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PHD THESIS

CONTRIBUTIONS CONCERNING THE MINIMIZATION OF INDUSTRIAL RISKS ASSOCIATED WITH GASODUCTS AND PIPELINE GEARS

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IMPORTANCE AND NECESSITY OF THE THEME

The importance of the theme

The importance and topicality of the theme addressed is given by:

- the occurrence of cases of energy collapse with devastating effects on the industrial and economic security (total or partial fall of SNP or SNGN).
- the use of oil (oil / gasoline / ethane) or natural gas as a possible pressure instrument on poorly developed or developing countries.

Certain devices and equipment (SP / SRM / PM / SC, etc.) within critical energy infrastructures (oil and gas pipelines) may be targeted for terrorist attacks (bomb attack / cyber attack). These devices and equipment may be subject to natural disasters or technogenic risks (not properly dimensioning the thickness of the pipelines or pipelines). Failure to provide consumers with oil (oil / gasoline / ethane) or natural gas leads to a national crisis.

This triggers the state of imbalance and the safety of the citizen, since almost all sectors of the national economy depend on oil, natural gas and electricity. In this context, SNP and SNGN become strategic objectives of national importance, being generators of critical national and European infrastructures.

In the context of increasing energy security, energy stability factors must be created by:

- ensuring the necessary primary resources (oil, natural gas, coal, uranium, electricity, etc.) and limiting the dependence on import.
- diversification of primary sources of imported resources; increasing the level of security and safety of national oil and gas transportation networks.
- the protection of the critical infrastructure regarding the physical integrity of the oil and gas pipelines.
- securing jobs and workers by avoiding and / or stopping accidents / technical incidents that can lead to disruption of the energy system.

Romania's energy security is jeopardized by:

- *vulnerabilities* (natural and anthropic hazards).
- *threats* (terrorism, political instability, armed conflict and piracy).
- *hazards* (non-supply of raw materials, use of oil and GN as a pressure instrument) may affect the safety and security of SNP and SNGN.

It is urgently needed that SNP and SNGN be rigorously subjected to:

- sectoral risk assessments - oil and natural gas transport.
- technogenic risk evaluations.

It identifies, combats and eliminates the vulnerabilities, dangers and threats that can generate uncertainty and insecurity of the two important systems of the national economy.

Need for the theme

The need to identify vulnerabilities and technogenic risks on oil and gas pipelines (national and European critical infrastructures within SNP and SNGN) results from the following considerations:

- SNP and SNGN are of national strategic importance, the evaluation and monitoring of sectoral risks - transport of oil and natural gas from the identification of vulnerabilities.
- sectorial risk assessment also comes from the European perspective, Romania being interconnected to the natural gas energy system of the U.E. - ENTSO-G.
- by knowing the vulnerabilities, one can automatically identify the dangers and threats to which SNP and SNGN are subjected and engaged.
- national / European measures or strategies for the protection and security of national / European critical infrastructures can be created.
- some developed risk scenarios have a high level of risk with devastating effects on industrial and economic security.

- MPI, MR and MSSM must form an integrated security system, coherent, transparent and convergent towards the objective: SECURITY.
- it is considered that the critical infrastructure - oil / gas pipeline, is the common place where the national security and the civil side meet.
- the duty of each specialist (national / civil security) is to find methods and means of securing oil and gas pipelines, offering security to Romania, the U.E. and NATO.
- access to oil and natural gas which is created by these critical infrastructures (oil / gas pipelines) is a common right of every citizen.
- the responsibility to find together technical and security solutions in time of peace but also in times of crisis or war.
- the vulnerability of energy security must be prevented, combated and eliminated through major investments in energy infrastructure (oil pipelines, gas pipelines).
- specialized personnel in critical infrastructure security and SNP and SNGN security.
- the problem regarding the security of the devices and equipment within the critical energy infrastructures must be addressed by:
  - the perspective of the essential safety requirements that designers and manufacturers of energy appliances and equipment must consider.
  - human-infrastructure interaction.
- the risks, dangers and threats generated by the workers through the energy devices and equipment within the critical infrastructures constitute a particular area of the risks through:
  - the dangers and occupational threats to which they may be exposed. They cannot be dissociated and treated separately, and they must benefit from a systemic and integrated approach.
  - the complex set of conditioning and interdependencies specific to modern work systems is taken into account.
  - the importance and the opportunity of the scientific research dedicated to the evaluation of the sectoral risks - transport of oil and natural gas.
  - development of evaluation methods dedicated to minimizing technogenic and occupational risks that can be used by all entities involved.

OBJECTIVES AND STRUCTURE OF THE DOCTORAL THESIS

Objectives. General objectives

The main objective of the doctoral research is to define a methodological approach, as well as the specific application tools that allow:

- identification, designation, analysis, evaluation.
- protection and security of national and European critical energy infrastructures (oil/ gas pipelines).
- structuring the global and specific security requirements when operating these critical infrastructures.

The target result consists of:

- developing and integrating tools applicable by experts or specialists on security issues.
- operating personnel from SP / SRM / PM / SC, etc. who works and operates critical infrastructure.
- preventing and minimizing sectoral and technological risks, combating and eliminating vulnerabilities, dangers and threats.

Specific objectives

- carrying out a study regarding the evolution, the principles of prevention and minimization of the technogenic risks.
- combating and eliminating vulnerabilities, dangers and threats.

- legislative framework regarding the protection and security of critical energy infrastructures and workers.
- synthesizing the typology and security features of critical energy infrastructures.
- structural analysis of the risk assessment process for critical energy infrastructures.
- multifactorial analysis of the statistics of technical incidents, technical failures and accidents at work in the operation of critical energy infrastructures.

STRUCTURE OF THE DOCTORAL THESIS

I have structured the thesis on **7** chapters and includes **168** pages, **47** pages corresponding to **2** annexes, **42** figures, **77** tables and **129** bibliographic references.

The first part of the doctoral thesis is consecrated to the current stage regarding the importance of oil and gas pipeline engineering in the context of industrial security. The second part of the doctoral thesis reflects the contributions regarding the identification, evaluation and minimization of the industrial risks associated with the pipelines and gas pipelines within the energy system.

In Chapter 1 I presented the analysis and study of the conceptual framework of oil and gas pipelines as national and European critical infrastructures within SNP and SNGN.
I synthetically presented:

- relevant aspects aimed at analyzing the legislative and structural framework in the field of national and European critical infrastructures and industrial sectors.
- generalities regarding the functioning of the SNP and SNGN, as systems generating critical infrastructures, in order to ensure the energy security.

The results of the analysis carried out for the evaluation of the risks regarding the vulnerabilities and the technogenic risks of the oil and gas pipelines, are the basis of the necessity of the theme of this doctoral thesis.

In **Chapter 2** I presented the technical-engineering analysis on the main generalities and characteristics regarding the oil and gas pipelines.

The chapter I discussed:

- aspects of security, monitoring, diagnostics and maintenance of critical energy infrastructures.
- environmental risk (pollution) regarding the possibility of soil contamination with petroleum products.

In **Chapter 3** I described the technological analysis regarding the main generalities for the protection of oil and gas pipelines, an important detail in the security and protection of these critical infrastructures.

In this chapter, I have also detailed the problems of route and launch of the pipes and the delimitation of the areas of protection and security.

In **Chapter 4** I presented the seismic and anti-seismic engineering, anti-seismic protection systems and solutions for reducing the seismic risk level of oil and gas pipelines.

At the end of the chapter I analyzed the seismic risk level of the oil and gas pipelines.

In **Chapter 5** I described the evaluation of the risks associated with the critical infrastructures and the integration of the sectoral risk analyzes - Transport Petroleum and GN (the 4 risk scenarios).

In this chapter I have presented also the level of technogenic risk - wall thickness (*Oil pipeline Ø10, Natural gas pipeline Ø12).*
At the base of the identification of vulnerabilities and the need to improve the safety and security of SNP and SNGN by implementing technical - organizational solutions, the following are:

- the results obtained from the assessment of the level of technological risk associated with the critical infrastructures.
- integration of sectoral risk analyzes - Oil and Natural Gas Transport.
- evaluation of the technogenic risks (wall thickness).

In **Chapter 6** I presented the solutions the technical-organizational solutions regarding the assessment of the risks associated with the critical infrastructures - Petroleum Transport and Natural Gas and the assessment of the technogenic risks - the wall thickness.

The technical-organizational solutions, proposed by the author, of the risk assessment through SNPICE - oil and gas pipelines, underpin the safety and security of SEN (SNP and SNGN).

In **Chapter 7** I described the conclusions, the original contributions, the limits of the study and the future directions of development present in the doctoral thesis.

The conclusions, the original contributions, the limits of the study and the directions of future development, highlight the need and applicability of the present doctoral thesis in the energy industrial environment.

Within this chapter I presented the main aspects of the study and analysis of concepts, phenomena, methods, applications and results obtained.

By presenting personal contributions on the 2 components, theoretical contributions and applicative contributions, special attention was paid to the way of their implementation and capitalization.

I identified the main research directions, through which efforts to prevent, reduce, combat, stop, eliminate risks and vulnerabilities must be targeted in the future.

I identified the protection and security of critical infrastructures, as well as the safety and health of the workers who operate the critical infrastructures have been identified.

In **ANNEX 1** - Example of oil pipeline (Ø10) and **ANNEX 2** – Example of gas pipeline (Ø12), I developed the research methodology and risk assessment regarding the oil pipeline and the natural gas pipeline.

The novelty of these doctoral theses consists of:

- principles and assumptions in the field of protection and security of critical energy infrastructures (oil / gas pipelines).
- environmental risk management.
- analysis of the risks associated with the critical infrastructures analyzed and evaluated.

The degree of complexity of the thesis gives it an interdisciplinary and multidisciplinary character by:

- the nature of the critical energy infrastructures addressed.
- the importance of the legislative and regulatory context.
- the information explosion.
- the evolution of scientific research in the field of security, for:
    - conceptualization of the system and theoretical foundation of the models used.
    - elaboration of the methodology for the assessment of the technogenic risks.

CONCLUSIONS, ORIGINAL CONTRIBUTIONS, LIMITS OF THE STUDY AND FUTURE RESEARCH DIRECTIONS

Conclusions

The systems for the transportation of petroleum products and GN in Romania are different, being executed in a large period of time, with the help of the technologies and the material existing at the time of making each section or pipeline network.

The time from the commissioning of the networks and the operating conditions differ, causing different degrees of wear.

The main security risk of pipeline systems for the transport of petroleum products and GN consists of the failure of a pipe due to the decrease of the wall thickness, and below the minimum value allowed , the sealing is lost and it causes the fluid transported to be released outside the pipeline (oil / GN).

Although the pipeline transport is considered the safest method of long-distance transport, the data collected from the various faults produced, have raised the level of risk associated with their exploitation corresponding to the operation of a refinery. Preventing pipeline failure creates an advantage in reducing these risks.

In addition to economic losses, oil and gas leaks from pipelines can cause major incidents by initiating explosions.

The operation of the transport pipes with a minimum degree of risk implies the permanent monitoring of the possible leakage of fluids.

The gases from the defects of the transport pipes, which reach the surface of the soil, are the basis of the possible incidents that may occur.

Therefore it is important to know both gas flows dropped and geometric configuration of the affected area.

The doctoral thesis intended to minimizing the industrial risks associated with the oil pipelines and gas pipelines by reducing and eliminating the main factors that cause high severity events regarding the functioning in the parameters of the pipelines.

Monitoring of all specific intrinsic and operating parameters of the pipelines and pipelines can be technically detected and diagnosed by:

- existing defects;
- through rapid and efficient intervention to eliminate the damages, if they occurred.

The technical diagnosis is made through non-destructive MPM based on sounds, noise, vibration and acoustic emission in (electro) magnetic field, with the help of special means.

In order to establish the maintenance programs that can ensure the proper functioning of the oi land gas pipelines, it is necessary to establish their technical status.

Preventive and predictive maintenance systems that significantly reduce the risk of breakdowns can be applied after finding out the technical status of the oil pipelines and / or gas pipelines. These two maintenance systems are less expensive compared to corrective maintenance.

The establishment of the maintenance plan for the oil pipelines and / or gas pipelines is done as follows:

- identification of the state limit for intervention;
- the probability of reaching the limit state;
- the volume of fluid (gas or oil) that can be released following an incident;
- the number of population in the incident area.

The reliability of a technical / technological system is determined by all the factors involved in its implementation:

- concept;
- implementation;
- system processing.

The preparation and maintenance of a high level of reliability of the technical / technological system involves the analysis of the material factors or human factors and the corresponding actions on them.

The security of the functioning of the technical / technological systems, in this case the oil and / or gas pipelines, represents a basic component of the processing requirements, through the four specific elements:

- security;
- availability;
- reliability;
- maintenance.

Mechanical technical security criteria ensure with high levels of reliability and technical security.

The risk assessment is used to determine the identification of the maximum risk areas.

Following the statistical analysis of the data regarding the damage of the oil pipelines and

/ or gas pipelines under pressure, the following conclusions are drawn:

- the major risk of failure corresponds to the welded areas.
- over 50% of all the damages of the oil pipelines and / or the gas pipelines under pressure are due to the deviations from the rules of the prescribed operating conditions.
- risk of fatigue and / or corrosion damage to oil and / or gas pipelines.

The pipelines of the transport networks are protected against corrosion by measures to prevent corrosion processes, by passive protection and by electrical active protection.

Passive protection is achieved by applying an anti-corrosive coating on the pipe surface.

The electrical active protection of the pipes against corrosion under the action of dispersion currents (tramps) is achieved by:

- increasing the electrical resistance of passage between the pipes and the ground using a protective layer with high resistivity.
- insulating flanges at the entrance of thermal networks to consumers.
- directly polarized or intensified drainage, as well as by applying cathodic source protection.

In the most recent study on losses caused by natural and man-made disasters, earthquakes are in the first place.

Seismicity is represented by the Vrancea area, the Banat, Crisana, Maramures areas, etc., where crustal earthquakes of lower intensity and frequencies occur.

Sustainable development is that we humans must be aware of the natural hazards, that can be dangerous and harmful to society in some cases.

Natural hazard cannot be cheated, but without hesitating to approach the appropriate practices, the society can certainly reduce its consequences.

In his book *Natural Issues*, Seneca the well known philosopher makes specifics related to earthquakes, noting that:

- ✓ no danger is without a cure that we cannot avoid;
- ✓ lightning never destroyed entire nations;
- ✓ plague depopulates cities but does not destroy them;
- ✓ earthquake catastrophe is the most widespread, inevitable, unfulfilled, the most general of all the dangers.

Following the evaluation of the critical energy infrastructures (oil and gas pipelines) within SNTP and SNTGN, I built the following risk scenarios:

- for Risk Scenario 1 I found the following:
  - to establish the probability of producing the event, I adopted class 3 (average).
  - for the gravity of the consequences I adopted level 5 (very high).
  - the calculated risk has the value 15 (high risk).
  - after the risk reduction measures were applied,irecalculated the severity of the consequences and adopted level 2 (low).
  - the recalculated risk has the value 6 (low risk).
- for Risk Scenario 2 I found the following:
  - in order to determine the probability of the event occurring, I adopted class 2 (low).
  - for the gravity of the consequences I adopted level 5 (very high).
  - the calculated risk has the value 10 (average risk).
  - after the risk reduction measures were applied, I recalculated the severity of the consequences and adopted level 3 (average).
  - the recalculated risk has the value 6 (low risk).
- for Risk Scenario 3 I found the following:
  - to establish the probability of producing the event, I adopted class 3 (average).
  - for the gravity of the consequences I adopted level 5 (very high).
  - the calculated risk has the value 15 (high risk).
  - after the risk reduction measures were applied,irecalculated the severity of the consequences and adopted level 2 (low).

- the recalculated risk has the value 6 (low risk).

- for Risk Scenario 4 I found the following:
  - to determine the probability of the event occurring,iadopted class 2 (low).
  - for the gravity of the consequences I adopted level 5 (very high).
  - the calculated risk has the value 10 (average risk).
  - after the risk reduction measures were applied,irecalculated the severity of the consequences and adopted level 3 (average).
  - the recalculated risk has the value 6 (low risk).

For the prevention and reduction of sectoral risks - Transport Petroleum and GN, I have formulated proposals for reduction measures which are developed extensively in the Original Contributions section, for:

- risk scenario 1;
- risk scenario 2;
- risk scenario 3;
- risk scenario 4.

Following the assessment of the technogenic risk level of the oil pipeline (Ø 10) I found the following:

- to determine the probability of the event occurring, I adopted class 4 (high).
- for the gravity of the consequences I adopted level 5 (very high).
- the calculated risk has the value 20 (very high technogenic risk level).
- after the risk reduction measures were applied, I recalculated the severity of the consequences and adopted level 3 (average).
- the recalculated risk has the value 12 (average technogenic risk level).

Following the assessment of the technogenic risk level of the GN pipeline (Ø 12) I found the following:

- to determine the probability of the event occurring,iadopted class 4 (high).
- for the gravity of the consequences I adopted level 5 (very high).
- the calculated risk has the value 20 (very high technogenic risk level).
- after the risk reduction measures were applied,irecalculated the severity of the consequences and adopted level 3 (average).
- the recalculated risk has the value 12 (average technogenic risk level).

ORIGINAL CONTRIBUTIONS

In this PhD thesis I conducted the case study on the assessment of the technogenic risk level of the oil pipeline (Ø10) and the GN pipeline (Ø12).

We calculated the level of risk of failure (%) according to the wall thickness and the level of risk of failure (%) according to the maximum operating pressure, for S_{nec} MIN and S_{nec} MAX, after the circumferential and longitudinal direction, at 3 control pits of each pipeline. I evaluated the technogenic risk level for the pipeline and pipeline by establishing the probability and severity, the vulnerability and impact analysis, the calculation of the severity of the consequences and the level of the technogenic risk, the risk treatment.

I evaluated the technogenic risk level for the oil and GN pipeline by establishing the probability and severity, the vulnerability and impact analysis, the calculation of the severity of the consequences and the level of the technogenic risk, the risk treatment.

By recalculating the severity of the consequences and the level of risk after applying the reduction measures, I have obtained the reduction of the risk of producing the scenario chosen for both the oil and gas pipeline.

I presented technical and organizational solutions regarding the safety and security of the

National Petroleum System through the proposed measures of new energy infrastructure constructions, namely: refineries, automated crude oil import stations, automated crude oil stations, crude oil pipelines, gas stations, pipelines for the transport of gasoline and liquid ethane transportation pipelines.

I described the real maps of SNTP - oil / gasoline / liquid ethane and SNTGN - natural gas, and based on them and following the proposals of technical solutions (construction of new infrastructures) regarding the elimination of vulnerabilities, these maps have undergone modifications.

As a result of the proposed technical solutions to combat and eliminate vulnerabilities, I have developed a National Strategy for Critical Energy Infrastructure Protection 2020 - 2035, which consists of proposals for technical solutions regarding the prevention, control and elimination of vulnerabilities (new constructions of energy infrastructures), the importance work and deadline.

The theoretical foundations, methodological and applicative tools that I developed during the doctoral period are summarized below.

These original research contributions are aimed at increasing the level of safety and security of oil and gas pipelines within SNT and SNGN.

The personal contributions in the mentioned field include both theoretical and practical aspects.

Theoretical contributions

I made an analysis taking into account the identification, evaluation and minimization of the industrial risks related to the oil and gas pipelines, through the 4 risk scenarios regarding the natural calamity and the technical failures.

In the thesis I presented (for both oil and gas pipelines) the DCVG method of investigating the insulation defects from the soil surface, non-destructive examinations, assessment of the technical state by the technical sizes of the pipe section, description and presentation of the behavior of the tubular material regarding the modification of thicknesses of the wall.

I have highlighted the factors that influence the integrity of the oil and gas pipelines, namely the insulation defects, the addition of corrosion, the weight of the defect and the possible period of extension depending on the remaining corrosion addition.

Theoretical studies and the quantifications resulting from them, can become useful tools for the implementation of technical solutions for the prevention, control and elimination of vulnerabilities (new constructions of energy infrastructures).

Practical and applicative contributions

Due to the lack of energy infrastructures, I proposed measures of new constructions of energy infrastructures, through:

- drawing up maps, namely:
  - Real SNT map - oil, gasoline and liquid ethane.
  - SNT map (crude oil) following the proposals of technical solutions (construction of new infrastructures), regarding the elimination of vulnerabilities.
  - SNT map (gasoline / liquid ethane) following the proposals of technical solutions (construction of new infrastructures), regarding the elimination of vulnerabilities.
  - The real map of SNTGN.
  - SNTGN map following the proposals of technical solutions (construction of new infrastructures), regarding the elimination of vulnerabilities.
- carrying out the analysis of the sectoral risks - Transport Petroleum and Natural Gas, through
  - Analysis of sectoral risks - Transport of Oil and Natural Gas.
  - Identification of Risk Scenario 1: Oil Pipeline Technical Damage.

- Identification of Risk Scenario 2: Oil Pipeline Natural Disaster.
- Identification of Risk Scenario 3: Gas Pipeline Technical Damage.
- Identification of Risk Scenario 4: Gas Pipeline Natural Disaster.
- Assessment of Risk Scenario 1: Oil Pipeline Technical Damage.
- Assessment of Risk Scenario 2: Oil Pipeline Natural Disaster.
- Assessment of Risk Scenario 3: Gas Pipeline Technical Damage.
- Assessment of Risk Scenario 4: Gas Pipeline Natural Disaster.
- Interpretation of Risk Scenario 1: Oil Pipeline Technical Damage.
- Interpretation of Risk Scenario 2: Natural Disaster Oil Pipeline.
- Interpretation of Risk Scenario 3: Technical Damage Gas pipeline.
- Interpretation of Risk Scenario 4: Natural Disaster Gas pipeline.

➢ Technical NR analysis, technical state assessments on the oil pipeline (Ø10) and the natural gas pipeline (Ø12).

The assessment of the technogenic risk level for the oil pipeline (Ø10) was obtained by:

- NR transfer values → S_{nec} MIN, S_{nec} MAX, Pmop → 3 GC → oil pipeline (Ø10).
- Technogenic risk level assessment for the oil pipeline (Ø10):

✓ Establishing probability.

✓ Determining the severity of the consequences of the proposed scenario:

- Vulnerability analysis.
- Impact analysis.

✓ Calculation of the level of technogenic risk.

✓ Risk management.

✓ Recalculation of severity of consequences.

The assessment of the technogenic risk level for the gas pipeline (Ø12) was obtained by:

- Transfer NR values → S_{nec} MIN, S_{nec} MAX, Pmop → 3 GC → pipeline (GN Ø12 transport pipeline).
- Technogenic risk level assessment for the pipeline (GN Ø12 transport pipeline):

✓ Establishing probability.

✓ Determining the severity of the consequences of the proposed scenario:

- Vulnerability analysis.
- Impact analysis

✓ Calculation of the level of technogenic risk.

✓ Risk management.

✓ Recalculation of severity of consequences.

I have developed technical and organizational solutions regarding the safety and security of the National Energy System in order to increase the energy security, namely:

- solutions for combating and eliminating vulnerabilities within the National Petroleum Transport System.
- solutions for combating and eliminating vulnerabilities within the National Natural Gas Transport System.

I have proposed a National Strategy for Critical Energy Infrastructure Protection - Pipelines and Pipelines 2020 - 2035.

Limits of the study

The main limits of the research we presented during the doctoral thesis are the following:

➢ approach.

➢ identification.

➢ evaluation.

➢ interpretation of the sectoral risks Oil and Natural Gas Transport.

➢ assessment and interpretation of technological risks (technical assessments on the thickness of the walls of the oil and gas pipelines).

I have synthesized these limits of research by:

- Relevant approach of the theme proposed in the thesis, in order to identify the vulnerabilities of the critical energy infrastructures within SNP and SNTGN.
- Applicability by experts and specialists on energy security issues (oil / natural gas).
- The response to their needs and competences requires the documentary study to focus first on the provisions of the legislation in force.
- The bibliography includes national / international references, the synthesis realized in Part I focusing on normative documents, through the development and consistency of the studies.
- The topic addressed is of great importance and topicality, because:
    - Occurrence of cases of energy collapse with devastating effects on industrial and economic security and use of oil or GN.
    - Using them as a pressure tool on the underdeveloped or developing countries.
    - Knowing that certain devices and equipment within critical energy infrastructures (oil / gas pipelines) may be targeted for terrorist attacks (bomb attack / cyber attack).
    - Or they may be subjected to natural calamities or technogenic risks (not properly dimensioning the thickness of the oil or gas pipelines).
    - The perspective necessary to deepen the researches through detailed quantitative analyzes to refine the results achieved in the present doctoral thesis.
- Failure to provide oil or GN to consumers will automatically trigger a national crisis.
- Almost all sectors of the national economy depend on oil, GN and electricity, which can be produced by these components.
- The crisis triggers the state of imbalance and the safety of the citizen is endangered.
- SNP, through SNTP and SNGN, through SNTGN, become strategic objectives of national importance as they generate national / European critical infrastructures.
- In the context of increasing energy security, energy stability factors must be created by:
    - providing the necessary primary resources (oil, natural gas, coal, uranium, electricity, etc.).
    - limiting dependence on import.
    - diversification of primary sources of imported resources.
    - increasing the level of safety and security of the national oil and gas (oil / gas / ethane) and natural gas networks.
    - the protection of the critical infrastructure regarding the physical integrity of the oil and gas pipelines.
    - securing jobs and workers by avoiding and / or stopping accidents / technical incidents that can lead to disruption of the energy system.
- It is imperative that SNP and SNGN be subjected to sectoral risk assessments and technogenic risk assessments.
- It identifies, combats and eliminates the vulnerabilities, dangers and threats that generate insecurity and insecurity of the two important systems of the national economy.

Future research directions

As a result of deepening the knowledge and personal contributions brought, I propose the following main research directions to be channeled towards further research:

- the continuation of the studies addresses significant aspects of the *security culture* research to each owner and operator of critical infrastructures, deficient at national level.
- the culture of security and the empirical investigation of the relation between it and the safety performances of the work system, aims to identify the mediation factors. They can become the focal point of future interventions to improve the safety of the work system, through intervention efforts in a oriented and efficient manner.
- it is necessary to verify the way in which security experts, specialists and liaison officers implement and manage the protection and security of critical energy infrastructures.
- how they perceive the security culture within the owner and operator of critical energy

infrastructure for the purpose:

- prevention.
- combat.
- eliminating vulnerabilities.
- hazard.
- threat to oil and gas pipelines.