O P E R A T I O N S R E S E A R C H A N D D E C I S I O N S
No. 4 2018
DOI: 10.5277/ord180404

Marina SHKROBOT[1]
Edyta ROPUSZYŃSKA-SURMA[2]

POLISH AND UKRAINIAN FORESIGHT INTO THE DIRECTIONS FOR THE INNOVATION OF POWER PLANTS

The main aim of this article is to present an approach to planning the implementation of innovative technologies and introducing strategical modernization into power plants using the results of two foresight studies conducted by the authors. The results of these foresights were obtained from the two projects: a corporate foresight conducted in Ukraine and a regional foresight linked to the energy sector in Lower Silesia (a region in Poland). Using the method of foresight allows us to look at strategical modernization more holistically and take the different points of view of a wide range of stakeholders into consideration. Such an approach could be used to establish a set of measures aimed at the continuous improvement of technical, technological, socioeconomic and environmental processes in power plants (e.g., the operation of Ukrainian hydroelectric power plants). Although various approaches to foresight (e.g., corporate foresight and regional foresight) have been applied in different countries, the corresponding processes of planning innovation and modernization are similar.

Keywords: *method of foresight, energy company, innovation*

1. Introduction

In recent decades, the energy sector has been rapidly changing in both developed and developing countries. The start time of this process varies according to country, but, at present, these changes are system-structural and can be compared, in terms of scale, with the intensive electrification process that occurred immediately before and after World War 2. These changes have been influencing the strategical decisions made by governments, local and regional authorities, together with energy companies and energy

[1]Faculty of Management and Marketing, Igor Sikorsky Kyiv Polytechnic Institute, Kyiv, Ukraine, e-mail address: shkrobotmarina@ukr.net

[2] Faculty of Computer Science and Management, Wrocław University of Science and Technology, Wybrzeże Wyspiańskiego 27, 50-370 Wrocław, Poland, e-mail address: edyta.ropuszynska-surma@pwr.edu.pl

consumers, who now may become a new type of player, called *prosumer*, on the energy market.

Considering such countries as the USA, Australia, the Western European countries and the Central-Eastern European countries (e.g., Poland), it should be noted that the environment of energy companies was much more predictable, or even completely predictable, in the past compared to today. In the UK, the USA, Poland, the USSR and its republics, e.g., the Ukrainian Republic, the energy companies belong to the government and energy plants conducted their main activities, secured resources, made current investments and so on within a fairly simple framework. Fossil fuels were used as the foundation of energy production all over the world. Only a few countries had nuclear power stations (e.g., France, the UK, the USA, the USSR, Sweden, and Japan) or large hydro-power stations (e.g., China, Brazil, Venezuela, and the USA). Since the 70s of the XX century, many ecological movements have been established and have developed rapidly. They have put an ever increasing amount of pressure on governments, forcing ecological ideas to be included in energy policy, particularly in Germany. New technologies based on gas turbines and renewable energy sources (RES) are being implemented. The energy markets of developed countries, which were earlier perceived as government monopolies, have been liberalized. The idea of a common energy market has been created and systematically introduced into a number of countries, especially in the EU. The IT revolution, called the fifth revolution, was the next determinant involved in completely changing the mechanisms governing the energy market and its structure. Technological progress has become increasingly rapid. In short, the environment of energy companies has become more unpredictable and much more risky, and the sources of this risk lie in politics (including international relationships), technological progress, society, ecological interest groups and the existing legislation. The acronym VUCA was introduced at the beginning of 90s in the USA army to describe the environment [19]. These initials stand for: volatility, uncertainty, complexity and ambiguity. This uncertainty has led to a change in the approach to strategy management. As a result, energy companies are creating their own strategies and have to run their business in a turbulent environment. The foreseeing of: (1) technological progress, (2) the social acceptance of new technologies, (3) possible support for economic instruments and (4) directions of governmental energy policy is a key factor influencing the strategic decisions made by energy companies.

A similar situation is present at higher levels, i.e., macroeconomic and mezzoeconomic. Governments and regional authorities (particularly in Europe) have to look at energy policy in a new manner. Governments have focused on energy security but have recently established additional goals, such as: (1) weakening the influence of the energy sectors (and others) on the natural environment, (2) supporting the development of "green energy" installation, as well as (3) promoting social acceptance for innovative technologies in the energy sector. In particular, "green energy" and environmental is-

sues have been becoming more important. The EU has established goals for the limitation of greenhouse gas (GHG) emissions. Each member state should reduce its emissions to an established limit. Finally, the EU has adopted the "3×20" energy package. This means that the EU should achieve the following targets by 2020: (1) a reduction in GHG emissions by 20% compared to 1990, (2) an increase in the share of RES in total energy consumption within the EU to 20%, (3) an improvement in energy efficiency by 20% (compared to projected use of energy in 2020). Poland is a country which has a less stringent goal for increasing the share of RES than the average in the EU. The Polish target for the share of energy from renewable sources in gross consumption of energy in 2020 is 15%, due to the Polish economy being at present heavily based on coal and geographical factors (limited possibilities for utilizing wind turbines, solar panels and hydro-electric plants). Some of the EU member states should achieve a greater than 20% share of RES in energy consumption, e.g., [6]: Denmark (30%), Estonia (25%), France (23%), Latvia (40%), Lithuania (23%), Austria (34%), Portugal (31%), Romania (24%), Slovenia (25%), Finland (38%), and Sweden (49%). Compared to *Energy Package 2020*, the percentage of energy consumption from RES planned for 2030 is much higher (see *The 2030 Framework for Climate and Energy* presented by The European Council in October 2014). According to this proposal, the EU plans to achieve more ambitious targets by 2030 [8]: (1) to cut GHG emissions by 40% compared to 1990 levels, (2) to increase the share of RES in total energy consumption to at least 27%, (3) an improvement in energy efficiency at the EU level by at least 27% (compared to projections of future energy consumption based on the current criteria).

All of the EU countries have implemented intensive programmes related to the development of "green energy". Germany and Finland are leaders in such activities, e.g., Germany aims, *inter alia*, to reduce the share of fossil fuels in total consumption to 20%, as well as to reduce GHG emissions by 85–90% by 2050 according to the current German flagship policy called *Energiewende* (a long-term energy and climate strategy) [1]. The Central-Eastern European countries and post-soviet republics present an interesting situation. Most of them are less dependent on coal than Poland, e.g., Hungary, Latvia, Lithuania, Romania, Slovakia, Ukraine[3]. Generally, there are positive trends in the development of RES, and state policy has been active in this area. Such policy could, however, be a source of uncertainty, as in Poland, where the law on RES was not only established over a long period of time, but has also been changing a lot recently. In Ukraine, the political situation is the main source of uncertainty. Its energy sector is under the strong influence of political and economic factors. In particular, deregulation and the transition to a new model of the electricity market, new pricing mechanisms, integration into the European energy grid, together with the corresponding obligations, have no appropriate legal or political support. Due to such uncertainty in the economic-

[3]Based on statistical data from the International Energy Agency, www.iea.org/statistics

legal environment, key investors are withdrawing from some counties or cancelling investments focused not only on innovation and modernization, but also investments in the maintenance of assets. In such uncertain conditions, energy security is endangered.

The foresight method, which has developed out of technological forecasting, could be helpful for creating energy strategies. Nowadays, the implementation of an *adaptation strategy* is not sufficient to become more competitive. Companies must "run forward", make predictions about the future (such as in an *invention system* (see [37])) and, sometimes, create the future[4].

Thus, the main aim of this article is to present an approach to planning the implementation of innovative technologies and strategical modernization in power plants using the results of two foresight studies conducted by the authors. The results of these foresights were obtained from the two following projects: (1) a corporate foresight study conducted in Ukraine called *Provision of the Strategic Modernization of Hydroelectric Power Plants*[5, 6], and (2) a regional foresight study linked to the energy sector in Lower Silesia called *An Energy Development Strategy for Lower Silesia Using Foresight Methods*[7, 8]. Foresight projects from Poland and Ukraine were chosen for comparison since: (1) both of them are post-communist countries, (2) the environment of their energy sectors is uncertain, (3) energy companies produce power mainly from conventional fuels (namely, coal power plants and hydroelectric power plants), and in Ukraine additionally from nuclear fuel, which could pose a problem in the long-run due to the problem of storing nuclear waste, (4) the fixed assets of conventional power plants are depreciated to such an extent that modernization is imperative. Another reason is the fact that Poland is a member of the EU and Ukraine is not. Foresight projects conducted in Poland and Western European countries have been initiated by EU directives (mainly regional foresight projects) and the methods applied in foresight were selected from those recommended by European documents. However, there are no analogous recommendations in Ukraine. Also, the authors participated in these projects and know all the aspects connected with their realization.

Using foresight methods allows us to look at strategical modernization more holistically and to take the different points of view of a wide range of stakeholders into consideration. One open question is whether an energy company should carry out foresight research on its own or whether it should create a strategy for innovation using the results from, e.g., regional foresight. This article compares the two foresight projects presented

---

[4]See [35].

[5]Provision of the strategic modernization of hydroelectric power plants: specialty: 08.00.04 [35].

[6]In the rest of this article, this study will be referred to as the Ukrainian foresight.

[7]This project was conducted by an interdisciplinary team from WUT from 2009 to 2011 and co-funded by the European Regional Development Fund (ERDF), Operational Programme Innovative Economy 2007–2013, Grant No. UDA-POIG.01.01.01-02-005/08-00.

[8]In the rest of this article, this study will be referred to as the Polish foresight.

on the basis of the general characteristics of corporate and regional foresights. Their methodologies and main results are also presented.

2. Approaches to strategic management and foresight

2.1. Approaches to strategic management

In 1976, Ansoff, Declerck and Hayes published a book almost prophetically entitled *From strategic planning to strategic management* [2]. Since then, thinking about strategic management has been constantly changing. As noted by Mintzberg [22], Ansoff's concept was appropriate in a more predictable environment. Taking into consideration different dimensions, one may distinguish various schools (also called approaches or concepts) of strategic management. The most popular classification seems to be Mintzberg's, who distinguished the following ten schools: design, planning, positioning, cognitive, entrepreneurial, learning, political, cultural, environmental and configurational. Due to the limited scope of the article format, the authors consider the classification according to Obłój [24], who divided the approach to strategic management into two dimensions[9]:

- The ability of an organization to predict and/or create the state of the environment. Based on this dimension, one can distinguish between the planning strategy school and the evolutionary school.
- The factors influencing the success of an organization based on this dimension. There are two main schools: the market-based-view (MBV) (proposed by Porter [27]) and the resource-based-view (RBV) (proposed by Hamel and Prahalad [12]).

Strategic planning may result from foresight projects, i.e., foresight research is conducted before the planning process (Fig. 1). Such a planning strategy is most popular in a predictable environment – similar to technological forecasting. This concept was criticized by Mintzberg [22], who supported an evolutionary concept of strategy. Porter's MBV school highlights the key function of resources in achieving a competitive advantage. According to this school, a company's resources should be adapted to the opportunities and threats coming from the organizational environment. SWOT analysis, value chain analysis and Porter's five forces analysis are the main methods supporting the construction of a strategy according to the MBV approach. A different view is presented by Hamel and Prahalad, who state that core competences are sufficient to achieve a competitive advantage. To create core competences, there should be [18, p. 12]: (1) the dy-

[9]A more detailed comparison of these schools was presented in [18, p. 9–12].

namic stretch between an enterprise's resources and its strategic aims, and (2) cooperation between different entities, including competitors. The RBV is similar to cooperative networks and network thinking in management.

Another problem is connected with the relation between intended strategy and realized strategy in a VUCA environment. According to Mintzberg [22, p. 24], the realized strategy is a mix of the intended strategy and an emergent one. In a turbulent environment, they are usually different because the intended strategy is only partially realized in reality. The part of the intended strategy which is realized is called the deliberate strategy which indicates the *intentions that are fully realized* [22, p. 24]. This is a component of the realized strategy. Two opposing approaches to creating and implementing a strategy can be distinguished: a synoptic approach (a rational process based on long-run planning) and an incremental approach (here, a strategy is the effect of quick reactions to changes in the environment) [18, p. 24–25]. Foresight research could be used to create both types of strategy, the intended strategy and the emergent one.

2.2. The genesis of the foresight method

Strategic management and the foresight method have evolved together. Foresight research has its source in technological forecasting. It was used for the first time to plan innovation processes in the arms industry by the RAND Corporation in the USA in 1948. Next, it was promoted by Kaplan, Helmer and Rescher, as well as Dalkey [16, p. 349]. Technological forecasting became more popular in the 50s and 60s of the XX century and mainly quantitative methods were developed in this period, although the RAND Corporation used the Delphi method successfully. A number of prominent organizations implemented technological forecasting, e.g., the Stanford Research Institute, which focused on creative solutions to engineering problems, or the Royal Dutch Shell Group, which adapted these methods to control-oriented planning approaches.

It seems that technological forecasting was most popular in the 1970s and at this time a number of institutions were influential in introducing forecasting into policy making, e.g., the National Institute of Science and Technology Policy (NISTEP) and the Club of Rome forecasting group. At that time, scientists focused mainly on methods of estimating long-term trends in technological development using logistic functions (e.g., the Gompertz function) or the technological substitution model introduced by Fisher and Pry. These mathematical models were based on an evolutionary approach to innovation diffusion and could be used if the researched technology was known. Scenarios of economic development and the diffusion of technologies were made on this basis. On the other hand, NISTEP successfully formulated guidelines for scientific research and support of technological policy in Japan using a heuristic method – the Delphi approach.

When the environment became more turbulent, other factors apart from technology and the dynamics of its diffusion started to be significant to decision makers (e.g., governments, ministries of science and technology), such as social changes, economics, ecology. As argued by Porter [26, p. 292] *the use of foresight processes to engage previously uninvolved players may hold a higher priority than technology information products themselves*. Therefore, the term technology forecasting was replaced by the term technology foresight, which has a wider meaning. According to Martin, technology foresight is *the process involved in systematically attempting to look into the longer-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits* [21]. Thus, technology foresight is widely used to describe extensive programs of research and innovation, as well as priorities in the light of potential long term future developments.

In Poland, foresight research has become more popular since the accession of Poland to the EU, because EU policy and strategies support innovation in economies, regions and, of course, companies. Most Polish foresight projects have been supported by public funds, including EU structural funds. Therefore, the foresight methods used (mainly the Delphi method) in these projects were recommended by national or regional operational programs co-funded by EU structural funds, mainly during the period 2007 –2013. The foresight method used in each project was adapted to the subject of study, e.g., the type of sector, the range of foresight (national, regional or sectoral). Polish researchers[10] who have conducted such foresight projects include Klasik [17], Borodako [4], Czaplicka-Kolarz [5] and regional, sectoral and national foresights have been carried out. Their main results have been: to point out key technologies (e.g., *EurEnDel Technology and Social Visions for Europe's Energy Future. A Europe-wide Delphi Study* [7]), to create strategies, to build scenarios (e.g., *Energy foresight for Poland 2005–2030* [5]), as well as to propose policy that promotes innovation (e.g., *Foresight for Our Future Society – Cooperative Project between NISTEP (Japan) and (Finland)* [10]). These results are well adapted to the strategic planning approach.

Corporate foresight has been less popular in Poland. In 2009, Borodako wrote: *Unfortunately, Polish companies have not yet been seen to apply corporate foresight* [4, p. 141]. It seems that this state has not changed, which is confirmed by Polish publications indexed on the Web of Science[11]. On a global scale, corporate foresight has supported strategic management, mainly planning in companies where the product life cycle, the

[10]It is very difficult to give an exhaustive list of all the Polish scientists conducting foresight projects. More can be found on the website http://www.foresight.pl/polskie-osiagniecia-w-zakresie-foresightu.html (accessed 1.02.2018).

[11]More information can be found on the website http://www.foresight.pl/polskie-osiagniecia-w-zakresie-foresightu.html (accessed 1.02.2018).

R&D phase, and the introduction phase of new products take a long time, e.g., in companies belonging to the following sectors: telecommunications (including ICT operators), energy, banking and finance [28, p. V, 57], automotive [33, p. 37–48] [28, p. 57] and pharmaceutical. The following Ukrainian scientists should be noted as having successfully applied foresight: Fedulova [9], Zgurovsky [40], Malicki [20].

2.3. Strategic management as the basis of the method of foresight

A study of the prerequisites for the strategic modernization of enterprises highlights the urgent need to solve the theoretical and methodological task of formulating a scientific hypothesis that would define the conceptual direction of the application of foresight. The concepts involved in the innovative development of enterprises in the energy sector are illustrated in Fig. 1. Analogous elements are usually taken into consideration when a regional strategy is being built.

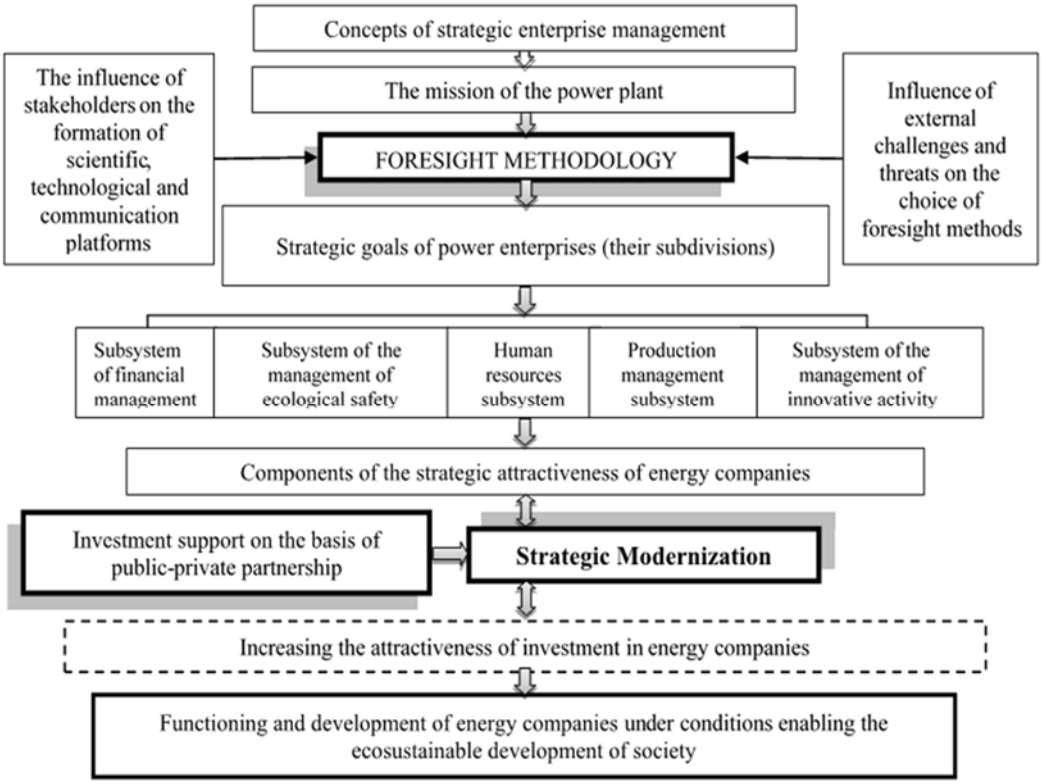

Fig. 1. Concepts involved in the innovative development of enterprises in the energy sector. Source [34]

These concepts are based on the principles of strategic management in conjunction with the theoretical and practical basis for the use of foresight method to establish strategic directions for supporting investment on the basis of public-private partnerships (PPP), together with the modernization of enterprises in the long-term perspective, while taking external challenges and threats into account. In the process of the strategic modernization of energy sector enterprises, the scale of the need for enterprises to be more flexible in regulating loads in the energy system is increasing. Rational use of the capacity of energy producers is required to cover peaks in the load schedule.

The foresight method is not a substitute for long-term planning. It is a tool for improving the quality and accuracy of strategic management, as well as a way to enhance the potential of power plants to establish a public dialogue (which is in accordance with the network thinking approach to strategic management). The use of foresight method makes it possible to more clearly outline the main directions of the strategic modernization of priority sectors, in particular the energy sector, enabling policy stakeholders and partners to create a scientific and technological platform for the development of selected sectors of the economy in terms of improving security, the quality of life and the economic, energy, technological and environmental needs of the state.

Summarizing, foresight research supports strategic planning in a natural way and should be carried out before the planning process. Foresight research is useful in combination with an evolutionary approach to strategic management to identify the weak signals coming from a turbulent environment by using such foresight methods as: TRIZ, the Delphi method and environmental scanning. Therefore, foresight projects provide results which could support the creation of the future [37]. As Rohrbeck states *corporate foresight capabilities are a resource in their own right* [28, p. 49], which is in line with the RBV approach. Foresight research focuses on discovering knowledge and creates networks and network thinking by using such methods as expert panels and the Delphi method.

3. Regional and corporate foresight

EU documents recommend that regional foresight is adopted by the appropriate authorities to plan regional development. Regional foresight should be used as a source of opinions about issues that are important to a local (regional) society. It is a specialist platform for communicating knowledge and information exchange, as well as being a starting point for building a regional strategy.

According to Rohrbeck [28, p. 11], there are two schools of thought about corporate foresight. The first school presents corporate foresight as a process [3, p. 12], [14, p. 5], but the second one as an ability [36, p. 382], [38, p. 10]. In this article, Rohrbeck's

definition of corporate foresight is adopted. This definition states that corporate foresight is *an ability that includes any structural or cultural element that enables the company to detect discontinuous change early, interpret the consequences for the company, and formulate effective responses to ensure the long-term survival and success of the company* [28, p. 11].

Based on a literature review [39], [4, p. 140], [25], [23, p. 14, 58] and the authors' experiences, regional/sectoral and corporate foresight can be compared. Firstly, they have different aims, because the decision makers have different ranges of competencies. The key goals of regional/sectoral foresight are:

- foreseeing the future, preparing for environmental changes, and defining potential threats (e.g., in the Polish foresight the following were carried out: a SWOT analysis, and an extrapolation of the trends for electricity, gas and heat demand until 2050),
- formulating the vision and strategy of regional or sector development (e.g., in the Polish foresight, a vision and mission for the energy sector at regional level was developed, together with a proposal of actions aimed at different kinds of stakeholders),
- pointing out key competences,
- pointing out potential differences in interests,
- learning,
- creating networks (during the Polish foresight, stakeholders could present their points of view and some participants of the panels and the conferences said that the project was similar to a specialist information platform).

Corporate foresight has such aims as:

- foreseeing the future, preparing for changes in the local/business environment, and defining potential threats,
- formulating an innovation strategy,
- adapting to changing environmental conditions,
- identifying potential threats (such as in the Ukrainian foresight),
- treating the launches of new products as an opportunity to promote and develop the whole enterprise,
- developing new markets.

Of course, providing information is an aim common to both kinds of foresight.

The results desired from these kinds of foresight stem from their aims. Usually in regional/sectoral foresight, the main results are a regional/sectoral strategy, action plans or tools supporting certain actions (e.g., financial support, promotion, lobbying). For comparison, the aim of corporate foresight focuses mainly on: (1) developing and improving a company's competitiveness by implementing an innovative product or technology, and (2) formulating an innovative strategy taking into consideration barely-visible symptoms in the environment.

Multiple stakeholders participate in regional/sectoral foresight, e.g., in the Polish foresight there were about 100 experts. A characteristic feature of corporate foresight is

its multifunctionality, that is to say the participation of several departments within a company, e.g., in the Ukrainian foresight there were about 50 experts from different departments.

Regional foresights are usually carried out in a non-systematic manner, but corporate foresight should support strategic planning, so it should have a systematic character and coherency, e.g., the Ukrainian foresight is carried out once every 5–10 years depending on the influence and strength of VUCA conditions.

Another difference between these types of foresight is their relation to knowledge. The adaptation of existing knowledge is a typical feature of regional foresight, while corporate foresight creates new knowledge. In the Polish foresight, existing knowledge was used to construct theses. The Ukrainian foresight presents the grounds for the need for a transition from purely technical upgrading to the strategic modernization of Ukrainian hydroelectric power plants as a set of measures aimed at the continuous improvement of technical and technological, socio-economic and environmental processes in the operation of hydroelectric power plants, which, in turn, enables long-term qualitative changes through the use of the foresight method, including the consideration of external challenges and threats.

The planning horizon could be 3–90 years, but is usually from 10 to 20 years in regional foresight (e.g., it was 20 years in the Polish foresight but the experts pointed out that some theses might only be achieved by 2050). The planning horizon in corporate foresight is usually shorter and is maximally 15–20 years, e.g., in the Ukrainian foresight it was 5–10 years, including the influence and strength of VUCA conditions.

To conduct regional/sectoral foresight, regional or sectoral authorities need financial resources, because such research is outsourced and often conducted by academic units. Enterprises also need their own sufficient sources of financial and human resources to conduct corporate foresight or implement their results but the greatest limitation on corporate foresight seems to be constraints on time. For Ukrainian energy companies, the main problem is connected with the unpredictable influence of the external environment of VUCA conditions.

The next criterion for comparison is the methods used. In regional/sectoral foresight, from 1 to 15 techniques of different kinds are used during a single study but, most frequently, from 3 to 7 methods. In the Polish foresight, 11 methods were used: conferences, a panel of experts, survey, the Delphi method, a literature review, expertise reports, scenarios, brainstorming, benchmarking, forecasting (trend extrapolation) and SWOT analysis. Usually, the most popular methods used in regional foresight are: literature reviews, expert panels, scenarios, extrapolation of trends/megatrends. In corporate foresight, 5 or 6 techniques of different kinds are used during a single study. The most popular methods are: trend analysis, literature reviews, scenarios, roadmaps, the participation of potential customers, scanning and brainstorming. The Ukrainian foresight used the Delphi method, a literature review, an expertise report, scenarios, brainstorming, and SWOT analysis. In both kinds of foresight, the selection of a method

depends on the resources available, including time, access to information and the availability of highly qualified experts.

The final criterion for comparing these two types of foresight is the set of typical limitations on foresight research. The most frequent limitations in regional foresight are:

- the possibility of diminished responsibility for the implementation of a strategy based on foresight, which stems from the administrative structure of executive entities,
- changes at the level of public administration which can cause discontinuities in particular policies,
- public authorities are obliged to use public financial procedures at the stages of both research and implementation of the results,
- a lack of cooperation between regional administration and actors in a particular sector,
- a lack of sufficient resources or of their mobility between subjects.

The most frequent limitations in corporate foresight are:

- failure of the highest level of management or stakeholders to fully use information about the future in an appropriate manner,
- a hierarchical organizational structure,
- the existing framework, communication and carrier paths controlling system of an enterprise,
- frequent changes among high level managers,
- a lack of resources.

The differences between the goals and the objects of study in regional and corporate foresight are apparent. The foundation for strategic choices and decision making in regional foresight is the goal of shaping an innovative strategy for regional development which accounts for external challenges and threats regarding the coordination of interests between state and private partners.

Corporate foresight involves a similar goal, yet the specifics of the innovative development of a particular economic activity are studied in a more detailed way. In our case, the functioning of hydroelectric power plants is under study.

The application and the combination of different methods in the process of regional and corporate foresight are alike in their method – in accordance with the set goal of the innovative development of energy enterprises or of a region. The difference between them lies in the informational and analytical support employed, namely in the number of experts involved and the volume of analytical data.

3.1. A short description of the Polish foresight – the method

The project *The Energy Development Strategy of Lower Silesia Using Foresight Methods* was based on a combination of two kinds of foresight – sectoral and regional. The data sources come from both outside of the energy sector (e.g., statistical data, the

opinions of experts who are not connected with the energy sector) and inside (the opinions of employees and historical data obtained from these energy enterprises). The stages of this project are presented in Fig. 2.

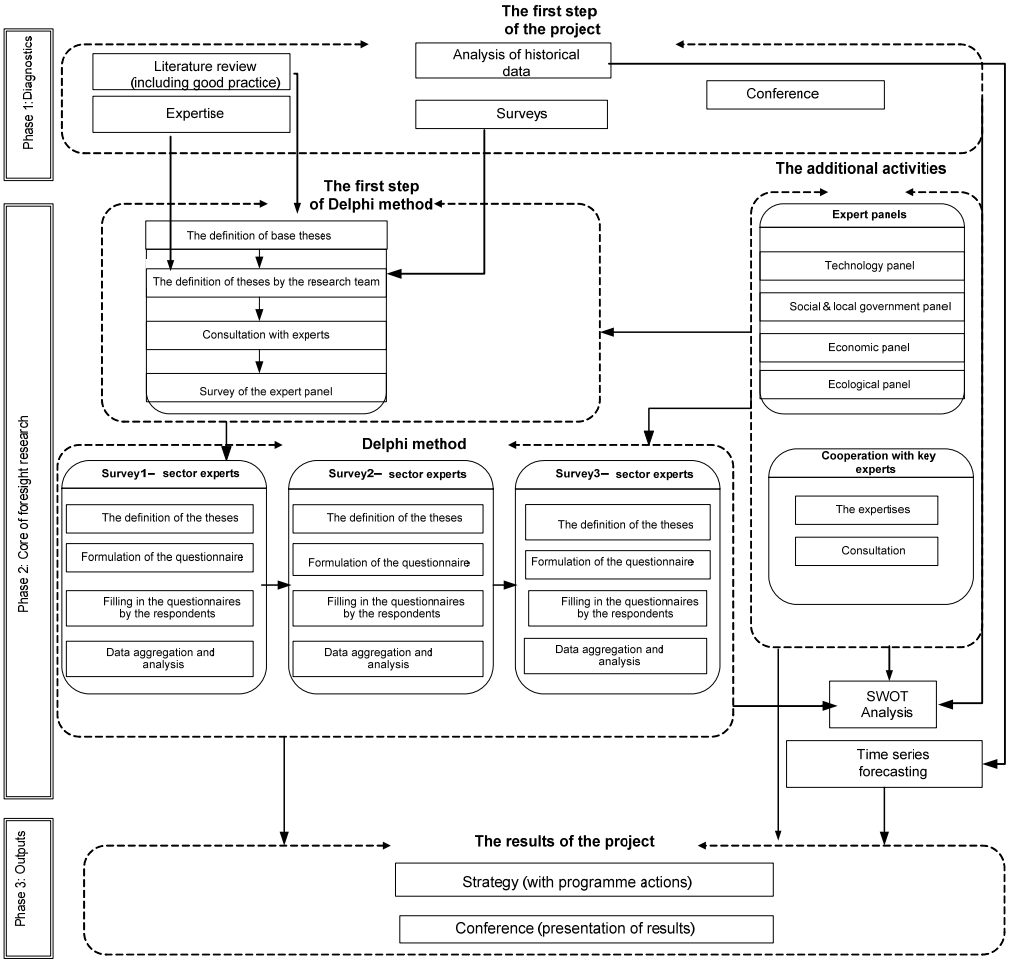

Fig. 2. The stages of research for the project
Energy Development Strategy for Lower Silesia Using Foresight Methods. Source [29]

A more comprehensive description can be found in such publications as [30–32]. Two kinds of experts participated in the research and these types are called: key experts and sectoral experts. Each kind of expert possessed knowledge related to one of the four following branches of energy: electricity, gas, heat and RES. In addition, experts came from other areas such as: production processes and technology, economics, ecology,

social issues and local government policy. The participation of different groups of experts bridges the gap between technical analysis and the real world, where resources (e.g., finance) are limited, and various social attitudes exist (e.g., the level of acceptance for innovative technologies).

Taking into consideration the aim of this article, the most important stage of this study is phase 2 (see Fig. 2), because the technological theses (potential aims) were formulated during this phase and during application of the Delphi method, the sectoral experts pointed out, e.g., the most innovative theses. In the next step, the sectoral experts made an assessment of each thesis, pointing out the barriers to its implementation.

Based on a literature review and the key experts' knowledge, a few thematic groups that focus on particular technologies or branches of the Polish energy economy were defined. Technologies were assigned to such categories as: (1) energy production based on coal and lignite, (2) energy technologies using biomass, (3) energy technologies using biogas, (4) energy systems based on wind, (5) energy systems based on water, (6) energy systems based on solar energy, (7) energy production based on nuclear power engineering, (8) technologies in the natural gas industry, (9) innovative technologies of energy storage, transmission and distribution, (10) Technologies of heat, heating and cooling systems, (11) fuel cells, (12) smart grids (SG), (13) behaviour of users and technologies improving the efficiency of energy use, (14) transport and energy based on hydrogen and synthetic fuels, (15) organizational and structural changes at regional and local levels. The last group of these categories was added at the request of the first panel of experts (the technology panel). Next, each of the theses developed from the Delphi analysis was assigned to one of these thematic categories and the appropriate project team prepared a survey. At the same time, during the technology panel, the experts carried out another survey, whose main aim was to indicate which phase of the life cycle each technology corresponded to. Phase I – future technology – is appropriate when theoretical or preliminary (introductory) research has been carried out and scientists are optimistic about its implementation. Phase II, called prototype, means that research on a prototype is presently being conducted. Phase III – growth – means that a technological solution had been introduced onto the market ('early implementation phase'). Phase IV implies that a technology is already being used and will also be used in the future. Only technologies judged to be in one of the first three phases were taken into account for the next stage of the research, called the first round of the survey, using the Delphi method. The number of selected technological theses totals 65, and the number of theses related to social and organizational aspects is 15[12].

Generally, the Delphi survey was repeated three times. Based on the first Delphi survey, the experts could modify the theses. They answered 11 questions which were

[12]These theses are not presented in this article due to constraints on the length of the article. For more about this subject, see [13]. Technologies judged to be in phase IV, but important to Polish regions, were also taken into account in the Delphi survey.

assigned to each thesis. These questions concerned: the deadline for achieving a potential aim, any business which may develop if such an aim is realized, the benefits for the region, as well as the practical results of realizing such an aim, the positive and negative factors, and the cost of its realization. The second survey was similar to the first, but was more detailed, and the number of theses was reduced, since the least important aims for the region were not taken into account. Also, the questions concerning benefits and barriers were formulated more precisely. The third survey was different because experts had to indicate the influence of each thesis on the achievement of three positive scenarios, focusing respectively on: ecological, business (economic) and social aspects in Lower Silesia. One question regarded the deadlines by which a potential aim would need to be realized for each scenario. In the final question, the experts outlined activities (such as: financial, educational, related to regional law) which should be carried out if a scenario were to be realized.

3.2. A short description of the Ukrainian foresight – the method

The use of foresight method allows us to define the directions of investment support for the strategic modernization of enterprises in the long run, as well as to develop theoretical and methodological provisions regarding the choice of strategies for modernizing hydroelectric enterprises under VUCA conditions. This project applied such economic and mathematical methods as correlation data mining, regression data mining and multivariate regression to stratified data. This enabled a methodical, scientific approach to the assessment of the degree to which innovation in an energy enterprise is facilitated according to the formula:

$$Fp_i = L_1 Pec_i + \mathrm{L}_2 Pecol_i + \mathrm{L}_3 Psoc_i + \mathrm{L}_4 Ptec_i + e_5 \tag{1}$$

Fp_i – the degree to which innovation is facilitated in the ith company, Pec_i – the index of influence of economic indicators on Fp in the ith company, $Pecol_i$ – the index of influence of ecological indicators on Fp in the ith company, $Psoc_i$ – the index of influence of social indicators on Fp in the ith company, $Ptecxi$ – the index of influence of technical and production indicators on Fp in the ith company, e_5 – residual random error for Fp in the ith company, L_1, L_2, L_3, L_4 – coefficients of the influence of the corresponding indexes on Fp in the ith company.

Assessment of the facilitation of innovation in enterprises opens up new opportunities for diversifying the interaction between domestic and foreign investors, and increases the likelihood of foreign investors participating in investment projects.

The results obtained in such an assessment process enable us to determine the directions for priority investments and innovation in energy companies, which will stimulate the transition to a qualitatively innovative type of development.

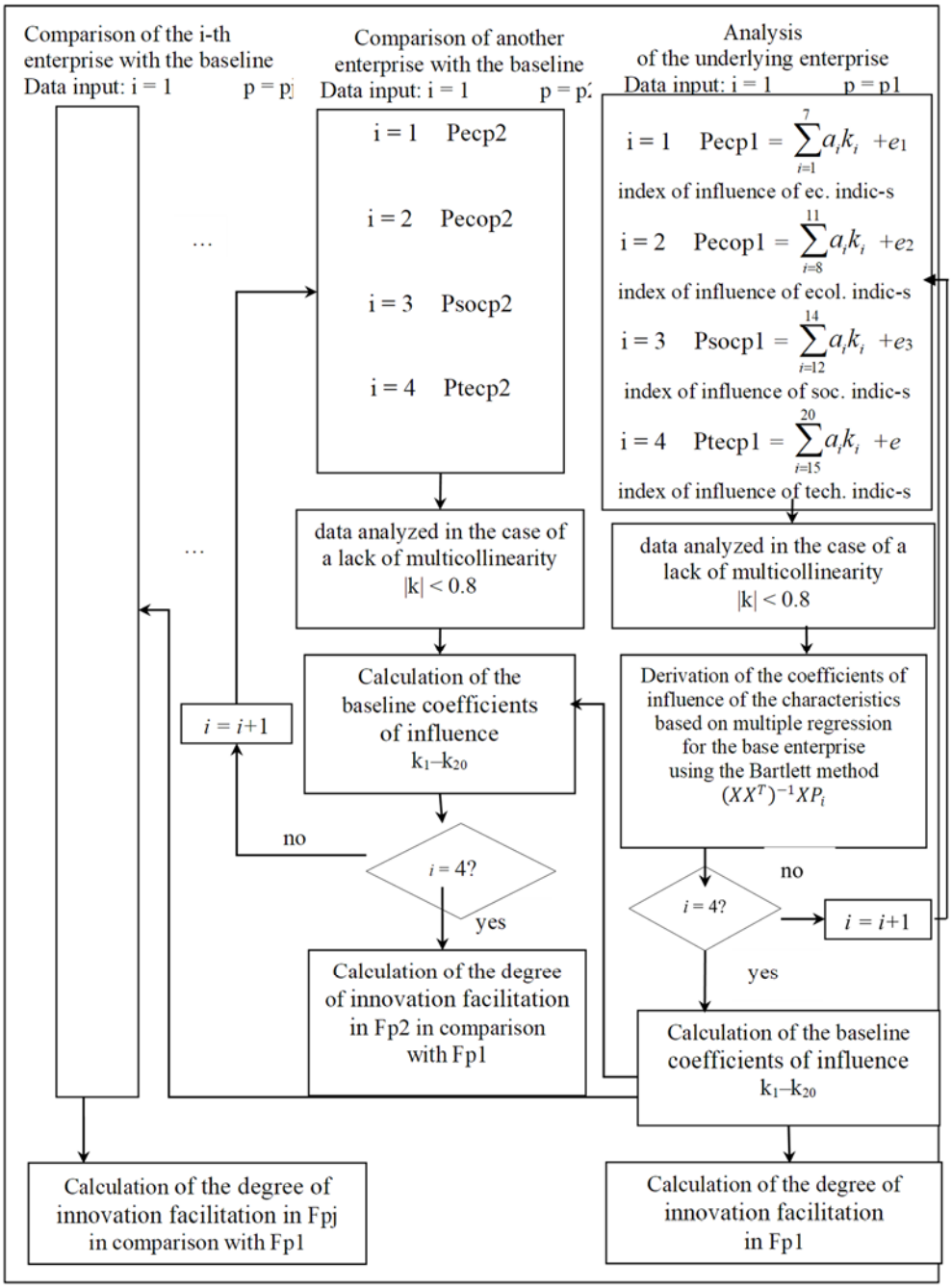

Fig. 3. Algorithm for modelling and forecasting the change in innovation for power enterprises based on multiple regression. Source [35]

Increasing the competitiveness of unprofitable enterprises will contribute to modernizing the economy and increased economic growth in Ukraine.

It can be said that, at present, such aspects as (1) the development of the economy, (2) the possibility of innovative development in the national fuel and energy industries (3) and attractiveness to investors are not limited to technical, economic and financial indicators. It is necessary to analyse and improve environmental and social components, which require partnership, not only between partners in the private sector, but also co-operation with the state. The algorithm used to model the level of innovation in an energy company is presented in Fig. 3.

4. The main results of the foresights

The concept of developing a method which is not dependent on the level or range of a study is common to both types of foresights–regional and corporate. However, there are differences in their limitations, both quantitative and qualitative.

Changes of a strategic scope in innovative development within a society come as a result of the process of interactions between three factors: the detection of problems, the identification of solutions to these problems, and the distribution of responsibilities for implementing the measures and mechanisms of an innovation strategy. In some cases, foresight reveals newly-emerging problems which have the potential to influence the development of the market in a long-term perspective, and it also restructures existing problems in such a way as to mobilize the potential of each and every party interested in solving them. In such cases, foresight might make a substantial contribution towards forming new priorities for the innovative development of a region or industrial enterprises. Foresight may also influence society by forming suitable conditions for the development of new networks for implementing the currently prioritized goals. Such networks share a common vision of development perspectives and an agreement on what has to be done and what structures have to initiate and implement these measures.

An important question is whether the direct beneficiaries of the presented foresight projects did indeed find the conclusions from them helpful. Moreover, did they influence the decisions and actions aimed at implementing innovative technologies and for implementing strategical modernization in power plants?

4.1. The main results of the Polish foresight

The main result of the Polish foresight was the proposal of a regional energy strategy. The approach to building this strategy included its mission, main aims and actions directed at different kinds of stakeholders [20, p. 18, 107–135] (Fig. 4).

For such stakeholders as energy companies, the outcome of the three rounds of the Delphi survey are interesting results, which energy companies can use to create their strategies because the experts involved came from different interest groups and indicated which theses were acceptable to society. Of course, energy firms can select other information, e.g., which theses: (1) are the most important for Lower Silesia, (2) support energy security in the region, (3) support innovation in the regional energy sector, (4) are the most economically beneficial for society and the most important for ecological aspects.

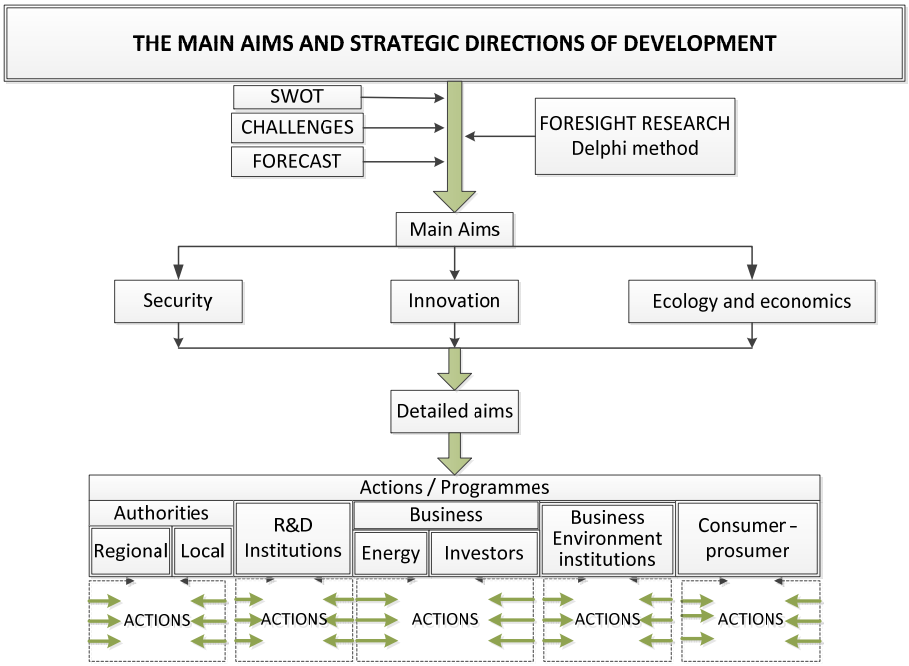

Fig. 4. The method of building an energy strategy for Lower Silesia. Source [30, p. 18]

Energy companies can obtain similar results by carrying out their own study, thus engaging their own resources and creating additional costs. Regional foresight provides a freely available analysis, which allows energy firms to reduce the private costs of environmental research before creating innovation strategies.

4.2. The main results of the Ukrainian foresight

It is without doubt that each innovative project has its own distinctive features, and various internal and external factors should be accounted for. During the implementation of foresight programs, an action plan needs to be developed. Such a plan has to address what has to be done and what strategic management mechanisms should be

implemented. Also, agreement should be formed on the subject of what structures should be held responsible for implementing the measures developed.

The foresight method has to account for the ever-increasing complexity of systems and problems. Therefore, the dispersion of specialist knowledge amongst various stakeholders and the interdisciplinarity of information and knowledge have become part of our reality. These new realities of the knowledge economy imply that the information necessary to implement a strategy for modernizing hydroelectric stations can be accrued by means of social networking. In turn, this means that foresight itself should be designed to work with networks, both in its organization and method.

As previously noted, in the age of the knowledge economy, foresight should assume uncertainty to be a part of the evolution of any system. Although uncertainty is increasing, foresight provides opportunities to achieve stability in an unstable environment, which is particularly relevant to Ukraine. If all of the actors could come to a common vision of development prospects, more predictable rules would be formed and the stability of innovative development would increase for all members of society, as well as improving competitiveness. Therefore, foresight leads to minimizing the costs of implementing a strategy. Foresight strategically mobilizes intellectual potential for the purpose of developing strategies for the innovative development of energy enterprises.

Analysis of particular features of investment support for the modernization of Ukrainian energy enterprises reveals the fact that the possibilities of development by expansion have been exhausted. This shows that the development of conceptual provisions for strategic modernization is necessary. Such modernization should be based on the principles, priorities and the targets set by foresight-based method. The proposed provisions for the strategic modernization of hydroelectric energy enterprises lie in the implementation of an approach that follows a clear method for CEOs and specialists to establish strategic directions of investment support for the strategic modernization of enterprises, while accounting for market tendencies and state regulations.

5. A holistic model of an organizational-technical-economic mechanism promoting strategical innovation/modernization

A mechanism for supporting the innovative development of energy enterprises is shown in Fig. 5. The following points should be taken into consideration when such a mechanism is being formed [34]:

- the causal relationships between enterprises and industries within a state,
- the originality of the implementation process, which is a result of scientific and industrial procedures and operations,
- the ability and need to replace old means and subjects of labour with new ones, to update technological processes and the product assortment,

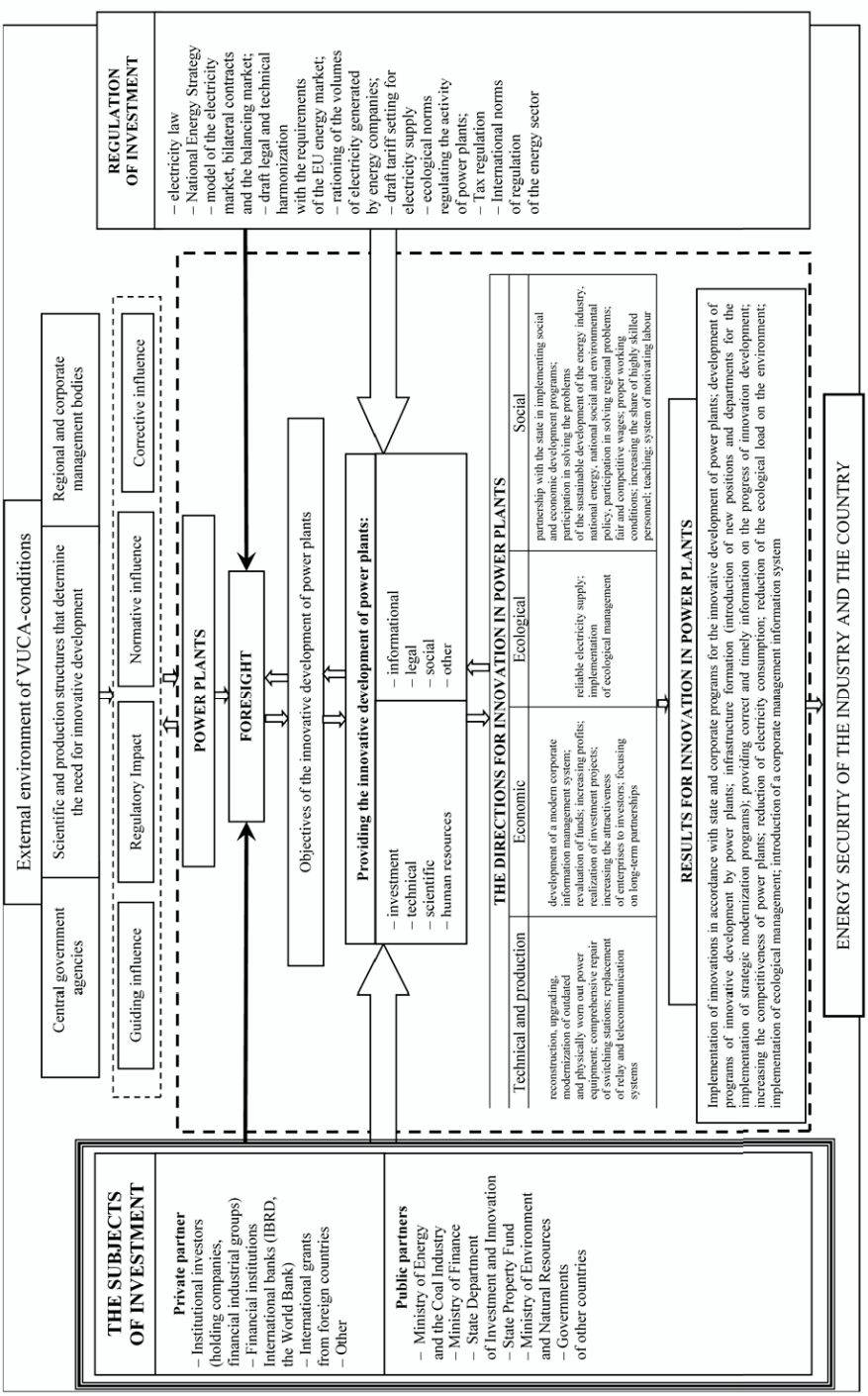

Fig. 5. The innovative development of energy enterprises. Based on [33]

- the necessity of providing periodical conversion of production processes based on new technologies,
- the accelerating pace of obsolescence on which scientific and technical progress is shaped,
- the necessity for industrial enterprises to master the latest advances in science and technology based on scientific principles,
- the importance of ensuring harmonization of the economic interests of society, teams and individual employees.

This model is based on common patterns in combination with the approaches and principles of investment support, which are implemented via instruments and actors with various functions. This is directed at the object of investment activity, so that the optimal result is achieved. In this case, this is defined as the development of measures to ensure favourable organizational and economic conditions for the innovative development of energy enterprises.

5. Conclusions

The foresight method enables clearer identification of vectors of innovative development in prioritized regions and industries where policy is assessed by all its actors, stakeholders and partners in order to develop scientific and technological platforms for the development of selected economic sectors in the sense of increasing the quality of life and providing economic, technological, and ecological security at state level.

Taking VUCA conditions into consideration, a holistic model of a mechanism for the innovative development of energy enterprises has been developed on the basis of the principles of a partnership between the state and enterprises from the private sector. This model enables us to define particular socioeconomic measures to reconcile the interests of the state with those of its private partners. It also enables accounting for the influence of investment institutions on the implementation of the selected vector of innovative development at macro-, mezzo- and micro-levels.

As a result, the roots of the challenges facing the foresight method as well as the direction of transformations of the foresight method which result from these challenges, lie in the following aspects: (1) the increasing complexity of systems and problems during the present transition to the knowledge economy, (2) the increasing tempo of evolution, (3) the changing roles that various actors in the process of management are taking in the evolutionary development of society. Consequently, one should search for the answers to these challenges in the theories of complexity, chaos and evolution.

There still remain unanswered issues regarding harmonizing the aims of various stakeholders during the application of holistic methods via the process of foresight as

well as regarding the appropriate application of information and communication technologies in the research process. The processes of globalization, harmonization and international cooperation demand the application of a single approach towards research, in order to address the social and economic issues experienced in partner countries.

Such an approach could be used to establish a set of measures aimed at the continuous improvement in the technical, technological, socioeconomic and environmental aspects regarding power plants *(*e.g., the operation of Ukrainian hydroelectric power plants and RES in Poland). Despite different types of foresight (corporate and regional) being applied in these two countries, the processes of planning innovation and planning modernization are similar, but the influence of decision makers is completely different in the case of innovation processes in energy companies. Regional authorities can only use the results of foresight to create favourable conditions for investment by enterprises, e.g., via the construction of action plans, while energy companies provide the actual innovation or investment required for modernization.

References

[1] Agora Energiewende, *Understanding Energiewende. The most commonly asked questions regarding transformation of the energy sector in Germany*, January 2016.
[2] ANSOFF H.I., DECLERCK R.P., HAYES R.L., *From strategic planning to strategic management*, Wiley, London 1976.
[3] BECKER P., *Corporate foresight in Europe. A first overview working paper*, European Commission, Brussels 2002, 31.
[4] BORODAKO K., *Foresight in strategic management*, C.H. Beck Publishing, Warsaw 2009 (in Polish).
[5] *Scenarios of the technological development of the petrol and energy sector in ensuring energy security in Poland*. Part 2. *Scenarios developed on the basis of a foresight study of the energy sector in Poland for the period 2005–2030*, K. Czaplicka-Kolarz (Ed.), GIG, Katowice 2007 (in Polish).
[6] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001.77/EC and 2003/30/EC, L140, 6.06.2009.
[7] *Technology and Social Visions for Europe's Energy Future: a Europe-wide Delphi Study. Final Report*, EurEnDel, 2004.
[8] European Council 23/24. *Conclusions*, EUCO 169/14, Brussels, 24 October 2014.
[9] FEDULOVA L., *A new approach to the formulation of regional development policies: the foresight method*, 2007 [Online], available at: www. nbuv.gov.ua/portal/Soc_Gum/zbirnuk_RE_4_139.pdf
[10] *Foresight for Our Future Society*, Cooperative project between NISTEP (Japan) and Tekes (Finland), M. Syrjänen, Y. Ito, E. Ahola (Eds.), Tekes Review 242/2009, NISTEP Policy Study No. 14.
[11] GAPONENKO N., *Foresight. Theory. Method. Experience*, JUNITI-DANA Publishing, Moscow 2008 (in Russian).
[12] HAMEL G., PRALAHAD C.K., *Competing for the future*, Business Press, Warsaw 1999 (in Polish).
[13] HERLENDER K., ROPUSZYŃSKA-SURMA E., SZALBIERZ Z., WĘGLARZ M., WYŁOMAŃSKA A., *Surveys carried out among experts, their analysis and verification*, Report of the Institute of Organisation and Management, Wrocław University of Science and Technology Ser. PRE, No. 56, Wrocław 2010 (in Polish).
[14] HORTON A., *A simple guide to successful foresight*, Foresight, 1999, 1, 5–9.

[15] JANTSCH E., *Forecasting and systems approach. A frame of reference*, Manage. Sci., (pre-1986) 19 (12), August 1973, available in database ProQuest Central, https://search.proquest.com/docview/205836899?accountid=46407 (access: 6.09.2017).
[16] KASPRZAK W.A., PELC K.I., *Innovations. Technical and developmental strategies*, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2012 (in Polish).
[17] *Regional and technological foresight. The initial experience of Polish Regions*, A. Klasik, T. Markowski (Eds.), Polish Academy of Sciences, Committee on Spatial Planning, Studia, Warsaw 2010, Vol. 127 (in Polish).
[18] KUBIŃSKI P., *Creating and implementing strategies in firms and local government*), Dolnośląskie Centrum Studiów Regionalnych, Wrocław 2007 (in Polish).
[19] LAWRENCE J.A., STECK E.N., *USDA – Forest Service, Overview of Management Theory*, U.S. Army War College Military Studies Program Paper, February 1991, http://www.dtic.mil/dtic/tr/fulltext/u2/a235762.pdf
[20] MALITSKYJ B.A., POPOVYCH O., ONPRIENKO M.V., *Foresight as a scientific-technical approach to defining priorities*, NAN Publishing Ukrainy, Center for Scientific and Technical Potential and History of Science named after G.M. Dobrov, National Academy of Sciences of Ukraine, Kiev 2008.
[21] MARTIN B.R., *The origins of the concept of "foresight" in science and technology. An insider's perspective*, Techn. For. Soc. Change, 2010, 77, 1438–1447.
[22] MINTZBERG H., *The rise and fall of strategic planning*, FT Prentice Hall Financial Times, An imprint of Pearson Education, London, Person Education Ltd., Edinburg 2000.
[23] NAZARKO J., *Regional economic foresight. Method and research instruments*, Union of Employers in Warsaw and Mazovia, Warsaw 2013 (in Polish).
[24] OBŁÓJ K., *Organizational strategy*, PWE, Warsaw 2014 (in Polish).
[25] POPPER R., *How are foresight methods selected?*, Foresight, 2008, Vol. 10, No. 6, Emerald Group Publishing Limited.
[26] PORTER A.L., *Technology futures analysis. Toward integration of the field and new methods*, Techn. For. Soc. Change, 2004, 71, 287–303.
[27] PORTER M.E., *Competitive strategy techniques for analyzing industries and competitors*, PWE, Warsaw 1998 (in Polish).
[28] ROHRBECK R., *Corporate foresight. Towards a Maturity Model for the Future Orientation of a Firm*, Springer-Verlag, Berlin 2011.
[29] ROPUSZYŃSKA-SURMA E., *The foresight methods as support of the regional and sector policy*, Int. Conf. Trends in Economics and Management for the 21st Century, Brno, Czech Republic, September 20–22th, 2012.
[30] ROPUSZYŃSKA-SURMA E., *Combining quantitative and qualitative methods based on the example of regional foresight related to the energy industry*, Econometrics, 2014, 4 (46), 135–150 (in Polish).
[31] *Development strategy for the energy sector in Lower Silesia based on the Delphi approach to foresight*, E. Ropuszyńska-Surma, Z. Szalbierz (Eds.), Oficyna Wydawnicza Politechniki Wrocławskiej, Wroclaw 2011 (in Polish).
[32] ROPUSZYŃSKA-SURMA E., WĘGLARZ M., *Regional energy strategy as a guideline for novel regulation process*, Comp. Reg. Net. Ind., 2014, 15 (3), 258–283.
[33] RUFF F., *The advanced role of corporate foresight in innovation and strategic management. Reflections on practical experiences from the automotive industry*, Techn. For. Soc. Change, 2015, 101, 37–48.
[34] SEMENCHENKO N., SHKROBOT M., *Interactions between the foresight method and public-private partnerships in the formulation of a strategic program for the modernization of hydroelectric power stations*, Ef. Ekon., 2013, 7, available at: http://www.economy.nayka.com.ua/index.php?op=1&z=2804 (in Ukrainian).
[35] SHKROBOT M., *Defining a strategy for the modernization of hydroelectric power stations*, NTUU KPI, Kiev 2014.

[36] SLAUGHTER R.A., *Futures studies as an intellectual and applied discipline*, Am. Behav. Sci., 1998, 42 (3), 372–385 (in Ukrainian).
[37] TONN B.E., *The future of futures decision making*, Futures, 2003, 35, 673–688.
[38] TSOUKAS H, SHEPHERD J., *Managing the future. Foresight in the knowledge economy*, Blackwell Publ., Malden, MA, USA, 2004.
[39] VISHNEVSKIY K.O., EGOROVA O.E., *Strategic Foresight for SMEs. Choice of the Most Relevant Methods*, 26th ISPIM Conference – Shaping the Frontiers of Innovation Management, Budapest, Hungary, 14–17 June 2015, available: www.ispim.org (access 18.06.2016, 3–4).
[40] ZGHUROVSKYY M., *Foresight in the construction of a strategy for socio-economic development in Ukraine in the midterm (till 2020) and long-term (till 2030)*, NTUU KPI, Kiev 2016.

Received 11 February 2018
Accepted 8 December 2018