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SELF-ASSESSMENT IN THE ELECTRICITY SUB-SECTOR

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Abstract

The critical infrastructure (hereinafter referred to as CI) is a complex unit made up of a plurality of elements, which are mutually connected. CI covers processes, systems, equipment, technology, to ensure the functioning of the state in and civil society. In society, you need to make every CI element working. The failure of the CI element can lead to disruption of the functioning of the relevant sector, for example, transport, energy, industry, which can lead to disruption of basic service delivery. A serious outage would have a negative impact on society. The most important sub-sector of CI is the electricity sub-sector. The current life of citizens and the functioning of the company is dependent on the supply of electric energy. Since the year 2013, the electric energy is considered a unique critical sector in the framework document PPD-21. Increasing the security of the elements incorporated into this subsector can be achieved by increasing the level of resilience. Increasing the level of resilience of elements can be achieved through self-assessment by operators. Self-assessment can analyze the current situation and give answers to the questions addressed.

Keywords: *infrastructure, private sector, public sector, resilience, electrical energy, critical infrastructure.*

1 INTRODUCTION

Critical infrastructure security issues and the protection of CI elements themselves are closely linked to resilience issues. (Dvorak, Leitner, & Rehak, 2019) Resilience is more closely related to maintaining the element's essential functions in the event of an adverse event. Resilience development began in 1973 in the work of Holling and continues to this day. In the case of the protection of elements incorporated into the electricity sub-sector, it is necessary to concentrate on the self-assessment of durable axes. Self-assessment of resilience is directed primarily to know the current state of the object and the achieved level of resilience. The self-assessment should analyze the current level of adaptability, robustness, and renewability at the beginning of the process. By the self-assessment of resilience, the operator can reveal problems that are required to be solved and can involve external entities. In the case of finding larger deficiencies, external entities can be called to address the situation.

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2 RESILIENCE OF CRITICAL INFRASTRUCTURE

The contemporary world is facing many threats arising from the various processes taking place in nature and society. The natural and anthropogenic threats facing society so far have had widespread consequences that negatively impacted the functioning and life of the affected country. Alternatively, we meet and the cases in which the consequences have also hit neighboring countries. Therefore, it is necessary to focus on building robust systems. Resilient systems will make it possible to reduce the likelihood of an adverse event and, where appropriate, allow the system to respond effectively if the adverse event occurs.

The concept of resilience, respectively. Resilience is often used in various scientific disciplines, such as psychology (Patterson & Kelleher, 2005), the economy (Hallegatte, 2014), in medicine (Lecklin & et al, 1996), environmental science (Stip, Mao, Bonzanigo, Browder, & Tracy, 2019) and in the field of security (Rehak, Senovsky, Hromada, & Lovecek, 2019).

The term resilience was first defined in 1973 by C. S. Holling. In the context of the examination of the resilience and stability of ecological systems. Holling understands resilience as a characteristic of a system that results in the persistence or likelihood of extinction of the environmental system. In his work, he mentioned the relation to resilience; resilience determines the stability of interrelationships in the system and is a measure of the ability of these systems to absorb changes in the state of variables, control variables, and parameters and to remain in that state. (Holling 1973)

In general, resilience means the ability to adapt to "normal", foreseeable, or unexpected adverse events. (Zubieta, 2013)

As regards approaches to resilience, each author has taken a specific stance on the explanation of this concept. In his study on food security, Maxwell (1996) understood resilience concerning "resilient households", which are affected by adverse events but can recover quickly.

Barnett (2001) in his scientific publication on adaptation to climate change in Pacific island countries defines resilience as a problem of uncertainty. He stressed resilience as a key ability of the country to cope with uncertainty and surprising events while maintaining the overall balance of the system. Barnett argues that resilience is about learning from the mistakes that have occurred and returning to equilibrium in a better form that will be ready for future adverse events. Resilience is, according to Barnett, an integral part of the development of adaptation capacity. Resilience is most often manifested in response to impacts that are basically negative, but a company that is flexible and able to recover quickly can take advantage of all the positive opportunities that might arise for the future. (Barnett 2001)

Manish Bapna (2009), with a team of authors, addressed in their publications the priorities of rural poverty in a changing climate. Their publication focused on the problem of the rural population related to the changing climate, which has a negative impact on the functioning of ecosystems. They focused on increasing the resilience of the population, focusing on their property and income so that they could adapt and face the challenges of climate change. Resilience is the ability to manage stress or recover from disorders. Resilience in the context of rural dependent communities consists of ecological, social, and economic resilience. (Bapna, McGray, Mock, & Withey, 2009)

Allen, Macalady, Chenchouni, D. Bachelet, and others (2010) claim that resilience has two main variants. One variant is so-called "engineering resilience". It is the ability of the system to return to equilibrium after failure. It focuses primarily on efficiency, consistency, and foresight. It is a concept where engineers try to develop optimal safety designs in the event of a system failure. The second variant is called "environmental resilience". This is the amount of disturbance that can be absorbed before the system; it predefines its structure by changing the variables and processes that control behavior. It focuses on conditions outside the steady state where instability can change, transform, the system to another mode of behavior. Both options deal with aspects of system equilibrium stability and offer alternative measures for the system to maintain its functions even in the event of a failure. (Allen, Macalady, Chenchouni, D. Bachelet, & et al, 2010)

2.1 Assessment resilience of critical infrastructure

When examining the issue of resilience and the way of evaluation, it is necessary to analyze several information sources that can provide new ideas and ideas. Approaches to resilience evaluation are different. Part of the evaluation is usually a combination of quantitative and qualitative methods that allow quantifying the level of resilience of the evaluated object. In practice, the issue of resilience evaluation is addressed as follows.

The issue of CI resilience has attracted many authors who have started to address it in various contexts. Luiijf and Klaver (2019) in relation to resilience focus on resilience access to information relating to CI. In their scientific publications, they discuss a new social risk related to the use of information and communication technologies and operational technologies. It is this technological advancement that represents a new risk related to cybersecurity for critical infrastructures, essential services, and society. The authors argue that the current national approaches to protection mainly focus on the telecommunications sector and critical sectors and, as such. energetic on, health care, transportation in, etc. To properly deal with cyber threats, it is necessary to apply the appropriate procedure to address these risks, and that before there is a serious incident. A new approach is needed to increase the resilience of society in general. (Critical infrastructure, 2018)

Virendra Proag (2014) devoted itself to assessing and measuring CI resilience in her Assessing and Measuring Resilience. In her publication, she displayed a list of infrastructure systems that affect everyday life, drawing attention to resilience issues. A quick overview of resilience can be obtained by examining cases where infrastructure has been roads, hospitals, disrupted by adverse events, e.g. flooding. The robustness of the system depends in part on its features or those built into the system. To define, quantify and overall design to improve resilience, Proag (2014) introduced features such as absorption, adaptation, and recovery. In the paper, the author also mentions steps for the evaluation of the resilience of socio-economic systems, e.g. defining the system - understanding the system components and how resilience affects the system, resilience assessment - identifying the recovery path and performing recovery using models, etc. It also presents indicators within individual infrastructures e.g. emergency services - number of lives saved, telecommunications - number of interrupted phone calls, and others. The publication includes a quantitative and qualitative evaluation of resilience. When quantitative assessment addresses the effectiveness of resilience (Resilience efficiency) and in qualitative evaluation is conducted risk analyses reveal the sources of risk.

The assessment of the resilience of the CI food and agriculture sector was dealt with by Meuwissen et al. (2019) with a research team consisting of authors from different European countries who created the framework for assessing the resilience of agricultural systems. The article “A framework to assess the resilience of farming systems” dealt with the growing economic, environmental, and social threats facing the agricultural system in Europe. The authors have created a framework for assessing resilience, focusing on three systemic capacities that are critical to understanding the resilience of agricultural systems: robustness, adaptability, and transformability. For the frame, see Fig. 1, it consists of 5 steps, wherein steps 1 to 5 deal with specific resilience, while steps from 5-1 focus on general resilience.

The basis for the elaboration of step-by-step methodological steps was the just defined framework. The individual steps made it possible to compare analyzes between several cases examined. The methodology consists of a mixed-method approach that includes quantitative methods (statistics, econometrics, and modeling) qualitative methods (interviews, workshops providing stakeholders with more detailed information). (Meuwissen, et al. 2019)

In the publication Complex Approach to Assessing Resilience of Critical Infrastructure Elements, Rehak, in collaboration with several authors, focused on a comprehensive approach to assessing the resilience of CI elements. Resilience was perceived as a quality that makes it possible to reduce the vulnerability of a KI element, absorb the effects of adverse events, increase the ability of the element to respond and recover, allowing it to adapt to negative events similar to those that occurred in the past. The paper presents the CIERA methodology, which is designed to evaluate the resilience of CI elements in the Czech Republic. CIERA methodology can be applied in various technical branches. (Rehak, Onderkova, & Brabcova, 2019)

These approaches were mainly focused on static resilience evaluation. When dealing with resilience, it is necessary to mention not only the static resilience evaluation but also the dynamic aspect of the resilience evaluation.

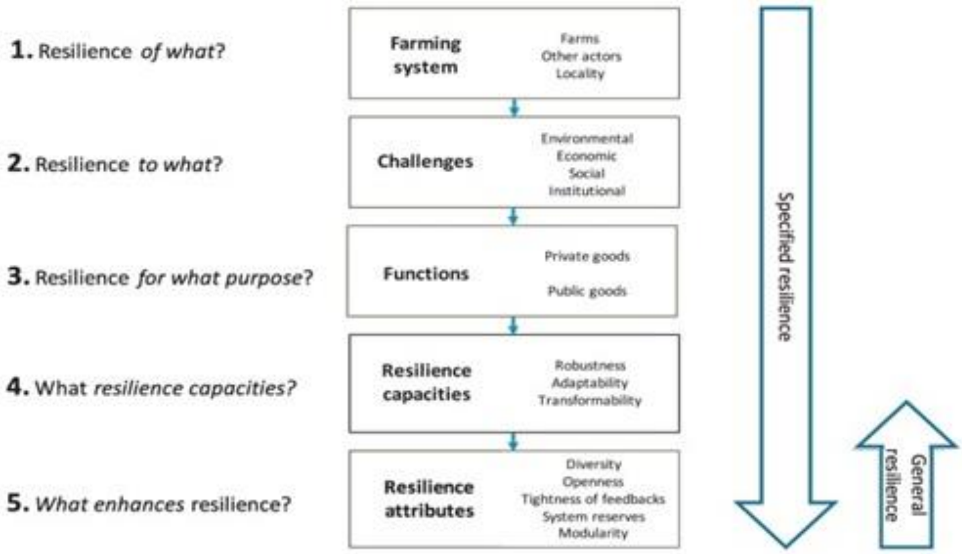

Fig. 1 Approach to assessing the resilience of agricultural systems (Meuwissen, 2019)

Zinetullina et al. (2019) in the article Dynamic resilience assessment for process units operating in Arctic environments. The study aims to develop a method of a quantitative assessment of the resilience of processing units operating under arctic extreme conditions. They use Dynamic Bayesian Network (DBN) to model probability relationships between causes and consequences. The proposed method for assessing dynamic resilience:

- identify absorption, adaptation, and recovery parameters,
- creating a butterfly diagram,
- mapping of butterfly diagram by DBN,
- estimate the likelihood of system reliability states using the DBN model,
- develop a dynamic resilience curve,
- revise the design of the processing system to increase resilience,
- assess the robustness of the system and compare it with the previous durability curve.

The proposed approach will contribute to the detection of critical operating parameters under extreme conditions for production units. It also helps to identify potential areas where improvements are needed to increase process safety. (Zinetullina et al. 2019)

The project Dynamic Assessment of Resilience of Corresponding Critical Infrastructure Subsystems was established in the Czech Republic. The project was supported by the Security Research of the Ministry of the Interior of the Czech Republic. The group of authors Martin Hromada, David Rehak, Pavel Fuchs, Tomas Apeltauer, Petr Hruza, Michal Bil, Vit Stritecky, Zdeněk Dvorak and others participated in the work. The project focused on the dynamic evaluation of the correlation of European major sectors (i.e. energy, transport, information, and communication technologies) and their elements. The project should include a description of the synergic effect of the failure of these systems and their impact on impact assessment and the establishment of a dynamic assessment of CI resilience. The practical part of the project was aimed at creating a system for identifying key elements of land transport infrastructure, critical infrastructure in the energy and ICT sectors in the context of their correlation, and in relation to the crisis preparedness of territorial units (Resilience 2015-2019). This project involved the processing of several publications. One of them is the Determinants of Dynamic Resilience Modeling in Critical (Rehak, Onderkova, & Brabcova, 2019). The authors claim in the publications that immunity is an important factor in protecting IC elements from the adverse effects of adverse events. The higher the level of resilience, the longer the element can withstand adverse events. The resilience depends on the duration of the adverse event acting on the element. The longer an adverse event affects the object, the lower the level of immunity. Dynamic resilience allows you to capture changes in resilience when it is exposed to negative factors. The publication deals with the issue of modeling the dynamic resilience of the CI element. The authors pay attention to the factors influencing the resilience of CI elements and the nature of adverse events. Factors define the basis for dynamic resilience modeling. (Rehak, Onderkova, Brabcova 2019)

2.2 Proposal process of self-assessment of resilience

The resilience research carried out by the author represents a way to increase the resilience of critical infrastructure elements. Each element demonstrator should focus on self-assessment when determining the level of resilience. Through the internal information on the operation of the element, it should be able to carry out a self-assessment of resilience, which would lead to the detection of errors and the consequent adoption of adequate measures. Self-assessment would save operators the many costs needed to perform analyses to identify deficiencies in processes and safeguard the element. The self-assessment could be carried out based on a set structure. The following issues would be addressed in the structure:

- The resilience of what?
- Resilience to what?
- Purpose of resilience testing?
- Method of resilience evaluation?
- How to increase resilience?

The content of the answers to the questions asked would include a description of the selected sector to which the element belongs, a description of the threats, a description of the areas, a description of the resilience components and, consequently, resilience measures. The entire structure can be seen in Fig. 2.

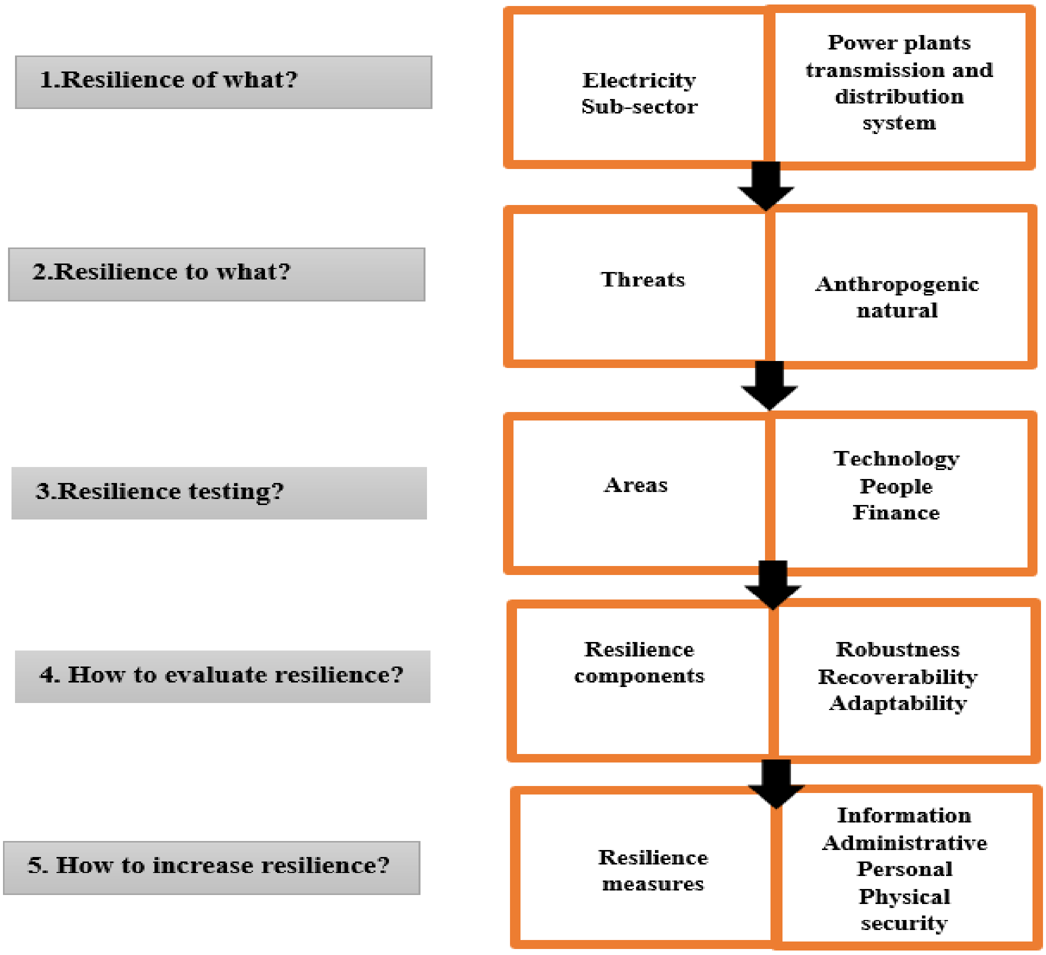

Fig. 2 Resilience self-assessment structure

RESILIENCE OF WHAT?

Characteristics of the relevant area to which the element to be assessed including a detailed description of the critical infrastructure element concerned. Describe the internal and external processes that take place on the board. Based on the evaluation, this section may focus on a general description of the e.g. subsector.

RESILIENCE TO WHAT?

The current fast development of society brings many adverse factors that may endanger the operation of the CI. This part should be oriented on the identification of threats of natural and anthropogenic character. Identification can be done, for example, through a checklist that will be evaluated by several evaluators. Subsequently, the results from the checklist can be shown in a graph, see Fig. 3.

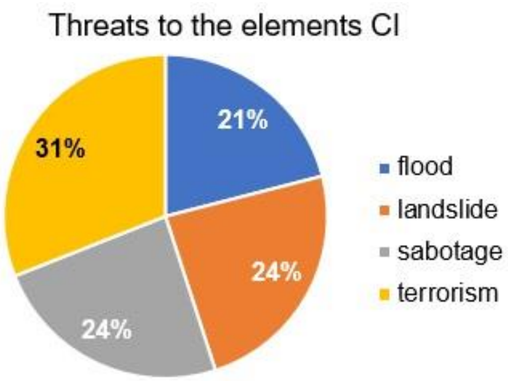

Fig. 3 graphical response display

RESILIENCE TESTING?

Step 3 is intended to determine the purpose of the immunity study. The purpose of the resilience study is to reconsider the security of the individual components in the specified areas that are in each element. Based on the CIERA methodology, the following areas have been identified:

- technology,
- people,
- finance,
- activation of measures.

All these areas have an impact on the level of resilience. To efficiently quantify the resilience, it is necessary to know the technologies and technological processes that take place in the assessed power plant. It is also necessary to know the way of training and education of workers in the building, providing financing in case of breakdown, how the measures are carried out, because all activities taking place in the electricity building may have deficiencies, which are a source of the unwanted event or a factor reducing resilience. Individual areas will be reviewed as part of the established static resilience assessment procedure.

HOW TO EVALUATE RESILIENCE?

CIERA methodology from the Czech Republic is an excellent starting point for the self-assessment of resilience. The methodology is designed for the complex determination of a static level of resilience. The self-assessment of resilience would result from its three components, which are shown in Fig. 4.

Fig. 4 Basic resilience components

Self-assessment would consist of evaluating the individual indicators in the relevant components. Subsequently, indicators would be assigned values from 0-3 based on the representation of the indicators for the component. The areas would be

evaluated based on the established scale, see Fig. 5 and Fig. 6.

Electrical distribution			
Ro	**Re**	**A**	**Resilience**
3	3	1	7
3	0	0	3
2	2	1	5
2	2	2	6
2	0	1	3
2	1	0	3

Fig. 5 Resilience self-assessment

THE LEGEND	
RESILIENCE LEVEL	
7-9	higher level
4-6	medium level
1-3	low level

Fig. 6 Resilience levels

HOW TO INCREASE RESILIENCE?

Through self-assessment of resilience, it is possible to identify weaknesses in individual areas and take appropriate measures to increase the resilience of individual components. Measures that would aim to increase resilience will be applied in the 4 areas shown in Fig. 7

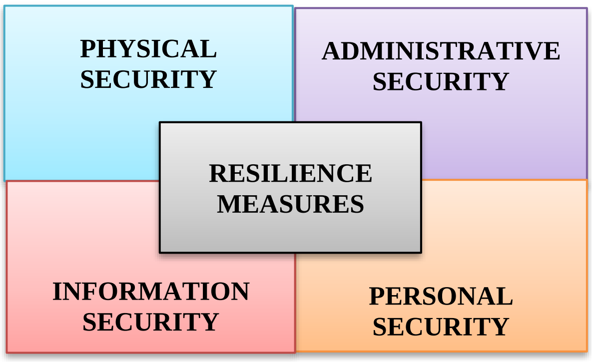

Fig. 7 Displaying security areas

The sets of measures are always prepared in real-time for a specifically selected object, based on the results of the self-assessment. In the area of administrative security, measures are usually directed at organizational processes. Information security needs to be improved through technical and organizational measures directed at its employees. Personnel security requires measures especially in the area of selection and education of people. Physical security measures need to be directed towards effective, time-based solutions.

3 CONCLUSIONS

Research on the resilience of energy systems and infrastructure is currently focused on an in-depth analysis of the various variables of robustness, adaptability, and renewability. The research reveals new areas of technical security and organizational security of energy systems and buildings. Today, electricity is considered a subsystem whose functionality affects dozens of other subsystems. The uninterrupted power supply is crucial for the life and functioning of modern society. In the case of short-term outages or long-term blackouts, the life of the whole company will gradually become more complicated. Production, transport, service provision, and state functions will stop. It is, therefore, necessary to look for new methods and procedures to increase the resilience of the electricity industry.

WORKS CITED

Allen, C. D., Macalady, A. K., Chenchouni, H., D. Bachelet, N. M., & et al. (2010). A global overview of drought and heat-induced tree mortality reveals emerging climate change risks for forest. *Forest Ecology and Management*, 660-684.

Bapna, M., McGray, H., Mock, G., & Withey, L. (2009). *Enabling Adaptation: Priorities for Supporting the Rural Poor in a Changing Climate.* Washington DC: WRI Issue Brief. World Resources Institute (WRI).

Barnett, J. (2001). Adapting to Climate Change in Pacific Island Countries: The Problem of Uncertainty. World Development. 29, p. 977-993, ISSN: 0305-750X

Critical infrastructure [online]. European Commission, 2018. Available from: https://ec.europa.eu/home-affairs/what-we-do/policies/crisis-and-terrorism/critical-infrastructure_en.

Dvorak, Z., Leitner, B., & Rehak, D. (2019, July 15). Critical Infrastructure Protection Specifications in the Transport Sector. (Z. Cekerevac, Ed.) MEST Journal, 7(2), 31-40. doi:10.12709/mest.07.07.02.04.

Hallegatte, S. (2014). *Economic Resilience : Definition and Measurement. Policy Research Working Paper; No. 6852.* Washington, DC: World Bank. Retrieved from https://openknowledge.worldbank.org/handle/10986/18341

Holling, C. S., (1973). Resilience and Stability of Ecological Systems. Annual Review of Ecology and Systematics, 4, pp. 1-23. [online].Available from: https://www.zoology.ubc.ca/bdg/pdfs_bdg/2013/Holling%201973.pdf.

Lecklin, T., & et al. (1996). Effect of temperature on on the resistance of individual red blood cells to flaw through cappilary-sized apertures. *Pfluger arch*, 753-759.

Luiijf, E., & Klaver, M. (2019). *Resilience Approach to Critical Information Infrastructures: Theories, Methods, Tools and Technologies.* Springer, Cham. doi:10.1007/978-3-030-00024-0_1

Maxwell, J. A. (1996). Qualitative research design: An interactive approach. *Applied social research methods series, 41*.

Meuwissen, M. P. M., et al. (2019). A Framework to assess the resilience of farming systems. Agricultural Systems, 176, pp 1-10. ISSN: 0308-521X

Patterson, J. L., & Kelleher, P. (2005). *Resilient school leaders : strategies for turning adversity into achievement.* Alexandria, Va.: Association for Supervision and Curriculum.

Proag, V. (2014). Assessing and Measuring Resilience. *Procedia Economics and Finance, 18*, 222-229. doi:10.1016/S2212-5671(14)00934-4

Rehak, D., Onderkova, V., & Brabcova, V. (2019). Determinants of Dynamic Resilience Modelling in Critical Infrastructure Elements. *Proceedings of the 29th European Safety and Reliability Conference* (pp. 3314-3319). Hannover: European Safety and Reliability Association. doi:10.3850/978-981-11-2724-3_0070-cd

Rehak, D., Senovsky, P., Hromada, M., & Lovecek, T. (2019). Complex approach to assessing resilience of resilience of critical infrastructure elements. *International Journal of Critical Infrastructure Protection*, 125-138.

Stip, C., Mao, Z., Bonzanigo, L., Browder, G., & Tracy, J. (2019). *Water infrastructure resilience: Examples of dams, wastewater treatment plants, and watersupply and sanitation systems.* Washington, DC: World Bank.

Zinetullina, A., et al. (2019). Dynamic Resilience Assessment for Process Units Operating in Arctic Environments. Safety in Extreme Environments. [online]. Safety in Extreme Environments. 1-19. DOI: 10.1007/s42797-019-00008-3

Zubieta, L. L. (2013). *Resilience Framework for Critical Infrastructures.* Donostia - San Sebastian: tecnun Universidad de Navarra.

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