A CLASSIFICATION OF RISK MANAGEMENT METHODS IN COMPLEX ELECTROTECHNICAL SYSTEMS

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Abstract

The present paper summarizes the results from the theoretical and applied research into the systematization of the methods of risk identification and management under prolonged operation of complex energy systems, such as the modern electric machinery and transformers. On the basis of a profound theoretical research, using different criteria, classified and characterized are several groups of methods. Put forward, under the principle of analogy, are their advantages and disadvantages to facilitate the selection of those methods, that ensure full compliance with the requirements and peculiarities of risk management under prolonged operation of complex energy systems. The basic purpose of the present research paper is to bring forward, on the basis of scientifically-grounded classification and systematization, a selection of practical application methods to be further recommended to the electricity transmission companies operating within the territory of the Republic of Bulgaria.

Key words: Risk management, Energy industry, Electric machinery and transformers

1. Introduction

The main tasks of the present project are derived from the practical needs of the Ministry of Economy and Energy for the development of efficient, competitive and sustainable energy system. Within the context of EC Energy Strategy and the Bulgarian National Energy Strategy, the production of electricity is considered as a heterogeneous industrial complex, as a system of diverse, yet interrelated sources – nuclear energy, electricity (electric power), "green" energy and others. The involvement and parallel operation of such diverse sources poses a number of technical, technological, economic, social and other risks.

The systematic studies of the transformer park of Bulgaria show persistent tendency towards obsolescence or ageing leading to increase in prevention and maintenance expenditure. In 2011 over 60% of the transformers 110-400 kv in our country have been in operation for more than 20 years, approaching or rather, being well beyond their 20-25-year- amortization (depreciation) period, as specified in the technical documentation. Market research reveals that current transformer price of that class towards August, 1st, 2012 exceeds 1 million leva. To continue to function properly in a time of crisis, the only plausible solution for the national energy system, is to extend their operational life period through diagnostic testing, repair and

modernization. This will entail the application of modern risk identification and management methods, following consequently from the extended, beyond the amortization period, operational service of these complex pieces of equipment.

The main purpose of the current paper is, on the basis of scientifically-grounded systematization and classification to bring forward a selection of practical application methods in risk identification and management, which are to be further recommended to the electricity (electric-power) transmission companies operating within the territory of the Republic of Bulgaria.

2. Fundamental terms and concepts of risk management in complex energy systems

Inherent characteristics of the complex energy systems are uncertainty and risk.*"Risk"* and*" uncertainty"* are concepts having a similar meaning and, therefore, are often considered as being synonymous. What the two concepts have in common, however, is that they both are used to designate *"lack or shortage of definiteness"*.[5, p.13].

The differences between the two concepts can be attributed to the *information approach*. Its underlying assumption is that the differences between uncertainty and risk are limited to the easily available amount of information about the situation under study. All theoretical advancements so far, have not disputed the axiomatic assumptions formulated already in 1921 by F.Knight. **"The concept of risk** *is to be used when the distribution of the random variable that helps model the risk situation is known, this will be called "measurable uncertainty" or "probabilistic certainty"*. "**The concept of uncertainty** *will be applied in those cases, where the outcome is not certain and the probability distribution remains unknown, this will be called "immeasurable uncertainty*"[15, pp.12-13].

Such a classification presupposes *objective* and *subjective* perception of the risk as far as different people have different attitudes as to the probability of a risk situation adverse outcome occurrence. The risk can be both objectively and subjectively assessed on the basis of whether the ambiguity of the potential outcome of a certain risk situation is related to the objective nature of the object or to the subjective lack (deficiency) of required knowledge among the managers controlling it.

Risk Management *is a process of making and implementing such managerial decisions, which minimize the material, financial and other consequences following a risk situation adverse outcome effects.* This particular definition allows for the three essential characteristic features of risk situation management to be disclosed:

- risk management is not a single (one-time) act, but a continuous *process*, part of the overall managerial cycle;
- risk management is oriented towards *neutralization of the adverse effects* of a random event occurrence;
- risk management aims at achieving *prevention and minimization* of the negative effects of a risk situation adverse outcome occurrence.

This definition is universal in its nature and can be applied to the three levels of the energy management system:

- *to the national level* for decision-making processes in Government or Ministry of industry, energy and tourism;
- *to the business (company) level* for decision-making processes by the energy production company management and its electricity transmission companies as well;
- *to the third, i.e the lowest level– to the workplace itself*, where the human factor can also generate unexpected risks.

Irrespective of the sources, scale (proportion) and type (form) of manifestation, the malevolent or threat-posing risks have to be identified, defined, analyzed and assessed through a system of quantitative and qualitative methods.

The process of risk management in energy systems *is a complex, multi-staged and multi-level process*, involving more sophisticated research methodology, based on the study of the structural characteristics of the risk.

3. Structural characteristics of the risk in complex energy systems

The analysis of the risk situations in complex energy systems makes it possible for the persistently recurring inherent characteristic features of the risk to be defined. In Fig.1 shown is the structural profile of the risk in complex energy systems.

Fig.1: Structural characteristics of the risk in complex energy systems.

The structural profile of the risk comprises the following elements:

Danger – this concept refers to potential threat of loss or other type of risk realization, determined by the specificity of the object or peculiarities of the risk situation. This characteristics reflect the interaction between two fundamental elements: *risk bearer* is the object for whom the risk assessment is carried out and the *surrounding environment* which can trigger the realization of the risk. Danger is a key characteristic feature of the risk which would not otherwise be realized.

The object of the risk refers to the system being managed (controlled), the risk bearer, whose effectiveness and efficiency are not defined in advance.

The subject of the risk refers to individual or collective management body (manager), directly related to the outcomes of the decision-making as to the object of the risk.

The source of the risk are those factors, phenomena, processes, which induce or enhance the uncertainty and/or conflictness, generating outcomes not consistent with the expected results.

The uncertainty is such a situation where information about the structure and capabilities of the object of the risk and the respective immediate environment is, to a greater or lesser extent, not available.

The situation of risk (A risk situation) distinguished by uncertainty, contradiction and alternativeness, as well as opportunity for alternative assessment.

The identification of the risk is accomplished in two consecutive, coherent stages: *qualitative and quantitative analysis*.

- *The qualitative analysis* determines the object of the risk and its causes, the scale or extent of the risk exposure, types of risk and the risk elimination or reduction possibilities, where applicable
- *The quantitaive analysis* uses numerical data to estimate the risk and its consequences or effects.

4 Risk management methods in complex energy systems

Globalization and the world crisis has made the relationship between the economic agents or operators more complex, transforming their external surroundings into a *turbulent environment*, in which only those professionals who are the most flexible can survive. The electricity system is of great infrastructure value for the national and European industrial complex, which predetermines the *improved* operational *criteria for continuity and reliability*. The increase in external environment-induced risks and the introduction of a brand new type of "green" sources, has markedly transformed the Energy industry into one of the most complex and at the same time one of the riskiest industrial systems. At present, the national energy management system is inconceivable without the development of reliable risk identification and management system as an integral part of the overall management of companies producing electrical energy and electric- power or electricity transmission companies. Such a system should be hierarchical one incorporating all the three levels of management in the respective industry sector or branch.

The initial starting point in designing and implementing the *hierarchical risk management system* is the proper selection of a right method of management. Since the concept of risk is defined in a rather ambiguous or vague way, in the scientific literature and practice presented is *a large number of approaches, methods, procedures and instruments or tools* for risk neutralizing or minimizing and eliminating the effects of the adverse risk events.

The analysis of the main approaches to minimization of the risk event adverse effects and their consequences as well permits a separate identification and individual study of the risk management *general procedures*. A question arises as to the *criterion or system of criteria for their grouping and analyzing*.

The first studies into the issue under discussion were undertaken as far back as the beginning of the XXth century. In 1921 it was F. Knight who first succeeded in classifying the risk management methods into three groups [15, p.46]:

- *Risk elimination methods,* integrating all possible risk avoidance techniques, applying measures that prevent a risk from occurring at all.
- *Risk reduction methods,* referring to all management measures and interventions to facilitate the reduction of the adverse consequences of a potential risk situation realization. Employing these techniques implies that the management of the company takes full responsibility for the potential consequences of the decisions they have made, and explains, accordingly, the reasons why these methods are also known as *Risk retention* or *Risk assuption.*
- *Risk transfer methods*, involving a set of measures and activities, through which the responsibility for reduction of possible adverse effects of a potential risk situation realization is shifted to another subject (for example insurance company).

A whole new stage in the development of the intense disputes and controversies in science as regards the choice of criterion for risk methods classification is the emergence of a classification based on the relationship between *the moment of risk situation realization and the moment of concrete event management implementation* [19, p.72]. In terms of this criterion the methods should have *preventive and prophylactic* function, and being management events or activities they should *precede and impede (prevent) any risk situation adverse outcomes*. Two groups of methods are attributed to this issue:

- *Pre-event risk management methods* – planned and put into practice prior to the occurrence of a risk situation so as to ensure adverse effect prevention or minimization. This group comprises all the risk transformation methods, which are consequently known as *Risk control* or *Risk control method stop-loss*. For that reason, these methods are commonly associated with prevention and preventive control for avoidance of a certain risk situation and its adverse effects.
- *Post-event risk management methods*– are applied after the risk situation occurrence with the prime purpose of minimizing adverse outcome damages. Considered as part of this group are also the risk financing methods, that provide for sources of financial resources and funds to cover losses caused by risk situation adverse effects. This is the reason why, these methods are easily recognized as *Risk financing* or *Risk financing to pay for losses.*

The two classifications proposed above have important implications for ensuring proper understanding of the role and specificity of each risk management method. We believe that the creation of a new classification is feasible, only if it is based on the two classification criteria. In Table 1 presented is a systematic classification of the management methods on the basis of the two classification criteria.

Table 1: Classification of the risk management methods

Riskmanagementprocedures	**Group methods**	
	Characteristics of therisktransformation	Characteristics of riskfundingmethods
1. Risk of diversion	*1. Riskavoidance (refusal)*	-
2. Minimisingrisk	*1. Methods of risksegregation of exposures* *2. Riskmanifestationfrequencyreduction* *3. Lossmagnitude (extent) reductionmethod* *4. Othermethods*	*1. Coverageforlossesattheexpense of currentproceeds* *2. Lossreservecoverage* *3. Coverageforlossesattheexpense of a credit* *4. Coverageforlossesattheexpense of self-insurance* *5. Othermethods*
3. Transfer of therisktoexternalorganization	*1. Riskoutsourcingmethods* *2. Othermethods*	*1. Insurance coverageforlosses* *2. Coverageforlossesattheexpense of stateormunicipalAnti-crisisprograms* *3. Coverlossesbycontractwith a foreignorganizationsponsor* *4. Othermethods*

The new classification allows for a more accurate and in-depth study into the nature and the role of the risk management methods. On this basis, what should be examined more precisely is the logical sequence or coherence when they are jointly applied. Different methodsdiffer not only in their impact forces but also in the ways the result of their application is manifested.

4.1. Characteristics of the risk transformation methods

This group is broken down into several sub-groups ofmethods, having a direct effect upon the risk in order to neutralize or ignore it:

- *Risk avoidance (refusal) methods*– all these methodsare employed for the purpose of eliminating the causes for a risk situation occurrence. In the practical day-to-day life of the companies, there exist large-scale and powerful sources of catastrophic risks, whose manifestation cannot be limited or prevented. For example, the risk of bankruptcy of the company, explosion or untimely (premature) death of workers and employees as a result of an operational or industrial accidents. Despite the possible partial limitation of these risks, the high degree of probability of losses accomplishing the catastrophic outcome of a risk situation is not diminished. Applying this method, the management seeks for an answer to the following question "Is it possible to eliminate all the sources and causes for generating such risks?". The fundamental nature and purpose of application of these methods is to create such operationally-technical, organisational and social conditions for a company to function and operate, under which the sources and main causes for the occurrence of large-scale catastrophic risks are eliminated. Risk avoidance at such a situation is not simply *the best, but the only possible alternative*. These methods are applicable irrespective of the risk specificity– uniform or non-uniform, single (separate) or mass (large-scale), and with no consideration to the concrete magnitude or extent of the potential losses.
- *Risk outsourcing methods* – with these methods the responsibility for reducing the likelihood or probability of a risk situation adverse outcome occurrence is assigned (transferred) to external organization (subject of the risk management). This particular transference of the responsibility should be agreed in writing. The application of these methods is possible under certain *conditions* 1) precise identification and definition of the extent of danger; 2) definition and specification of the causes generating the risk; 3) availability of effective mechanisms for exercising control over those factors that generate the risk or increase the likelihood of its occurrence; 4) possibility of control over the factors generating the risk or increasing the probability of manifestation of the risk situation adverse outcome. As a rule, in the presence of the above conditions, the risk outsourcing is the preferred method over other methods, in which the responsibility stays with the management of the company. A special instance of risk outsourcing is the concept of risk (venture) capital, with which the responsibility for the risks of a newly established firm or other business is transferred onto external organization, which is actually funding the project.
- *Methods of risk segregation of exposures (differentiation)* – this method is applicable for all types of complex risks, allowing segregation or differentiation of separate (single) risks. This is a way of reducing the overall force and the possibility for a separate risk neutralization or limiting the exposure to a risk. A method of this type presupposes spatial differentiation of the sources of loss occurrence or of the objects who might be affected by the damages. For example, the huge manufacturing premises could be enclosed with parting heat-resistant barriers or special doors, so that should there be an outbreak of fire, it could be quickly located, and thus, consequently, reducing potential losses.
- *Risk manifestation frequency reduction method (Loss prevention)*– the essence of this method lies in the implementation of preventive measures or activities, ensuring reduction of the probability of risk event occurrence. This method is applied to different types of risks – uniform and non-uniform, mass and separate (single). This method is preferably employed in two cases: 1) with very high probability of risk situation negative outcome and 2) with high magnitude of potential damages. The practical application of the method is associated with the development of a preventive measure and activity program, whose implementation is subject to a strictly controlled and detailed analysis. The development of such programs requires the joint co-operation of experts in various fields– engineers, financiers, psychologists, doctors (physicians), who are accordingly invited as external experts.
- *Loss magnitude (extent) reduction method (Loss reduction method)*– the essence of this method lies in conducting preventive activities, ensuring reduction of the extent or magnitude of the potential losses. This method results in transformation of the vulnerability or susceptibility of the risk object.

If, despite all risk prevention efforts, the probability for a risk situation adverse outcome remains very high, activities for reduction of the expected damages should be carried out. To this effect, this method successfully complements all other methods. It is acceptable in two cases: 1) with high potential loss magnitude and 2) with small probability for occurrence of risk situation adverse effects.

4.2. Characteristics of risk funding methods

This group of methods, also recognized as *Risk financing,* has a purpose of providing the money to pay for the incurred damages out of a company's own funds or to transfer the funding to external organizations. Their close examination and practical application have to provide an answer to the following question *"Who will pay for the damages caused by a probable occurrence of a risk situation adverse outcome and what type of funding will be used?"*. Depending upon the source of funding attributed to this group could be plenty of methods [1, 2, 3 6, 8, 18, 19, 20]. Worldwide, most commonly used are the following:

- *Coverage for losses at the expense of current proceeds (Curentexpensing)* – the essence of this method lies in the fact that the losses caused by a risk situation occurrence are covered by the current financial flows (cashflow)of the firm, with no internal or external reserve funds to be set up. Employing such an approach is feasible when the magnitude of the losses is not that high and when the occurred risk situation did not affect or infringe upon the main manufacturing activity of the company and its course of trade.
- *Loss reserve coverage (Reserving)* – this method presupposes that the losses caused by the occurred risk events are covered at the expense of a risk fund set up in advance. Thus, the source of funding is kept internal and the firm itself decides upon the amount of the blocked funds (sum of money). In terms of the financial management, determining the amount of the risk fund is the most decisive issue. On the one hand, it has to be large enough to meet the concrete situation with the occurrence of a risk event. On the other hand, the "freezing" of large amounts of ready money or cash is likely to result in operating cash flow imbalancing and posing liquidity problems, thus, calling the solvency of the company into question.

Coverage for losses at the expense of a credit (Borrowing) – a great number of banks offer special credit products and when risk events occur they are capable of funding the coverage of losses. However, such credits are granted only if the firm is within the normal financial "leverage" values and its credit indebtedness is within permissible limits. If the extent of losses is high and the requested loan increases the credit indebtedness of the firm beyond the permissible limits (resulting in over-indebtedness), this method shouldn't be employed. In some literary sources or publications this approach is examined together with the study of the bank credit risks [2, 4, 11, 14,].

- *Insurance coverage for losses `(Ìnsurance)* –it is one of the most commonly used methods in the last decade and it is also the most popular method of external funding source. Nowadays, there are no other types of business activities, with such a direct and radical or "large-scale" effect upon their customers or users as the insurance business. It is employed with regard to the human life, with regard to one's home, business, movable and immovable property. Contemporary insurance and reinsurance companies are dynamic and innovative, offering protection against a great number of risks. The essence of this method resides within the transfer of responsibility for recovery of the potential losses to an external subject (specialized insurance and reinsurance company). The application of insurance brings about reduction or complete exclusion of the involvement of the firm in covering the losses caused by a risk event occurrence. Insurance is appropriate to all types of risks, regardless of their uniformity and large-scaleness. A lot of authors consider this method to be compulsory and recommend it in two cases: 1) with high probability of catastrophic risk occurrence and 2) with non-uniform yet mass risk soccurring on a large-scale with high

magnitude of the expected losses, when the firm is no longer capable of covering or paying for them from internal sources[11, 13, 16]. A lot of European countries apply special laws to determine these risks subject to obligatory insurance.

- *Coverage for losses at the expense of self-insurance (Self-insurance)* – this method is particular private or individual case to the previous one. It should be pointed out, that in the scientific literature or publications there is no unambiguously clear or uniform understanding as to the essence and the functions of the self-insurance. To support this claim we would like to bring forward two definitions:

(1) *"a method of risk self-insurance,* using internal sources of the firm – reserve or other funds owned by the firm" [3, p.67];

(2) *"a kind of insurance,* realized within the firm itself, if it is a financial-industrial group or industrial group with its insurance subsidiary company"[4, p.29]

It should be pointed out that in the Bulgarian commercial law the concept of *"financial-industrial group"* hasn't been introduced, and also the fact that the insurance business undertaking (activity) in our country is subject to stringent licensing requirements, strictly regulated by the state, meaning that not every firm is eligible to be granted permission to take up, in addition, the insurance line of business. To this effect the application of this method in our country needs further legal regulation. The analysis of the international best practices in the field of self-insurance allows for some concrete conclusions and findings to be drawn up:

- Cash is reinvested within the firm itself, improving its financial stability [3, p. 68];
- The company's line of business is diversified and its portfolio is extended, making it possible for the profits or gains from the insurance activity to be within the firm and thus, increase its financial strength [3, p.69];
- Avoided are the beaurocratic procedures associated with the conclusion of insurance contracts [4, pp.30-31];
- The firm gets tax reductions (relief), subject to law regulations and conditioned by the different types of insurance products.
- *Coverage for losses at the expense of state or municipal Anti-crisis programs (Budget suport)* – this method ensures further reduction of the involvement of the firm in the recovery of the losses and is entirely or partially transferred to the state or municipality. This method is appropriate under specific conditions and in certain cases stipulated by the state for covering:
- *Specific risks associated with major societal implications* –operational and industrial accidents and incidents, national and regional national disasters, risks associated with national and regional based infrastructure development projects and others;
- *Social risks,* are of great significance for the society and for which the state has taken the responsibility for covering the losses.

5. Conclusion

Risk management methods can be classified under different criteria. Every analyzed method has both advantages and disadvantages, requiring for a thorough examination to be considered prior to their application. The highest efficiency is obtained with an appropriate combination of two or more methods.

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