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K. Reich, M. Pompili, K. Bakic & Y. Bondarenko

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Development of resilience issues and challenges in the SEERC region

South East European regional council of CIGRE

K. Reich, M. Pompili, K. Bakic, Y. Bondarenko

This paper aims to report on the South East European Regional Council of CIGRECIGRE (SEERC) activities related to resilience of electrical power networks. Based on the results of an organized SEERC workshop focusing on resilience of network issues during which member countries of the region presented their own experiences in resilience planning, the paper presents new measures recently put into force in SEERC countries as well as endeavours to immediate technical modifications of assets imposed by lessons learned during past emergency events.

The first part of the paper presents the SEERC region of CIGRECIGRE, the energy data, the size of the T&D electrical network, the emission of the CO_2 equivalent due to the potential impact on future transition planning of the energy sector, and consequences to the resilience of electric networks. The second part of the paper deals with resilience experiences of different countries in the region after large weather disasters as well as with threatening events caused by cyber attacks. The last part of the paper analyses innovative measures for strengthening resilience in selected systems as it was presented at the SEERC workshop in Rome (2018).

The paper also deals with the assessment of loading limits of selected essential network components aiming to reduce system vulnerability during emergencies, hence increasing its resilience. The majority of the experienced emergencies were produced by harsh weather conditions during winter. There were many cases of Overhead Line (OHL) failures which triggered detailed analyses to determine the encountered mechanical loads. A suitable refurbishing of critical parts of OHL has been done respecting the new standards for the construction of electrical overhead lines in Europe. Aiming to allow the expedited restoring of OHL operating capability in emergencies, the introduction of using emergency (modular) towers was selected and successfully implemented.

Intensive support to asset management was provided, e.g., maintenance optimization, state-of-the-art approaches, condition monitoring of HV equipment, life cycle assessment, evaluation of assets etc.

Keywords: resilience; electric power network; disturbances; extreme weather events; climatic change; cyber security; physical security; system recovery; survivability

1. Introduction

Electricity is a fundamental value to our society. For this reason, electric power systems (EPS) need to be more resilient and flexible to extreme environmental and human threats. Natural or environmental threats are e.g. extreme wind intensities, ice storms, floods, wildfires, droughts, and earthquakes. Human threats could include physical attacks on electrical equipment, cyber-attacks or equipment failures [6] [7]. All of the mentioned threats occurred to some extend in the last few years in the region of SEERC (South-East European Regional Council of CIGRECIGRE). Some of those attacks caused a lot of damage and energy not supplied (ENS) events. Therefore, increasing resilience of EPS is a very important issue, particularly due to climate change and the transition to a decarbonized system.

The Technical Advisory Committee (TAC) of SEERC implemented a discussion in the Southeast and Central European region in the form of a workshop to share experiences in planning of resilience and innovative approaches. The interest of this topic was also expressed in a biennial questionnaire. There, members of SEERC are able to exchange interests for the regional CIGRECIGRE cooperation every two years.

Over the last decades, the majority of our society became aware of climate change and the increasing intensity and frequency of natural disasters in many parts of the world. Thus, resilience issues became popular and many countries increased their efforts and made many studies about that subject, e.g. [R6, R7, R8, R9]. Building a strategy to increase system resilience requires an understanding of a wide range of preparatory, preventative, and remedial actions, as well as the knowledge on how these actions impact planning, operation, and restoration over the entire life cycle of different kinds of grid failures. Although there are many different definitions of resilience, the definition by CIGRECIGRE C4.47 (R1) seems to be a very acceptable one, separating the resilience properties from key measures that contribute to reinforce power system resilience (PSR). PSR is achieved through a set of key measures, which should be taken before, during and after extreme events. Here, the lesson learnt from previous events play an important role as well as innovative applications.

The first part of the paper presents technical parameters of the EPSs in the Region SEERC, which covers a territory of 2.70 million square kilometres with a population of more than 270 million people. The chapter after that describes natural disasters and cyber-attacks that happened in this area during the last couple of years. Different countries reported new measures on how to avoid network

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Reich, K., APG, Vienna, Austria (E-mail: klemens.reich@apg.at); **Pompili, M.,** University "La Sapienza", Rome, Italy; **Bakic, K.,** ELES, Ljubljana, Slovenia; **Bondarenko, Y.,** EMPASELECTRO, Kyiv, Ukraine

disasters. The final part of the paper explains some new and innovative measures in some countries with the aim to enhance resilience of the electric power network.

2. Short presentation of the region SEERC

SEERC (South-East European Regional Council) is a Region of CIGRECIGRE spanning over 17 countries of southeast Europe (Fig. 1). The population of all member countries of SEERC comprises more than 270 million people and a total electrical consumption over 1.100 TWh/a. There are several hundred thousand of people working in the electric industry within the SEERC Region. Those numbers show the great potential of the SEERC Region and a fast-developing electrical engineering sector. At the end of 2019, NC CIGRECIGRE of Israel joined the SEERC region. The data showcased below was acquired before that and Israel is therefore not represented in this figure.

The SEERC questionnaire of technical data and mutual interests for cooperation To gather up-to-date information of all involved countries, SEERC is issuing a questionnaire approximately every two years. The last questionnaire was created in 2018 and the results helped to create the following reported overview of the electrical sector of SEERC Region.

Currently, the SEERC Region has a total electrical consumption of about 1.100 TWh/a (2017), where import and export are almost balanced. The electricity grid of SEERC members is synchronized with ENTSO-E with the exception of Georgia, Israel and Ukraine, the synchronisation being prepared for the latter. Israel joined SEERC end of 2019 and is not yet included in the following data.

The SEERC Countries' electrical energy consumptions are reported in Fig. 2.

Figure 3 depicts the consumption in terms of kWh/capita for each SEERC Country for 2017 based on the results of the Questionnaire.

Carbon emissions in the region From Fig. 4 and Table 1 it is evident that total CO_2 equivalent emissions (ton/capita) decreased in the Region for the last seven years. The decarbonisation of the electricity sector could affect future resilience of system indexes. SEERC is in global average and below EU average.

Comparison of SEERC region with EU and US From Table 2, which compares the main data of the SEERC Region with EU and USA, it is evident that the CIGRECIGRE Region presents half of the population of the EU.

The SEERC Questionnaire also analysed the transmission and distribution grid in terms of overhead line length, underground and subsea cable length and power transformers categorized by voltage level. The circuit length of the transmission grid exceeding 100 kV of the Region is over 220 000 kilometres not including data of Serbia, North Macedonia, Czech Republic and Slovakia, Israel, Georgia (Fig. 5) including 9 600 km of underground and sea cables, while the distribution network reaches values of 4.1 million kilometres circuit length (Fig. 6).

Estimated numbers of the transformers in operation in SEERC Region are reported in Figs. 7 and 8, distinguishing between TSO and DSO units. Further investigations of number and types of these transformers are still in progress.

Finally, the questionnaire tackled the technical fields of interest for each SEERC member.

With this information, future collaborations and activities within the Region can be defined, which are, among others, the integration of renewables, resilience issues, weather and demand forecasting, as well as power interconnections between neighbouring countries.

Table 1. CO_{2eq}. Emissions in CIGRECIGRE Region SEERC

Country in 2017	Global ranking	Emissions CO_2 (Mt)	Population (millions)
1. Turkey	15	448	81.95
2. Italy	19	366	59.35
3. Ukraine	28	212	44.50
4. Czech R	38	108	10.62
5. Romania	46	80	19.95
6. Greece	47	76	11.30
7. Austria	49	70	8.73
8. Hungary	50	59	9.72
9. Serbia	62	45	8.80
10. Bosnia & Herz.	80	27	3.50
11. Croatia	91	17	4.20
12. Slovenia	94	15	2.09
13. Georgia	100	11	3.91
14. N. Macedonia	118	7.6	2.07
15. Montenegro	146	2.6	0.66
Total 15 countries		1 544.2	

Table 2. Comparison of the main data of SEERC region with EU and USA

	SEERC	EU	USA
Population (Inhabitants)	276 000 000	504 000 000	318 000 000
Geographic area $(km)^2$	2 701 941	4 326 253	9 834 000
Electrical energy consumptions (GWh)	1 138 000	3 001 000	4 129 000
Electrical energy consumptions (kWh/capita)	4 123	5 913	12 984
CO_2 emission (ton/capita/a)	5.03	6.4	16.5

3. Large network disturbances and resilience experiences in the SEERC region

Generally, the number of natural disasters is increasing as shown in Fig. 9 from [2](4) as was reported in all participating countries at the SEERC workshop in Rome in 2017 [3]. Following descriptions of different experiences with natural and cyber-attacks in the period of the last few years prove the increase of natural and human attacks on networks correct and the need for new planning approaches. In some countries consequences of events caused very high costs.

Slovenia in 2014 – 2015 [2] (10) and [4] In 2014 and 2015, Slovenia was affected by severe icing storms as well as severe wind, see Fig. 10. Extreme weather conditions affected almost the whole country and triggered red alarm. Damages of electricity network infrastructure were catastrophic as never before. In one week, in February 2014, all damages in different infrastructures exceeded 600 million Euro for the whole country. Considering T&D electricity sector damages amounted about 80 million Euro.

Fig. 1. Member countries of SEERC Region (2018): Austria, Bosnia and Herzegovina, Croatia, Czech Republic, Georgia, Greece, Hungary, Italy, Kosovo, North Macedonia, Montenegro, Romania, Serbia, Slovakia, Slovenia, Turkey and Ukraine, Israel (not shown on this map)

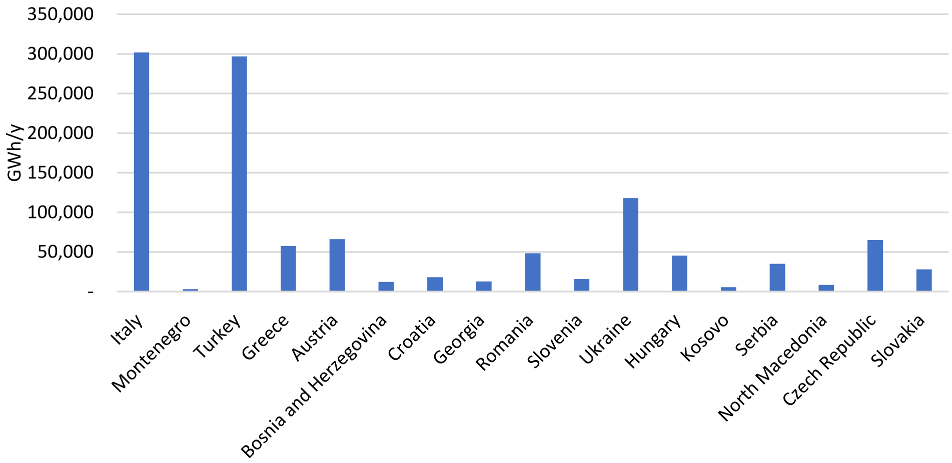


Fig. 2. Electrical energy consumption of SEERC's Countries as in 2017. Data for Serbia, North Macedonia, Czech Republic and Slovakia are estimated. Source: SEERC questionnaire results

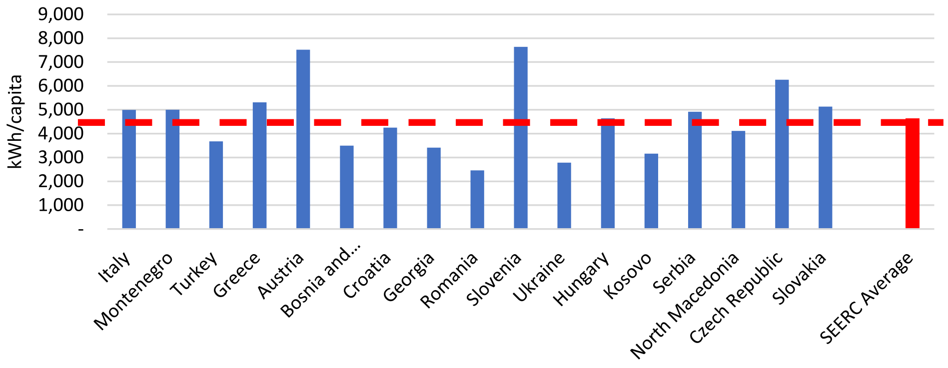


Fig. 3. consumption in terms of kWh/capita/2017 for each SEERC Country

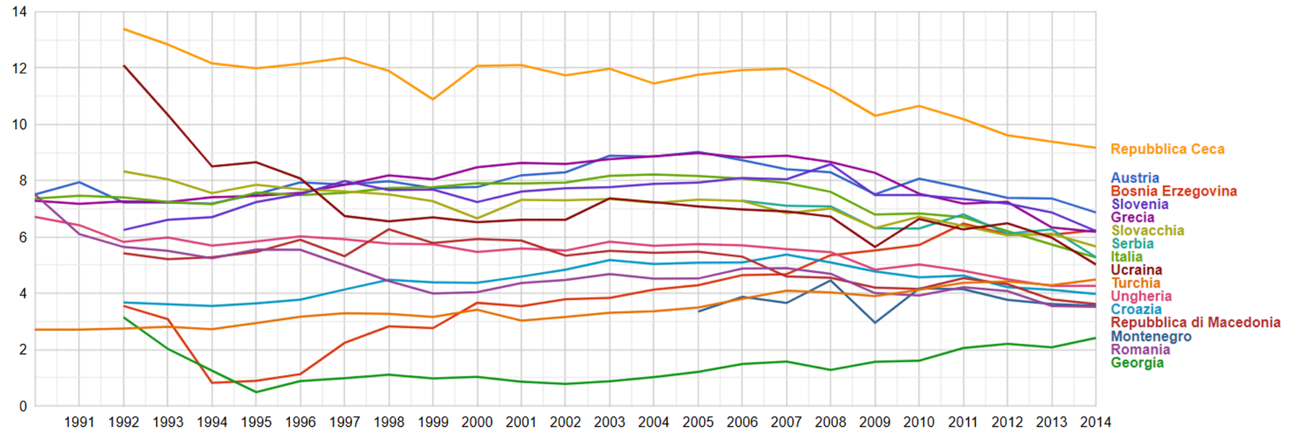
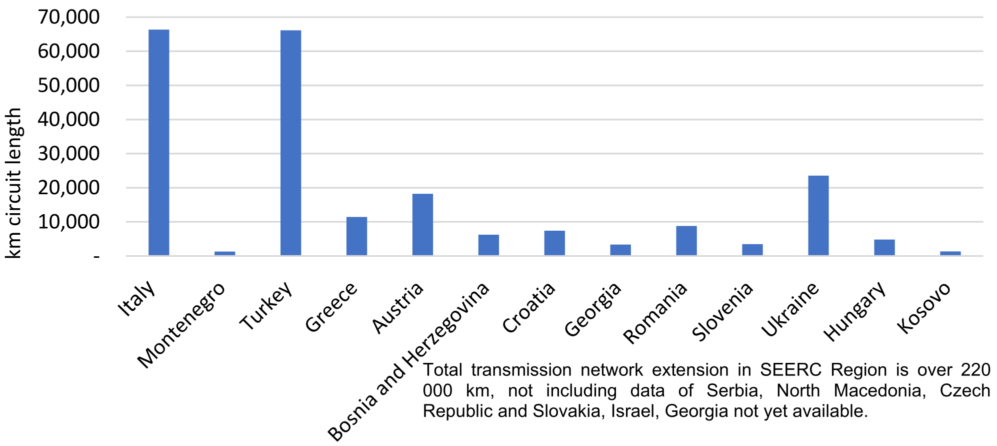
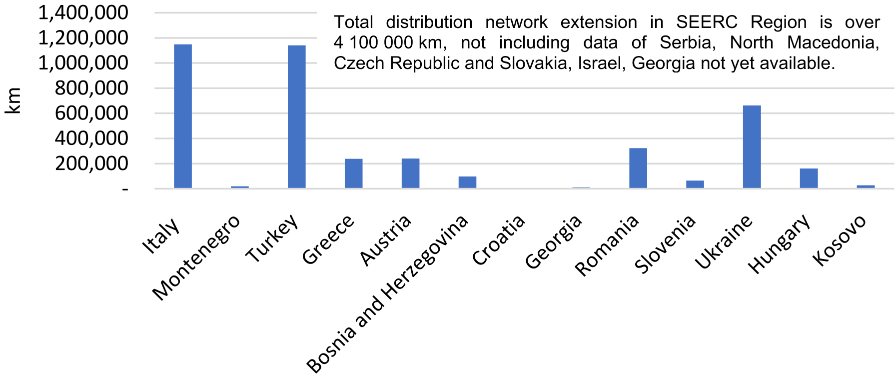


Fig. 4. CO_2 emissions (ton/capita) of each SEERC Country along the last three decades. Source: World Bank data (2014)



Total transmission network extension in SEERC Region is over 220 000 km, not including data of Serbia, North Macedonia, Czech Republic and Slovakia, Israel, Georgia not yet available.

Fig. 5. Transmission network extension (circuit km) for the year 2017, in terms of overhead line and underground/subsea cables (100–750 kV). Source: SEERC questionnaire



Total distribution network extension in SEERC Region is over 4 100 000 km, not including data of Serbia, North Macedonia, Czech Republic and Slovakia, Israel, Georgia not yet available.

Fig. 6. Distribution network extension (circuit km) for the year 2017 for voltage levels of 0. 4–100 kV. Source: SEERC questionnaire

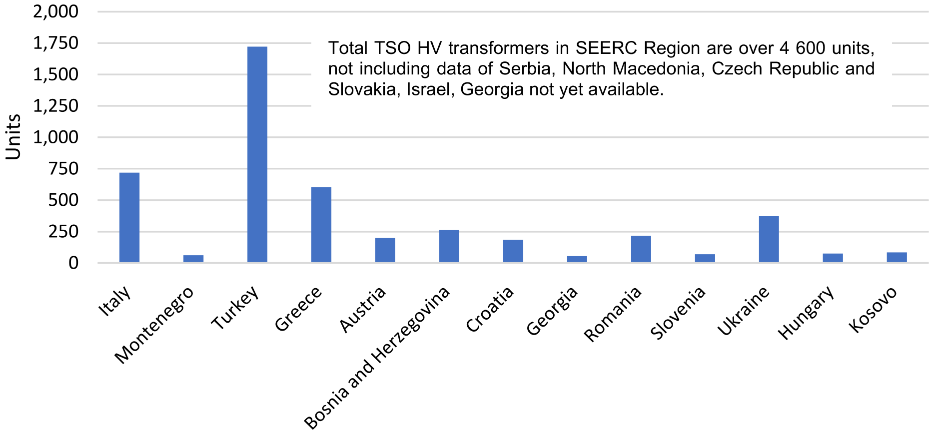


Fig. 7. TSO High Voltage transformer units for the year 2017. Source: SEERC questionnaire

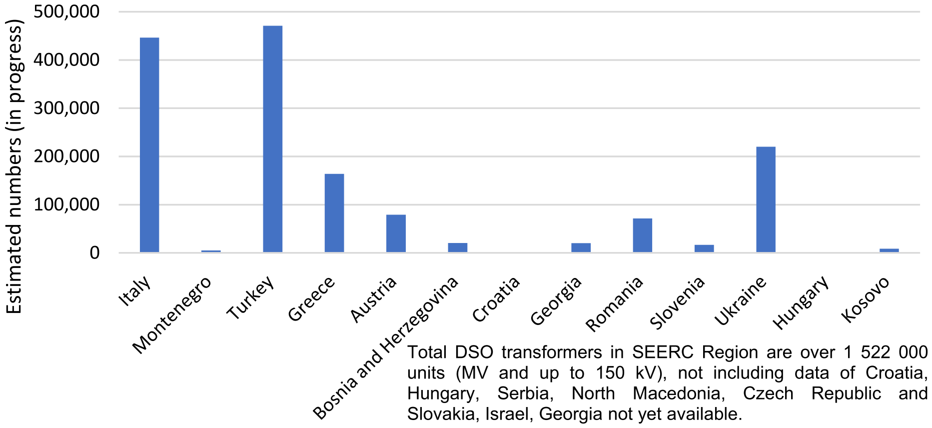


Fig. 8. DSO transformer units (MV and up to 150 kV) for the year 2017. Source: SEERC questionnaire

In the Transmission sector, 62 towers collapsed and seven transmission OHLs were out of operation, which amounts in 52 km or 1.9% of all OHLs. Complete restauration of assets lasted 3 months costing 8.5 million Euro but the recovering period for the energized Transmission network was much faster using Emergency towers in the meantime. In the Distribution sector, the level of damage was much higher, and amounted in 68 million Euro (917 km of MV and 655 km of LV networks, or together over 13% of the distribution network).

In 2015, the Slovenian electricity infrastructure was affected by severe wind events exceeding 200 km/h causing high level of damages in the transmission infrastructure. In the following years, more severe weather events were indicated, and utilities devoted more attention to defense activities considering new approaches.

In summary the lessons learned from recent years about weather conditions are:

- Design and construction of lines so far are not appropriate to climate change conditions, so the upgrading of standards is one of the first actions to be done,
- In the new framework of national normative aspects in EN standards (NNA) there are needs to increase reliability factors as well as increase numbers and values of icing zones,
- For distribution networks, new approaches with cabling the MV network were accepted, particularly in forests,
- Importance of Management guides in crises, and staff trainings are crucial.
- Communication assets improvement and well-organized cooperation with neighbouring countries are very important.

Large disturbances caused by unfavourable weather conditions are not predictable but by using new approaches, e.g. Artificial Intelligence (AI) it is possible to improve observability. How to do that will be explained in next chapter of the paper.

The past long-term experiences learned from frequent components failures caused by low material quality led to an early introduction of dedicated diagnostics to prevent excessive outages; from time-based diagnostics at the very beginning to condition based diagnostics and finally to diagnostics supporting reliability-oriented maintenance. Lightning arresters, instrument transformers, power transformers, OHLs, underground cables and rotate ding machinery were included in that customary defense program.

That was the reason for a much easier step forward while introducing enhanced procedure with the purpose to respect the new Network Code prerequisites and requirements.

Serbia in 2014 [5] Serbia experienced floodings in May 2014, with extreme thunderstorms in June 2014 and ice-storms in December 2014. All three natural disasters caused large damages and customers without energy supply in the Electric Power System of Serbia.

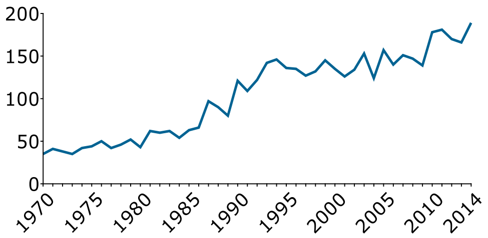


Fig. 9. Number of natural disasters [2] [4]

Fig. 10. Collapsed towers in Slovenia, February 2014

Fig. 11. Flooded coal-mine in Serbia with over 200 million cubicmeters of water

The extreme floodings in the area of one of the largest coal-mines Kolubara flooded five rotation excavators as well as other equipment as shown in Fig. 11. Two mining fields were flooded by over 200 million cubic meter of water. In the transmission network almost all substations of 400/220 kV were switched-off. In the distribution network, 40% of the substations were out of operation in the affected region. One month later extreme thunderstorms, which destroyed 17 OHL towers at 110 kV level, occurred. Lessons learnt were the need to upgrade the design approach for new OHL towers with approx. 20% higher wind intensity (126 km/h).

Fig. 12. Ice storm in Serbia, which caused horizontal icicles and collapsed 75 towers of 110 kV

The next natural disaster affecting the transmission network happened on the 1st of December 2014 with ice-rain see Fig. 12, which caused the outage of all substations in the eastern part of Serbia. Reduced load was evaluated to 20 MW. The TSO needed a lot of efforts to rapidly recovery the network. New modular "temporary towers" were used for "by-passing" the damaged parts of the affected lines. Experiences with temporary towers were very positive.

The importance of resilience planning and systematic analyses of preparation, sustainment of critical system operations and facilities for rapid recovery were underlined after all these events.

Italy in 2004 – 2018 [2] (4, 5, 6, 7 and 8)

The Italian report on resilience of the electric power system against natural hazards covers four main groups: ice-snow storms, saline pollution, high wind speeds and floods. For the last 15 years and considering only major events, following consequences of Energy Not Supplied (ENS) were evaluated:

- Ice storms (mostly wet snow) 5563 MWh
- Saline pollution 2043 MWh
- Wind speed/tornados 668 MWh
- Floods 142 MWh

The occurrences of outages of the network related to severe weather conditions, increased over time.

In 2015, due to the increase in extreme weather events, the Italian Regulatory Authority for Energy, Networks and Environment, mandated the TSO and all DSOs serving a minimum of 50.000 consumers to work jointly for the implementation of the first **National Resilience Plan (NRP)**. In March 2017 the Italian TSO (Terna) released the first edition of the NRP with following structure:

- Analysis of the extreme events of the last 15 years that have caused difficulties in the daily operation of the national transmission network,
- Definition of Resilience and consistent approach for its assessment based on a range of technical, economic and environmental indicators that play a role in the operator's decisions,
- The main technological solutions to improve system resilience and
- Description how the methodology is applied, and what the technical solutions are in each technical area.

Similar natural disasters have been reported from Italian distribution utilities.

Croatia in 2014-2018 [2] (2)

The Croatian transmission and distribution network has experienced similar natural disasters caused by ice storms in 2014. However, at a workshop Croatian experts reported about typical planning approaches for increasing resilience of

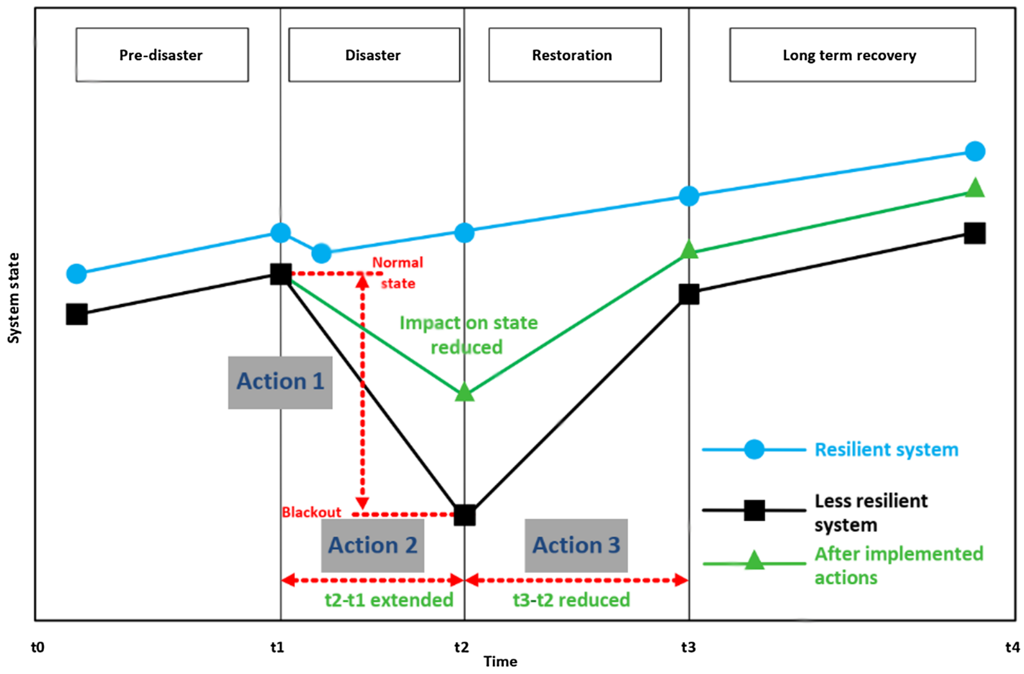


Fig. 13. Model of resilience planning approach in Croatian TSO

the grid in the western part of Croatia's transmission network (Istria). This part of the transmission network has a peak load in summer due to the touristic season and frequent overloads of the electrical network (double 220 kV line) due to thunderstorms. Better preparation on disaster management reduced restoration time effectively in a short amount of time. As a long term approach, new surge arresters and a strengthened grid with new connections reduced the outage rate on the critical 220 kV line further.

Montenegro [2] (9) The TSO from Montenegro reported a natural disaster in January 2014 with daily thunderstorms over 14 hours per day. The result of that was huge damages on six 110 kV towers. During reconstruction, the amount of ENS (energy not supplied) was about 500 MWh.

Greece [2] (3) In Greece reported natural hazards consist mostly of forest fires, snowstorms, landslides, floods, saline pollution. Preventive measures from saline pollution is, e.g. washing the insulators in distribution networks (see Fig. 14). Forest fires in Greece are reported in August 2007 and 2017 with large damages in the electrical network. Very severe floodings were reported in November 2017, which affected about 1500 customers.

Ukraine cyber threats [2] (12 and 13) In December 2015, December 2016 and June 2017 the Ukrainian Electric power system was attacked with cyber threats, which caused blackout in a part of the Ukrainian system.

The Consequences of the Cyber Attack were as follows:

- In December 2015, a cyber-attack happened on the informational infrastructure of three regions and as a result of unauthorized management of switches at distribution substations, a short-term disconnection of consumers of various categories occurred (about 225.000 customers were affected); The remaining part of the servers, workstations (dispatching control system) and the telecommunications network remained unworkable;

Fig. 14. Preventive insulators washing in Greece

- In December 2016, a cyber-attack on a 330 kV substation in the Kiev region occurred: As a result of unauthorized management of circuit breakers (330 kV, 110 kV, and AT 330/110 kV) the 330 kV substation was de-energized. Some regions of Kiev (145 MW load) and the Kiev surrounding region (58 MW load) were affected. Servers have been infected with malicious software.
- In June 2017, a cyber-attack was carried out on SCADA/EMS/AGC NEC "UKRENERGO": failure of the main system SCADA/EMS/AGC NEC "UKRENERGO"; 3 servers stopped working; the restoration of the system took 36 hours.

From the presented natural and human attacks on electrical infrastructure, it is evident that resilience issues play an important role in electric power systems of the SEERC region. Mechanisms, methods, tools and new innovative equipment for mitigate or avoid many presented examples have to be implemented in EPSs.

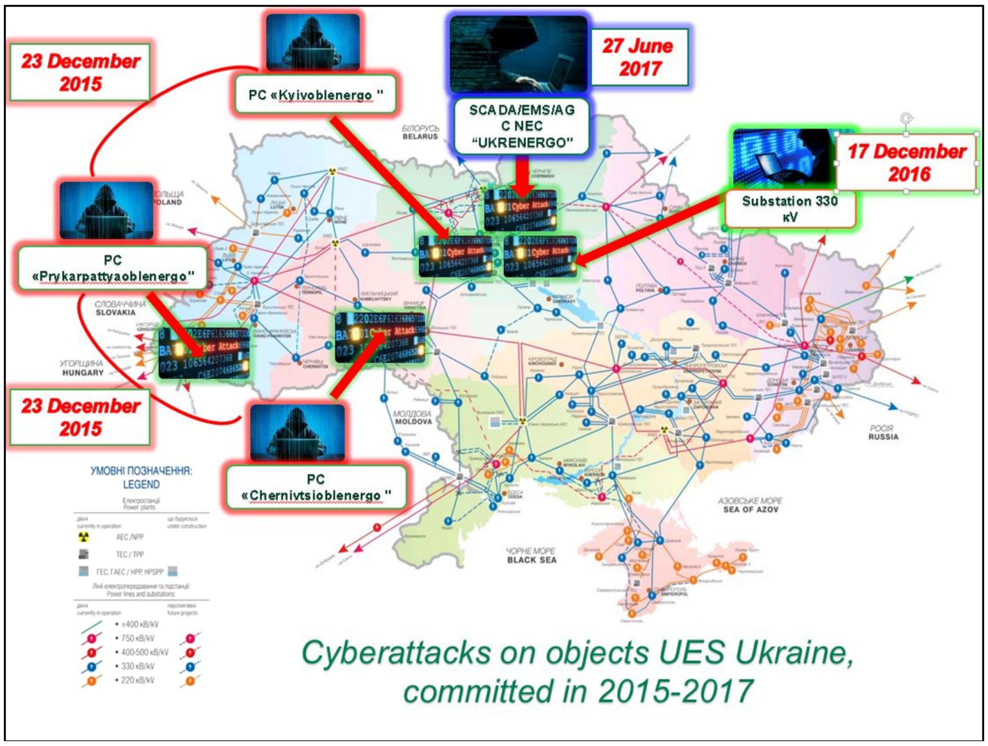


Fig. 15. Map of attacked substations in 2015-2017 in Ukraine EPS

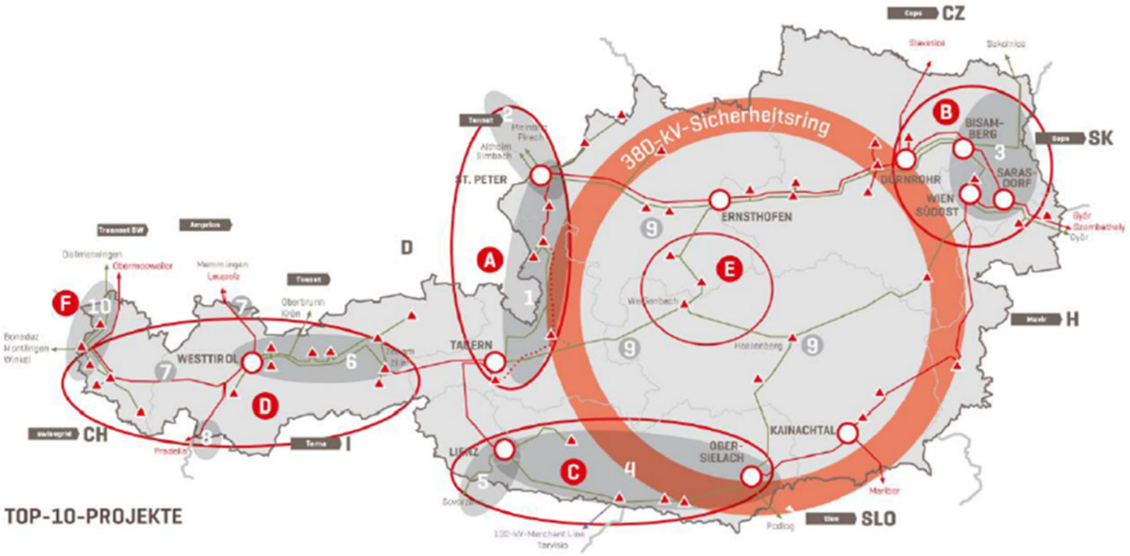


Fig. 16. Austrian plan for increasing resilience of grid with new investment projects (clusters A…*F*). Source: www.apg.at

4. Resilience, state of the art solutions

In the majority of countries of the SEERC Region, it is evident that a lot of work is done to strengthen and digitalize the national transmission and distribution networks with the aim to increase the resilience of system. Some state of art solutions are presented below.

Italy The following technologies for system strengthening and digitalization were introduced as measures for increasing resilience of infrastructure and assets [1]:

- Replacing existing conductors with upgraded components (for improving conductor mechanical characteristics)
- Undergrounding of OHLs (for immunization against environmental threats (ice, wind, …))
- System redundancy and meshing (building new interconnections)
- New tool ("WOLF Trasm") for remote monitoring and an alert system (to take appropriate preventive dispatching actions)
- Automatic N-1 simulation running periodically (in 15 minutes) in real time and DSA (to identify operational limits regarding loading and/or voltage…)

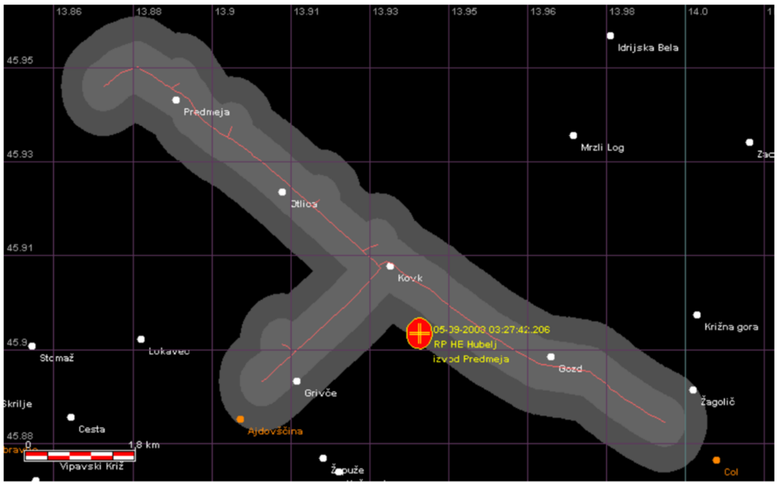


Fig. 17. An example of 20 kV line fault correlated with lightning on September 5, 2008 at 3:27:42.206

- Anti-rotational fittings for conductors (to prevent the rotation of conductors)
- Tree trimming (to reduce the possibilities of falling trees and branches into transmission lines),
- Install testing station for checking naturally polluted insulators,
- Hydrophobic coatings of conductors,
- Special recovery equipment,
- Fiber optic passive sensors for ice/snow overload detection of conductors
- Fault location sensors (digital protections).

Austria Due to the mountainous area of Austria and high ice loads the Austrian National Normative Annexes are rather strict when it comes to dimensioning towers and components. The experiences of the last decades show, that towers could withhold the severe weather conditions. With the current trend to digitalization of assets, which includes for example the introduction of Wide Area Monitoring and the usage of ice sensors in Austria, a more profound data basis allows analyses that are more detailed.

Another important step was the implementation of Dynamic Line Rating (DLR) in 2013, which also helped increasing the resilience of the grid operation. However, since DLR is weather dependant, it is essential not to rely solely on it when it comes to security of supply, but focus on reinvestments to the grid and refurbishment of old lines, as shown in Fig. 16.

Regarding cyber security, the Austrian system is obliged to fulfil the EU-Directive concerning measures for a high common level of security of network and Information system across the European Union.

Slovenia The Slovenian system implemented several measures to increase resilience of networks as:

- Improvements obtained with new design and better observability of the OHLs,
  - New standards and reinforcing of existing Transmission lines,
  - Introduction of OHL Surge arresters (LSA)
  - Improving observability of lightning flashes related with line failure data,
  - Real-time assessment and short-term forecast of network operational limits (SUMO)
- Weather forewarning system,

Fig. 18. Emergency towers

- Improved power transformer loadings system, and
- Use of emergency (modular) towers, showcased in Fig. 18

New standards and reinforcing of Transmission lines will strengthen components and resilience parameters.

Introduction of OHL Surge arresters to improve lightning performance of OHLs in regions with very intensive lightning activity and difficulties to achieve a good line grounding. The analysis to determine the number and the locations of LSA installations was achieved by using a computer tool, which became a standard practice in managing LSA applications in the country. The "Sigma slp" software is used to determine arrester installation configurations and computations of arrester energy duties. All statistical simulations are performed on the section of the line model represented by ten towers (without reflections from the section ends). The following data and representations are used when applying the tool Data gathered by the Lightning Localization System (SCALAR).

Improving observability of lightning flashes related with line failure data is another step forward which allowed the increased location accuracy of SCALAR Lightning Localization System. A usable correlation between SCALAR and SCADA gathered data became practically applicable.

Real-time assessment and short-term forecast of network operational limits (SUMO) was developed to care of network operation

Fig. 19. Steps to improve cyber security in Ukraine as descripted in R.2.12

in contingencies and in emergencies. The TSO encouraged experts to provide for a suitable method and tool facilitating the evaluation of the network operational limits. The preconception was initiated by knowing the use of Dynamic Thermal Rating (DTR), which covers the thermal assessment of components in the entire transmission system.

Weather forewarning system, Improved power transformer loadings system and Use of emergency towers all together supports increased level of resilience of transmission grid in Slovenia.

Montenegro The TSO approved recommendations to improve resilience of the grid by

- introduction of meteorological monitoring on the OHLs
- adoption of a new Rulebook for emergency
- harmonization of standards for designing and construction of OHLs with European (EN 50341)
- formation of a dossier of OHLs
- improvement of procurement procedures and installations of the missing elements of OHLs
- introduction of preventive measures such as security teams and analyze the possible consequences to the public.

Ukraine The Ukrainian EPS approved new structural solutions for technology in telecommunication networks as shown in Fig. 19:

- Building of technological telecommunication networks in the energy sector, fiber-optic communication lines (fiber optic lines) Optical Ground Wires OPGW were installed, which have already found wide application in several European countries
- Organization of dedicated communication channels between substations and dispatch centers
- Construction of a dedicated network for information exchanges of technological data, separate from the companies "office" network
- Use of the standard IEC 62351 on both nodes of information exchange
- Provision of centralized protection

New tendencies in the area of cybersecurity:

- protection should be comprehensive, structured and focused on ensuring the "sustainability" of the energy system and its components
- protection should be not only for the perimeter of critical infrastructure objects, but also for the devices themselves like controllers, internal local networks
- digitalization with use of artificial intelligence plays an increasing role in cyber defense

5. Conclusion

In conclusion, increasing the resilience of the Electrical Grid is a global topic that can only be solved in cooperation. The South-East European Regional Council of CIGRE (SEERC) stimulates the discussion and the exchange of experiences between members in Region.

A significant portion of the OHLs all around the world were designed and built around 30 to 60 years ago according to the design standards at that time. The increase of severe weather conditions, which affect overhead lines, require new approaches in designing, monitoring and planning to successfully enhance the resilience of the grid.

To achieve this, it is important to evaluate the National Normative Annexes (NNAs) of the European standardization for each country to cope with the possibly more volatile weather conditions for long-term climate predictions. This could also mean to strengthen and oversize components or towers to strengthen the grid for unforeseeable conditions. Emergency plans need to be put in place in case of further natural or human attacks. Digitalization of the grid with monitoring systems, sensors, etc is another approach to make the grid more resilient. In times of interconnected substations and digitalization it is essential to have a strategy against cyber attacks. Also, it is important to improve current weather models to get more reliable forecasts. For lower voltage levels using underground cables is also a good approach to prevent damages from severe storms. However, this is not advisable e.g. for high voltage lines or mountainous areas with landslides. Decisions must be taken on a case by case basis.

Our experiences led us to the conclusion that the assets have to withstand increasingly severe stresses due to climate change while maintaining reliable operation.

Grid operators need comprehensive information of the grid's status to ensure proper handling of emergency situations. The help of new, innovative technologies in the telecommunication and information sector offer new opportunities in grid operation and control. In the upcoming years even more innovative solutions are to be expected. The introduction of new assets will change the power system structure and create the need for more advanced automation, control and protection systems. More flexible system operation will produce unsteady loads and is therefore expected to speed up the aging process of assets.

Therefore, an enhanced approach in monitoring of assets' operational stresses, the careful design, erection as well as maintenance is needed.

The work within SEERC signifies a way to strengthen international cooperation between neighbouring countries with similar weather conditions, share best practice examples and find solutions for a secure and reliable electricity supply.

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