

DISRUPTION OF CRITICAL INFRASTRUCTURE AND QUANTIFICATION OF ITS IMPACT

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Abstract: *Critical infrastructure consists of a system of interrelated elements, which represent the backbone of the national economy of any country, or the economic union. Disruption of any element could have significant consequences not only for the continuous function of other elements of critical infrastructure, but also for every market entities which are depending on their stepless action. This dependence was significantly manifested in the January 2009, when several countries in the South-East Europe were hit by the gas crisis triggered by a dispute between Russia and Ukraine.*

Quantification of losses, which incurred on the basis of the failure of any elements of critical infrastructure, is very complicated. This complexity results from a number of factors and interdependencies between the elements of critical infrastructure as well as other market operators.

Contribution highlights the interdependence of the various elements of the national economy and their dependence on a functional critical infrastructure, on the example of gas crisis. It describes primary and secondary consequences of gas crisis and tries to quantify losses caused to businesses, householders and State economy.

INTRODUCTION

Critical infrastructure (CI) in the Slovak Republic as well as in the European Union is a relatively young field of investigation. In Europe the agenda of the critical infrastructure and its protection was adapted by the European Commission Green Paper for the first time in 2005. This document defined the critical infrastructure as follows: "Critical infrastructures consist of those physical and information technology facilities, networks, services and assets which, if disrupted or destroyed, would have a serious impact on the health, safety, security or economic well-being of citizens or the effective functioning of governments in the member states. Critical infrastructures extend across many sectors of the economy, including banking and finance, transport and distribution, energy, utilities, health, food supply and communications, as well as key government services. Some critical elements in these sectors are not strictly speaking 'infrastructure', but are in fact, networks or supply chains that support the delivery of an essential product or service." [1]

The critical infrastructure in the Slovak Republic is defined as “that part of infrastructure (selected organisations and institutions, objects, facilities, services and systems), whose destructing or making non-functional causes threat or disruption of the political and economic operation of the state or threat for life and health of inhabitants”. [2]

The European Critical Infrastructure elements are divided to sectors and the member states of European Union create their own structure of CI. It is based on analyses for securing the basic functions of the state. However, this structure has to include also the elements stated by the European Programme on Critical Infrastructure Protection.

The law No. 45/2011 Coll., about the critical infrastructure which became effective on 1st March 2011 states the structure and scope of activity of the state administration, the criteria for determining the elements of the critical infrastructure and defines the tasks for the natural persons and legal entities participating in the operation and protection of the critical infrastructure. An element of the critical infrastructure is defined as follows: "building, service in the interest of public and information system in the sector which disruption or destruction would have a serious adverse consequences or the conduct of economic and social function of the Country, and thereby the impact on the quality of life, protection of life, health, safety, property and environment according the sector criteria and cross-cutting criteria [4].

1. IDENTIFICATION OF THE ELEMENTS OF CRITICAL INFRASTRUCTURE

The Government of the Slovak Republic developed the Concept of critical infrastructure in the Slovak Republic and method of its protection and defence which set out the criteria for determining the sectors and elements of CI. These criteria have been determined on the basis of the threat of a terrorist attack and were divided into two groups: basic and complementary criteria. [2]

Under this concept, element of CI can be such an element that is important for any of the areas of national security and meets one of the **basic criteria** at least::

1. the probability that an element could be the goal of terrorist attack, or other risk factors,
2. unacceptable risk, which would mean disrupting the functioning of the State, and his defences,
3. the uniqueness of the element, (in the case of his disruption, there is no element that could replace)
4. possibility of generalization if there is a group of elements with the same function.

Complementary criterion: exclusivity is used in addition to the basic criteria. This criterion applies only if one of the elements of the national economy is not included among the elements of CI, but meets the required criteria.

Currently, sector and cross-cutting criteria are used for identification of elements of CI in the Slovak Republic. The cross-cutting criteria laid down by the Law on critical infrastructure are:

1. the number of vulnerable people, including those killed and injured persons,
2. the economic impact, which includes:
 - economic losses
 - deterioration of goods
 - deterioration in the quality of public services
 - negative impact on the environment
3. the impact on the population degrading the quality of citizen`s life in terms of
 - severity of loss of supply and the recovery time

- severity of failure in providing public services and recovery time
- availability of replacement supplies
- availability of compensation for the services provided in the public interest.

Figure 1 shows the way how to select the element of CI.

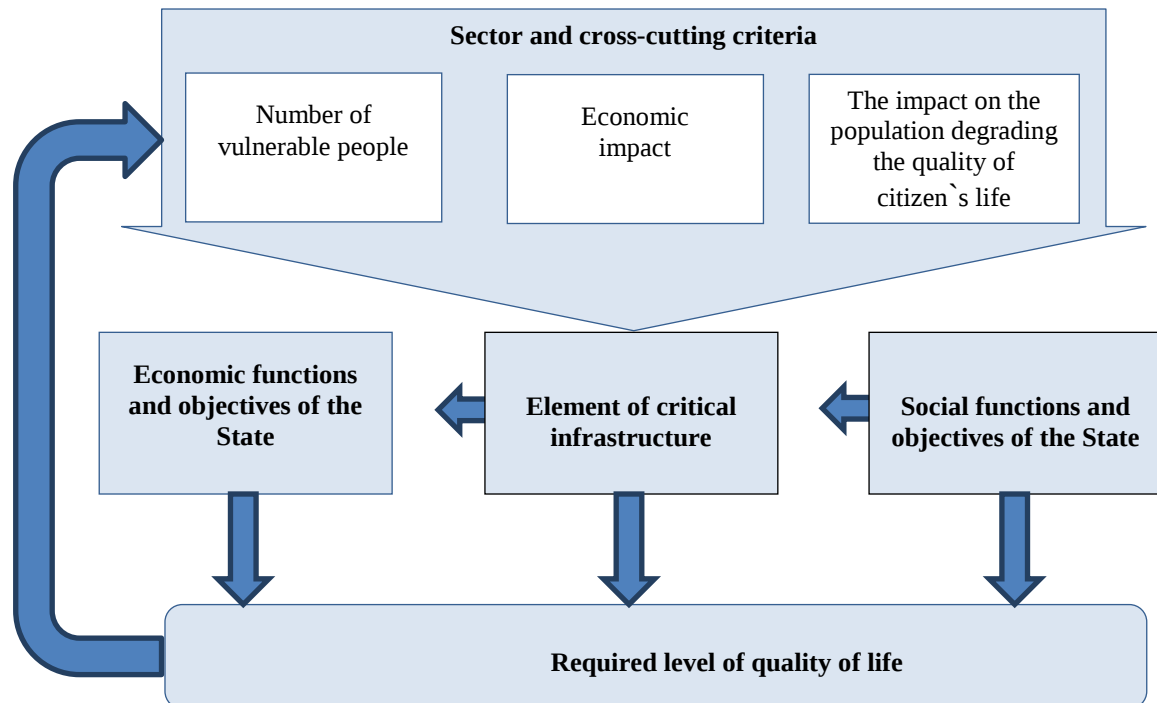


Fig. 1 The criteria for selecting an element of the critical infrastructure

Following statement results from the figure 1:

- element defined on the basis of the sector and cross-cutting criteria has a link to the economic and/or social objectives of the State,
- achievement/non achievement of economic and social functions of the State has an impact on the quality of life of citizens,
- required level of quality of life affects the determination of sector and cross-cutting criteria.

2 CONSEQUENCES OF DISRUPTION OF CRITICAL INFRASTRUCTURE

A characteristic feature of CI is the interdependency of the individual elements to each other as well as the dependence of other economic elements on functionality of CI.

If we analyze interdependency of individual elements we need to consider:

- range of the consequences – the way in which one element of CI can affect other sectors, or other economic element,
- number of affected elements – the number of elements that will be affected by the disruption of the element of CI,
- space-time factor – the time in which the disruption of one element will cause consequences on other elements.

If we take into account only interdependency of elements of CI, then it can be defined as relationship between two elements, through which the status of each element affects or is in

correlation with the other element. Specifically the interdependence can be described in two levels:

1. system of relations in the framework of the infrastructure (e.g. in transport sector) identified,
2. a system of relations to other sectors of the infrastructure (e.g., transportation and telecommunications, relationship between the banks and financial institutions.

In addition to these two levels, it is necessary to consider the interaction defined as coupling order, which indicates whether two infrastructures are directly connected to each other or indirectly coupled through one or more intervening infrastructures. [3, 5]

Dependence described in second level and coupling order are frequently manifested regarding to consequences of disruption of any element on economy of country.

Interdependency and correlation between the elements of CI as well as other economic elements is reflected in the following types of dysfunction [3, 5]:

- cascading – when a disruption in one infrastructure causes the failure of a component in a second one,
- escalating – when an existing disruption in one infrastructure exacerbates an independent disruption of a second one,
- common cause – when two or more infrastructures networks are disrupted at the same time.

The consequences of described interdependency are usually negative, but in some case they could have some positive aspect. These arrive primarily from the need of recovery or functions replacement of some economic element or element of CI. We can show it on example of disruption or lockout of section of the railway network. If the transport service in region has to be continued it must be replaced by another kind of transport. At the same time, maintenance and repair of railway is in progress. And what about consequences? Railway company loses profit and pays the additional costs for repair of railway tracks. On the other hand, road hauliers and construction companies accounting profit.

However, interdependency of infrastructure elements reflected also in a much larger extent. Example of such a strong dependence is of the gas crisis in the January of 2009. During this crisis supply of gas has been stopped on the territory of the Slovak Republic and other countries. The most critical situation occurred in the Republic of Bulgaria. But, the damage caused by the pipeline increased to the high values also in Slovakia. This situation forced the Slovak Government to look for alternatives, which could prevent similar damage in the future.

The primary effect of this incident was a statement of emergency regulatory level number 8 for the wholesale market, which resulted in a decline of economic performance for 60% of the normal value. Big companies, which need the gas for their production, were forced to stop production. It caused reduction in sales and therefore reduction of income taxes at the rate of more than 16.5 million euros. Many companies lost their customers, and for this reason, they considered moving production to other countries. But, economic crisis was fully reflected in the same year, so it was very difficult to quantify economic impact on businesses and the economy of the State.

Cessation of production had already a significant impact on the quality of life of the population because they were forced to take leave, or unpaid leave. From the perspective of citizens, the worst situation was in Eastern Slovakia. Flats, in which the citizens lived, were cold because heating plants did not produce heat for lack of gas. People used unprofessionally installed

sources of heat (electric heaters, ovens and fireplaces on solid fuel) in effort to improve the quality of life. It led to a fire in many households, but also in small companies.

This example shows that disruption of one element of critical infrastructure could lead to significant distortion of the economic and social functions of the State as well as to a reduction in the quality of inhabitants' life.

But it is necessary to apply any quantitative methods to understand of the interrelation between the various sectors and elements of CI as well as other elements of the State economy and to calculate the potential losses due to dysfunction one of them. Some of methods that can be applied are described in following statement:

- econometric methods — allow to express relationship between total amount of losses and number of dysfunctional of CI,
- logical trees – allows to express the total amount of losses for the decomposed events that are associated with the likelihood of its occurrence,
- simulation – it is a method based on imitating of the real system behaving,
- direct quantification – it is a method which is used to quantify the potential losses in the framework of risk analysis; calculation of the total loss is derived from the costs associated with dysfunction of selected elements of CI,
- curve of exceedence probability for a given loss (EP curve) and the probable maximum loss (PML),
- application of the method the cost/revenue (cost benefit analysis),
- specific methods, form example implied cost of fatality (ICAF) or annualized loss expectancy (ALE).

In addition to these methods, it is possible to apply any other, which is used in the calculations of expected losses for insurance purposes.

CONCLUSION

Whereas the concept of critical infrastructure has its political, social and economic dimensions, governments should not solve the problem of ensuring its functionality in isolation but in cooperation with owners and managers who are responsible for day to day operations of these elements. Only in this way losses resulting from disruption of any element of CI could be prevented.

LITERATURE:

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НАРУШАВАНЕ НА КРИТИЧНАТА ИНФРАСТРУКТУРА И КОЛИЧЕСТВЕНО ОПРЕДЕЛЯНЕ НА ПОСЛЕДИЦИТЕ ОТ НЕГО

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Ключови думи: елемент на критичната инфраструктура, нарушаване на функционалността, взаимозависимост

Резюме: Критичната инфраструктура се състои от система от взаимосвързани елементи, които представляват гръбнака на националната икономика на всяка страна или на икономическия съюз. Нарушаването на някой елемент може да има значителни последици не само за непрекъснатото функциониране на другите елементи на критичната инфраструктура но и за всяка пазарна единица, която зависи от тяхното непрекъснато действие. Тази зависимост се проявява особено силно през януари 2009, когато няколко държави от Югоизточна Европа са засегнати от газовата криза, придизвикана от спор между Русия и Украйна.

Количественото определяне на загубите, които възникват въз основа на отказа на някой елемент на критичната инфраструктура е много сложно. Тази сложност е резултат от редица фактори и взаимозависимости между елементите на критичната инфраструктура, както и други оператори на пазара.

Статията акцентира върху взаимозависимостта на различните елементи на националната икономика и тяхната зависимост от функционалната критична инфраструктура по примера на газовата криза. Тя описва първичните и вторичните последици от газовата криза и се опитва да определи загубите за бизнеса, домакинствата и икономиката на страната.