



**UNIVERSITY OF PETROSANI
DOCTORAL SCHOOL
THESIS**

**PROTECTION, SAFETY AND SECURITY OF COMPLEX
OBJECTIVES IN THE ENERGY-EXTRACTIVE FIELD IN
ROMANIA**

**PROTECȚIA, SIGURANȚA ȘI SECURITATEA OBIECTIVELOR COMPLEXE
ÎN DOMENIUL ENERGO-EXTRACTIV DIN ROMÂNIA**

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2024

The work is a knowledge challenge in the field, it is useful for decision-makers and developers of development strategies, among researchers and developers of productive-economic, engineering and socio-technical solutions for sustainability, protection, safety and security.

• The conceptual framework for motivating the research through the doctoral thesis

- Complex energy-mining objectives include, for example, 1) electro-nuclear power plants, 2) underground uranium extraction/exploitation mines, 3) plants and institutes for the concentration and preparation of uranium nuclear fuel.
- In 2019 in an early manner and, further, concretely on May 24, 2022, between the Government of Romania (SN Nuclearelectrica) and the USA (NuScale Power) the world premiere construction agreement was signed in Romania, in Doicești-Dâmbovița a Small Modular Reactors, SMR.
- The future investment (the time horizon for commissioning is 2030) in addition to the internationally validated set of protection measures, will have to have designed and operationalized specific protection, safety and security measures.
- Through this Doctoral Thesis, based on own research, new, innovative solutions, original contributions with first-of-its-kind solutions for the protection, safety and security of complex industrial objectives SMR and uranium mines in Romania are brought to the decision-makers.
- Mainly, the holistic, integrated operation of the PSS and the use of the entire autochthonous nuclear cycle, starting from the extraction of uranium from the underground, its preparation-concentration, burning in atomic-nuclear reactors and storage of radioactive waste, are recommended.

In context, Safety, Safety and Security (PSS) deficits, taken together, refer to::

1) Lack of firmly assumed vision, 2) Lack of a real Energy Strategy, 3) Incoherence, unpredictability and legislative contradictions in the field, 4) Lack of concrete Plans and Programs for nuclear energy investments and maintenance, 5) Lack of Sources of domestic financing or the insufficient capitalization of foreign ones, 6) incomplete PSS, resorting to imports of uranium-type fuel despite the fact that Romania has deposits of this kind and experience in the exploitation, processing and use of domestic uranium.

At the same time, it manifests itself:

7) Stagnation/state of waiting and lack of offensive for collaborations, cooperations, attracting investors and investments in the big energy-mining targets in Romania, 8) General managerial and administrative capacity in decline in the field, 9) Physical and moral wear and tear of the System National Energy of production, transport, distribution, 10) Weak research for the identification of new deposits and energy resources, lack of distinct programs for investments, PSS adapted and completed specifically regarding complex energy-mining objectives.

The following were considered:

- Description of the existence of complex energy-mining objectives on a national and international level, and of the technical-technological issues, protection, safety and security in these infrastructures;
- Identification of the complexity of the future investment objective, a global first in Romania (Small Modular Reactors, SMR) in the researched area (Doicești-Dâmbovița);

- Description of possible critical situations, obstacles and non-conformities regarding SMR investment in the researched area;
- Examining the PSS and the multitude of constructive-functional variants (investment) in the scientifically examined area;
- Proposals for integrated, non-redundant PSS solutions, variants and alternatives that provide investment, technical, technological and regulatory feasibility in the area;
- Defining the perspective model for SMR investments in Romania and the EU.

The main objective of the doctoral thesis is the case study of SMR Doicești-Dâmbovița (a world premiere investment, which will be carried out in Romania) and some mining units (Tulgheș-Harghita and Grințieș-Neamț) from the perspective of the original, new approach to protection, the safety and security of these complex energy-mining objectives.

It is considered highlighting the modern technological character of the SRM objective and expanding the impact on the Romanian and European energy system from the perspective of the energy security of Romania and the EU, the environment, technological flexibility and sustainability, with the possibility of generalizing this on a global level type of industrial activity.

In Romania and globally, there are multiple nuclear protection, safety and security provisions, distinct and separate, which in various cases are inconsistent, excessive or non-comprehensive, which calls for their integrated, complex, united, articulated or combined approach for efficiency and relevance.

The protection, safety and security assessments are systematic and consist of checking whether the applicable requirements are fulfilled in all phases of the life cycle of the nuclear power plant.

The analytical quantitative study is carried out to demonstrate the safety of the nuclear power plant, the appropriate design situation and the overall performance.

Deterministic protection, safety and security analysis, probabilistic hazard assessment, is frequently used.

Consider the probability and consequences of various transitions, as well as possible accidents.

Knowing the impact of integrated nuclear protection, safety and security is the strategic object of the research.

The united, integrated, harmonized, articulated, combined vision of nuclear protection, safety and security, from mining to radioactive waste, contributes to alerting the decision-makers in real time, with celerity, using modern means of telecommunications and Artificial Intelligence to prevent, avoiding or reducing the negative effects of nuclear incidents/accidents in SMR and, in general, in the field.

The issue being complex, some modern mathematical and statistical methods were also used, as well as graphic representations (especially through block diagrams) of the events and processes investigated

The analysis of the activities of harmonizing the objectives of productive-economic organizational entities (complex energy-mining objectives) with the types of regulations related to protection, safety and security was used, advancing new proposals in the field, to which were

added the resources/types of problems of allocation of resources to increase protection, prevention, based on modeling and simulation.

The methodological approach was realized through diversified methods of data collection and analysis: on the ground, from official meetings with investors, decision-makers and operators from complex energy-mining objectives, focusing on the case study of protection, safety and security situations in the field of nuclear power plants and underground uranium mines, which provide the food for these units.

On this basis, own conceptions for the researched field, personal, original scientific contributions were developed.

Data analysis methods refer to interpolation, extrapolation, matrix arrangement of variables, SWOT and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) analysis, use of computers, the Internet and data scrolling software programs, block diagrams, the wide bibliography and the logical relations of formulation of the proposed new solutions.

This original approach is useful for the development through the world premiere investment in Romania of Small Modular Reactors, SMR; it is also useful for developers of updated National Energy Strategy, tactics, plans and programs in the field.

Chapter I has the title Complex systems of energy and mining resources in Romania, in the EU and internationally. Developments and trends.

Complex energy-mining objectives, their protection, safety and security are treated, considering the fact that these industrial infrastructures continue to play a decisive role in contemporary societal development and in the future.

Chapter 2 is entitled Technical, economic and legislative basis for the protection, safety and security of complex and dangerous nuclear and mining energy targets.

In its content, as a case study, the technical basis for the protection, safety and security of complex and dangerous nuclear energy and mining objectives is highlighted.

Considerations regarding Small Modular Reactors, SMRs, and the significance of neutral technology in the field are presented.

It is used to supplement the legislative basis for the protection, safety and security of complex nuclear energy and mining objectives in the researched field.

Chapter 3 is called Integrated Management for PSS in the nuclear energy complex objective with small modular reactors SMR in the Doicești-Dâmbovița area.

The location of the SMR Plant in the Doicești-Dâmbovița area and the influences on nuclear protection, safety and security are investigated.

In essence, the US modular nuclear power plants and the NuScale Power investment in Romania are presented, as well as the expected nuclear protection model.

Chapter 4 is entitled Protection, Safety and Security Requirements for SMRs and Uranium Mining Deposits.

In their own way, the problems and new protection solutions in these complex and dangerous fields are systematized.

The links between the nuclear operational space and that of decisions in the protection, safety and security of complex SMR-type systems are eloquently treated.

Chapter 5 is called Technical-economic and legal PSS Solutions of the SMR system. Results of applied research.

Mainly, the proposal for the integration of the PSS from the case study, the results obtained and the own recommendations regarding protection, safety and security in the SMR are presented.

Chapter 6 has the title Integrated protection, safety and security system settlements for SMR Doicești-Dâmbovița.

The comprehensive approach to protection, safety and security in complex energy-mining objectives is presented with reference to the new approach of PSS from the perspective of efficiency and comprehensiveness of the issue of protection of the examined system.

Chapter 7 is entitled Technical-economic evaluation of the proposed solutions, directions of developments in the field. It reports conclusively about the running of the data for the computerized evaluation of the proposed technical-economic solutions.

Mainly, clarifications and proposals are made about the architecture of risk and safety systems for SMR and for uranium mines (complex energy-mining targets).

In all situations, the requirement for information and involvement of the public in the Doicești - Dâmbovița area regarding SMR is felt.

Each of the 7 core Chapters ends with Preliminary Conclusions.

Chapter 8 is entitled Final conclusions, proposals and recommendations, highlighting own, original contributions and future research directions.

In essence, the original proposal advanced by the author is presented, based on PSS integration for complex energy-mining targets.

The theoretical and practical results in the doctoral thesis can be found in a total of 86 graphic representations (diagrams, drawings, figures, images), of which 50 are original, developed by the author, 1 mathematical relationship, 11 tables (out of a total of 14) with data and information new, original, released for the first time in the field, all entered under the scope of copyright reproduced in specific Indexes.

The doctoral work, in its structural essence, has 8 chapters, bibliography with 202 updated references from the country and abroad, also 24 personal bibliographic references.

The doctoral thesis presents preliminary conclusions related to the investigations according to the theme and the requirements of personal scientific contribution.

In the last chapter of the obtained results, there are 14 final conclusions, 20 proposals and recommendations, respectively 21 own, original scientific contributions.

A number of 3 main directions of research in the field will be added to them in the future.