Study Committee C2

Power System Operation and Control

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Resilience Enhancement Applications in Operational Planning and Control for the TSO of Serbia

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Motivation and paper goal

The electric power industry is currently undergoing important changes, mainly due to the society-initiated decarbonization efforts performed with the integration of large amounts of RES, electrical storage, and electrical transport in the system. These new resources are typically power-electronic interfaced to the system with a sizable negative impact on system inertia, strength, and power quality. Variability and uncertainty associated with DG/RES additionally complicate system operative planning and control.

The effect of extreme weather on power systems is increasingly evident worldwide during the last decades, which together with other extreme events (equipment failures, of natural origin or man-made) could lead to the power system blackout and lengthy restoration and recovery process. The resilience of the power system to high impact low frequency (HILF) extreme events is consequently gaining growing concern within the industry and R&D community.

So far, the utilities were mostly focused on grid hardening aspects while the R&D community was mainly focused on developing suitable metrics, methodologies, to quantify and prioritize planning/investment decisions aimed at infrastructure resilience enhancement.

This paper's focus is on the operational resilience enhancement issues that are mostly related to the extreme event detection and mitigation, and system restoration as seen from the control center. As an illustration of the proposed resilience framework, a wider development effort to enhance operational resilience in the TSO of Serbia (EMS) and the implementation results is presented and discussed.

Power system threats and hazards

The power system can be exposed to the threats and hazards that can be classified according to the origin as **natural** threats; **human-caused** threats, and **technological** threats and hazards. Available data points out that in the last four decades number of extreme events of natural origin significantly increased, as in Fig.1, while share of different causes of supply loss is due to equipment failure is in Fig.2. Massive digitalization that was ongoing for decades is resulting in complexity growth, but also in higher vulnerability, due to the rising connectivity and interdependencies. In such a condition large disturbances become more often and reliability of supply mainly declined.

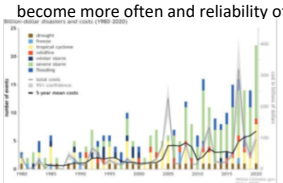


Fig.1

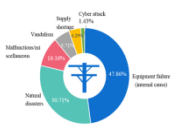


Fig.2

Power system resilience concepts

Power system **resilience** is the ability to limit the extent, severity, and duration of system degradation following an extreme event. Power system resilience is achieved through a set of key actionable measures to be taken before, during, and after extreme events, such as anticipation, preparation, absorption, sustainment of critical system operations, rapid recovery and adaptation, application of lessons learned. In the power system, resilience enablers and activities that impact resilience can be classified according to the moment an extreme event occurs, with a mapping as in Fig.3.

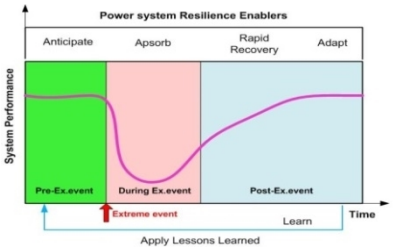


Fig.3

The resilience framework for TSO of Serbia

The basic structure of the methodological framework for system resilience proposed for EMS JSC has several key segments as in Fig.4.

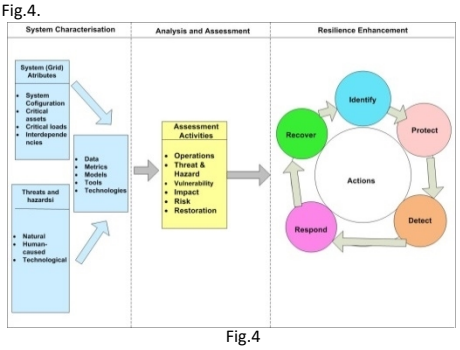


Fig.4

Finally, on the practical side, both soft and hard approaches are proposed for the enhancement of operational resilience. To mention some most important ones: adaptive system protection and control, advanced restoration control, advanced visualization and awareness, dynamic loading of critical transmission elements (OHL, transformers), use of back-up supply at all CC, OTS based operator training, procedures, and coordination of control actions with other participants (TSO, DSO, Genco's), procedures and training with interdependent critical infrastructures and government agencies.

RESILIENCE ENHANCEMENT APPLICATIONS IN OPERATIONAL PLANNING AND CONTROL FOR THE TSO OF SERBIA
continued

PRACTICAL APPLICATIONS in SERBIA

Structural resilience enhancement

- Lessons learned from serious incidents are an important source of ideas in the process of resilience enhancement;

Floods in May 2014

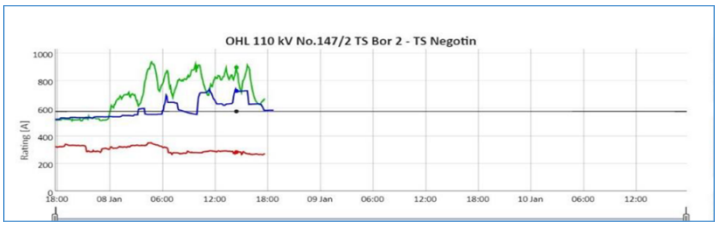
- Development a flood protection plan
- Building of a protective bank around the substation
- Secondary equipment within the SS has been mounted above ground level

Extreme weather conditions December 2014,

- Mechanically stronger lines in the affected area
- Purchase more mobile towers

Operational resilience enhancement

- Power transformer and power lines dynamic loading app's ;
- Dynamic Line Rating pilot projects;



- Lightning detection and location system;
- Back-up National Control Centre;
- PMUs & WAMS in National Control Centre;
- Improving the HPP black-start capabilities.

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RESILIENCE ENHANCEMENT APPLICATIONS IN OPERATIONAL PLANNING AND CONTROL FOR THE TSO OF SERBIA continued

Research projects aimed to enhance operational resilience

- Serbian TSO with other TSO's and research institutions has been involved in HORIZON 2020 TRINITY project.
- Software tools related to operational resilience enhancement in project:
    - T-COORDINATION platform
    - T-SENTINEL toolset

T-COORDINATION platform

- T-COORDINATION platform is envisaged as distributed modular ICT platform which would serve for RSC-TSOs and TSO-RES producers' communication and coordination
- Most important subproducts related to operational resilience:

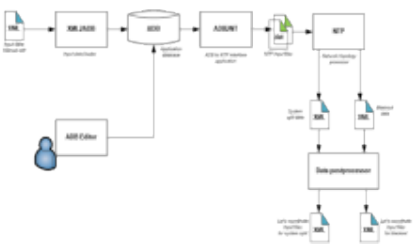
➢ System split and blackout detection application

➢ Coordination in Critical Grid Situation process

➢ Coordination in Consistency Assessment of System Defense and Restoration Plans

System split and blackout detection

- This product is part of the Emergency Restoration Process TRINITY module
- Will be hosted at the site of the , Regional Security Coordinator (RSC) and to base its operation on the data, network models, and telemetry provided by participating TSO's
- Analyzes the data generated by the network topology processor (NTP) results in the current and previous cycles has been developed to detect if new network splitting and blackout occurred



Coordination in Critical Grid Situation process

- The main purpose of this module is the implementation of the coordination platform that could support explained coordination and communication procedure between TSOs and Regional Security Coordinator (RSC) during critical grid situations.
- According to the list of predefined risk scenarios, each period can be related to potential critical grid situations.

Coordination in Consistency Assessment of System Defense and Restoration Plans

- The main objective of this module is to provide the communication platform that will be capable of supporting the mentioned business process while improving coordination and information verification (currently this process is being done via e-mails) between RSC and TSOs regarding the alignment of CA templates.
- Another important improvement is easier and more secure communication between TSOs and RSCs in the process of exchanging such confidential information.

T-SENTINEL TOOLSET

- T-SENTINEL toolset is envisaged as regional management and operation toolset to enhance the security and reliability of the existing regional structures.
- The T-SENTINEL toolset will enable remedial action optimization at the regional level, as well as develop novel algorithms for improvement of Reliability Margins calculation, which will facilitate the accommodation of more RES in the region.
- More information is available on the EU Trinity project site.

Conclusion

To successfully enhance power system operational resilience adequate methodological framework must be designed first, one that is focused on relevant system extreme events and hazards, together with the controls aimed at all phases associated with the extreme event development. Special attention is focused on absorption and recovery phase controls and resources, and training of operational personnel.