

Critical Electricity Infrastructures at Risk The Advent of the System of Systems Engineering Concept

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Critical infrastructures represent large scale-dynamic systems, potentially having non-linear behavior and being interconnected, prone to multiple threats and posing risks themselves (e.g. electric power system, transportation system, water supply, information and communication systems). As meta-systems, critical infrastructures are characterized by a high degree of connectivity, complexity and relevance to society. A single failure can cascade, potentially affecting security and social welfare of any nation. Critical infrastructures have given priority by International Risk and Governance Council (IRGC), with specific aspects related to systemic risks induced by electric power systems and the impacts on other vital systems. Current societal needs continue or even increase to fully address such systems, in many respects due to their performed functions within the society. An evaluation process of risks of the critical infrastructures is currently taking place in various countries or at the level of international organizations, which process is endorsed by the OECD study on Emerging Systemic Risks.

A number of initial questions related to the overall aspects of critical infrastructures technical related risks as well as risk governance are being addressed within this study, in the context of the general assessment of current structures and future technical changes, management and legal aspects and instruments. Among those of significant importance being:

Question 1: Is the Electricity Power System at (higher) risk?

Question 2: If yes, then why (including reasons, and the advent and the presence of new threats)?

Question 3: What are the trends in the area of negative and positive developments (e.g. adequate countermeasures)?

Question 4: What are the adequate frameworks to deal with the new situation: a chance for risk governance!

Within the course of this study a “worldwide inventory” of schools of thoughts, to delineate risk and vulnerability of interconnected vital systems, in view of resilient governance was assessed. The investigation on the digitalization of selected critical infrastructures, that, in turn, allowed the assessment of risks, vulnerabilities and dependencies with applicability to design and management of structures of overarching importance.

There is a need for providing guiding principles for assessing risks and vulnerabilities in various critical infrastructure mixes, by use of distinct methodologies, models, data and knowledge bases depending on the degree of country’s economic and social development, various safety culture, emergency awareness, and safety/security options or/and practices. Following a detailed technical and governance assessment of blackouts and other recent accidents which took place in various countries and regions in Europe,

the present study concentrates on relevant recommendations on how to reduce risks and vulnerabilities for individual and/or mixes of critical infrastructures. Additionally, study indicates how to measure the resilience performance of critical infrastructures under internal stress, external hazards, a variety of potential threats, modality of usage of insurance policies, all in order to stabilise and provide operational continuity for various infrastructures.

The structure of the present presentation is based on a compilation of the best practices of the individual communities in Europe, in particular, and which offers a possibly harmonised and structured approach to understand, address and handle a wide range of different risks in a pro-active, comprehensive and systematic manner. The project aimed to develop a structure to characterise risk with a view to derive adequate management strategies and to examine what critical electricity infrastructures means in the context of risk and how governance can assist in framing, assessing and managing the risks of a number of selected critical infrastructures.

The work reported here has been commissioned has the following initial structure:

- Reviewing the essence of critical (electricity) infrastructures for assuring vital services to any nation, by taking into account risks induced by the increasing digitalization potential of and within specific classes of critical infrastructures e.g. electric power system, rail transportation, information and communication systems taking in a range of cultures and relating it to “risk” and vulnerability.
- Developing the assessment of critical infrastructures further, i.e. refining the analysis of the interdependencies among distinct critical infrastructures in view of the degree of digitalization in place, risk assessment and risk management process while taking full account of wider societal and economic concerns.
- Further refining and testing the methodological aspects on interdependencies, risk and vulnerability. This is being done by a range of means including:
 - Enlarging the number of critical infrastructure systems already adopted, and / or the number of world regions where critical infrastructures operate, by also using the methodology developed within the other IRGC projects, e.g. risk taxonomy and governance, nanotechnology,
 - bringing together specific working groups to test the details and adopt more generalized rules of operation and interconnection failures against a particular critical infrastructure system or risk and vulnerability generated by these

The work aims also on the following aspects in order to produce:

- A method for measuring and comparing the performance of critical infrastructures as key elements on risk and vulnerability assessment which is based on advanced systems interaction model approach.
- A compendium of principles in order to address security and safety relevant topics due to the increased ubiquity of digitalization and ubiquity of computing (also called pervasive computing) and associated risk management actions
- Inclusion of policy options e.g. market deregulation as an additional component of the performance of critical infrastructures.

Attempts are being made in order to debate in general whether it is desirable to fully address issues on risk and vulnerability of a large number of critical energy infrastructures fully dispersed around the world, or to focus first on distinguished aspects related to interdependencies, complexity and the impact of the increased ubiquity of digitalization and of the ubiquity of computers.

To begin with the electricity supply industry is becoming increasingly complex. This is partly due to the technological development of the system of systems for critical (energy) infrastructures. Regional electricity networks have been connected to each other, so that we now have only a small number of synchronous networks that span the continent.

- The enormous technical complexity of a continent-wide electricity system manifests itself in ‘emergent behaviour’: system behaviour which cannot be predicted based upon the analysis of the components of the system. The complexity is further increased by the application of information and communication technology at every level. An exogenous source of complexity is the liberalization of the electricity sector, which has led to a large number of actors who control the electricity system together, compared to the former monopoly situation.
- A second source of risk is that the environment of the European electricity supply industry is changing quickly. Other, related sectors such as the natural gas sector are also being liberalized; the tradable CO₂ emissions scheme presents a new challenge, not least because the future emissions cap is uncertain. The political uncertainty about the phasing-out of nuclear power in certain countries further adds to the uncertainty for investors in the electricity supply industry. Last but not least, the new threat of terrorism poses an uncertain but potentially large risk.
- A third source of risk is the increasing reliance upon other infrastructure systems such as the natural gas and the ICT infrastructures. While these are becoming more complex themselves, the increasing interdependence leads to the development of a ‘system of systems’, a system of multiple interlinked infrastructures. Thus the complexity is multiplied and the performance under stress becomes that much more difficult to predict and analyze.

While the increasing complexity, the changing environment and the increasing interdependence of infrastructures pose increasing risks to the electricity supply industry, society’s dependence upon it is also increasing. As a continuous supply of electricity is increasingly taken for granted and necessary for an ever-increasing number of activities, the social costs of supply disruptions rise proportionally. Having become accustomed to a stable electricity supply, modern society cannot function without it anymore. Therefore a thorough analysis of the changing risks and possible strategies for society to deal with them is in place.