

## Research Article

# An Efficient Multifeature Model for Improving the Performance of Critical Energy Infrastructure

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Energy infrastructure is well thought-out to be one of the complex infrastructures due to its convoluted configuration and automatic control among all of the systems. With such systems, various connections are made for the purpose of configurations. The energy system infrastructure aims to analytically evaluate each element of the system based on fundamental energy branches according to the customer demand. Developing a novel critical evaluation approach for complex energy infrastructure is pertinent to the evaluation of mixed energy system infrastructure. Considering the functional relationships between elements and their infrastructures, a system is needed to overcome the limitations of the current systems. By doing the efficient modeling of enhancing the performance infrastructure of critical energy infrastructure enable better quantitative evaluation of system. The purpose of the proposed study is to develop an evaluation approach for enhancing the performance of critical energy infrastructure. With the help of the proposed approach, efficient multifeature model for enhancing the performance of critical energy infrastructure was experimentally calculated. The experimental setup of the proposed study was done in the Super Decision tool for an efficient multifeature model for enhancing the performance. Results of the experiments reveal the effectiveness of the proposed research.

## 1. Introduction

Humans have become increasingly reliant on the computer infrastructure networks that support our everyday lives (including electricity grids, pipelines, transportation systems/thoroughfares, and equipment). The information technology that underpins such infrastructures has made the society more complex, effective, and efficient while also making it more vulnerable to cyber threats [1]. Conflict over resources has existed since the dawn of time, and energy infrastructure has long been the victim of targeted attacks [2]. Critical is described as forming or having the nature of a vital, crucial, extremely significant, or necessary. Energy may refer to the “ability of a body or device to do work” or “a

source of usable power, such as a fossil fuel or electricity.” Infrastructure can be defined as the basic physical facilities required for a society to work [3]. A complex infrastructure is one containing convinced criteria of value for national importance such that the services it offers are critical to national economic vitality, security, and way of life [4]. It is characterized as physical and information technology structures, networks, facilities, and properties that, if damaged or destroyed, would have catastrophic consequences for citizens’ health, safety, security, or economic well-being, as well as the active operation of nations [5]. CIE comprise setting up and producing electricity and mining oil and gas, keeping them in refineries, terminals, and nuclear plants [6].

Critical energy infrastructure (CEI) is critical to the state's long-term sustainability. As a result, CEI is one of the most critical elements of national security. Clearly, the future advancement of CEI is dependent on specific measures pertaining to the implementation of modern information technology (IT), including various styles and models of cloud systems into the domain of network infrastructure [7]. CEI stability is a duty for which the government bears primary responsibility. The government's job is to do everything possible to protect its people, but it cannot do so alone. To a large degree, this is due to the fact that many possible terrorist targets, such as electrical power, natural gas, and oil production and transmission facilities, are owned and/or run by the private sector. Government and the private sector also play critical roles in fostering and establishing a "stable economy" [8]. A rise has been noted in the number of nonstate actors attack on vital energy infrastructure for the last three decades. There are persuasive causes for believing that insurgents would be more inspired to target infrastructure of energy in the near future. Numerous reasons for insurgent to attacks critical infrastructure such as energy is essential to functioning, consistent societies, from the economy to social institutions, making it a valuable target. Second, energy infrastructure is combined and organized with a plethora of incredible material and unimportant assets, ranging from network communication to public services provision networks, any disruption of which could have crippling social and economic consequences. As energy has more importance to communities, politics, economies, and power in modern decades, so has the number of attacks [9]. CEI is vulnerable and resilient for attacks [8] that include extremist attacks on gas and oil reservoirs, attacks like extensive energy "denial" operations, various physical attacks such as explosives, biochemical attacks, and cyber-attacks. For the first time in history, cyber-attacks and other IT security concerns have risen to the top of the industry's priority list. Threats and their creators are becoming more prevalent and will almost certainly continue to do so in the future, making them even more difficult to identify and mitigate against. Owing to a society's dependency on ICT technology and systems, a new class of cyber-physical threats known as "cyber-enabled physical attacks" on critical infrastructure has emerged. While the means and behavior of such attacks are virtual, the result could be physical. It may disable surveillance and security equipment or cause extreme physical harm [5]. The following are the contributions of the proposed study:

- (1) To identify multifeature model for improving the performance of critical energy infrastructure
- (2) To develop an evaluation approach for enhancing the performance of critical energy infrastructure
- (3) With the help of the proposed approach, efficient multifeature model for enhancing the performance of critical energy infrastructure was experimentally calculated
- (4) To use SuperDecision tool for the experimental process and showing the effectiveness of the results of the experiments performed for the proposed research

This paper is organized as follows. Section 2 briefly discusses the literature review associated to the proposed research. Methodology along with the process of comparisons of the current research is elaborated in Section 3. Results and discussions of the experimental work are given in Section 4. The paper is concluded in Section 5.

## 2. Literature Review

Related cybersecurity capability maturity models were analyzed to define the requirements and controls available to critical infrastructure providers to increase their degree of security preparedness. These capability models are defined and classified based on their relevance to various infrastructure domains, and guidelines for using capability maturity models to assess and communicate responsiveness [10]. A new approach for assessing the vital infrastructures of the energy system is introduced. The approach is dedicated to both the general and specific elements and classes of the device criticality evaluation in terms of the requirements of final energy consumers. This approach was used to conduct an aggregated criticality assessment of the Lithuanian energy system infrastructure. A mathematical model for assessing the criticality of energy systems infrastructure was developed. The model allows for a more objective evaluation of criticality than conventional approaches without reliability assessment. Following an evaluation of the analyzed energy system infrastructure criticality, it was discovered that the highest average criticality has five elements with average criticalities ranging from 0.16 to 0.72 in analyzed district heating systems, and seven elements with criticalities ranging from 0.1 to 0.77. Using logistic regression to assess the reliability of analyzed energy system elements, elements and their combinations with a likelihood greater than 1/2 have a criticality of 0.6, and over 60 combinations of such elements were discovered [11]. Cloud computing and cloud networking are being used to ensure the proper operation of critical energy infrastructure management systems. The application of additional Wide-area Measurement and Control Systems (WAMCSs) improves the informativeness of the Supervisory Control and Data Acquisition system because most of the processing and transition operations of the WAMCSs' data information streams can be performed on clouds. It is crucial to obtain detailed modelling results when taking into account a wide range of input data and the latency time between critical energy infrastructure components and cloud infrastructure components. However, researchers did not have the option of receiving more appropriate results based solely on mathematical modelling. In this case, simulation models that take into account cost time are superior to mathematical models. In the spirit of promoting this idea, the authors propose using a simulation

model based on virtual technology and the Matlab Simulink toolkit to obtain modelling results for the more important online mode of operation of the WAMCSs [12].

Agent-based models (ABMs) can be used to evaluate transition assemblage alternatives *ex ante*. A typology was created to aid in determining whether the design of a specific model is appropriate for its intended intent. Three versions were evaluated: (1) a model of the effect of CO<sub>2</sub> policy on the power production sector; (2) a model of the global LNG infrastructure transition; and (3) a model of the impending transition triggered by the arrival of light-emitting diode (LED) lighting systems. All three models can be used to compare alternative transformation assemblages and could be modified to determine regulatory adaptability [13].

It is important in modern society to ensure the resilience of critical infrastructures, but most of the deployed infrastructure has yet to fully exploit modern technological advances. This paper demonstrates how deep learning can boost resiliency in the electricity sector by intersecting two distinct fields: deep learning and critical infrastructure security. Machine vision is the combination of machine intelligence, or computer systems that learn patterns from exemplar data, and image recognition, which is the automated segmentation and identification of objects of interest from video image data. This technology has the ability to automate threat assessments in the context of critical infrastructure security. Rather than conventional reactionary methods, a method for leveraging deep learning to identify threats to critical infrastructures before they collapse was presented. The current state of the art in deep learning was addressed for building machine vision systems, and the principles are applied to improve the resilience of vital infrastructures. The intersection of machine vision and critical infrastructures is addressed, as well as the main benefits and challenges of implementing such an approach, and examples from many critical infrastructure fields are presented. The use of vehicle-mounted video acquisition equipment for automated power infrastructure inspection is investigated [14].

### 3. Methodology

Decision support systems have various applications in diverse areas of real life [15–18]. A method for assessing the quantitative vulnerability of critical infrastructure networks was addressed. The primary focus was on smart electric power delivery systems, such as smart grids for transmission and distribution, as well as SCADA and EMS systems. Perceptions and findings from social network and graph theories were implemented and applied to the analysis of the WSCC-Smart Power Grid Network-SCADA-EMS System.

The topological networks characteristics were determined, and their error and attack tolerances were compared. Generation models of topology such as small-world, random graph, and scale-free models were investigated. The model of scale-free graph social network theory was discovered to be followed by the WSEE method [19]. The key characteristics of progressive communication model pointed at improving the security of critical energy assets from man-made attacks

(terrorism) or natural disasters were identified. Hybrid network architecture was used in the proposed model that incorporates the benefits of various wireless technologies, including delay/disruption tolerant networking, mobile Ad-hoc networks, and wireless sensor networks. The solution involves the creation of an expanded routing protocol that accounts for the various networking technologies involved. It was also demonstrated that the hybrid network architecture can be used to protect real energy assets such as oil refineries and pipelines [20]. Table 1 shows the features identified from the literature. These features were checked with in-depth knowledge, so that the significant features should be extracted and be used for the proposed study.

### 4. Experimental Setup

The proposed study was carried out in the Super Decision tool for an efficient multifeature model for enhancing the performance of critical energy infrastructure. The proposed research and approach work well in situation where complexity arises among the criteria and multiple alternatives available. Figure 1 describes the hierarchy of the proposed experiment for critical energy infrastructure. The figure contains three phases: the goal, criteria, and alternatives.

After plotting the goal, criteria, and alternatives in the tool, the process of calculating the criteria for the available alternatives was started. Figure 2 describes the comparisons of the criteria (features) with respect to the available alternatives.

The same comparison process was done for the rest of the criteria with respect to available alternatives and alternatives with respect to criteria. Here for information, only the comparison of these tables are given. Various shapes of comparison process are available in the Super Decision tool. These shapes of comparisons include comparison through graphical, verbal, matrix, questionnaire, and direct. Figure 3 represents the node comparison with respect to energy infrastructure.

The graphical comparison is shown in Figure 4.

Once, all the process of comparisons was done, the processed values of comparisons were brought into a summarized unweighted matrix for further process. Table 2 represents the unweighted super matrix.

In the unweighted super matrix, the values are not normalized. So again, the comparison process was done and weighted super matrix was obtained. Table 3 describes the weighted super matrix.

Once the weighted super matrix was obtained, this matrix was converted into limit matrix for obtaining the priorities of the available alternatives. Table 4 shows the limit matrix of the available criteria and alternatives. From the limit matrix, the decision can be made regarding the available alternatives that which option among the existing is more appropriate.

### 5. Results and Discussions

The aim of the proposed study was to suggest efficient multifeature model for enhancing the performance of critical energy infrastructure. The experimental process of the proposed study was carried out in the SuperDecision

TABLE 1: Significant features identified from literature.

No.	Features	Citation
1	Privacy	[5]
2	Survivability	[1, 2]
3	Reliability	[1, 21]
4	Availability	[1]
5	Security	[1, 8, 22]
6	Safety	[1, 8]
7	Surveillance	[2]
8	Interdependency	[2]
9	Protections	[5, 23]
10	Energy efficient	[24]
11	Interoperability	[25]
12	Confidentiality	[26]
13	Robustness	[21]

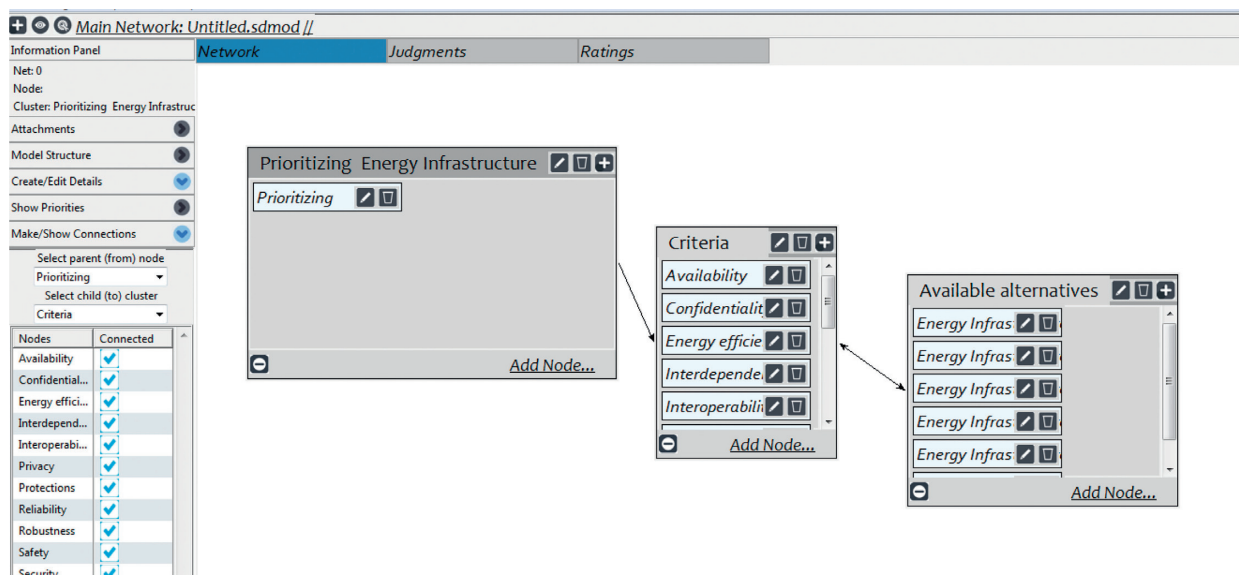


FIGURE 1: Hierarchy of the proposed experiment for critical energy infrastructure.

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FIGURE 2: Comparisons of the criteria (features) with respect to the available alternatives.



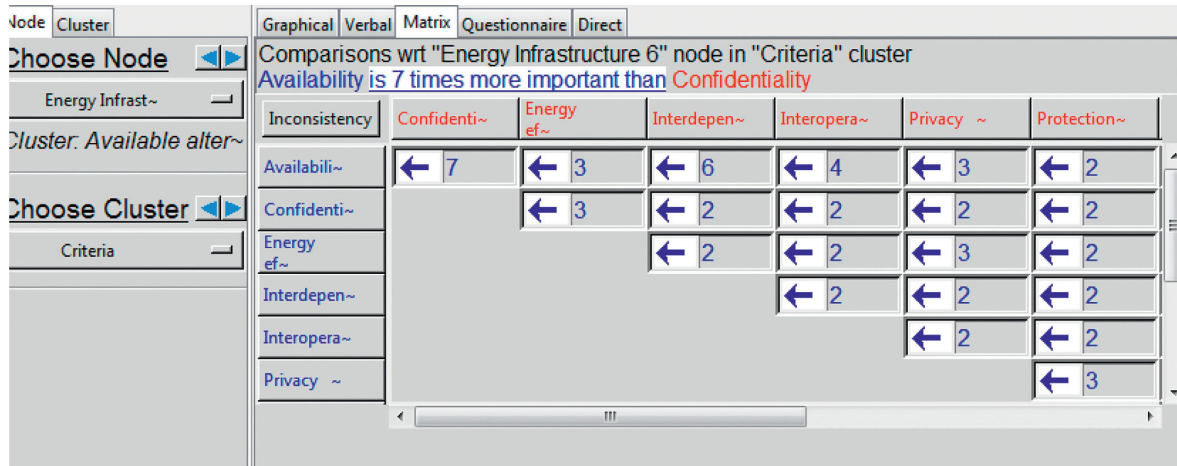


FIGURE 3: Representation of the node comparison with respect to energy infrastructure.

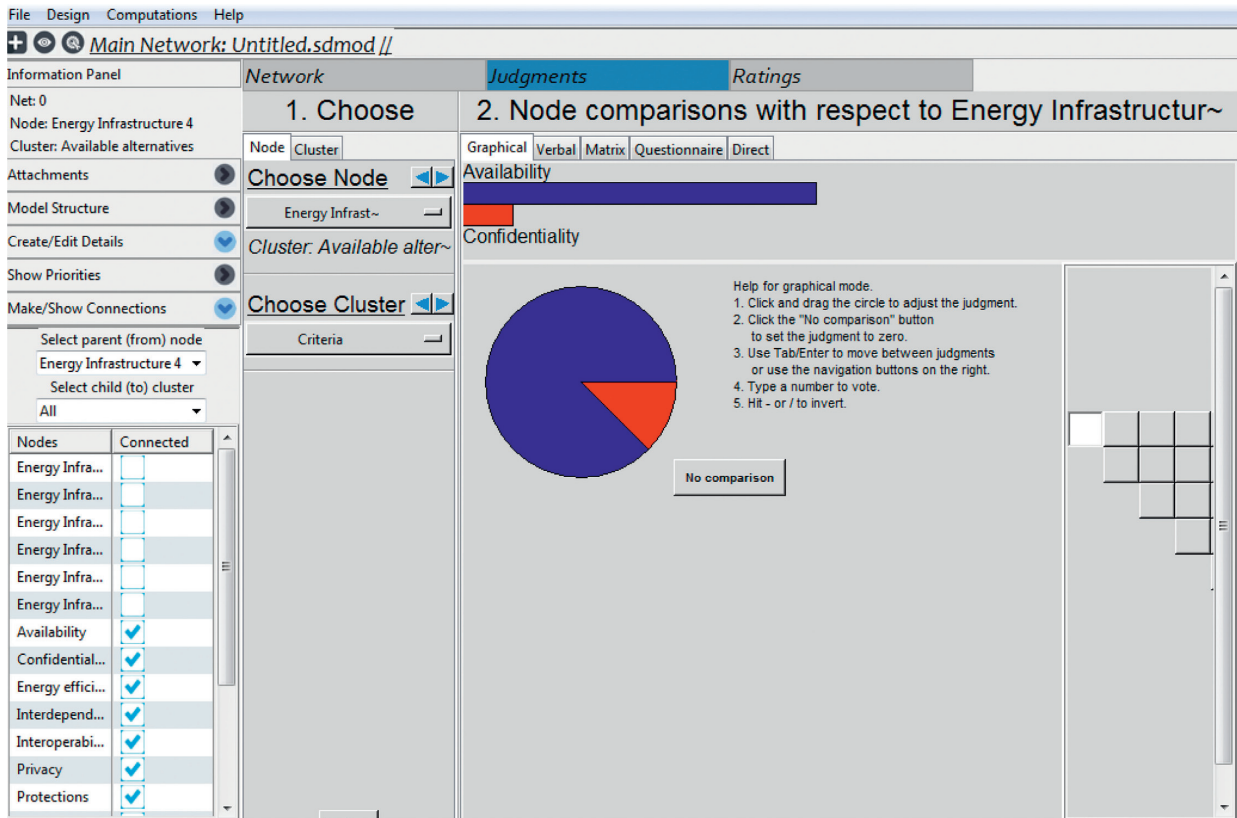


FIGURE 4: Graphical representation of the comparison for criteria.

tool. The pairwise comparisons of the criteria along with the alternative and alternative to criteria were done. Once the process was completed, priorities for the available alternatives were obtained. Figure 5 shows ranking of the available alternatives. From the figure, it is seen that energy infrastructure 1 is the top most priority among the available options followed by energy infrastructure 2, and so on.

The overall synthesized priorities for the alternatives are shown in Figure 6. This was obtained from the process of comparisons and is synthesized from the main network of hierarchy.

Figure 7 describes the AHP sensitivity for the proposed research.

The ANP sensitivity is given in Figure 8.









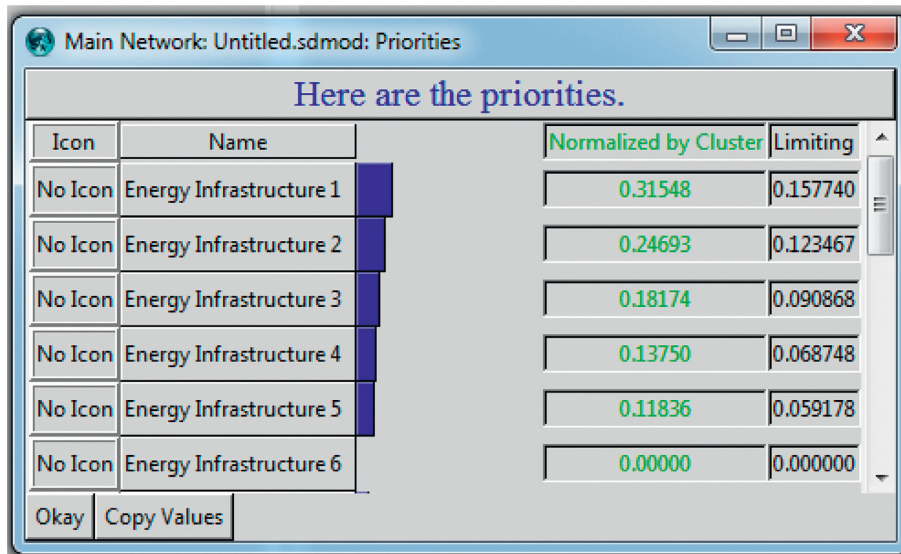


FIGURE 5: Ranking of the available alternatives.

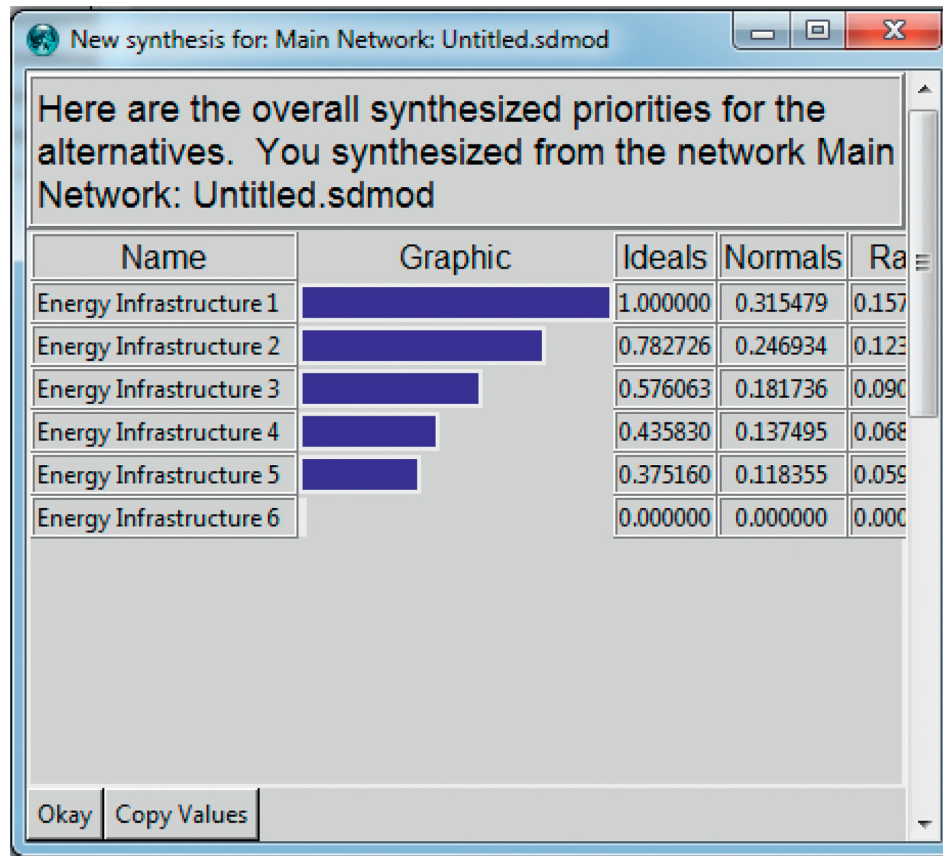


FIGURE 6: Overall synthesized priorities for the alternatives.

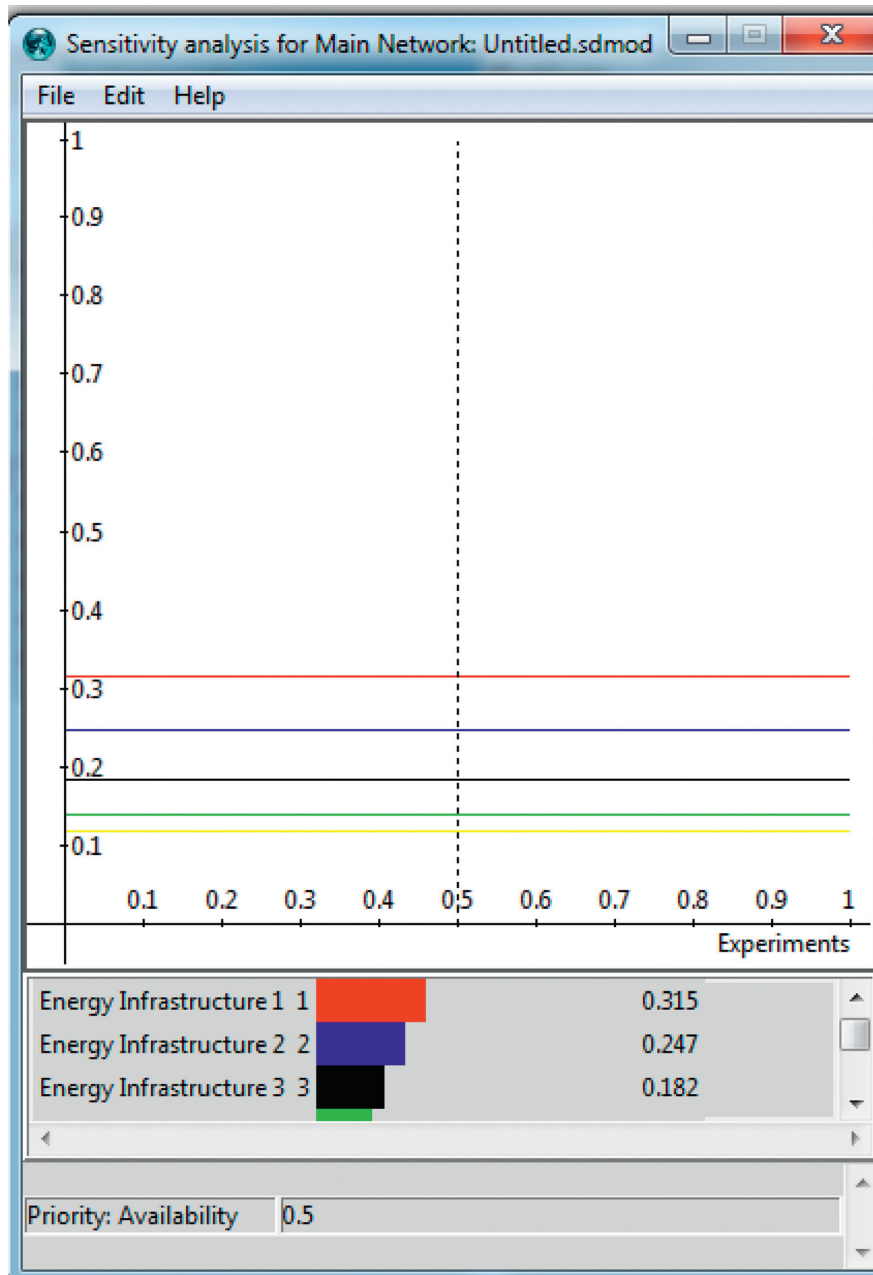


FIGURE 7: AHP sensitivity of the proposed study.

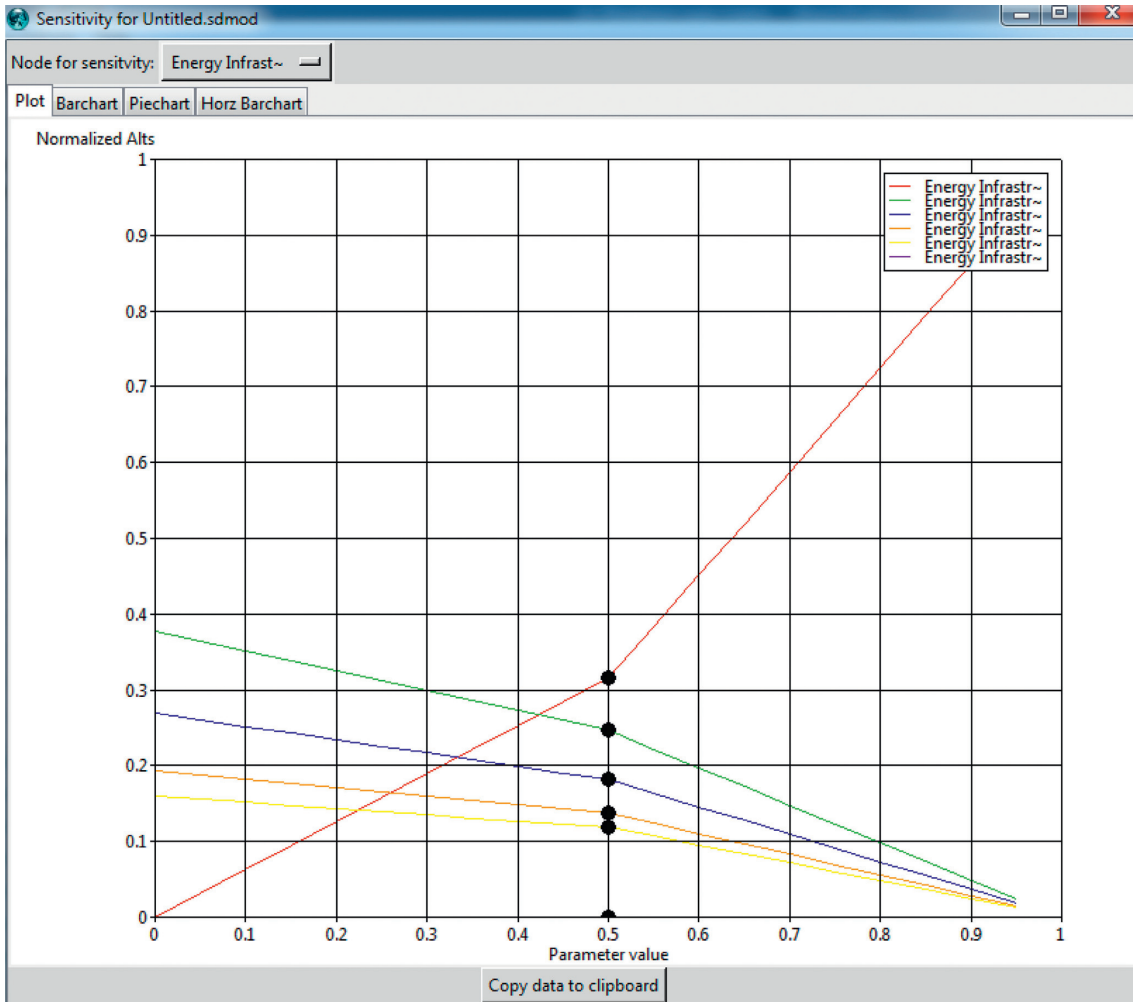


FIGURE 8: ANP sensitivity.

## 6. Conclusion

The aim of the study is to systematically assess elements of the energy infrastructure system based on fundamental energy branches according to the customer demand. CEI is critical to the state’s long-term sustainability and is considered as one of the utmost critical elements of national security. Undoubtedly, the future development of CEI is dependent on explicit measures pertaining to the implementation of modern information technology including various styles and models of cloud systems into the domain of network infrastructure. Developing of novel critical evaluation approach for complex energy infrastructure is pertinent to the evaluation of mixed energy system infrastructure. Considering the functional relationships between elements and their infrastructures, a system is needed to overcome the limitations of the current systems. The aim of the proposed study was to suggest efficient multifeature model for enhancing the performance of critical energy infrastructure. The experimental process of the proposed study was carried out in the SuperDecision tool. The pairwise comparisons and calculations of the criteria along with the alternative and alternative to criteria were done in different

phases and then unweighted, weighted, and limit matrix were obtained. Once the process completed, then priorities for the available alternatives were obtained. The determination of the proposed study was to develop an assessment approach for increasing the performance of critical energy infrastructure. With the support of the proposed approach, efficient multifeature model for enhancing the performance of critical energy infrastructure was experimentally calculated. Results of the experiments have shown the efficiency of the proposed study.

### Data Availability

No data are available.

### Conflicts of Interest

The authors declare that they have no conflicts of interest regarding this study.

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