Electrical Engineering Enterprise Stability Model in the External Environment Uncertainty in the System of Strategic Planning

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Abstract: The article presents the results of the research devoted to the development of a model that ensures sustainable development of an electrical engineering enterprise under conditions of environmental uncertainty. In the course of the research the peculiarities of the external environment uncertainty formation in electrical engineering were revealed due to the dependence of the enterprises of this industry on the uncertainty conditions of their main customer - electric power industry. The systematisation of external environment uncertainty factors in the electrical engineering and electric power industries has been carried out. The key events that have influenced the increase of the external environment uncertainty of the electrical engineering industry over the last decade have been identified and their consequences for the industry enterprises have been analysed. The place of the external environment analysis in the system of the electrotechnical enterprise strategic planning as a tool for quick response to changes is determined. PEST-analysis of the electrotechnical industry is carried out. According to the results of the analysis, the key strategic decisions for the successful development of an electrical engineering enterprise under uncertainty conditions within the framework of the enterprise sustainability model proposed by the authors. The classification of investment strategies for knowledge-based industries by investment volume is developed.

1 INTRODUCTION

The electrical engineering industry emerged in the 1980s of the 19th century. It developed particularly rapidly in Germany and the USA, where from the very beginning it was monopolised by the largest industrial associations. By the end of the 19th century, branches of a number of foreign companies were established in Russia. The establishment of this industry in our state is associated with the implementation of Lenin's GOELRO plan after the October Revolution of 1917. It was a successful monocentric project that concentrated a huge amount of the country's resources.

Electrical engineering is one of the largest and most knowledge-intensive industries in Russia. Its structure is represented by a set of small, medium and large enterprises, research and development institutes engaged in the development and production of high-tech equipment and systems for power generation, transmission, distribution and consumption. Advanced scientific and technical knowledge, innovative technologies and materials are used in the process of product development and production. Electrotechnical products include electrical machines and apparatuses, electrical products, cable products, electronics, etc.

The electrical industry plays a crucial role in the Russian economy. It is a key supplier of the electric power industry, which accounts for about 3% of GDP, promotes the development of science and technology, creates new high-paid jobs, and makes a significant contribution to the country's export

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potential. It is no coincidence that the National Technology Initiative project noted the electrical industry in Russia as having a huge potential for development.

However, like any other industry, electrical engineering faces serious problems and challenges. Among the most critical at the moment are lack of investment, outdated equipment, lack of qualified personnel, and competition from foreign manufacturers.

The modern world is changing with high intensity. The uncertainty and unpredictability of these changes reduces the accuracy of the external environment behaviour forecasting. In these conditions, strategic planning, which is the basis for any management decision, is the primary tool for any enterprise, regardless of the industry, to ensure its sustainable development. Its relevance in the current situation in the Russian Federation, when risks and threats arise with a higher probability and frequency, is beyond doubt, and especially for the enterprises of the electrical industry in the conditions of sanctions pressure.

The purpose of the study is to design a sustainability model for an electrical engineering enterprise that can ensure its development under conditions of external environment uncertainty.

The scientific novelty of the research lies in the development of the above model, the peculiarity of which is the emphasis on flexibility and the ability of the enterprise to quickly adapt to changes in the external environment. The stability model, which is proposed to be deduced on the basis of the strategic planning mechanism, should ensure sustainable development of electrical enterprises even under conditions of increased uncertainty.

The practical significance of the research results lies in the possibility of their application by electrical engineering enterprises and enterprises of other industries when developing their own sustainability model.

2 METHODOLOGY

The methods of analysis and synthesis, generalisation and systematisation, content analysis were used in the course of the research.

The theoretical basis of the study was provided by the scientific works of domestic and foreign authors devoted to the development of strategic decisions under uncertainty (Bowen and Bowen, 2014; Jakobson, 2023; Dynin, 2024), the impact of global factors on the results of electric power and electrical engineering enterprises (Syrovatskaya, Lashmanova and Sadyrin, 2021; Khan and Sahabuddin, 2021; Shugaeva 2021), development and strategic planning of electrical engineering and electric power enterprises in the conditions of structural changes in these industries (Bramstoft and Skytte, 2017; Castrejon-Campos, 2022; Pfenninger, Hawkes and Keirstead, 2022; Ma , Zhang, Ali, Nazar and Khalid Anser, 2024).

The structure of the scientific study includes:

1. Identification of the external environment uncertainty formation peculiarities in electrical engineering.
2. Analysis of key events that have contributed to the increased uncertainty in the external environment of the electrical industry.
3. Determination of the external environment analysis place in the system of strategic planning at the electrical engineering enterprise.
4. Designing an electrical engineering enterprise stability model under conditions of external environment uncertainty.

3 RESULTS OF THE RESEARCH

Uncertainty of the external environment is the existing conditions when it is impossible to accurately predict future events and their consequences. The factors of external environment uncertainty are changes in the political environment, economic crises, sanctions, technological innovations, changes in consumer behaviour.

Participants of economic relations (enterprises, investors, consumers) under uncertainty cannot accurately predict future prices, demand, supply and other economic indicators (Lan, Wu, Wu, Li and Pan, 2024). In this conditions, the probability of errors in strategic decision making and risks of financial and reputational losses increase.

In such an environment, economic agents can use various strategies to reduce the impact of uncertainty and minimise risks. It is necessary to carefully study the current situation, conduct market analysis, use expert forecasts, develop action plans for different scenarios, diversify the portfolio of investments, products, and the organisation itself (Varathan and Belwin, 2024).

The high level of uncertainty and unpredictable behaviour of the external environment is an unavoidable modern component and requires from enterprises flexibility, adaptability and ability to identify and assess risks.

Features of the external environment uncertainty formation in electrical engineering.

The formation of the external environment uncertainty formation in electrical engineering has its own peculiarities. The largest customer of the electrical engineering industry is the electric power industry, so the uncertainty formed by various factors in this industry, affecting the generation, transmission and distribution of electricity, mainly creates conditions of uncertainty for the electrical engineering industry.

The main factors forming uncertainty in the electric power industry are:

– economic factors: inflation, unemployment, GDP growth or decline affect electricity demand and prices;

– political factors: new laws and political agendas affect the availability and cost of electricity;

– technological factors: the development of new technologies (renewable energy, microgrids, blockchain) can dramatically change electricity generation and consumption patterns;

– climatic factors: extreme weather conditions trigger dramatic changes in electricity consumption;

– social factors: increasing prosperity of citizens causes a sharp increase in electricity consumption;

– international factors: trade wars, reorientation of markets and logistics of goods, energy prices affect the availability and cost of electricity;

– environmental factors: pollution, thawing permafrost, changes in river flows affect electricity generation.

These factors can have a huge impact on the development of the electricity sector. Environmental damage, resource scarcity, and reduced quality of life in the regions where fossil fuels are extracted and used force governments to impose strict regulations and restrictions in the energy sector. The development and adoption of clean energy sources is contributing to changes in energy production, distribution and consumption patterns (Hernández-Romero, Barajas-Villarruel, Flores-Tlacuahuac, Fuentes-Cortes and Rico-Ramirez, 2023).

Under the influence of the above factors, such uncertainties for the electrical industry are formed as:

– changes in legislation and regulations affecting product and service requirements;

– instability in the prices of electrical materials and components, leading to changes in production costs;

– technological changes and innovations requiring upgrades to equipment and manufacturing processes;

– uncertainty in demand for products and services due to changes in market conditions;

– risks related to the safety and reliability of electrical systems, possible equipment failures or malfunctions, cyber threats;

– the impact of natural phenomena, magnetic storms or natural disasters;

– geopolitical factors affecting the supply of materials and components from abroad (changes in trade relations or political situation).

Key events that have contributed to increased uncertainty in the external environment of the electrical industry.

In order to assess the current situation in the industry, it is necessary to understand the cause-and-effect relationship of events. It is worth noting the most significant events that have had a global impact on the electrical industry.

The year 2014 is characterised by the departure of a number of foreign electrical engineering companies and the beginning of the import substitution process in the Russian Federation, the introduction of sanctions, and a sharp decline in the ruble exchange rate (Oparin, Leont'eva and Pleshkov, 2023).

The COVID-19 pandemic started in 2020 had a significant impact on the electrical industry in Russia (Khan and Sahabuddin, 2021; Syrovatskaya, Lashmanova and Sadyrin, 2021). The main consequences of this impact are:

– decrease in electricity demand - due to quarantine measures and restrictions, many enterprises were forced to reduce production, which led to a decrease in demand for electricity;

– reduced investment - in the face of uncertainty and economic instability, many investors have postponed or cancelled their plans to invest in the electrical industry;

– increased production costs - quarantine measures have forced many businesses to increase production costs, including costs for worker safety and sanitation, personal protective equipment and disinfection;

– increased logistics costs - this was due to restrictions on the movement of goods and people;

– increased personnel costs - this was primarily due to sick leave and holiday pay.

The most significant damage to the electrical industry during the pandemic was the shortage of semiconductors (Shugaeva, 2021). It was caused by a number of factors:

– the pandemic led to the closure of many factories around the world, including semiconductor manufacturers, resulting in decreased production and increased shortages of microchips;
– reduced demand for cars, and the automotive industry is one of the largest consumers of semiconductors;
– demand for electronics, especially smartphones and laptops, increased as people began to work and study more from home;
– supply chain problems arose, making it difficult to get semiconductors from manufacturers to consumers;
– strict quarantine measures have resulted in labour shortages in many countries, including China, where most semiconductors are produced.

The impact of the above factors has led to lower production and increased demand for semiconductors, which in turn has caused higher prices for these important components and delays in the production of many products.

On the one hand, the COVID-19 pandemic had a negative impact on the electrical industry in Russia; on the other hand, it provided an impetus for innovative development and forced companies of the industry to adapt to new working conditions (Bendikov and Braginsky, 2020).

In 2022, Russia faced unprecedented sanctions pressure from Western countries. Many foreign vendors ceased operations in the Russian Federation. The electrical industry lost its key suppliers of components and software licences.

However, for any periods of turbulence, there are methods and practices that help companies cope with the challenges more effectively. They began to build new sustainable supply chains and customise products to fit the available component base. Electro-technical enterprises started to transfer their own software products to domestic Linux systems. The need to develop cybersecurity solutions for critical information infrastructure increased.

Place of the external environment analysis in the system of strategic planning at the electrical engineering enterprise.

Strategic planning is the process of determining the long-term goals of the enterprise and ways to achieve them within the framework of the chosen development strategy. The description of the strategic planning main stages is presented in Table 1.

Table 1: Strategic planning stages.

Name	Description
Defining mission and goals	A prerequisite for strategic planning is the development of a mission. On the basis of the mission, the vector of the enterprise's development is determined and long-term goals are set.
Analysis of external environment	The external environment is analysed in terms of economic, political, social, technological and other factors. Opportunities and threats for the enterprise are determined.
Analysis of internal environment	The enterprise development potential is assessed, including the analysis of such elements of the internal environment as production, marketing, finance, personnel, organisational structure. The strengths and weaknesses of the enterprise are identified.
Strategy development	Strategy development involves the development of two or three alternative solutions, taking into account the results of analysing the external and internal environment. Choosing among alternative strategies allows minimising the risk of making an ineffective decision.
Action plan development	In order to achieve the set goals, specific steps and activities are developed with the definition of timeframes, necessary resources, assignment of responsible persons.
Control	Monitoring and evaluating the implementation of the action plan and the achievement of objectives to adjust the strategy and plan if necessary

Strategic planning is an effective tool for the enterprise, which helps in making effective management decisions based on data analysis and risk assessment, as well as allows it to quickly respond to changes occurring in the external environment.

The most important stage of strategic planning is the analysis of the external environment, which allows us to assess the impact of global economic problems and crises on the electrical industry and to form narrower and more specific to the industry uncertainty factors.

Grouping of factors using analysis is in Table 2.

Table 2: PEST analysis of the electrical industry in the Russian Federation.

Political (P)	Economical (E)
– Import substitution policy. – Ensuring reliability of electricity supply. – Necessity of retiring generating capacities renovation. – Ensuring information security of CII	– Economic growth. – Tendency to reduce investment programmes of major customers. – Floating ruble exchange rate. – High inflation. – Price instability of electrical materials and

facilities. – Industry regulation. – Demand dependence on government policy. – Changes in legislation and regulations affecting product and service requirements.	components and their supply chains. – Increase in production costs. – Uncertainty of demand for products and services due to changes in the market or economic conditions.
Socio-cultural (S)	Technological (T)
– Shortage of qualified personnel. – Declining quality of education. – The threat of high-altitude nuclear explosion in military operations and the resilience of systems to nanohertz-induced interference.	– Emerging technologies. – Innovation in manufacturing. – Digitalisation and automation. – Need to update equipment and production processes.

PEST analysis helps to find out how the company's decisions or orientations relate to the objective factors of the macro environment. It helps to identify threats before they turn into problems and highlights projects and decisions that should not be launched due to the influence of external factors.

In an electrical company, making erroneous management strategic decisions is fraught with serious consequences that can negatively affect the company's performance. Such consequences can be:

– financial losses of the enterprise due to decreased profits, increased costs, reduced efficiency of work;

– clients loss and, as a consequence, a decrease in revenues;

– reduction of competitiveness and market share;

– loss of trust on the part of clients and partners;

– deterioration of reputation of the enterprise, etc.

Today for electrical enterprises in strategic planning it is important to combine the implementation of the strategy adopted by the company with flexibility in responding to changing inputs, analysing the changes occurring in the external environment in live mode. This approach is called «dynamic strategy».

Development of the electrical engineering enterprise stability model under conditions of the external environment uncertainty.

Despite all the complexities of functioning under conditions of uncertainty, it is necessary to develop a number of strategic decisions that are capable of the enterprise development ensuring with a high degree probability. At the same time, it is important to determine the key directions of the enterprise's movement and decision-making criteria. The result of strategic planning should be the construction of a «stability bridge», on which the enterprise will move over the raging unpredictability of the external environment.

The «Stability Bridge» is a model of enterprise development under conditions of uncertainty, the «pillars» of which are strategic decisions (Figure 1). How many «pillars» and which «pillars» should be included in this model depends on the forces of influence, each of which is a set of factors forming it. These forces include, first of all, the external environment uncertainty, as well as industry peculiarities and specifics of the company itself.

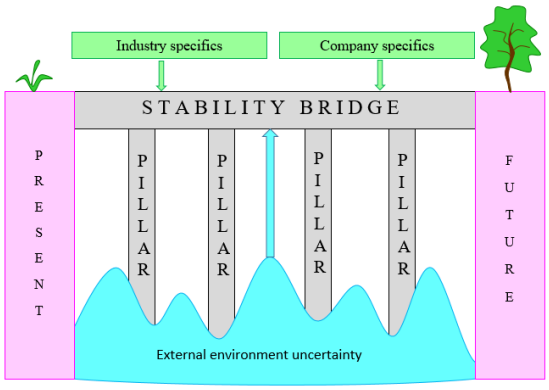

Figure 1: A model of enterprise stability in uncertainty conditions.

For an electrical company, the «pillars» of the «stability bridge » can be:

– *Expansion of production capacities*. The company should have at least 30% spare production capacity, as there may be a sharp increase in orders from customers due to the departure of foreign vendors, the introduction of renovation programmes, etc. The company also needs to duplicate production lines in case of unforeseen equipment failure to ensure a smooth repair. It is also necessary to duplicate production lines in case of unforeseen equipment failure for painless repair. This is important to maintain the reputation of a reliable supplier.

– *Reliance on new and breakthrough technologies.* Depending on the level of technology and its capabilities, the enterprise should choose an acceptable type of investment strategy. Table 3

presents the author's classification of investment strategies for knowledge-intensive industries by investment volume.

Table 3: Investment in knowledge-intensive industries.

Investment strategy type	Investment volume, % of revenue	Description
Degradation	<5%	The enterprise loses competitive advantages
Stagnation	5-7%	The enterprise maintains the current level of development, but gradually begins to lag behind competitors
Moderate	7-12%	The enterprise is developing moderately
High-tech	12-20%	The company aims to become a leader in the industry and set the technological trend
Innovative	20-30%	The company creates breakthrough technologies and new markets

– *Investments in own developments.* Investing in in-house development requires significant resources and can be accompanied by significant risks. Therefore, it is first necessary to thoroughly research the market and customer needs to determine which developments will be successful. A business must have sufficient resources and a certain level of expertise to realise its new developments. Investments in R&D are an essential component of its future development and the accumulation of knowledge, which is the basis of intellectual technologies.

– *Automation of business processes.* Introduction of modern production automation means increases the efficiency of the enterprise and each employee by at least 10%. Automation preserves the scarce staff of specialists and maximises their efficiency in business processes.

– *Implementation of internal regulations, policies of the organisation.* A detailed description of internal processes helps to improve the enterprise management efficiency. It is easier to implement business process automation systems in companies with developed regulations. The main regulations should comply with international quality management systems, the purpose of which is to ensure sustainable development of both the products and the enterprise as a whole.

– *Consideration of unexpected unavoidable critical risks.* It is necessary to take into account the risks of economic shocks in the country with a probability of occurrence in the anticipation period of 5-6 years. The occurrence of global shocks in the external environment can lead to a 10% reduction in the company's revenue.

– *Diversification of business and product areas.* An enterprise should strive to expand its sales markets and increase profits. Diversification allows to expand commercial opportunities and reduce potential risks, both in terms of dependence on certain customers and specific products.

– *Increasing marketing costs.* Attracting attention to the products and services of a company increases its image and ultimately increases sales. Marketing activities, provided with the necessary budget, allow to achieve the greatest effect.

– *Product Management.* Product management creates the most demanded products and services by the market. Effective pricing contributes to increasing the competitiveness of products. Implementation of the product lifecycle management mechanism taking into account the peculiarities of the enterprise allows timely responding to external challenges and adapting the product to the prevailing market conditions.

– *Providing MVP (or Minimum Viable Product) products.* Engineers often strive to create the perfect version of a technical solution that may not be competitive. For the perfect balance of features and capabilities, it is essential to build on customers' market needs.

– *Personnel Motivation.* Each employee should understand the strategic goals of the enterprise and be guided in his/her activity by the accepted vector of its development. The enterprise should strive to minimise staff turnover, for which it is necessary to improve the quality of its cultural environment, especially in conditions of staff shortage.

– *Education of young personnel.* In order to increase the quality of personnel, one of the methods is to deepen the work with educational institutions that train the necessary specialists. It is necessary to carry out propaganda activities, internship and practice of trainees. Mentoring programmes by more experienced employees should be introduced to nurture young professionals.

– *Concentration of internal competences for decision-making.* Creation of an initiative group of the most competent and loyal employees for collegial management decision-making allows to increase the efficiency of management at the enterprise and contributes to the development of the most balanced and well-founded decisions for long-term processes. One of the directions of strategic

planning development is the use of intellectual resources of the firm at all levels of management.

4 CONCLUSION

There is no doubt that strategic planning is an integral part of successful enterprise management in any industry, including electrical engineering. Moreover, in conditions of the external environment high level uncertainty caused by economic crises, political events, sanctions and technological innovations, strategic planning is becoming more and more relevant, as it contributes to the formation of the enterprise's readiness for changes, decision-making to minimise risks, ensuring sustainable development over a long period of time.

The conducted research allowed us to identify the peculiarities of the external environment uncertainty formation in electrical engineering, due to the dependence of the enterprises of this industry on the conditions of its main customer uncertainty - the electric power industry. The systematisation of external environment uncertainty factors in these industries presented in the article can be taken into account by electrical engineering enterprises when developing strategic decisions aimed at adapting to changes in the external environment of the main customer.

In the course of the study, the key events that have influenced the increase of the external environment uncertainty of the electrical industry over the last decade were identified, namely: the departure of a number of foreign electrical companies from the Russian market, the transition to import substitution, the COVID-19 pandemic, and the unprecedented sanctions pressure on Russia by Western countries. The consequences of these events listed in the article reveal the problems faced by the enterprises of the industry, which required immediate adaptation measures.

The next stage of the research was to determine the place of the external environment analysis in the system of strategic planning of an electrical engineering enterprise as a tool for quick response to changes. The conducted PEST-analysis of the electrotechnical industry can be used to correlate the influence of external environment factors with the strategy implemented by the enterprise in order to adjust it.

Based on the results of the analysis, the key strategic decisions for the successful development of an electrical engineering enterprise under conditions of uncertainty are identified within the framework of the enterprise sustainability model proposed by the authors. The decision on the choice of investment strategy is accompanied by the author's classification of investment strategies for knowledge-intensive industries by investment volume.

The proposed strategic decisions can be supplemented and combined depending on external conditions, industry characteristics and specifics of the enterprise.

The designed stability model («stability bridge») is an important tool to ensure stable and effective functioning of enterprises in conditions of uncertainty. The flexibility and adaptability of the model will allow enterprises to respond quickly to changes in the external environment, minimising risks and increasing the chances of success. The application of the proposed model will help enterprises not only to maintain, but also to strengthen their positions in the market, ensuring long-term and sustainable development.

REFERENCES

Bendikov, M.A., Braginsky, O.B., 2020. Strategic planning in anticipation of the end of the pandemic and the beginning of intellectualization. The economic science of modern Russia. No (4). pp. 147-155.

Bowen, G., Bowen, D., 2014. Strategy Formulation and Uncertainty in Environments. Journal of Business and Economics. Vol. 5, No. 12, pp. 2315-2326.

Bramstoft, R., Skytte, K., 2017. Decarbonizing Sweden's energy and transportation system by 2050. International Journal of Sustainable Energy Planning and Management. Vol. 14. pp. 3-20.

Castrejon-Campos, O., 2022. Evolution of clean energy technologies in Mexico: a multi-perspective analysis. Energy for Sustainable Development. Vol. 67. pp. 29-53.

Dynin, A., 2024. Strategic planning in an era of uncertainty: what to do. Higher School of Business of the Higher School of Economics.

Hernández-Romero, I.M., Barajas-Villarruel, L.R., Flores-Tlacuahuac, A., Fuentes-Cortes, L.F., Rico-Ramire, V., 2023. Strategic planning for sustainable electric system operations: Integrating renewables and energy storage. Computers & Chemical Engineering. Vol. 177.

Jakobson, L.I., 2023. Strategic planning in conditions of uncertainty: adaptivity for sustainability. Journal of the New Economic Association. No. 4 (61). pp. 230–236.

Khan, I., Sahabuddin, Md., 2021. COVID-19 pandemic, lockdown, and consequences for a fossil fuel-dominated electricity system. *AIP Advances* №11.

Lan, Z., Wu, G., Wu, J., Li, J., Pan, F., 2024. Study on the evaluation model of the contribution of power industry expansion considering the influencing factors of new

energy consumption. Journal of Intelligent and Fuzzy Systems. Vol. 46, No. 1. P. 10523-10534.
Ma, J., Zhang, J., Ali, S., Nazar, R., Khalid Anser, M., 2024. Strategic socioeconomic planning to address ecological footprints in an uncertain economic landscape. Socio-Economic Planning Sciences. Volume 95.
Mondshine, M., Weaver, S., 2010. Managing uncertainty through strategic planning Power Engineering. Vol. 114 Issue 11.
Oparin, S.I., Leont'eva, I.A., Pleshkov, K.V., 2023. Import substitution as a strategic priority for the development of the electrical industry. Ekonomika: vchera, segodnya, zavtra. 13 (11A), pp. 135-142.
Pfenninger, S., Hawkes, A., Keirstead, J., 2014. Energy systems modeling for twenty-first century energy challenges. Renewable and Sustainable Energy Reviews Volume 33, Pages 74-86
Shugaeva, O. V., 2021. The COVID-19 Pandemic and Its Impact on Public Health Production. Izvestiya Yugo-Zapadnogo gosudarstvennogo universiteta. Seriya: Ekonomika. Sotsiologiya. Menedzhment. Proceedings of the Southwest State University. Series: Economics, Sociology and Management. No. 11(5). pp. 95–104.
Syrovatskaya, O.Y., Lashmanova, N.V., Sadyrin, I.A., 2021. Impact of the COVID-19 pandemic on global energy in 2020-2021. Moscow Economic Journal. No. 8. P. 9-19.
Varathan, G., Belwin, E., 2024. A review of uncertainty management approaches for active distribution system planning. Renewable and Sustainable Energy Reviews. Vol. 205