requires a careful and thorough approach, especially since the debate on nuclear energy in Europe is too polarized. **Based on such a premise, the dissertation recommends an approach to take into account the main prerequisites for a national strategic decision:**

- the need for substitutes for coal-fired power plants to reliably meet the needs of the domestic market in the horizon after 2030;
- implementation of already mastered technology based on water-cooled reactors and taking into account all innovative solutions that define Generation III+ reactors as widely acceptable or future Generation IV technologies;
- the possibility of implementing a project that is based to the maximum extent on local resources and available assets, and for which the implementation period can be reasonably predicted within 6 years after the start of construction.

Taking into account the spectrum of diverse positions, the dissertation proposes an objectification of the analysis of nuclear power plant construction projects and an assessment of the factors of impact on the external environment.

The assessment of the aggregate potential of an investment project for the construction of a nuclear power plant, by applying the methodological approach to factor analysis, shows that at the initial stage of strategic analysis for the considered alternatives, reliable assessments of the admissibility of the investment initiative can be derived based on technical indicators, but their financial indicators can be assessed for admissibility only on the basis of specific parameters of the financing conditions, which should be fully clarified at the stage of the EIA.

The dissertation argues that the coverage of technical and financial indicators for the needs of systemic and economic analysis requires the development of models of different scope, and

the study has selected the summary formats of analysis offered by PEST/SWOT analysis, which correspond to such a need. The analysis of the external environment and the assessment of the immediate environment can be influenced by significant geopolitical events, a profound change in the market environment, instability at the national level or persistent resistance at the local level. **The dissertation shows that the formation of key indicators, as a result of an iterative process of analysis of literary and technical data, allows to supplement the widespread technical and economic analyses, by which the justification of the final investment intention acquires higher sustainability.**

The proposed methodological approach takes into account the influence of various factors through a system of quantitative and qualitative indicators for forming assessments. In this case, we consistently go through an analysis of quantitative technical indicators for assessing the regulatory admissibility of the investment initiative and in view of the set financial criteria for acceptability. The next step is to compare project initiatives, in which the quantitative indicators are applied together with qualitative indicators to form a summarized assessment of the aggregated potential for each alternative.

The application of the system with PEST/SWOT analysis and key indicators in relation to a nuclear power plant allows for the joint consideration of indicators that are often used independently for project evaluation, but taken together they form a complex assessment of the aggregated potential for successful implementation. **The sustainability of the FID results from the joint assessment of the leading influencing factors throughout the entire development cycle of the nuclear project.**

The results of the application of the methodological approach when comparing the three alternatives **confirm the formulated thesis that the policies in the EU for the establishment of a competitive electricity market with a low carbon footprint need complementarity through state intervention for the consolidation of resources for the implementation of national strategic projects for the construction of new nuclear capacities.**

The dissertation shows that the stages through which the investment project for new nuclear power goes include relevant tools for limiting project risks, and **confirm the thesis that the adoption of a final investment decision for the construction of a new nuclear power plant is a key event** for the implementation of such a project. **The sustainability of the FID** is achieved through detailed technical and financial assessments and the implementation of an analysis of factors of uncertainty arising from the external environment.

The final investment decision is essentially a strategic decision before entering the project implementation phase, which is based on a justification that it can be implemented according to the proposed schedule and within the budget. Such a strategic decision should take into account all influencing factors, which **supports the statement that at an early stage of the investment process for the construction of nuclear capacities it is necessary to take into account the interests of a wide range of stakeholders** and the influence of specific external factors on which access to financing and long-term public support for the project depend.

The high degree of uncertainty in the assessment of financial indicators is due to the specificity of nuclear projects and can be limited by dominant state participation in the initial stage of project development, as was shown with examples of modern projects and with the application of a factor analysis methodology.

The thesis substantiates the claim that the financing of nuclear projects cannot be protected solely by an analysis of the market environment, but requires the consolidation of supporting policies, in which the state is already becoming a leading factor guaranteeing the consideration of the public interest. This position is supported by examples of establishing dominant state participation, which is a practice in most modern nuclear projects, due to the possibilities for limiting the risks for investment projects.

Based on the results presented in the thesis, the following recommendations for the formation of a national strategic framework have been formulated:

- Integration of the electricity sector development plans in the current National Security Strategy and seeking synchronization with European policies for competitiveness and decarbonization;
- Binding national policies to meet the electricity balance with targeted selection of technological solutions, taking into account the existing experience and infrastructure in Bulgaria;
- Using the methodological approach for applying PEST/SWOT analysis to justify a project for a new nuclear power plant, which is prepared before making a FID and which allows for the wide range of leading factors identified in this dissertation to be taken into account;
- Ensuring the participation of a wide range of stakeholders in determining the key indicators and in discussing the results of their prioritization;
- After commissioning of the plant, reassess the leading participation of the state and opportunities for corporate equity participation in the project, but with an in-depth

analysis of the relationship between the owner, the operator and the state, in order to clarify the driving motives for a wide range of stakeholders.

III. SUMMARY OF CLAIMS FOR SCIENTIFIC CONTRIBUTIONS

1. The practices in the development of concepts for the ownership of nuclear power plants in the last 25 years are summarized, the main stakeholders, their interests and motivations are identified, and the special place of state ownership or state support in the construction of new nuclear power plants is justified.
2. The systemic and market challenges and influences of a general and specific nature are deduced for the implementation of projects for a new nuclear power plant in the context of market liberalization in the EU, and the scope of the justifications for making a final investment decision is argued.
3. A methodological approach for a complex analysis of factors through multi-criteria analysis is developed, in which key indicators are applied as a criterion for assessing the factors of influence when ranking an investment alternative in competition with other alternatives.
4. By applying the methodological approach and PEST/SWOT analysis, the sustainability of three alternative options for the development of a project for a new nuclear power plant in Bulgaria is tested and a leading alternative is recommended.
5. Visualizations have been synthesized for the methodological approach, the nuclear project cycle, and the aspects of preliminary studies and activities before FID for a nuclear project.

IV. REFERENCE TO THE AUTHOR'S SCIENTIFIC PUBLICATIONS

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