

# Production Structures of Energy Based on Water Force, Its Infrastructure Protection, and Possible Causes of Failure

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**Abstract**—The purpose of this paper is to contribute to the enhancement of a hydroelectric plant protection by coordinating protection measures / existing security and introducing new measures under a risk management process. In addition, plan identifies key critical elements of a hydroelectric plant, from its level vulnerabilities and threats it is subjected to in order to achieve the necessary protection measures to reduce the level of risk.

**Keywords**—Critical infrastructure, risk analysis, critical infrastructure protection, vulnerability, risk management, turbine, Impact analysis.

## I. INTRODUCTION

THE growth as never in the history, in the last decades, of the risks, dangers and threats to the vital objectives of the states and international organizations, together with the increase of their number and vulnerabilities lead to sedimentation and defining the new concept generically called critical infrastructure.

Infrastructures represent an essential condition of human life. They are a part of the material support for civilization. They are material ways for security of human life, they define the human life style, take a part of human nature, from human reality. By this reason, the quoted European Directive gives a special attention for defining, identifying and its security [6].

The Directive considers that ICE owners/operators should be granted access, especially through specialized authorities from member states, to best practices and methodologies regarding the protection of critical infrastructures. She defines the critical infrastructures and other notions related to them, as following:

- (a) Critical infrastructure means an element for maintenance of vital social functions, of health, safety, security, good social life or economical of persons and whose perturbation or destruction would have a significant impact in a member state as result of the incapacity in keeping those functions;
- (b) European critical infrastructure or ECI means a critical infrastructure localized in member states, whose perturbation or destruction will have a big impact on at least two member states. The importance of impact is evaluated from the perspective inter-sectorial criteria. This includes the effect that results from inter-sectorial

relationship and from dependency of other types of infrastructures;

- (c) Risk analysis means significant threats scenario analyzing, for vulnerability evaluation and potential impact of perturbation or of critical infrastructures destruction [3];
- (d) Sensitive information regarding critical infrastructures protection means information regarding a critical infrastructures that may be used, in case of disclosure, for planning and fulfillment of some actions that will lead to perturbation or the destruction of some critical infrastructures installations;
- (e) Protection means any activity that has as purpose the assurance of functionality, continuity and critical infrastructures integrity to discourage, reduce and neutralize a threat, a risk or a vulnerable point;
- (f) ECI owners/operators means those entities responsible with investigation in specific element, system or its component, designate as ECI, through direct presence and/or with its current handling [8].

Critical infrastructure owners and operators prioritize and implement risk mitigation activities based on their cost-effectiveness, feasibility, and potential for risk reduction.

Risk management actions include measures designed to deter, disrupt, and prepare for threats and hazards; reduce vulnerability to an attack or other disaster; mitigate consequences; and enable timely, efficient response and restoration in a post-event situation, whether a terrorist attack, natural disaster, or other incident [2]. The risk management approach focuses attention on that prevention, protection, mitigation, response, and recovery activities that bring the greatest return on investment, not simply the vulnerability reduction to be achieved [5].

Risk management activities also may include the means for reducing the consequences of an attack or incident. These actions are focused on mitigation, response, and/or recovery. Often it is more cost effective to build security and resilience into assets, systems, and networks than to retrofit them after initial development and deployment. Accordingly, critical infrastructure partners should consider how risk management, robustness, and appropriate physical and cyber security enhancements can be incorporated into the design and construction of new critical infrastructure and the redesign or repair of existing infrastructure [4].

## II. VULNERABILITIES, HAZARDS AND THREATS TO CRITICAL INFRASTRUCTURE IN ROMANIA

Assessment of vulnerability in relation to critical infrastructure is becoming increasingly important due to the urgent need to protect them against natural disasters, against the exploitation of technological failure, disasters caused by human factor, voluntarily or involuntarily, and against other types of interruptions that may affect these items. The vulnerability can be defined broadly as a combination of risks associated with an entity and its ability to resist and overcome internal and external emergencies [1].

In Romania, threats to physical infrastructure are all the more notable as the vulnerability of such infrastructures has increased over the years due to ineffective or inconsistent optimization in terms of physical integrity of the systems that constitute ICN (transport infrastructure numerous industrial and general built environment).

This paper seeks to address critical infrastructure risk management from an organizational perspective. Considering that this activity (risk management) is a task of prime importance in fulfilling the mission received by law component processes are analyzed in terms of effectiveness, while watching them to be updated and improved. Operator Security Plan (OSP) identifies elements of critical infrastructure (CI) and existing security solutions implemented for their protection [7].

A concrete example of this is a turbine failure.

### A. Risk Assessment Based on Threat Scenarios

#### 1. Type of Hazard / Threat

Stop the turbine operation FVM 24-158 (vertical Francis with metal casing) by breaking the metal casing.

#### 2. Background

On the morning of February 2, 2015 after maintenance activities at both turbines were observed ruptured metal part of the turbine FVM 24-158. Cracks have developed rapidly observed, occurring phenomenon of failure and automatic shutdown of the turbine casing's operation

#### 3. The Causes that Led to the Scenario

- Carrying out regular maintenance and repair delay.
- Failure to regular technical inspections and occasional;
- Failure program performance monitoring construction activity

#### 4. Early Warning

- Touching the alert threshold, at which were observed occurrence of the first cracks in the metal housing is announced management plant hydropower and Dispatch area energy and national level which will announce inspectorate emergency situations and all settlements downstream of the possibility shutdown the supply of electricity;
- It will switch to power up the possibility CHE (electric generator).
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### 5. Reference Incidents

- towns downstream of HPP by electricity nonfood
- towns downstream of HPP by evacuating the maximum flow allowed by the surge secondary (which is linked to the surge accumulation HPP).

### 6. People, Goods, and Other Systems at Risk

- In the first 30 minutes of the incident will be affected 59 households, economic and 8 social objectives. A total of 80 people with non-food electricity supply;
- After 60 minutes of incident 464 households will be affected, 10 economic and social targets and a total of 380 people with electricity non-food supply;
- 90 minutes of the incident will be affected 653 households, 25 economic social targets and a total of 590 people with electricity non-food supply.

### B. Establish Probability of the Chosen Scenario

For determining the probability, it was adopted a scale (Table I):

TABLE I  
PROBABILITY OF CHOSEN SCENARIO

Level / Associate score	Probability determination	Periods
<input type="checkbox"/> 1 - Very low	It has a very low probability of happening. Normal measures are necessary to monitor the evolution of the event	More than 13 years
<input checked="" type="checkbox"/> 2 - Low	The event has a low probability of occurring. Further efforts to reduce the probability and / or impact mitigation.	10 – 12 years
<input type="checkbox"/> 3 - Medium	The event has a significant probability of happening. Significant efforts are needed to reduce the probability and / or impact mitigation.	7 – 9 years
<input type="checkbox"/> 4 - High	The event has a probability of happening. Priority efforts are needed to reduce the likelihood and mitigate the impact.	4 – 6 years
<input type="checkbox"/> 5 - Very	The event is considered imminent. Immediate and extreme measures are needed to protect the lens to an alternate location evacuation / safe area where impact requires.	1 – 3 years

The likelihood of the chosen scenario is low (2) with a production period of 13 years.

Setting the severity of the consequences the proposed scenario

Given the gravity of the consequences are the worst levels of vulnerability and impact.

C. Vulnerability and Capabilities Analysis

TABLE II  
VULNERABILITIES AND CAPABILITIES

Vulnerability and capacity	Level
1. ICN placement in terms of road traffic or pedestrian areas	Very low
	Low
	Medium
	High
	Very high
2. The level of HPP staffing	Very low
	Low
	Medium
3. The degree of specialization of HPP staff	High
	Very high
	Very low
	Low
	Medium
4. Hydroelectric power facilities with specific equipment	High
	Very high
	Very low
	Low
	Medium
5. Worn turbine	High
	Very high
	Very low
	Low
	Medium
6. The level of competence of personnel involved in the operation / maintenance of equipment, technical assistance on equipment	High
	Very high
	Very low
	Low
	Medium
7. The technological equipment and facilities status	High
	Very high
	Medium

D. Impact Analysis

Impact analysis is an analysis of management at certain levels to identify the impact of the loss of ICN Resources. It will consider the scenario severity of all impacts and then will determine the severity of the consequences of producing hazard / threat scenario considered. It has chosen the highest level of severity levels associated impacts.

TABLE III  
THE IMPACT ANALYSIS

Impacts	Level	
Potential deaths	<input checked="" type="checkbox"/> 1 - Very low	0 - 5
	<input type="checkbox"/> 2 - Low	6 - 10
	<input type="checkbox"/> 3 - Medium	11 - 15
	<input type="checkbox"/> 4 - High	16 - 20
	<input type="checkbox"/> 5 - Very high	> 21
Potential damage or damage to infrastructure within the site that provides the main utilities (transport, electricity, drinking water, communications)	<input type="checkbox"/> 1 - Very low	temporal
	<input type="checkbox"/> 2 - Low	Significant damages
	<input type="checkbox"/> 3 - Medium	medium damages
	<input type="checkbox"/> 4 - High	high damages
	<input checked="" type="checkbox"/> 5 - Very high	Very high damages
Potential damage to equipment or property damage of those to whom services are provided by ICN concerned (public, commercial, private)	<input type="checkbox"/> 1 - Very low	0 - 10%
	<input type="checkbox"/> 2 - Low	11 - 20%
	<input type="checkbox"/> 3 - Medium	21 - 30%
	<input type="checkbox"/> 4 - High	31 - 40%
	<input checked="" type="checkbox"/> 5 - Very high	More than 41%
Potential damage or environmental damage	<input checked="" type="checkbox"/> 1 - Very low	0 - 20%
	<input type="checkbox"/> 2 - Low	21 - 40%
	<input type="checkbox"/> 3 - Medium	41 - 60%
	<input type="checkbox"/> 4 - High	61 - 80%
	<input type="checkbox"/> 5 - Very high	peste 81%
Potential social impacts	<input type="checkbox"/> 1 - Very low	0 - 10%
	<input type="checkbox"/> 2 - Low	11 - 20%
	<input type="checkbox"/> 3 - Medium	21 - 30%
	<input checked="" type="checkbox"/> 4 - High	31 - 40%
	<input type="checkbox"/> 5 - Very high	
<b>Level and associate score</b>	<b>Severity of consequences</b>	
<input type="checkbox"/> 1 - Very low	The event produces a minor disruption in activity without damage.	
<input type="checkbox"/> 2 - Low	The event cause minor material damage and disruption activity limits.	
<input checked="" type="checkbox"/> 3 - Medium	Product Injuries staff, and / or some loss of equipment, facilities and delays in service delivery.	
<input type="checkbox"/> 4 - High	Serious injuries of personnel, significant loss of plant equipment and facilities, delays and / or denial of service.	
<input type="checkbox"/> 5 - Very high	The consequences are catastrophic resulting in deaths and serious injuries of personnel, major loss of equipment, installations and facilities and cease providing the service.	

TABLE IV  
CALCULATING THE RISK LEVEL

PROBABILITY		Very high 5					
		High 4					
		Medium 3					
		Low 2				turbine turn off	
		Very low 1					
		0	V.low1	Low 2	Medium 3	High 4	V. high 5
Risk Level calculated	Level	Score	GRAVITY CONSEQUENCES				
	V. low	1-3					
	Low	4-6					
	Medium	7-12					
	High	13-16					
	V. high	17-25					

Note: The risk is given by the product of the probability of a hazard / threat and severity of the consequences.

Calculated risk has a value of 8 (Severity 4 x Probability 2) therefore there is a risk of producing medium chosen scenario. **Turbine turn off** has serious consequences "High" (value 4) while the probability of the scenario chosen is "Low" (value 2).

E. Risk Treatment

To reduce the risk reduction measures to be taken the vulnerabilities and/or capabilities (Table V):

TABLE V  
PROPOSED MEASURES

Vulnerability and/or capability	Proposed measures
HPP facilities with specialized equipment	- verification of existing equipment and the degree of wear - Installation of reliable and resistant to corrosive media
Condition of technological equipment	- checking the status of equipment and technological system - installation of new technological equipment

Protection of critical infrastructure consists of all the measures established to reduce risks unlocking operation or destruction of a critical infrastructure.

After applying measures to reduce the risk resulting:

TABLE VI  
RESULTS

Vulnerability identified	After applying measures
	Very low      Very low
	Low              Low
HPP facilities with specialized equipment	Medium        Medium
	High            High
	Very high      Very high
Vulnerability Identified	After applying measures
	Very low      Very low
	Low              Low
Condition of technological equipment and facilities	Medium        Medium
	High            High
	Very high      Very high

TABLE VII  
RECALCULATING THE SEVERITY OF THE CONSEQUENCES

Level and Related score	The severity of the consequences
<input type="checkbox"/> 1 - Very low	The event produces a minor disruption in activity without damage.
<input checked="" type="checkbox"/> 2 - Low	The event cause minor material damage and disruption activity limits.
<input type="checkbox"/> 3 - Medium	Product Injuries staff, and / or some loss of equipment, facilities and delays in service delivery.
<input type="checkbox"/> 4 - High	Serious injuries of personnel, significant loss of plant equipment and facilities, delays and / or denial of service.
<input type="checkbox"/> 5 - Very high	The consequences are catastrophic resulting in deaths and serious injuries of personnel, major loss of equipment, installations and facilities and cease providing the service.

TABLE VIII  
THE RISK LEVEL AFTER ABATEMENT MEASURES

PROBABILITY		Very high 5					
		High 4					
		Medium 3					
		Low 2		turbine turn off			
		Very low 1					
		0	Very low 1	Low 2	Medium 3	High 4	Very high 5
Calculated risk level	Level	Score	GRAVITY CONSEQUENCES				
	V. low	1-3					
	Low	4-6					
	Medium	7-12					
	High	13-16					
	V. high	17-25					

Risk recalculated has a value of 4 (Severity 2 x Probability 2) therefore there is a low risk of producing treated chosen scenario. **Turbine turn off** has serious consequences "Low" (value 2) while the probability of the scenario chosen is "Low" (value 2).

TABLE IX  
PREVENTION, CONTROL AND MITIGATION

Vulnerability and/or capability	Proposed measures
	- execution injections to restore sealing veil
CHE facilities with specialized equipment	-checking existing equipment and their degree of wear - installation of reliable and resistant to corrosive media
Condition of equipment and technologic system	- checking the status of equipment and technology - Installation of new technological equipment

III. CONCLUSION

As well as protected critical infrastructure will always have a high degree of vulnerability, as a rule, are the first target when seeking to destabilize and even destroy a system or a process. The identification, optimization, and securing critical

infrastructure is an undisputed priority for managers of systems and processes.

To reduce the risk has proposed measures to reduce vulnerabilities and / or improvement of capabilities.

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