# CRITICAL INFRASTRUCTURES – A CASE STUDY FROM THE NORTH – WESTERN ROMANIA POWER SYSTEM

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## Abstract:

Critical infrastructure is essential to the development and functioning of any society and economy. The goods and services of critical infrastructure, be they electricity, water or roads represent inestimable assets and most of them are vital to our modern society. Their absence often generates the increase of community vulnerability, while their development states the level of well being of a country. Romania, as one of the recently accepted member of the EU, needs to integrate its critical infrastructure system within that of the broader European framework.

Electricity is an essential component for the human society, and it has a direct impact on each individual, the social and economic activities and the industry. In the last decades, the Romanian electric network (especially the production and distribution systems) overpassed several restructuring measures, as part of an energetic efficiency and energy conservation policy. The paper describes the current situation of the North – Western Romanian electric power system (Maramureş County), with the objective of contributing to its adequate protection. The paper presents aspects regarding the assessment of technological risks associated to several malfunctions in the regional energy supply system and their consequences on the industrial consumers and local communities.

## Introduction

Critical infrastructures are those infrastructures with a significant role in providing operational safety of the economic, social, political, informational and military processes. They are considered critical due to several reasons:

- the one-of-a-kind nature within the infrastructures of a system or process;
- their vital significance, as a material or virtual support in the operation of systems and in development of the economic, social, political, informational and military processes;
- the irreplaceable role they have for the stability, reliability, safety, operation and especially security of the systems;
- enhanced vulnerability towards direct threats, as well as those connected to the systems they belong to;
- special sensitivity to the variation of the conditions and especially to sudden situation changes.

In Romania, there are many critical sites which lie across the country's borders, all of which could be potential points of failure of the critical infrastructure system. All these sites

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are simple elements of a complex system where the vulnerability of the whole is a function of the vulnerability of the weakest element (Linkov et al., 2007). Electricity network, water supply system, chemical plants or roads network are all elements of this complex system. In this paper, we review the current status of the Romanian electricity power system, with special focus on the North-Western county, the Maramures county.

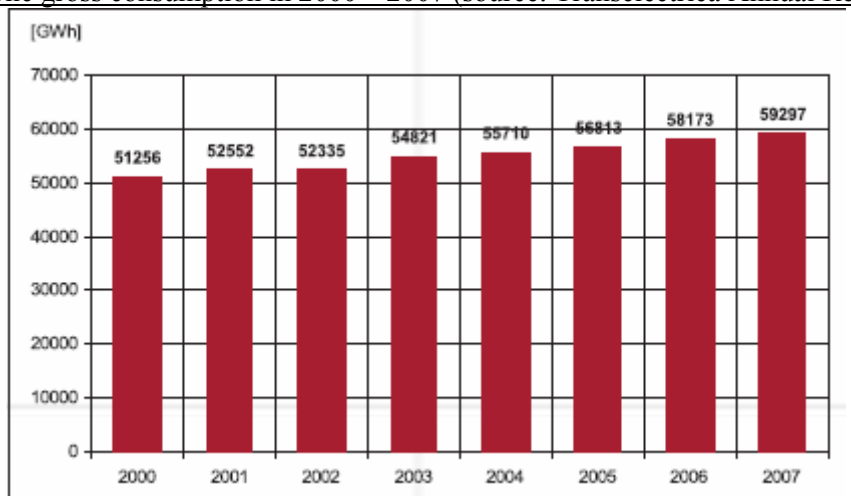
## Theory and Method

The energy network represents a critical infrastructure of major importance in the national economy and it represents the basis for the entire national development. At the same time, energy supply is a public service with a significant social impact.

The energy system in Romania had at the end of 2007 a total capacity of 18,314 MW, with the following structure: thermoelectric power plants – 11,391 MW, hydroelectric power plants – 6,216 MW and the nuclear power plant from Cernavoda – 707 MW. In 2007, the energy production was 62 TWh.

Generally, the evolution of energy consumption followed the national economy evolution, especially the industrial activities evolution. The electric energy production grew during 1999 – 2006 with approximately 10.7%. In 2000, the electric power consumption grew with 2.2% since 1999 and in 2002 the consumption grew with 6.8% since 2000, due to the intense economic activities. The reduced consumption periods generated critical situation in the energy field, which resulted in a poor financial situation of the economic agents in the field, in little investments and maintenance programmes and in significant dismissals. After the improvement of the economic activities and thus, of the entire Romanian economy, the energy consumption grew constantly, having small variation. In 2004, the energy consumption was 44.6 TWh, which represent a growth of 2.7% compared to 2003. The annual electric energy consumption per capita was in 2004 of approximately 2.055 kWh/per capita and it is estimated a growth to 2.071 kWh/per capita in 2015. In 2007, the gross electricity consumption registered a growth of 1.93% as compared to 2006, reaching the level of 59297 GWh. (fig. 1)

Figure 1. The gross consumption in 2000 – 2007 (source: Transelectrica Annual Report 2007)

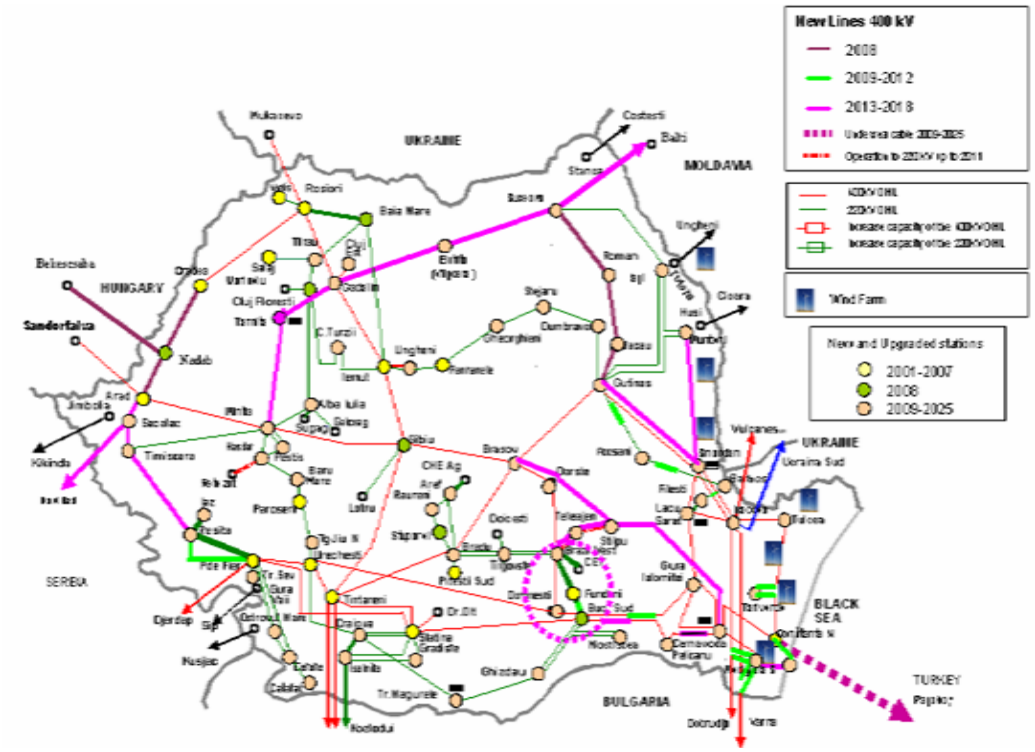



Approximately 41.7% of the final energy is consumed in industry and 32.1% is used in households and other domestic activities. Considering the future predicted energy consumption growth, of approximately 2.7% per year, some investments are necessary: the expansion of the existing production facilities, the use of renewable resources for energy production and reducing the energetic intensity. In 2007, renewable output was of 39 GWh, of which only 7 GWh was wind. During 2000 – 2007, the gross domestic consumption increased steadily with 1.6 – 4.7% annually.

Most part of the installations (82%) were put in place during 1970 and 1980 and have more then 25 years of functioning. (Fig. 2) The major projects under way are:

- New 400 kV interconnection OHLs:
  Oradea (RO) – Bekescsaba (HU), to be completed in 2008
  Sacalaz (RO) – Novi Sad (RS)
  Suceava (RO) – Balti (MD)
- 400 kV HVDC undersea cable Constanta (Romania) – Pasakoy (Turkey)
  Feasibility Study to be launched in 2008
- Rehabilitation and modernisation of another 10 existing substations
- Extension and reconfiguration in South-East of Romania (Dobrogea), due to massive new generation (5500 MW/3000 MW in renewables)
- Connection to the grid of new major greenfield projects (private investments)

Figure 2. Romanian transmission system network (source: Technical Results of the Electric Energy Sector in Romania in 2008)

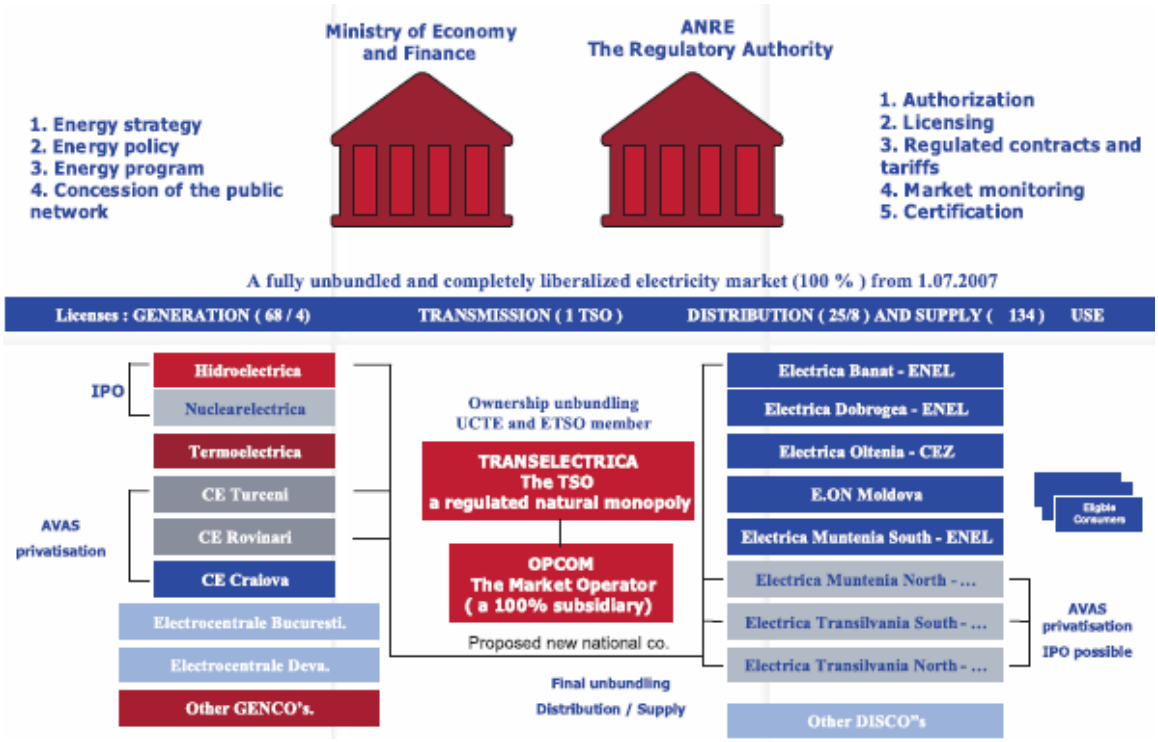



As for the extent of the energy network, almost of the households in the urban areas (99.4%) are connected to the electricity network, while in the rural areas, 96.3% households are connected. At the end of 2002, 93,613 households were not connected to the energy network, in 2,571 towns, of which:

- 4,636 households in 203 areas completely not connected
- 64,207 households in 2,218 rural areas partially connected
- 24,770 households in 150 urban areas where extensions of the distribution network are planned.

The Romanian power system comprises three sectors: the production, the transport and the distribution sectors, which are organized in several companies, with specific responsibilities in their sectors. Most of them are state-owned companies. The figure below presents the current structure of the Romanian power system, including all the companies involved in the energetic field.

Figure 3. The current structure of the Romanian Power System (source: Transelectrica Annual Report 2007)




*Electricity production sector* – at national level, there are 47 companies, certified by ANRE. The most important companies which produce electric energy, having state capital, are the Energetic Power Plants from Rovinari, Turceni, Craiova, S.C. Termoelectrica Bucharest S.A., S.C. Electrocentrale Bucharest S.A., SN Nuclearelectrica S.A. S.C. Hidroelectrica S.A. manages all the hydroenergetic power plants in Romania. The Rovinari thermal power plant has an installed power of 1320 MW and uses brown coal from the mining exploitations in the area (www.cerovinari.ro). The Turceni Energy Complex is the largest power plant in Romania with an installed capacity of 2310 MW (7 330 MW installed power) and a current operational capacity of about 1260 MW (5 x 330 MW operational units, 1 unit in rehabilitation, one unit retired from operation, net power delivered into the system by one 330 MW unit around 285 MW). The main fuel is lignite with a low heat value of 1400-1800 kcal/kg, supplied by rail from distances averaging 35 km (www.eturceni.ro). The Craiova Energy Complex has an installed capacity of 930 MW and is also uses brown coal to produce and sell electric and thermal energy (www.cencraiova.ro). The installed power within S.C. Electrocentrale Bucharest S.A. capacities was at the beginning of the 2007 of 2,008 MW, which is 20% out of the generation capacities at national level, as it is the main thermal and power producer in the thermal generation sector. In 2007, the company generated 6,759 billion kWh electrical energy, meaning about 12.7% of the production obtained at the national level, a quantity which was sufficient for 60% of the Romanian population consumption (www.elcen.ro). In the above mentioned period, the company also generated 6,662 million Gcal, representing about 40% of the national output. SN Nuclearelectrica S.A.'s main mission is the production of electrical and thermal power using nuclear fission and also the manufacturing of nuclear fuel, under terms of maximum security, proficiency and respect towards the environment and the population (www.nuclearelectrica.ro). S.C. Hidroelectrica S.A. manages 275 hydro electrical power plants and pumping stations, summing up an installed power of 6374.37 MW (www.hidroelectrica.ro).

*Electrical energy transport sector* – the electric energy transport system comprises all the electric networks of 750 kV, 400 kV and 220 kV. The main company in this field is Transelectrica S.A., totally owned by the state (www.transelectrica.ro). Transelectrica is the Romanian Transmission and System Operator (TSO) which plays a key role in the Romanian electricity market. It manages and operates the electricity transmission system and provides electricity exchanges among Central and South - Eastern countries, as a member of UCTE (Union for Coordination of Transmission of Electricity) and ETSO (Association of European Transmission and System Operators).

*Electricity distribution sector* – the distribution networks function at tensions between 0.4 kV and 110 kV. S.C. Electrica S.A. is the Romanian company responsible with electricity distribution and supply and provision of the infrastructure of communications and information technology. SC Electrica SA operates as a company with national coverage – the eight areas where both FDFEE and SISE are organized are:

1. Muntenia Sud (based in Bucharest),
2. Transilvania Nord (based in Cluj-Napoca),
3. Translvania Sud (based in Brasov),
4. Banat (based in Timisoara),
5. Moldova (based in Bacau),
6. Oltenia (based in Craiova),
7. Muntenia Nord (based in Ploiesti) and
8. Dobrogea (based in Constanta).

*The Romanian Energy Regulatory Authority (ANRE)* is an independent public institution, whose mission is to elaborate and implement the regulations systems necessary to ensure the proper functioning of the electricity, heat and gas markets, in terms of efficiency, competition, transparency and consumer protection (www.anre.ro). In discharging its competencies and tasks, ANRE works together with other central or local public administration bodies, electricity, heat and gas undertakings, with international organizations in the field, so that interests of all sector players may be harmonized and transparency of the regulatory process assured. Within the ANRE, the Romanian Agency for Energy Conservation (ARCE) is the specialized body at national level in the field of energy efficiency, with legal personality, operational, organizational and financial autonomy (www.arceonline.ro/arceonline/).

## Results

The Electrical Power Supply Agency Baia Mare (A.F.E.E. Baia Mare) supplies electrical power for 193 411 clients in the Maramureş County. The structure of these users is presented in table 1.

Table 1. Total number of consumers, according to type of prices and voltages levels (source: A.F.E.E. Baia Mare)

| Type of clients | | Type of prices | High voltage | Medium voltage | Low voltage | TOTAL |
|---|---|---|---|---|---|---|
| ECONOMIC AGENTS | | *TOTAL Large economic agents* | 0 | 170 | 64 | 234 |
| | | *TOTAL Small economic agents* | 0 | 254 | 12444 | 12698 |
| DOMESTIC | URBAN | *Total Domestic - Urban* | 0 | 1 | 102656 | 102657 |
| | RURAL | *Total Domestic - Rural* | 0 | 1 | 81507 | 81508 |
| *TOTAL GENERAL* | | | 0 | 426 | 196671 | 197097 |

The evolutions in the legislative process related to the development of the basic activities in the electro-energetic system have led to the regulation by the National Regulation

Agency in the field of Energy (ANRE), of the production, transport, distribution and supply of the electrical power supply. S.C. Electrica S.A. develops its economic activities under the terms of natural monopoly, with the obligation of ensuring the non-discriminating access of all users, suppliers and producers to the network.

S.C. "Electrica"-S.A. is the commercial society for the distribution and supply of the electrical power and covers the national territory – with a regional organization into 3 regions:
- Transylvania North (based in Cluj-Napoca)
- Transylvania South (based in Brasov)
- Muntenia North (based in Ploiesti)

The Transylvania North Electrica Supply Branch includes 6 Supply Agencies.

The Transylvania North Electrica Supply Branch is a juridical entity supplying electrical power to more than 1,120,000 clients in the North-Western counties: Cluj, Bihor, Maramures, Satu Mare, Salaj and Bistrita Nasaud. As one may notice from table 1, the percentage of the clients is: 7% economic agents and 93% domestic users.

AFEE Baia Mare is part of the Transylvania North Electrical Supply System. AFEE Baia Mare administers a length of 7,053.543 km electrical lines of which 972.082 km are underground lines. The rest of the electrical lines length represents aerial lines. This system also includes 1596 supply stations, 1713 low and medium-voltage transformers, and 23 TRAFO stations. The lines network also includes 2274 aerial service taps and 569 underground service taps.

## Discussion

The national energetic strategy for 2007 – 2020 emphasizes the need to maximize the nuclear energy production, by installing the 3 and 4 Units from the Cernavodă Nuclear power Plant and by increasing the use of hydro energetic resources with 6% until 2011. Other priorities are: rehabilitation/technological improvement of the energetic installations with long-service wear or old installations, closing of the unprofitable ones, promoting the private investments in new productions installations, based on renewable resources.

The improvement of the energetic efficiency in all sectors: production – transport – distribution – final use is very important, in the context of European Union requirements regarding efficiency, energy costs and environmental protection. European funding can support these improvements, by offering the needed financial aid. Also, it is intended to reach a high level of interconnection of the Romanian transport networks with those from the European Union.

A negative aspect of the Romanian power system is the little use of renewable resources (solar energy, biomass, wind power). The predicted increase of 33% until 2015 would also reduce the dependency on energetic resources import.

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## Author biography

Chemist engineer **Alexandru Ozunu** is born in Sighetu Marmatiei, Maramures County, Romania, on April 11, 1961. He graduated The Polytechnic University, in Bucharest Geography Faculty in 1986, and was granted the title of Doctor in Chemical Engineering, in 1998, at the Babes-Bolyai University, Cluj-Napoca. Ever since he developed an intense and fruitful teaching career at the Babes-Bolyai University. He is now the vice dean of the Faculty of Environmental Sciences within the Babeş-Bolyai University and the head of a master programme in risk assessment and environmental safety at the same department. In addition to these, he was also member or director of several research projects; he is member of many environmental NGOs and associations, General director of the Regional Centre of Major Industrial Accidents Prevention and president of the National Center APELL for Disaster Management Foundation. Also, as the main promoter of TIEMS in Romania, he is the President of the Romanian Chapter of TIEMS.
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