

Article

Emergency Board Management as a Tool for Strengthening Resilience of the Electric Power Industry: A Case Study in the Czech Republic

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Abstract: The study addresses the topic of disasters associated with the electricity sector in relation to strengthening its resilience as one of the basic elements of critical infrastructure. One of the important tools for the management of risks associated with the electricity sector is the activity and functioning of emergency boards, which are used during large-scale disasters. At the emergency board meeting, the current situation and the expected development of the event are assessed, possible solutions are proposed, and decisions are taken to coordinate activities at the strategic management level and to plan the disaster management process. Decision-making processes in the emergency board are often characterized by a high level of uncertainty in the incoming information. The case study and the research conducted are focused on the specific conditions of the Czech Republic. The purpose of the study is to assess the level of development of crisis-management plans with an emphasis on the electricity sector within the individual regions of the Czech Republic as a basic tool to strengthen the resilience of the electricity sector. Furthermore, it was examined whether there are standardized procedures for dealing with individual types of crisis situations and whether they are used as basic methodological support for the emergency board. This part of the investigation focused on a detailed examination of the use of each type of crisis situation in the conditions of the region. For the implementation of the actual investigation, general methods were used—analysis, synthesis, induction, deduction, and feedback methods. Furthermore, the questionnaire survey method was used to obtain information from crisis managers at the level of regions in the Czech Republic who are usually members of the emergency board. The sparse-scale evaluation method and Pareto analysis were used to process the information obtained. The survey itself yielded a large amount of interesting information on the level of processing of individual procedures for crisis situations, especially in relation to the electricity sector. Furthermore, the types of individual crisis situations were identified, where the procedures for dealing with them were processed with detailed analysis and details, and, on the contrary, disasters that are processed in a minimalist way.

Keywords: electricity; resilience; emergency board; crisis management; decision-making process; population protection



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1. Introduction

The daily life of society can be exposed to many security risks. Some of them are visible at first sight, but there are also some that are hidden and can have a significant impact on security breaches [1]. Large-scale power outages are also a significant risk; they can have a noticeable impact on society and on the economy of any state and impact individual lives. Electricity is one of the most important forms of energy. It can be easily converted into motion energy, thermal energy, light energy, and transmitted over long distances. Modern human society is increasingly dependent on the supply of electricity [2]. A prolonged outage can do great damage to modern civilization and disrupt the functioning of the state.

Emergency boards are used by law to deal with a variety of very serious emergencies (that is, crisis situations), which differ from “ordinary” emergencies mainly in their scale and impact. According to Rosenthal [3], a crisis is generally characterized by three features: severe and highly unpredictable impacts, high uncertainty, and the need to take decisions quickly. It is also necessary to reflect on the activities of the emergency board in relation to selected disasters in the electricity sector, where these activities are one of the elements of the resilience of society. Depending on the extent of the emergency, an adequate level of response management is chosen [4]. For example, a single firefighting unit is usually sufficient to manage a forest rake fire, which is managed at the scene by its commander. If the fire spreads to a part of the forest, the incident is managed by several fire-protection units under the command of the incident commander with his staff. If a large-scale forest fire occurred (e.g., such as those in California or Australia or in the Czech Republic in the Czech Switzerland National Park), the units would number in the dozens, and the emergency board of the municipality with extended powers, the region or even the Central Emergency Board would be engaged. These emergency boards would coordinate the activities needed to deal with such a fire and the activities collectively known as population protection.

According to the National Action Plan for Adaptation to Climate Change [5], the number of major emergencies that arise independently of human will and fault is expected to increase, in particular, “prolonged droughts, floods and flash floods, rising temperatures, extreme weather events and natural fires”. All these phenomena pose a challenge to the resilience of the electricity sector. Swartz [6] reminds us that current trends in technology, population changes, health care, ethnic conflicts, etc. may be setting up “inevitable surprises” that can be largely anticipated. Therefore, it is very likely that there will be events in the foreseeable future with large affected areas and resulting in many affected people [7]. Such events are characterized by a highly uncertain evolution of the situation [8], which places increased demands on those proposing to deal with the situation at the strategic level—members of the emergency boards. They must deal with many unexpected and original situations [9]. The common denominator of their decision-making processes is the lack of input information, which is often incomplete, not taken in the right order, and is hidden in redundant or false messages, and the possible serious consequences of each decision [10]. In addition, it must be considered that these are people who may be tired of long-term activity, stressed by the situation, and worried about their loved ones or their politically exposed superiors [11].

In the international environment, according to the research of the authors, no case study has been published that focuses on the activities of emergency boards according to the level of elaboration of plans for dealing with crisis situations and regarding disasters in the electricity sector. In the literature, sources can be found that mainly address the topic of interruptions in the power grid due to stability, loads in the distribution network, and manipulations in the transmission system [12–14]. Other authors focus more on possible causes, prevention of crisis situations [15–17], resilience, optimization, and risk management in society with respect to possible social and economic impacts [18–20].

The research gap in the addressed area can be characterized as an unexplored multiplicative relationship between disasters: disruption of critical infrastructure in the field of electricity, management of crisis staffs, strengthening resilience by the chosen perspective of prepared plans, and standardized procedures as the basic methodological support of crisis staffs. The purpose of the study is to evaluate the level of development of crisis management plans in individual regions of the Czech Republic as a basic tool for the activities of the emergency board. It presents standardized procedures for dealing with crisis situations as a means of increasing the resilience of the territory, including the electricity sector. Furthermore, it was examined whether these procedures for dealing with individual types of crisis situations are used as basic methodological support for the emergency board. This part of the investigation focused on a detailed examination of the use of each type of crisis situation in the conditions of the region. The elaboration is defined as a case study that focuses on the territory and conditions of the Czech Republic.

2. Materials and Methods

During this research, the general methods of analysis, synthesis, induction, deduction, and the feedback method were used. Emphasis was placed on inductive methods, the basis of the thesis being the use of qualitative research.

To obtain basic information, we used the method of researching sources, especially legal regulations, specialised literature, Internet servers, and our own experience. Subsequently, the data were analysed to establish the basic data required for the thesis. Qualitative research explores real-world problems, using mainly an inductive style of thinking [21].

The general research methods according to [21] include, in particular:

- Analysis (“The conceptual decomposition of the phenomenon under study into sub-components that become the subject of further investigation. The aim of analysis as a decomposition method is to explain a given problem by examining its components in detail” [22]);
- Synthesis (“The idea of combining parts into a whole. In synthesis, the essential connections between the individual components of a phenomenon or object are observed” [22]);
- Induction (“The examination of an individual event (phenomenon, fact) on the basis of which a general conclusion is then drawn” [22]);
- Deduction (“A method by which an inference is drawn from a general individual”, [22]);
- Comparison (“It is one of the most widely used scientific methods of work. It allows one to determine the correspondences and differences of phenomena or objects” [22]);
- Specification (“Allows the subject of a given class of subjects to be distinguished from other subjects of the same class” [23]);
- Analogy (“Analogy is based on the relationship of similarity of the objects being compared. Similarity enables one to compare the objects in question and to draw conclusions” [23]).

2.1. Questionnaire Survey

A questionnaire survey is a form of research that collects the required information from the respondents and must meet the following principles [24]:

- Use simple and clear questions (avoid confusion);
- Avoid ambiguity of content;
- Minimise long questions;
- Avoid overly terse questions;
- Avoid prejudices;
- Include detailed instructions for completion;
- Set a deadline for return;
- The answer choices offered should be exhaustive and cover all possible options;
- If the questionnaire is anonymous, it should not contain information that would allow anonymity to be revealed;
- Do not ask multiple things with one question (Why do you think children do not go to the forest and why does their school performance deteriorate?);
- Avoid using questions that no one will answer truthfully (Do you read? Do you use drugs? Do you cheat on your partner?);
- Avoid suggestion (Also, do you think Tesla is not a green car?).
- The questionnaire uses three types of questions [24]:
- Closed (respondent chooses an answer from the options offered);
- Semi-closed (the respondent chooses from the options offered or can write his/her own answer);
- Open (the respondent writes his/her own answer).

2.2. Evaluation of Sparse Scales

A person can distinguish a maximum of 12 different rating levels, but the lower the number of rating levels, the better respondents are able to distinguish them from each other [25].

Evaluation of such research must be done by frequency, not by the magnitude of individual values for which mean and variance are used [26]. Frequency evaluation is based on the distribution of frequencies and their distribution function [27].

The average can be used only if we are evaluating the size of individual elements of the evaluated set. In the case of subjective evaluation, the assessment of different sizes has the same meaning, and we use a frequency assessment of the evaluation set, which we express in quantiles, most often quartiles. It is not possible to quantify whether, for example, for the scales “Unacceptable”, “Acceptable”, “Very Good”, and “Good”, the difference between “Good” and “Very Good” is the same as between “Good” and “Acceptable”. In fact, the result could be “Good and a half” [28].

These assessments can be made on a maximisation or minimisation scale. The maximisation scale assigns a maximum value to the best result (as if it were a score), the minimisation scale assigns the lowest value to it (as if it were a school grade) [25].

The conversion between the minimisation and maximisation scales is performed according to Formula (1):

$$x' = (n + 1) - x \quad (1)$$

where x' is the new value, x is the original value, and n is the total number of scale values.

The resulting statistical characteristics $X(F = k)$ lie at X discrete points when the number of respondents is odd; when it is even, they lie at $X + 0.5$.

To obtain information corresponding to the number of respondents (not less than the number of points X), we evaluate the values of $x(F = k)$ by interpolating between X .

The Likert five-point scale is the most widely used. According to [29], it can be used safely even for a small number of respondents. The Likert scale, as well as other sparse scales, can be processed in point- or interval-terms. The point concept represents the idea that “the chosen value is exactly this one”, and the interval concept interprets the value as “the most acceptable value” for the respondent [30].

Carifio [31] recommends processing the Likert scale as intervals rather than individual values. Figure 1 shows an example of its representation in interval terms. The function p denotes the distribution of the points of X ; the function F is its distribution function. The points on the scale X are described in intervals $X \pm 0.5$ of frequencies p with constant distribution. The method respects the indeterminacy of the points of X , so the distribution function F starts at 0.5. For $X = 1$, the distribution function is $F(0.5) = 0$, $F(1.5) = 0.2$ and $p(1.2) = 0.2$. We denote the quantile values found by the interval method by $x(k)$. Calculating the quantile is carried out according to Formula (2) [27]:

$$x(k) = X(k^*) + 0.5 - \frac{F[X(k^*)] - k}{p[X(k^*)]} \quad (2)$$

For the interpretation and analysis of the results, the median $\tilde{x}$ is an important indicator of position. The median simply represents the point at which the distribution function reaches a value of 0.5. In the case of the model situation, the $\tilde{x} = x(50) = 2.5$. Furthermore, the uncertainty indicators are important: absolute and relative [27].

Absolute uncertainty describes the interval in which the middle 50% of respondents' answers fall. It is calculated according to Formula (3):

$$\Delta^\Sigma = x(75) - x(25) \quad (3)$$

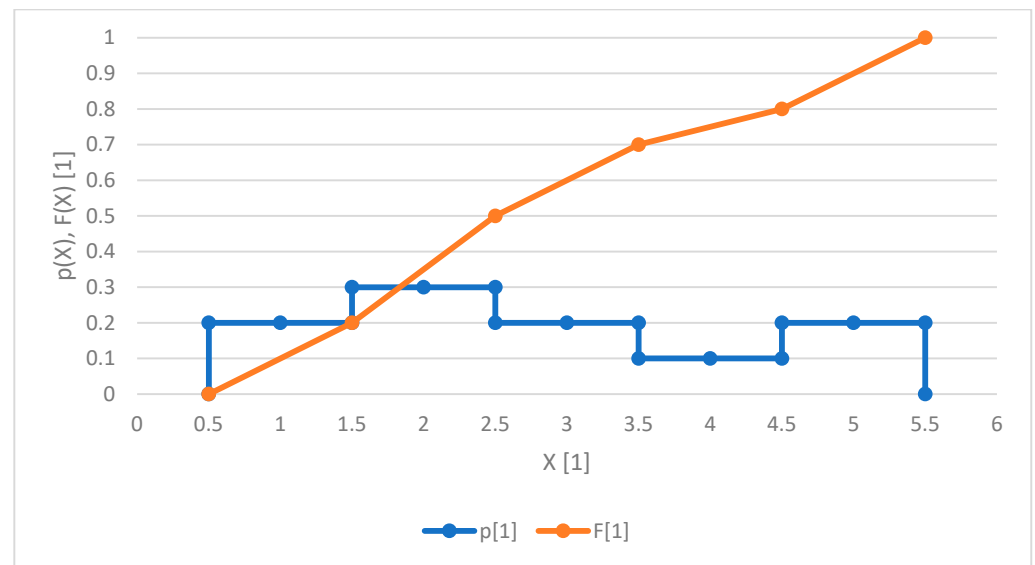


Figure 1. Example of an interval Likert five-point scale, [27].

The relative uncertainty is calculated according to Formula (4), where n is the number of elements on the sparse scale:

$$\delta^{\Sigma} = \frac{\Delta^{\Sigma}}{n} \quad (4)$$

The uncertainty asymmetry can also be expressed in absolute and relative terms. Absolute uncertainty is expressed from the right by Formula (5), from the left by Formula (6), relative to the right by Formula (7) and relative to the left Formula (8):

$$\Delta^{+} = x(75) - \tilde{x} \quad (5)$$

$$\Delta^{-} = \tilde{x} - x(25) \quad (6)$$

$$\delta^{+} = \frac{\Delta^{+}}{n} \quad (7)$$

$$\delta^{-} = \frac{\Delta^{-}}{n} \quad (8)$$

2.3. Pareto Analysis

In 1897, the Italian economist Vilfredo Pareto proposed a relationship that describes the unequal distribution of wealth among people. In 1907, the American economist Max Otto Lorenz graphically represented the same idea. The American specialist in production quality management, Joseph Moses Juran, applied this principle to several fundamental problems and many subordinate ones in production quality management (also known as the 80/20 rule, “vital few, trivial many”, etc.) and called this procedure the Pareto principle [32].

According to him, 80% of defects are due to 20% of causes. In practice, it is necessary to find this small group to optimise the whole [33].

Figure 2 shows an example of a Pareto diagram that shows that 83% of all faults in a given case are caused by faulty valve, button or clamp. These are the ones that are worth focusing on [33].

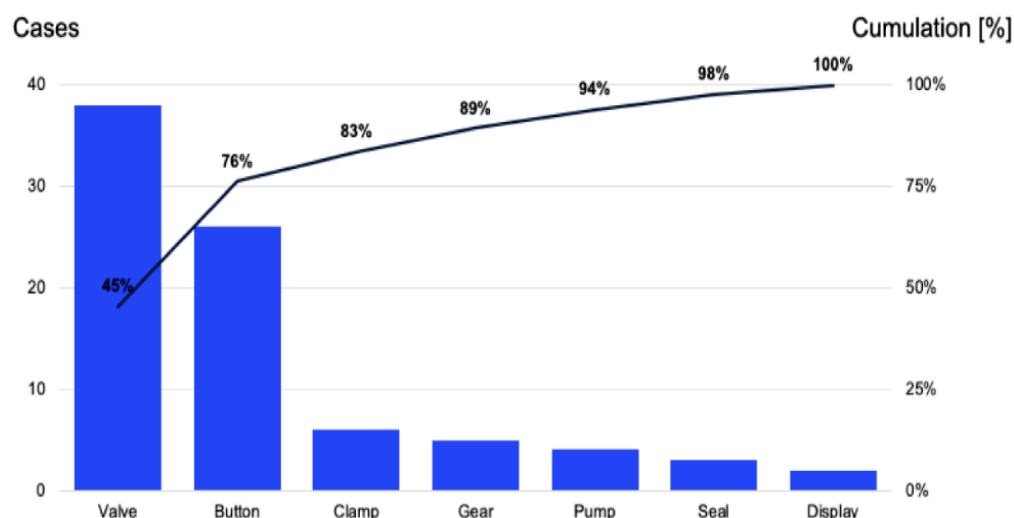


Figure 2. Example of a Pareto diagram, [34].

2.4. Identification of the Current Situation and the Needs of Stakeholders

The questionnaire was sent to 14 crisis managers at the regional level, who are usually members of the emergency board, and 10 completed questionnaires were returned. The intention was to find out the current state of the issues addressed, with particular emphasis on the existence of standardised procedures for dealing with several types of crisis situations that emerged from the risk analysis for the Czech Republic.

The questionnaire was created through the Google Forms platform and a link to it was emailed to the individuals concerned. The questionnaire was completely anonymous. The electronic questionnaire was chosen for better processing of the results and a more efficient response [35].

The analysis of the questionnaires, which contained closed, semi-closed, and open questions, provided the basis for the elaboration of the algorithmization (methodology) of the emergency board work.

Using a Microsoft Excel spreadsheet, line and bar charts were created to capture the input data values and other observed values.

The quantitative indicators questions were processed using classical statistical methods; the mean was used as an indicator of position, and the standard deviation and the derived confidence intervals as an indicator of variability [36].

2.5. Processing the Questionnaires

To properly understand the current situation, it was necessary to obtain information directly from the actors involved: representatives from each region who are responsible for prevention and civil emergency preparedness and are usually members of the regional emergency board. Ten out of fourteen respondents contacted participated in the survey (the Czech Republic is administratively divided into fourteen regions, and representatives of all regions were contacted within the survey), that is, a 71% success rate.

Some of the questions in the questionnaire assessed the status of the preparation of documents for the 22 types of hazards that emerged as types of hazards with unacceptable risk from the Threat Analysis for the Czech Republic [37], and Table 1 lists them. The table also shows the abbreviated names used in the graphs for the sake of clarity.

Table 1. Hazard types with unacceptable risk [37].

Full Name	Short Name
Long-term drought	Drought
Extremely hot temperatures	Temperature
Flash flood	Flash flood
Heavy rainfall	Rain
Extreme wind	Wind
Flood	Flood
Epidemics—mass infections of people	Epidemics
Epiphytie—mass infections of field crops	Epiphytie
Epizootic—mass infections of animals	Epizootic
Large-scale disruption of food supplies	Food
Disruption of the function of major electronic communications systems	Electro-comm.
Information security breach of critical information infrastructure	Information breach
Special flood	Special Flood
Leakage of a hazardous chemical from a stationary facility	Chemical leak. stat.
Large-scale disruption of drinking water supplies	Drinking water
Large-scale gas supply disruption	Gas supply
Large-scale disruption of oil and petroleum product supplies	Oil supply
Radiation accident	Radiation
Large-scale disruption of electricity supply	Electricity supply
Large-scale migration wave	Migration
Large-scale lawlessness (including terrorism)	Legality/Terror
Disruption of the financial and foreign exchange economy of the state on a large scale	Finance/Forex

3. Results

3.1. Activities of Emergency Boards in Relation to Selected Disasters in the Field of Electricity

The activities of emergency boards can be expected, especially in the coordination of management at the strategic level and in relation to possible disasters in the area of critical infrastructure in the electricity sector, as one of the key elements for population protection and the resilience of society.

The following types of events have been evaluated in the Czech Republic as having the potential to threaten critical infrastructure in the electricity sector: (a) large-scale disruption of electricity supply, (b) large-scale disruption of gas supply, (c) radiation accidents, and (d) large-scale disruption of oil and petroleum products' supply. These are specific potential critical situations that have been selected from the 22 types of hazards that emerged as unacceptable types of risk hazard from the Threat Analysis for the Czech Republic.

1. Large-scale disruption of electricity supply

Also called a blackout, it consists of an interruption in the production or supply of electricity. In the Czech Republic, these situations are practised, but few people have a realistic idea of the exact process.

The survey found that 80% of the respondents have blackout plans in place.

2. Large-scale gas-supply disruption

In the event of a large-scale disruption of gas supply, the operation of gas-fired power plants, which account for approximately 10% of electricity generation in the Czech Republic, could be cut [38].

The survey showed that 60% of the respondents have developed plans to deal with this crisis situation.

3. Radiation Accidents

In the Czech Republic, a radiation accident with grave consequences would be a possibility in two nuclear power plants, which account for approximately 40% of the energy mix (of which Dukovany and Temelín account for 48% and 52%, respectively) [39].

As already mentioned above, the formulation of the solution plans varies significantly from region to region, as the emergency planning zone of these two nuclear power plants extends into 3 out of 14 regions.

4. Large-scale disruption of oil and petroleum product supplies

Oil and petroleum products are hardly used (0.12%) [38]) for electricity generation, but if sustained in the long term, the life of the population and the operation of the industry would be severely limited. The plans for dealing with this emergency situation envisage the use of regulatory measures (e.g., maximum speed regulation on roads or rationing) [40].

The survey showed that 50% of the respondents have elaborate plans to deal with this crisis situation.

3.2. Decision-Making Processes in Emergency Boards

Decision-making means choosing between two or more options with different outcomes. Each decision will affect the solved system in some way; the goal is to make the resulting system as little different as possible from the desired state [41]. In the event of electrical power disasters, in addition to providing alternative power sources, it is also a necessary decision-making process to prioritise the distribution of power to affected locations and individual facilities to ensure the operation of the utility and, in particular, elements of the critical infrastructure.

The main activities of the emergency board are the collection of information and the preparation of documents for the decisions of its chair. Decision-making processes in the emergency board are often characterised by a high level of uncertainty of input information. The decision-maker usually does not have enough relevant information and time, and must rely on his/her instinct [42].

According to Hálek, the decision-making process has [41] six parts:

- Identification of problems;
- Analysis and formulation of problems;
- Creation of solution variants;
- Determination of criteria for the evaluation of options, determination of consequences of options;
- Evaluation and selection of the option to be implemented;
- Implementation of the chosen option.

The most important parts are the analysis and formulation of the problem, the creation of solution options, and the determination of evaluation criteria along with their evaluation. Subsequent selection of an option is the logical outcome of this process.

Moreover, the environment in which the emergency board operates has its own characteristic specifics: the problem to be solved is not clearly identified, and there is not enough time for its analysis and formulation, the creation of options, and their evaluation. This can fundamentally affect the chosen solution. Options are evaluated in terms of their acceptability/unacceptability (e.g., casualties, major material damage) and then the optimal one is selected. In the absence of information and the threat of fatal consequences, the optimal option may not be selected, but only the best feasible option according to available information. For this reason, Kopecký [42] recommends sufficient information support to the emergency board. Furthermore, the basis for the decision should be properly documented and archived for possible later dispute resolution.

Algorithmization can be used to manage the activities of the emergency board by using prepared procedures that do not have to be invented in a short time. Adamec [43]

uses an algorithm, although he does not call it that, in the emergency board management and decision-making cycle.

For example, the Ishikawa diagram can be a tool to support the work of the emergency board. This diagram is based on the simple assumption that every consequence has a cause or a combination of causes. The aim is to determine the most probable cause of the problem. Visually, the diagram looks like a fishbone. The Ishikawa diagram is shown in Figure 3 [44].

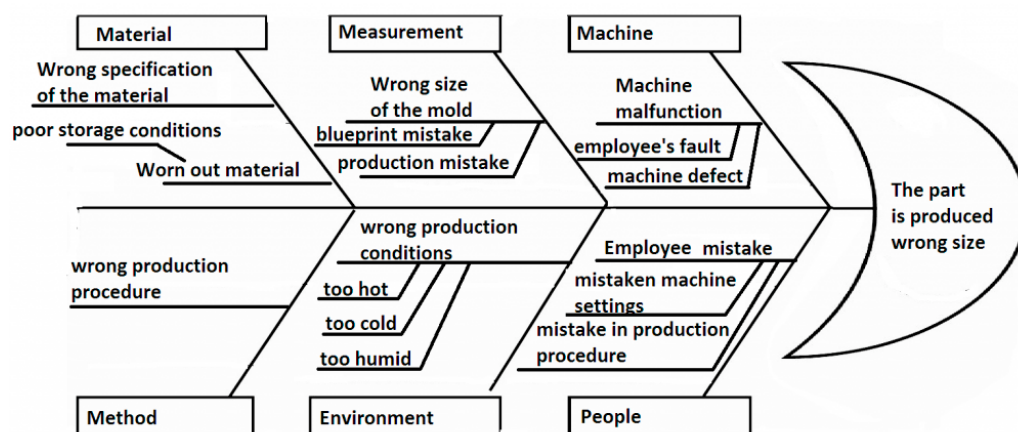


Figure 3. Ishikawa diagram [45].

Causes are found primarily in the underlying branches. For security, these are usually:

- Human-related causes;
- Material or technical causes;
- Caused by directives, orders, methodologies, etc.;
- Caused by low levels of protection against potential threats;
- Caused by the imperfect training of employees and the population;
- Caused by improper driving;
- Environmental causes [44].

The Ishikawa diagram can be used for a retrospective analysis of failure or as a precautionary measure against failure [44].

3.3. Emergency Board—Descriptions of Its Activities in the Conditions of the Czech Republic

The emergency board is convened when necessary to deal with large-scale/challenging emergencies or crisis situations as a working body of its chair. The chair may be the Prime Minister, the Minister of the Interior or the Minister of Defence [46], the President of the Region, or the mayor of a municipality. The emergency board analyses the situation and proposes measures as a basis for the decision of its chair [47]. At its meetings, the current situation and expected development of the event are evaluated, viable solutions are proposed, and further decisions are taken towards an approved solution of the event [48].

In the case of a region or municipality with extended powers (MEP), the emergency board consists of members of the security council and members of the permanent working group (including external experts) [49]. The continuous meetings of the permanent working group are a great stress for its members; moreover, most of the information from the affected area is analysed here, which is a great load when not organised.

There is no legally established subordination between the emergency boards of individual levels (Central Emergency Board, regional emergency board, emergency board of municipality with extended powers, and municipal emergency board), only between the flood commissions. It follows that it is almost impossible to “force”, for example, from the regional level, the MEP emergency board to do anything. This is because the chair of the emergency board is responsible for every decision of the emergency board, not the chair of a higher-level emergency board.

The work of an emergency board is affected by the following negative influences:

- The field of emergency boards is undergoing a terribly slow transformation towards a better working environment and education; a pleasant working environment and educated staffs would bring stress relief to its members;
- A wrong decision by the emergency board based on incorrect information can have profound consequences;
- There is currently no methodology for emergency boards that uses algorithms.

3.3.1. Emergency Board—Composition

The emergency board is composed of two basic parts: the members of the security council and the members of the permanent working group (hereinafter referred to as the “PWG”) of the emergency board. See the example of the composition of the regional emergency board in Figure 4.

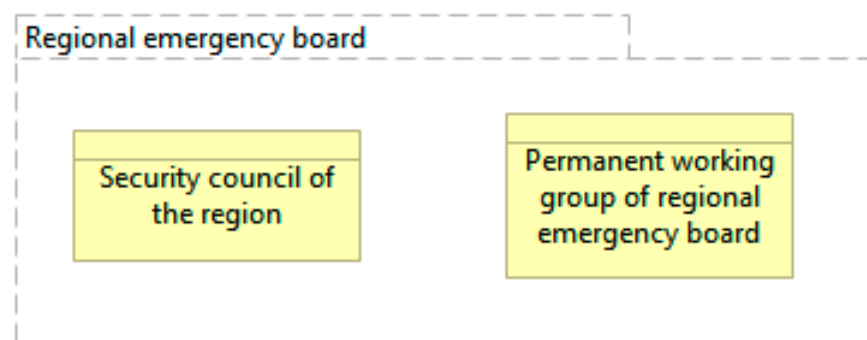


Figure 4. Emergency board of the region—general composition.

When the emergency board is convened, members of the respective security council become members of this board [50]. Currently in force is the Ministry of Interior (hereinafter referred to as “MoI”) Directive No. MV-117572-2/PO-OKR-2011, which establishes uniform rules for the organisational arrangement of the emergency board of a region, the emergency board of a municipality with extended powers, and the emergency board of a municipality. This directive provides that the PWG may be further subdivided internally in regard to the crisis:

- The expertise of members and other persons invited to deal with the emergency or crisis situation; or
- Ensuring processes for a unified and common approach to dealing with an emergency or crisis situation [51].

The basic set of the PWG is not changing for all types of crisis situations and is supplemented by experts according to the actual need. Although the current MoI directive only describes in general terms the possibility of dividing the PWG into expert groups, it is necessary to proceed from the historical division of CRADP—communication, rear services, analysis, deployment of forces and resources, and population protection. All these areas must be provided, regardless of the names of the individual specialist groups. Figure 5 shows this functional breakdown of the PWG, the symbol of a person in upper right corner means that it is one person, otherwise it refers to a group of people. The Directive sets out the organisation of the PWG but does not contain any recommended procedures for its operation.

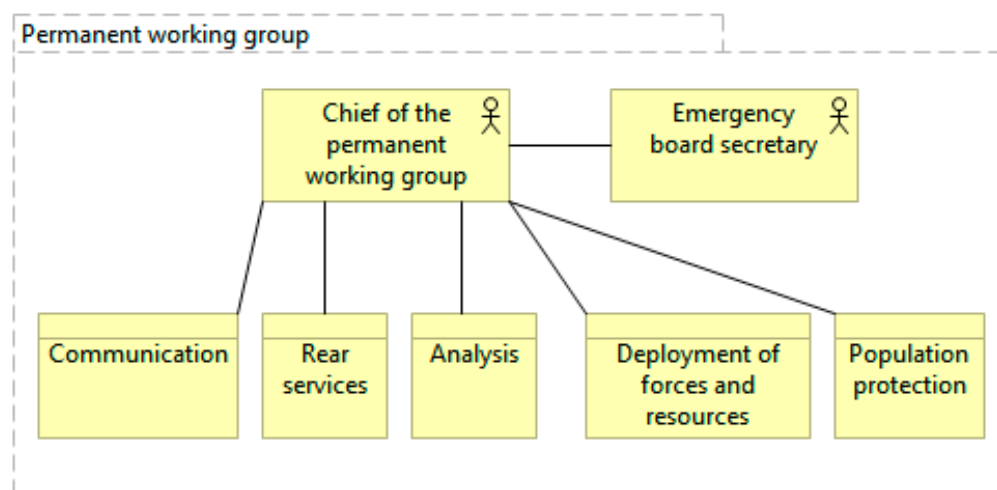


Figure 5. Functional breakdown of the permanent working group.

3.3.2. The Importance of Emergency Boards

The main benefit of the emergency board is the concentration of people responsible for dealing with the situation in a compact space, thus increasing the efficiency of information transfer and request transfer. At emergency board meetings, the current situation and the expected development of the event are assessed, possible solutions are proposed, and decisions are taken towards an approved solution of the event [48]. There are specific staffing requirements in the case of disasters related to the electricity sector, where the presence of engineers is required who can assess the situation and reflect on the further development of the situation.

Emergency boards are established in a compulsory way at the level of the state, region, and MEP. “Ordinary” municipalities are not obliged due to the possible low staffing. However, even the mayor of a small municipality has the same duties and powers as the mayor of a statutory town but does not have the same staffing capacity. For this reason, Adamec et al. [52] recommended the creation of a “virtual emergency board”, which would receive information from the integrated rescue system.

This virtual emergency board would be an information system that would automatically process structured information and evaluate this information using a built-in expert system. It would record its results and present them as recommendations to deal with the event. In addition, it would also be able to keep a timeline of the event resolution. [52].

3.4. Assessment of the Area of Crisis Management Procedures in Regions as a Basic Support to Increase the Resilience of the Territory

The survey evaluated the level of elaboration of the types of crisis situations (hereinafter referred to as “CS”) that could be considered and that could result from the risk analysis of the Czech Republic (possibly with additional ones). A sub-objective was to determine whether the standardised procedures for dealing with individual types of crisis situations are usable as basic methodological support for the emergency board regarding the issue of disasters in the electricity sector. A schematic representation of the findings is shown in the Figures 6–8.

The elaboration of the individual plans is shown in Figure 6. The graph shows that 40% of the regions have developed 77% of all types of CS that emerged from the territory risk analysis. The least amount of work in progress is 41%.

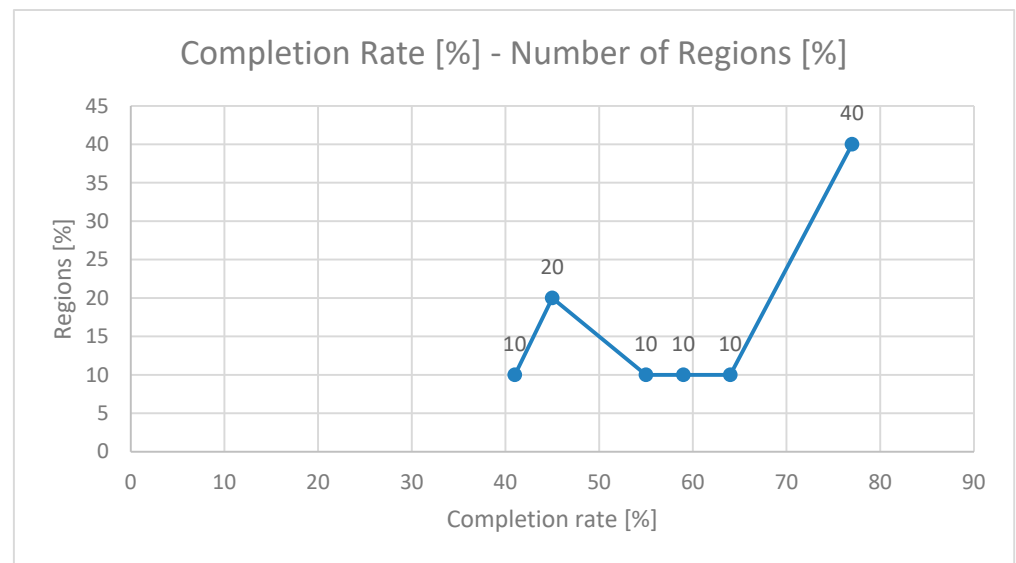


Figure 6. Overview of the work in progress of type plans in regions.

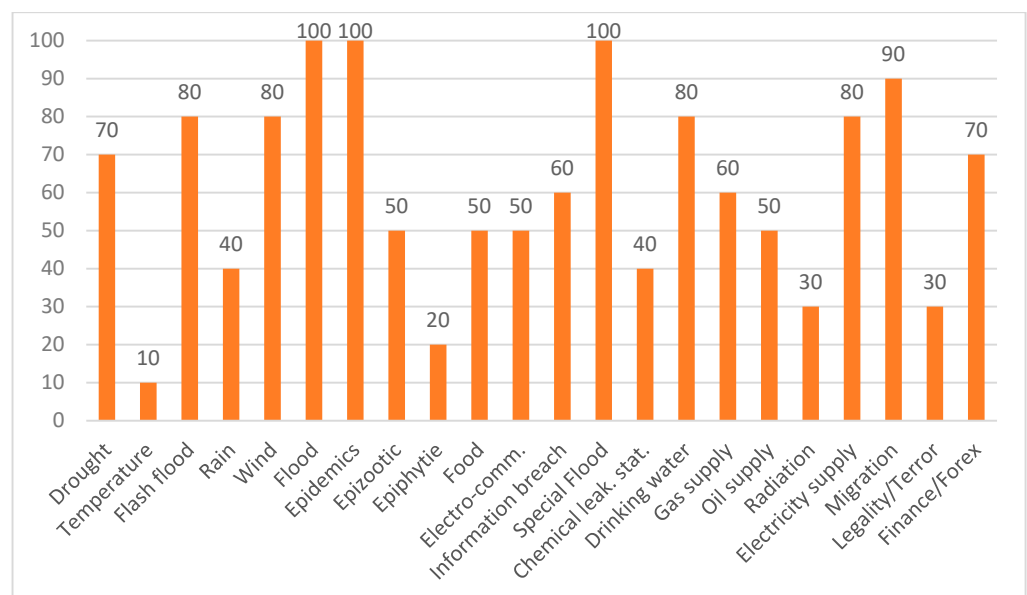


Figure 7. Existence of clear methodologies for different types of crisis situations.

Figure 7 shows that 100% of the regions have prepared documents for flood, epidemic, and special flood. Water-supply disruption, power-supply disruption, and large-scale migration wave are prepared in 90% of the regions. Flash floods and extreme wind have been observed in 80% of the regions.

Most existing methodologies are for flood, epidemic, and special flood emergencies. These are the types of events that are dealt with very frequently (floods), are topical (epidemics) or have major impacts (special floods).

Figure 8 shows the Pareto diagram of the types of crisis situations processed by each region. The Pareto threshold of 80% of processed documents is exceeded by the 15th most resolved crisis situation, disruption of the function of major electronic communications systems. A total of 134 plans have been created, so the Pareto threshold of 80% is 107.2 elaborated documents.

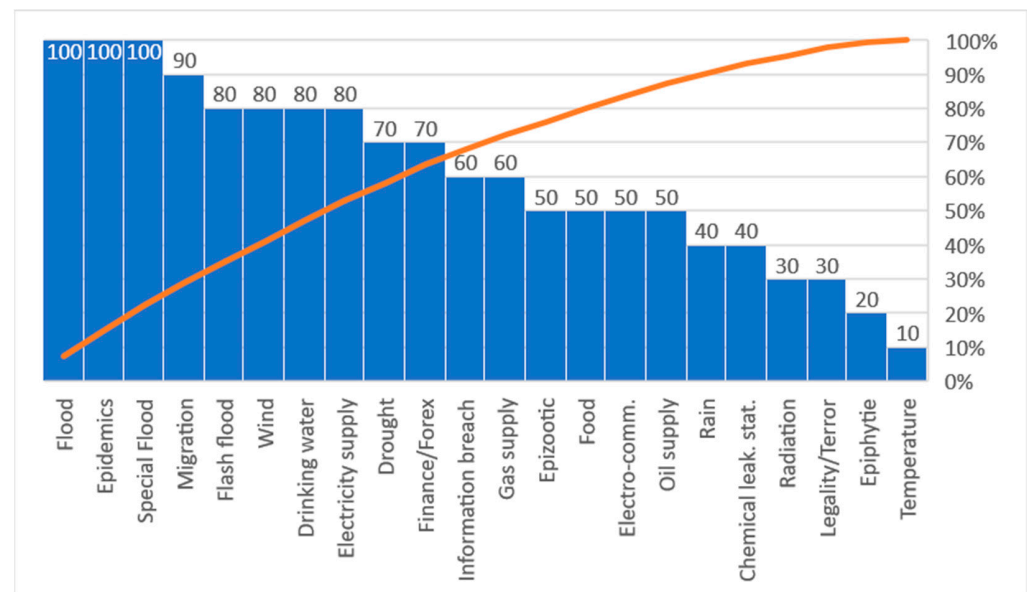


Figure 8. Pareto diagram of processed inputs by region.

The research investigated whether there are clear standardised procedures for dealing with selected types of crisis situation in individual regions (hereinafter referred to as “methodologies”). This part of the investigation focused on the detailed handling of individual types of crisis situations in the conditions of the given region.

Figure 9 shows in a Pareto diagram the percentage of regions that have developed methodologies to deal with each type of CS (blue) and the cumulative frequency converted to 100% (brown). For example, the cumulative frequency shows that out of 22 types of CSs, the 7 most processed ones account for 50% of all processed methodologies, i.e., 31.8% of CS types account for 50% of all processed methodologies. As in the case of the first question, the Pareto threshold of 80% is exceeded by the 15th most handled crisis situation, disruption of the functionality of major electronic communications systems.

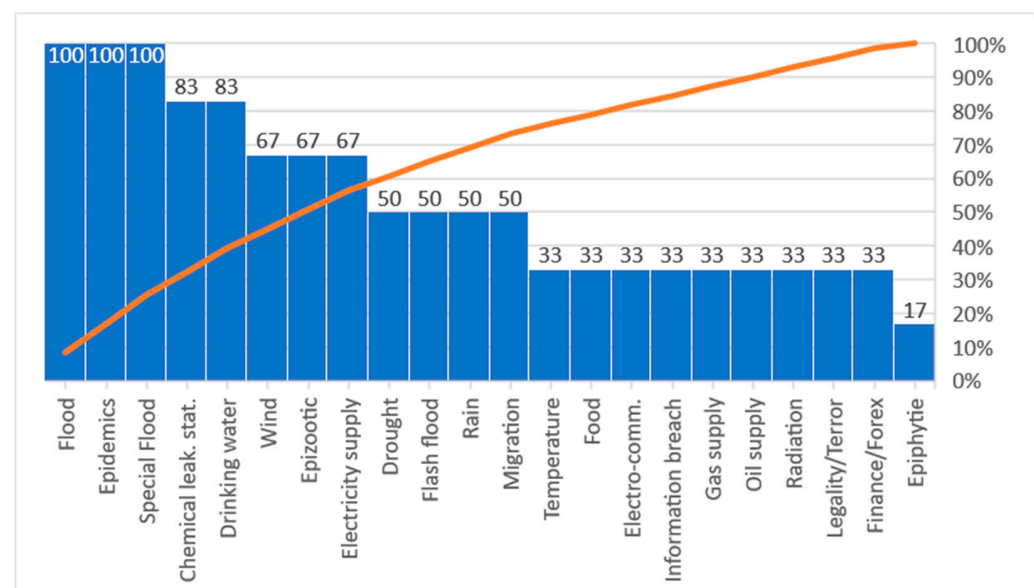


Figure 9. Percentage of regions with developed methodologies for dealing with CS.

Figure 10 shows the comparison between existing arbitrary methodologies (blue) and region-specific methodologies (red). The first question determines whether there is any

methodology, and the second question determines the region-specific elaboration. This graph shows that there are fewer specific methodologies developed, except for four types (epizootic, leakage of a hazardous chemical from a stationary facility, heavy rainfall, and extremely hot temperatures).

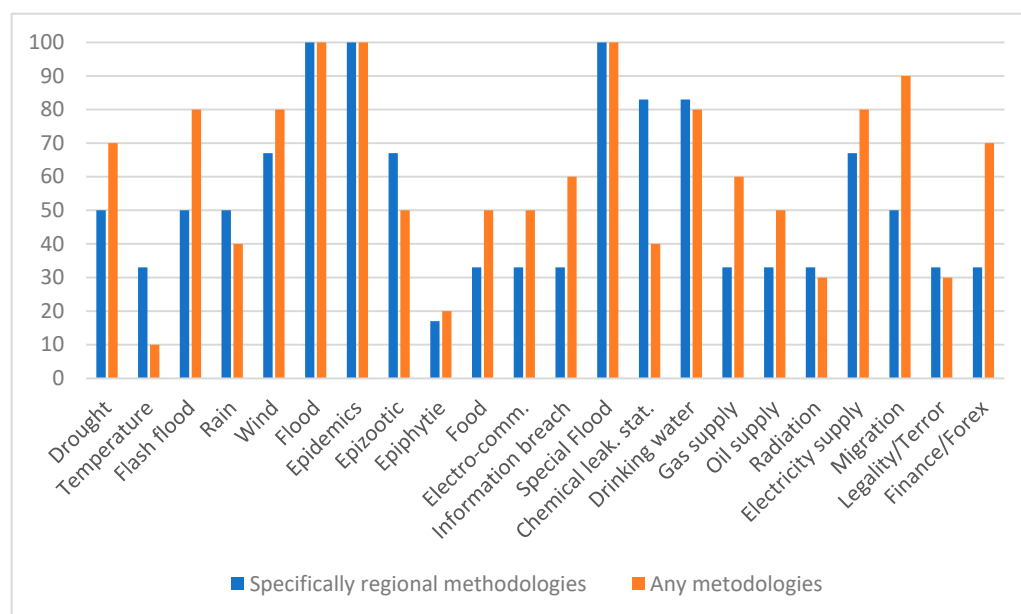


Figure 10. Comparison of existing methodologies.

3.5. Lessons from the International Environment

International emergency boards abroad face similar problems as emergency boards in the Czech Republic. The comparison includes the European Union, the North Atlantic Treaty Organization, and the United Nations agencies for disaster relief and humanitarian assistance to the affected population.

The terminology used in crisis management is not unified abroad, and therefore it is not possible to compare crisis management in other countries with the Czech one in detail, but it is possible to trace the fact that there are two levels of crisis management:

- Risks threatening the state as a whole: external military threats, threats to the democratic nature of the state, state sovereignty, widespread disruption of electricity, gas or oil supplies, etc. [48].
- Risks threatening part of the country: for example, natural disasters, large-scale fires, industrial accidents [53].

To ensure the transformation of the defence systems in Europe, which were established during the Cold War, into democratic systems aimed also at nonmilitary threats, the so-called “Stockholm Principles for Emergency Legislation” were adopted at a legislative seminar organised within the framework of the Partnership for Peace programme in Sweden in 1996. Although these principles are not legally binding (they are just recommendations), they enabled a number of countries in the 1990s to develop or supplement “emergency” legislation, with the following principles:

- The use of international law and the protection of freedoms in the application of emergency powers;
- The introduction of civil control when special powers are declared;
- The adequacy of crisis powers (measures) to the situation;
- Protection against abuse of crisis powers;
- Oversight and control by the judiciary and the legislature;
- Review of measures taken by the executive;
- Compensation for losses and damages;

- Shifting responsibility for crisis management to the lowest possible level of government [53].

3.5.1. European Union Civil Protection Mechanism

In the event of a disaster of such a scale that national actors cannot cope, assistance can be requested from the European Union Civil Protection Mechanism (hereafter referred to as the “Mechanism”), a solidarity action that involves all EU Member States, Montenegro, Iceland, Macedonia, Norway, Serbia, and Turkey [54].

The request for assistance is not limited to Europe or the states participating in the Mechanism but may be requested by any state in the world, the United Nations or its agencies, or any internationally recognised body. Since its inception in 2001, the Mechanism has been activated more than 250 times, for example, for the Haiti earthquake (2010), the earthquake, tsunami and nuclear accident in Japan (2011), Ebola in West Africa (2014), the Nepal earthquake (2015), and others [55]. From the above list, it is obvious that such aid can also be used in electricity crises (as in Japan in 2011).

The Emergency Response Coordination Centre (ERCC) is the liaison point for coordination of activities (a kind of emergency board), which further minimises duplication of (ineffective) assistance in possible simultaneous handling of different events. This is where requests for assistance under the Mechanism are brought together. The ERCC replaces and upgrades the former Monitoring and Information Centre [56].

The ERCC collects information on ongoing disasters, monitors anthropogenic accidents, and prepares plans for the use of experts, relief teams, and their equipment. The ERCC also participates in emergency response exercises [56].

3.5.2. North Atlantic Treaty Organization Disaster Response Coordination Centre

The Euro-Atlantic Disaster Response Coordination Centre (EADRCC) is a coordination centre in Brussels that, like the ERCC, continuously receives requests from individual states and coordinates possible assistance from other states in the event of large-scale natural or anthropogenic disasters. It also keeps a record of the aid requested and provided, the date of delivery, and the aid that will remain to be provided [57].

It is the main mechanism for responding to threats to the population of the North Atlantic Treaty Organization (NATO), covering all 30 NATO members and all NATO partner states. These states are informed about the assistance needed, and it is up to them to decide whether to help. It works in close cooperation with the Office of the Coordination of Humanitarian Affairs of the United Nations [57].

3.5.3. United Nations Office for the Coordination of Humanitarian Affairs

Like the ERCC or the EADRCC, the United Nations Office for the Coordination of Humanitarian Affairs (hereinafter “UN OCHA”) coordinates humanitarian assistance and aid to populations affected by natural or anthropogenic disasters [58].

The UN OCHA’s objective, according to [59], is:

- Mobilise and coordinate effective humanitarian assistance from national and international actors to reduce human suffering in disasters;
- Defend the rights of people in need;
- Promote prevention and preparedness for potential disasters;
- Simplify the implementation of sustainable solutions.

All the above-mentioned international structures are usable in the event of any crisis, that is, the resilience of the territory is strengthened.

4. Discussion

Working on an emergency board is very stressful and without clearly set procedures can become frustrating, as all members are exposed to a large number of unspecified tasks over a long period of time with potentially serious consequences and the need to react quickly. To successfully deal with emergent events, even in the electricity sector, it is

necessary to have the maximum amount of relevant information and to select the most appropriate of the possible solution options. Another important factor influencing the functioning of the emergency board is the current level of resilience of the territory and the readiness of critical infrastructure elements, also in the field of electricity.

Our own investigation has yielded a great deal of interesting information. Research showed that the level of processing of individual procedures varies greatly between regions. In all regions, epidemics, floods, and special floods are handled, mainly due to their large scale and severity (epidemic), frequent recurrence (flood) or devastating impact (special flood).

The least-handled procedures (i.e., perceived as least important) were as follows: epiphytie, large-scale disruption of a nation's financial and foreign exchange economy, large-scale disruption of law and order (including terrorism), large-scale disruption of oil- and petroleum-product supplies, large-scale disruption of gas supplies, information security breach of critical information infrastructure, disruption of the functionality of major electronic communications systems, large-scale disruption of food supplies, and extremely hot temperatures. Surprisingly, the areas that affect the resilience of electric power were perceived by the respondents as less important, except for blackouts.

The radiation accident, as mentioned earlier, is specific in that the only two Czech nuclear power plants have a designated emergency planning zone on the territory of three regions. The other regions do not deal with this situation, although the severity of the impact of the radiation accident certainly exceeds that of a specific flood.

The general usefulness/need for the prepared procedures emerged from the questionnaires as low to beneficial. A total of 20% of the highest-ranked emergencies are those that we can imagine (flood, special flood, chemical spill, extreme wind, and large-scale disruption of drinking-water supply). Surprisingly, prepared response procedures have not been adequately developed for these types.

In 70% of the responses, the respondents said that the existing procedures for dealing with crisis situations were too general and in 90% that specific measures were lacking. There were also views that the procedures were too detailed or factually incorrect. The responses are contradictory, even among the individual respondents. The main message is that the existing procedures are not well-prepared.

A majority (60%) of the respondents prepare at least an outline of the procedure at the beginning of the crisis situation, while the remaining 40% do not prepare anything. Most of the time, this happens because there is no time to do so.

In the question on the number of crisis situations dealt with, intervals were chosen for ease of completion, but this lost a tiny bit of information for processing. In the evaluation, the mean values of the intervals were considered. The analysis of the results showed that each region deals with approximately one crisis situation per year. This is of course a very approximate figure, first because not all regions provided numbers for the whole 10 years and secondly because of the use of intervals in the question. Furthermore, this number may be quite different in the future with respect to climate change or anthropogenic threats.

We are currently in a very socially unstable era, with the COVID-19 pandemic almost over, seamlessly followed by the war against Ukraine with a large-scale refugee migration wave and the economic hardships of the war and sanctions applied. In this situation, it is almost impossible to predict the future development of the situation and thus to estimate the number of crisis situations dealt with by the various emergency boards.

5. Conclusions

A possible disruption of critical infrastructure in the electricity area at the national level may mean a nationwide disruption of a wide-area system with a high degree of interconnection with the electricity systems of neighbouring countries. One of the elements of a proper disaster response is the operation of an emergency staff that can support even limited operation of a system that is highly sensitive to the proper functioning and desired interaction of its individual elements, which are closely interrelated and interact with each

other. Since electricity cannot be significantly stored, the balance between production and consumption must be maintained continuously. The electrical system as a whole must continually balance the time-varying magnitude of electrical consumption and production.

The activity of crisis staffs, standardization of procedures, and the mutual cooperation of individual actors will reduce the negative impacts on the power system and shorten the disruption time and subsequent restrictions in society. There are events that, depending on their severity, extent of the affected area, and frequency of occurrence, can cause damage or loss of function of one or more elements and lead to accidents of a regional or national nature. With the right tools, crisis management functions can respond to the situation in a timely and substantive manner.

One possible view of the electricity sector can be the Levelized Cost of Energy/Electricity (LCOE) and Levelized Avoided Cost of Electricity (LACE) views. LCOE can be calculated by first determining the net present value of the total cost of building and operating the power generation asset. This figure is then divided by the total electricity generation during its useful life. It allows for the comparison of different technologies (e.g., wind, solar, natural gas) of unequal life spans, project size, different capital cost, fuel costs, operation and maintenance (O&M) cost, risk, return, and capacities. LACE is a measure of what it would cost the grid to generate the electricity that is otherwise displaced by a new generation project that is a measure of the market value of that electricity. LACE is defined as the sum of the annual economic value generated over the life of the asset (including both generation and capacity payments) discounted to present value divided by the sum of electrical generation over the life of the asset discounted to present. The use of the LCOE and LACE approach is both appropriate for national assessment and is also useful and suitable for international classification and comparison.

A catastrophic power outage scenario is one of the real technical threats to the functioning of a municipality, a region, and ultimately the entire state. With the current dependence of modern society on electricity supply, the disruption of that supply will limit the functionality of vital everyday facilities. Fundamental in energy security issues is the responsibility of the state to create conditions for reliable and long-term energy supply, in addition to building a crisis management system as one of the elements of society's resilience.

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