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# IDENTIFICATION OF SECURITY RISKS ASSOCIATED WITH CRITICAL INFRASTRUCTURES WITHIN THE NATIONAL POWER GRID, IN THE CONTEXT OF POWER SAFETY GROWTH

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**Abstract:** In the context of power safety growth, the National Power Grid must become a major objective of interest for the national electricity system and transmission operator. Developments in recent decades have shown the vulnerability of the National Power Grid caused by acts of terrorism, natural disaster, incidents and technical damage. For the critical analysis of the Electricity Transmission Network within the National Power Grid, the possible risk scenarios with instability effects on power and national safety must be identified, described and evaluated. The aim of the paper is to identify the possible risk scenarios of the National Power Grid in the context of the critical analysis.

**Keywords:** National Power Grid, critical infrastructures, identification of risk scenarios, power safety.

## 1. GENERALITIES OF THE NATIONAL POWER GRID – NPG

### a) The purpose of NPG

The purpose of NPG's existence is to ensure all safety, technical and economic requirements of consumer's supplying with electrical or thermal energy.

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In order to do that, NPG must meet the following requirements, according to figure 1:

- Safety (security) in consumer's supplying;
- The quality of electricity;
- Economicity;
- Environment, other factors. [1],[3],[7], [9]

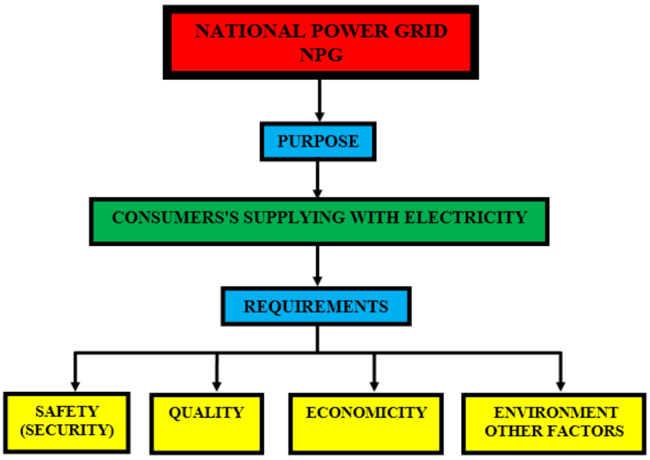


**Fig. 1.** The purpose and requirements of NPG

**b) NPG statutes**

NPG can be functionally found in one of the following status: according to figure 2, and transition from one status to another status, according to figure 3: [4], [10]

- Normal operation status – N;
- Exposed status (alarm) – E;
- Critical status – C;
- Damage status – D.

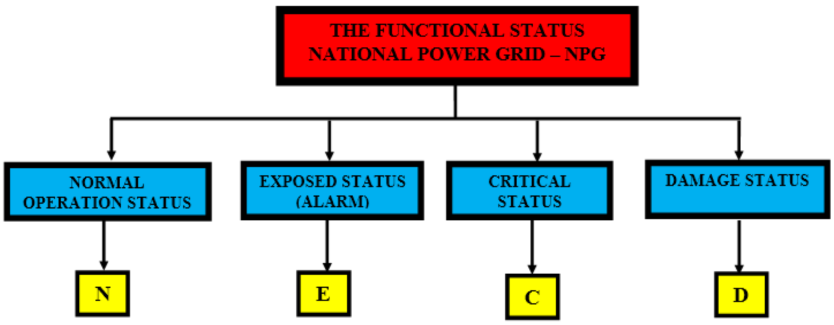


**Fig. 2.** Functional status of NPG
***N*** *– Normal operation status;* ***E*** *– Exposed status (alarm);*
***C*** *– Critical status;* ***D*** *– Damages status*

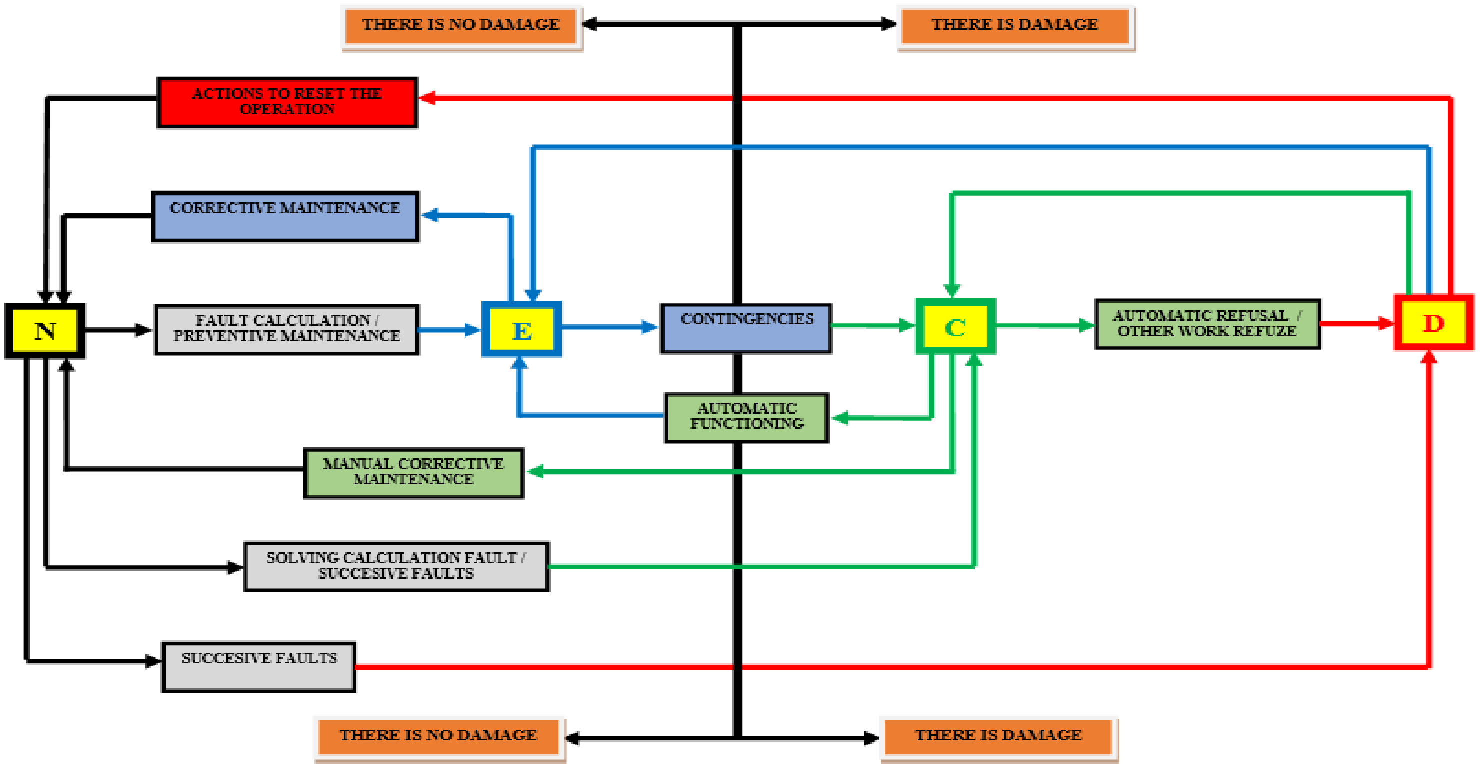


**Fig. 3.** NPG status and transition from one status to another status

Transition from one status to another status:

- from N (normal status) to E (exposed status) due to calculation defect or lack of preventive maintenance;
- from E (exposed status) to C (critical status) through different contingencies;
- from C (critical status) to D (damage status) by automatic refusal or other work refusals;
- from N (normal status) to C (critical status) by overcoming the calculation defect or defects in the cascade;
- from N (normal status) to D (damage status) due to cascade defects;
- from D (damage status) to N (normal status) through action to restore operation;
- from E (exposed status) to N (normal status) by corrective maintenance;
- from C (critical status) to E (exposed status) by automatic operation;
- from C (critical status) to N (normal status) through manual corrective actions. [2], [8], [11]

**c) NPG interconnection with neighboring power grid**

NPG interconnection is one of the main ways to increase its reliability and safety, without affecting power independence.

These interconnections provide emergency assistance without the need of installing and maintaining of a strong power reserve. [3], [12]

International interconnections of Romanian NPG, according to figure 4:

- Ukraine:
  - ➢ OHL 400 kV Rosiori – Mukacevo.
- Hungary:
  - ➢ OHL 400 kV Nadab – Bekescsaba;
  - ➢ OHL 400 kV Arad – Sandorfalva.
- Serbia:
  - ➢ OHL 400 kV Resita – Pancevo 2;
  - ➢ OHL 400 kV Portile de Fier 1 – Djerdap.
- Bulgaria:
  - ➢ OHL 400 kV Tantareni – Kosloduy;
  - ➢ OHL 400 kV Rahman – Dobrudja;
  - ➢ OHL 400 kV Stupina – Varna.
- Republic of Moldova:
  - ➢ OHL 400 kV Isaccea – Vulcanesti. [2]

**d) Criteria for participation in interconnected operation**

The recommendations of the ENTSO-E (**E**uropean **N**etworks of **T**ransmission **S**ystem **O**perators for **E**lectricity), which is the European transmission and electricity system of the European Union, concern 6 major aspects of the operation of an power system:

- Consumption coverage;
- Primary power adjustment;
- Secondary frequency – power adjustment;
- Voltage adjustment;
- Safety of operation at the criterion (N – 1) elements;
- Anti-damage measures.

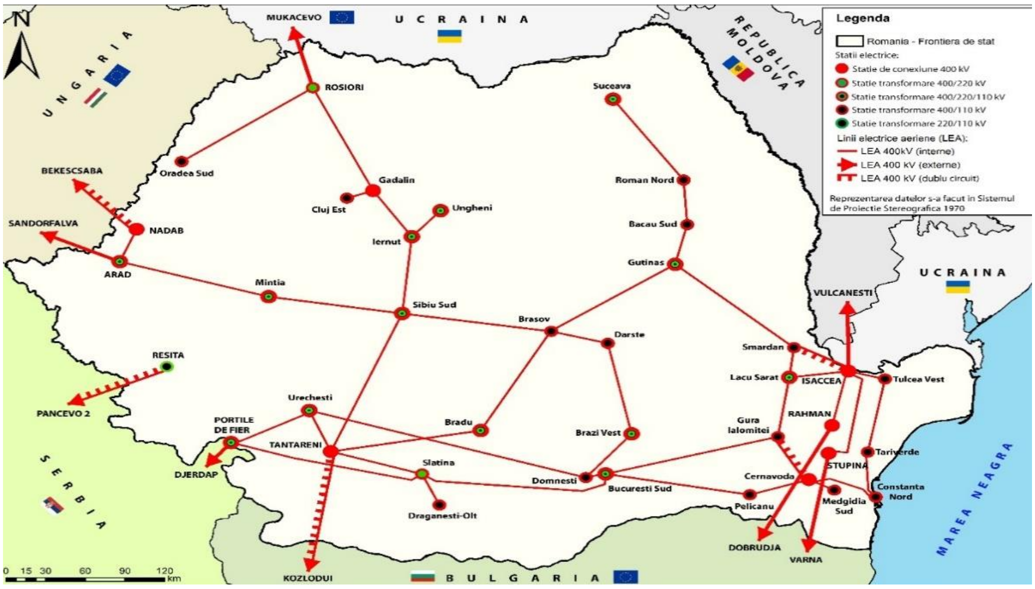


**Fig. 4.** Map of the Electricity Transmission Network at a voltage 400 kV and the interconnection with neighboring power grid

### e) Faults' typology (threats) in NPG operation

In NPG's, installations and power equipment running (power plants, power substations, over headlines) it may occur different faults' (threats) as follows, according to figure 5: [2] [3]

- Current malfunctions;
- Faults';
- Incidents:
  - isolated;
  - associated.
- Damage.

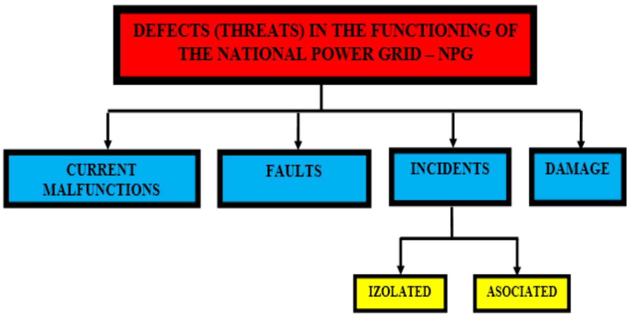


**Fig. 5.** Faults (threats) NPG's running

## 2. IDENTIFICATION AND DESCRIPTION OF SECURITY RISKS ON CRITICAL INFRASTRUCTURES WITHIN THE NATIONAL POWER GRID

For the critical analysis of the National Power Grid, four possible risk scenarios with effects of instability of the power safety and with major effects on the national security were identified:

- Risk scenario 1 – Technical Incident;
- Risk scenario 2 – Technical Damage;
- Risk scenario 3 – Natural Disaster;
- Risk scenario 4 – Terrorist Attack. [5] [6]

**a) Risk scenario 1 – Technical Incident: Power Substation 110 kV – 750 kV**

Sequential and causal development for the risk scenario 1 is shown in fig. 6 and the event description (TECHNICAL INCIDENT: Lightning → Explosion → Fire → Interruption in the supply of electricity consumer) in fig. 7.

**Comments regarding Risk Scenario 1:**

➢ **Causes:**

- the appearance of electric discharges;
- lack or incorrect operation of lightning protection installations;
- incorrect operation of the surge arresters;
- non-compliance with safety work and fire safety regulations;
- non-use of PPE-personal protective equipment;
- precarious condition of power equipment;
- lack of revisions to power equipment;
- use of non-compliant power subassemblies;
- lack of investments;
- non-modernization of the power substation;
- lack of specialized and/or trained maintenance personnel;
- lack of specialized and/or trained operational personnel;
- wrong maneuvers performed by the operational personnel of the power substation;

- non-communication or poor communication with TPD (Territorial Power Dispatcher) or NPD (National Power Dispatcher);
- lack/non-compliance/ignorance of national/European procedures in case of incident or serious damage.

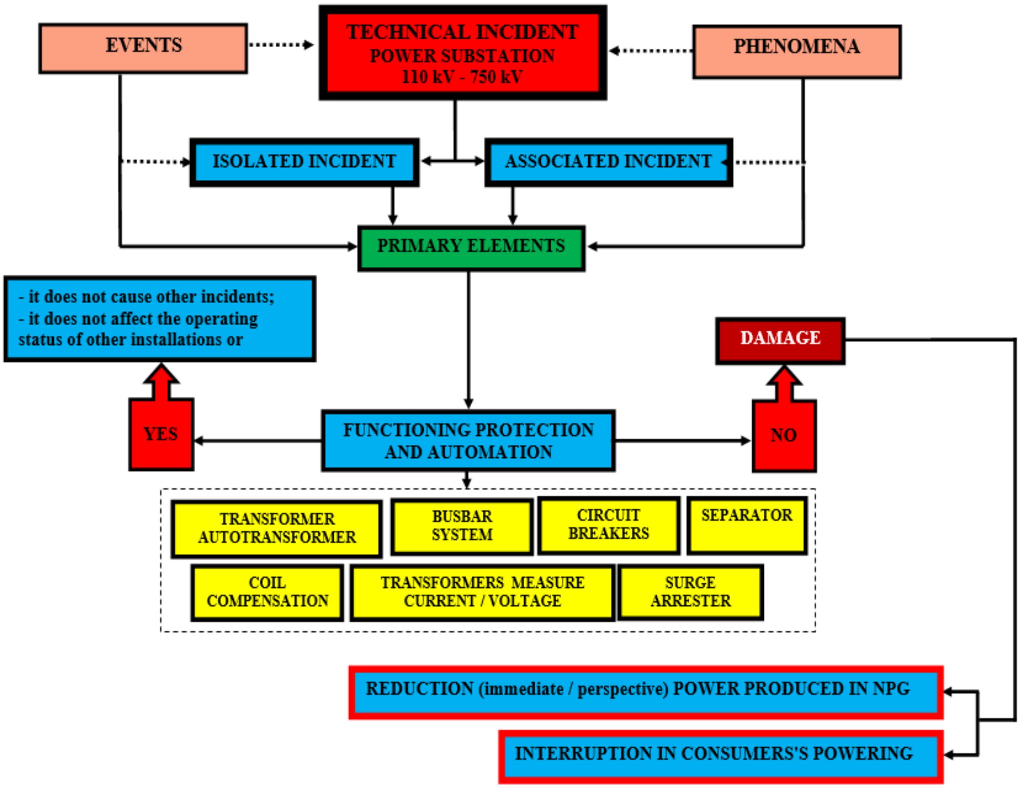


**Fig. 6.** Risk scenario 1 – Sequential and causal development

➢ **Effects:**

- work accidents (individual or collective) fatal or incapacitated for work, caused by the explosion that can generate fire;
- propagation of the explosion (fire) to other power equipment;
- propagation of the explosion (fire) to other external objectives (forests, houses, blocks, factories, etc.);
- untimely disconnection of the respective equipment;
- non-electricity supply to consumers;
- material damage caused by lack of electricity;
- major material damage resulting from the interdependence of other consumers.

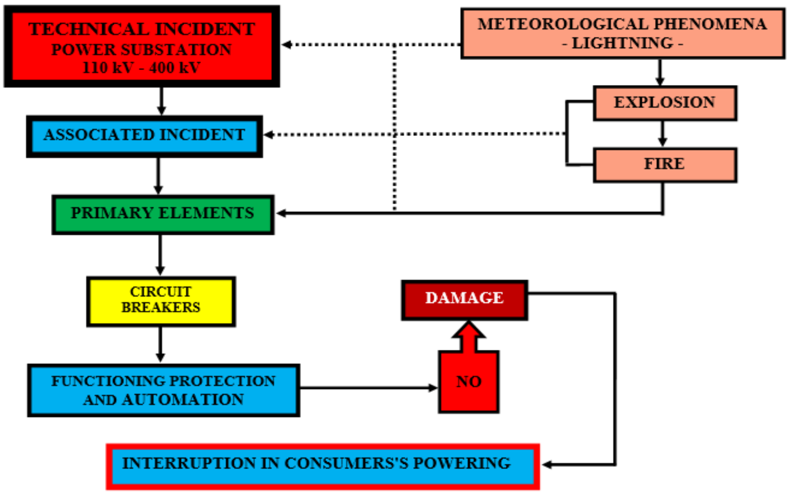


**Fig. 7.** Risk scenario 1 – Event description

### b) Risk scenario 2 – Technical Damage: Power Substation 110 kV – 750 kV

In fig. 8 we gave the sequential and causal development of phenomena diagram for the second risk scenario.

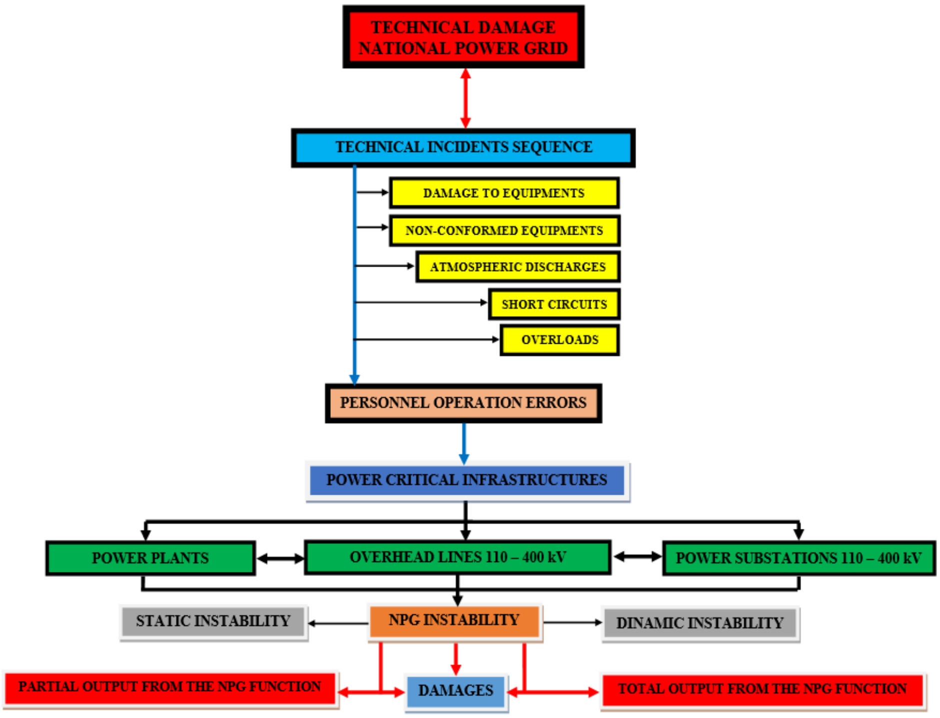


**Fig. 8.** Risk scenario 2 – Sequential and causal development

In this case, the event description (technical damage) consists in: Sequence of technical incidents + Operating personnel errors → NPG Instability → NPG Black/Brown Out → Damage (fig. 9).

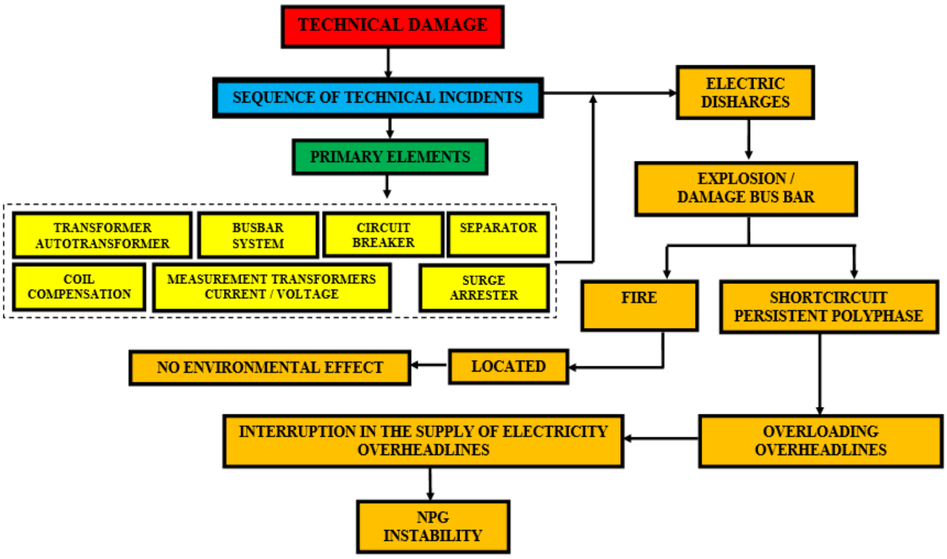


**Fig. 9.** Risk scenario 2 – Event description

**Comments regarding Risk Scenario 2:**

➢ **Causes:**

- the appearance of electric discharges;
- lack or incorrect operation of lightning protection installations;
- incorrect operation of the surge arresters;
- non-compliance with safety work and fire safety regulations;
- non-use of PPE-personal protective equipment;
- precarious condition of power equipment;
- lack of revisions to power equipment;
- use of non-compliant power subassemblies;
- lack of investments;
- non-modernization of the power substation;
- lack of specialized and/or trained maintenance personnel;
- lack of specialized and/or trained operational personnel;
- wrong maneuvers performed by the operational personnel of the power substation;
- non-communication or poor communication with TPD (Territorial Power Dispatcher) or NPD (National Power Dispatcher);
- lack/non-compliance/ignorance of national/european procedures in case of incident or serious damage.

- **Effects:**
  - work accidents (individual or collective) fatal or incapacitated for work, caused by the explosion that can generate fire;
  - propagation of the explosion (fire) to other power equipment;
  - propagation of the explosion (fire) to other external objectives (forests, houses, blocks, factories, etc.);
  - untimely disconnection of the respective equipment;
  - non-electricity supply to consumers;
  - material damage caused by lack of electricity;
  - major material damage resulting from the interdependence of other consumers.

**c) Risk scenario 3 – Natural Disaster: Power Substation 110 kV – 750 kV**

The sequential and causal development of phenomena and events (natural disaster: NPG Blackout → Power and national insecurity → Damage) diagrams for the risk scenario 3 are presented in fig. 10 and fig. 11.

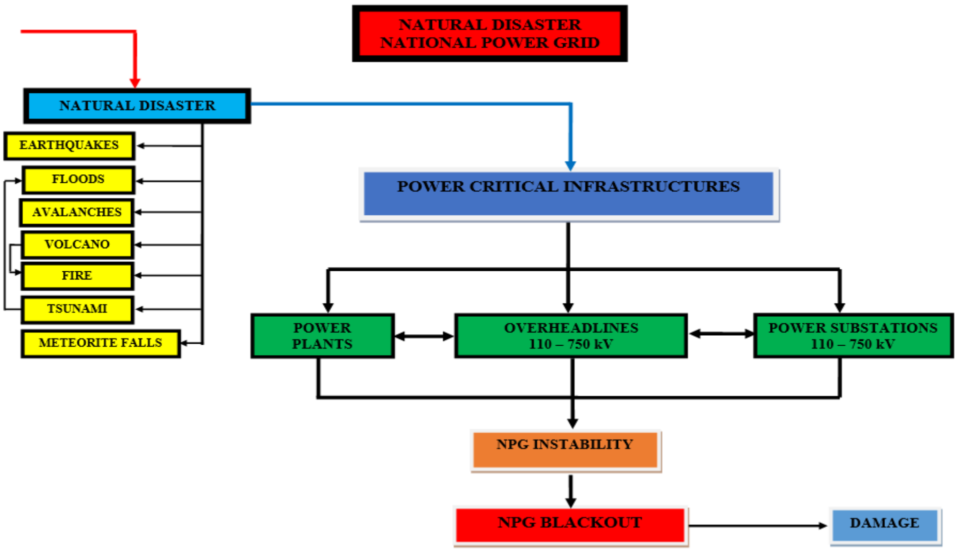


**Fig. 10.** Risk scenario 3 – Sequential and causal development

**Comments regarding Risk Scenario 3:**

- **Causes:**
  - earthquakes;
  - floods;
  - avalanches;
  - volcano;
  - tsunami;
  - meteorite falls;

- precarious/wrong design of power substation (from a seismic point of view);
- non-specialized operative/dispatching personnel during crisis;
- lack of work procedures in power substation during a crisis;
- lack/non-compliance/ignorance of national/european procedures in case of natural disaster.

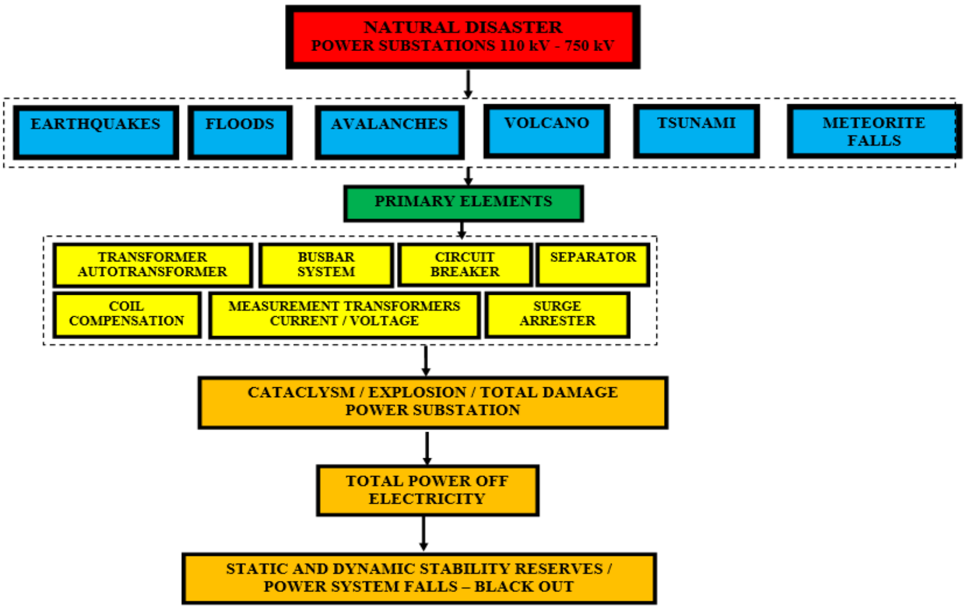


**Fig. 11.** Risk scenario 3 – Event description

➢ **Effects:**
- possible deaths;
- possible accidents with serious consequences;
- fires;
- enormous material damage generated by the lack of electricity;
- enormous material damage resulting from the interdependence of other systems;
- the possibility of a local, regional or natioanal black-out;
- power/economic collapse, crises.

**d) Risk scenario 4 – Terrorist Attack: Power Substation 110 kV – 750 kV**

In fig. 12 the sequential and causal development of phenomena diagram is shown.

The events, presented in fig. 13, consist in: TERRORIST ATTACK: NPG Blackout → Power and national insecurity → Damage.

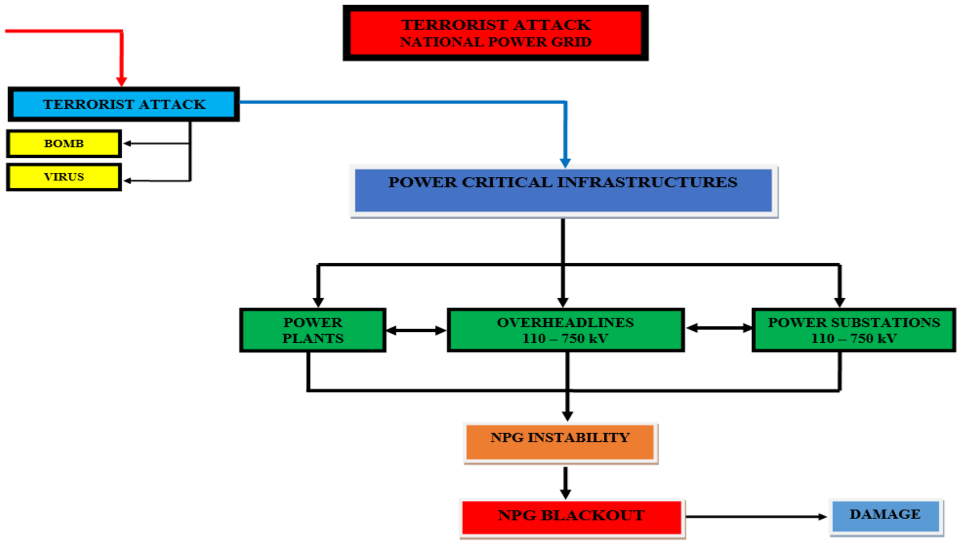


**Fig. 12.** Risk scenario 4 – Sequential and causal development

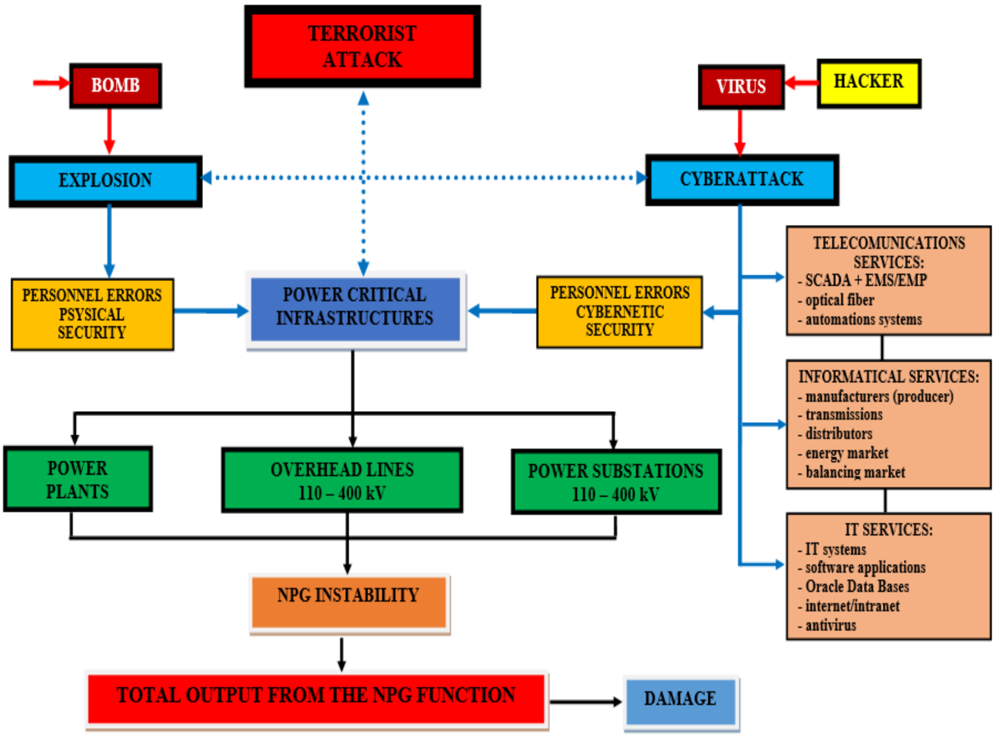


**Fig. 13.** Risk scenario 4 – Event description

**Comments regarding Risk Scenario 4:**

➢ **Causes:**

- explosions following a terrorist attack followed by fires;

- non-compliance with fire safey regulation;
- lack of training/precarious training of the Critical Infrastructure Protection Management;
- lack of specialized personnel for extinguishing fires;
- lack of personnel physical security;
- cyber attacks;
- hardware/software systems insecurity;
- insecurity of secret data transmission systems of critical infrastructures;
- lack of specialized cyber security personnel;
- insecurity of SCADA systems;
- operating with insecure and/or non-performing programs;
- insecurity communications;
- lack of cyber investments.

➢ **Effects:**

- possible deaths;
- possible accidents with serious consequences;
- fires;
- access to secret information about National Power Grid by unauthorized persons and the use of secret information for military or terrorist purposes;
- untimely disconnection of power equipment remotely controlled by hackers;
- enormous material damage generated by the lack of electricity;
- enormous material damage resulting from the interdependence of other systems;
- the possibility of a local, regional or national black-out;
- power/economic collapse, crises.

## 3. CONCLUSIONS

The increasing occurrence of cases of power terrorism (black-out), makes the work addressed very current and of great significance, knowing very well that critical power infrastructures are vulnerable to threats and dangers, due to lack of investment and resources qualified human.

Lack of electricity in certain areas or regions can create social imbalances and extreme damage to the national economy and without electricity, the economy and national security are paralyzed, which has an effect on all levels of society.

The identification and description of the Risk Scenarios 1, 2, 3 and 4 allow to evaluate each scenario, identifying and calculating the following items:

- Probability of occurrence of the event;
- Gravity (severity) of consequences;
- Risk calculation;
- Application of the risk reduction measures;
- Recalculation of the gravity (severity) of consequences;
- Risk recalculation.

Such an approach (risk identification) must start from the top management of owners and operators of critical power infrastructures and power safety must never subordinated to economic profit but combined with it.

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