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A Comparative Analysis of Buspro and Goosepro Systems Using AHP and TOPSIS: A Case Study of the National Electricity Company in Indonesia

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Abstract. This study compares two protection systems, Buspro and Goosepro, for electrical substations at the National Electricity Company in Indonesia. The Analytical Hierarchy Process (AHP) and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) methods are employed to determine priority criteria and sub-criteria for decision-making and evaluate alternative choices. The methodology involves a quantitative approach, collecting data through questionnaires from expert respondents within the company. The results highlight the importance of various criteria, such as system usability, security, ease of use, risk, user interface, interoperability, associated costs, and trust, in evaluating the protection systems. The findings indicate that the Buspro system outperforms the Goosepro system in several key criteria. The study underscores the significance of selecting the most suitable protection system based on specific criteria to enhance the reliability and efficiency of the power grid. The authors conclude that the conventional Buspro system is preferable to Goosepro for protection system at the National Electricity Company substations.

Keywords: Substation, Electric Power System Protection, Buspro, Goosepro, AHP, TOPSIS, Reliability, Electric Power Transmission.

1. Introduction

Substations have an important role in electricity transfer. Substation functions in changing the voltage level from high level to low level and vice versa using a power transformer and carrying out switching and protection operations (Hasmudi, 2020). Electric power system protection is a vital and integral component of the operation of the electric power system. An ideal protection plan effectively eliminates fault currents from the system in the shortest possible duration, while minimising power outages on power system equipment (RATNA DEWI, 2019). System requirements can include the implementation of different protection functions for both primary and backup protection in each system. For instance, in gearbox systems, distance protection is typically employed as the primary means of safeguarding, whereas in distribution systems, overcurrent protection is selected as the primary form of protection.
Busbars are switchgear components to which all electrical power system equipment is connected (Roza et al., n.d.), Busbars collect electrical power from incoming feeders and distribute it to outgoing feeders. Therefore, busbars play an important role in the overall reliability of the power grid. The failure of the busbar system protection method poses a risk to the stability of the system. This can produce a comparable impact to a simultaneous malfunction on all components linked to the busbar. Nevertheless, the inability to rectify flaws in the busbar or the improper functioning of the protection mechanism can result in tripping. Busbar differential protection is commonly employed as a specialised protection strategy for busbar systems, functioning on the current principles of Kirchhoff's law (Farito, 2022). When executed accurately, this scheme is a rapid and dependable method that may effectively distinguish between faults occurring within the protected zone in busbar system and faults occurring outside the zone. Nevertheless, the primary obstacle in employing differential protection systems from various suppliers is in the requirement to provide resources towards the establishment of an Intelligent Electronic Device (IED) infrastructure, encompassing relays and communication lines connecting each IED (Desri et al., 2023). Hence, electricity providers employ various methods to safeguard busbars.
The concept of the IEC 61850 standard is applied, where large amounts of data are exchanged between various Relays (Habibie et al., 2021). One of the protocols used is the Generic Object-Oriented Substation Event (GOOSE) Protocol, which is designed for bay & station level communications, distributing high priority messages through the use of multiple Relays. The security vulnerabilities of the GOOSE message protocol are mostly caused by inappropriate signal or data sending formats (Alvianto, 2013). The use of GOOSE increases the amount of important data exchanged and can be used for example commands to equipment at the substation. The increase in digital equipment in electrical systems creates potential vulnerabilities that can be misused to disrupt electrical power communications systems.

At National Elctricity Company, there is currently a situation where the busbar protection ("Buspro") relay is not functioning (block operation) in the high impedance type. This is because a new bay has been added, and the Current Transformer (CT) ratio in the new bay is different from the previous CT ratio (Pulungan, 2015) . However, it is becoming challenging to locate a CT with the current ratio due to the declining population. The low impedance type arises from the installation of a new bay without the corresponding addition of peripheral unit relays required for a busbar protection system. With these non-ideal conditions, if a Buspro disturbance occurs, the remote substation will localize the disturbance with a delay time of 400-800ms. So the distribution of electrical energy becomes unreliable and has the potential for widespread consumer outages (ADLI, 2022).

In addition, the distribution of energy relies heavily on the security of the protection system implemented at the substation. The consequences of power distribution failure can lead to significant financial losses for both enterprises and consumers. In order to prevent failures such as tripping and short circuits, it is imperative to address the issues with Buspro. Resolving these problems is crucial for maintaining a positive reputation and ensuring consumer satisfaction. Goosepro is a solution to the problems mentioned previously. Goosepro is a protection system based on IEC61850 Goose Message which requires the addition of a relay function to the conductor protection as a busbar fault detector. The Goosepro that was created is considered to be a fairly reliable solution.

This research attempts to reveal the priority order for selecting a protection system based on the criteria, sub-criteria and alternatives selected. This will make it easier for us to determine which criteria are the most important choices for National Electricity Company that have a special interest in the field of system protection. Currently, the protective system can be utilized using either Busbar or Goosepro. According to literature reviews (Trip), Goosepro is believed to have the capability to improve the reliability of electrical energy distribution and prevent blackouts caused by system failures. Researchers utilized the Multiple-Criteria Decision-Making (MCDM) approach, specifically the Analytical Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to Ideal Solutions (TOPSIS), to establish the main factors for selecting a protective system between Busbar and Goosepro.

One of the decision support system methods is the Analytic Hierarchy Process (AHP) which was developed by Thomas L. Saaty around the 1970s (Diana & Utari, 2016). The AHP method is used to find ranking priorities in several alternatives to obtain pairwise comparisons, both continuous and discrete. According to Setiyaningsih, (2015) AHP is a measurement scheme used to find a ratio scale through pairwise comparisons between factors (Wasis Agung Sutignya, 2023). This pairwise comparison can be found through actual or relative measurements of the degree of liking, level of interest, feelings (intuition), a person's experience, or facts, which is a basic scale that reflects relative strengths and preferences that are able to overcome complex problems, where aspects or there are quite a lot of criteria taken, but they can help decision makers to get the best decision.

TOPSIS is a decision-making system method developed by Yoon and Hwang in 1981. This method selects alternatives for the best ranking by using the positive ideal solution which has the shortest distance and the negative ideal solution which has the shortest distance. This approach has the capacity to address challenges in Multi-Criteria Decision Making (MCDM). The concept behind TOPSIS is straightforward and pragmatic, with a high processing efficiency and the ability to quantify the relative worth of each option alternative using basic mathematical expressions.

2. Literatur Review

2.1. Busbar Protection System

Large electrical power systems with large areas are very vulnerable to the possibility of disruption due to short circuits. Short circuits in high voltage electrical power systems can cause very large short circuit currents and have the potential to cause damage to equipment. If a fault occurs at the busbar of a substation, the resulting short circuit current can reach the maximum short circuit current in the system. The busbar serves as the central component of a substation, facilitating connections between all bays, including transformer bays and bay lines. Typically, substations are constructed using a dual busbar layout, consisting of two busbars. However, there are also substations that utilise a single busbar.

The busbar protection system is a crucial device designed to safeguard against disruptions that may arise on the busbar. The busbar relay is the primary protective device that operates based on the differential principle. Under normal system conditions, the sum of the phasors of all incoming and outgoing currents is expected to be zero. However, if a disturbance occurs outside the busbar, at least one direction of current will be opposite to the other current. If a disruption takes place on the busbar, the combined values of the phasors cease to be zero, resulting in the activation of the relay.

2.2. Standard IEC61850

The IEC61850 standard is a global standard that establishes an Ethernet-based communication protocol for intelligent electronic equipment in electrical substations. The IEC61850 standardises the communication, data formats, configuration languages, and test standards of Intelligent Electronic Device (IED) devices (IEEE, 2017). The IEC61850 standard encompasses multiple essential Data Models for protective systems.The Data Model comprises the Physical Device, Logical Device, Logical Node, Data Object, and Data Attribute.

One of the main features of IEC 61850 is the Generic Object Oriented Substation Event (GOOSE). GOOSE is a mechanism used to quickly transfer status, alarm, or event information between devices in a substation, such as protective relays, remote controllers, or other equipment. The link between IEC

61850 and GOOSE is that GOOSE is a component of the IEC 61850 standard, which regulates the transmission of information between devices in protection and control systems inside electric power plants. GOOSE facilitates rapid and dependable transmission of data among devices, hence enhancing the overall coordination and efficiency of the system.

GOOSE (Generic Object-Oriented Substation Event) Message is a high-speed data exchange mechanism used for transmitting and receiving various types of data/messages inside a single IP Address segment at a substation. These data/messages can include directives, alarms, or indications. A GOOSE message is a transmission of data sent by an Intelligent Electronic Device (IED) that can be received and utilised by many recipients. GOOSE leverages the capabilities of the Ethernet network to facilitate real-time exchange of information data.

The data transmission system consists of a GOOSE sender device, which sends the data, a GOOSE receiver device, which receives the data, and an Ethernet network, which serves as the communication medium. An IED is capable of transmitting data only to other IEDs that have been configured to accept that specific data. The response of each data recipient is contingent upon the arrangement and operations established by the data transmitter.

2.3. Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was devised by Thomas L. Saaty of the Wharton Business School with the aim of determining the relative ranking or importance of several choices when addressing a problem. The Analytic Hierarchy Process (AHP) was originally created by Thomas E. Saaty in 1970, as stated by (Dachyar et al., 2013). In our daily lives, we constantly encounter a multitude of alternative options. Hence, it is imperative to establish priorities and assess the coherence of the decisions that have been taken (Avrianto, et al., 2022). The Analytic Hierarchy Process (AHP) is a multi-criteria decision making (MCDM) technique that involves comparing optimal outcomes based on a set of evaluation criteria and a set of alternatives (Dachyar & Sijabat, 2019)

According to Masnuryatie & Triyono, (2022), the AHP method is a framework or model that can assist in making effective decisions on complex problems. The problem-solving technique applied is to break the problem into groups and then organize the groups into a hierarchical model. After forming a hierarchical model, the decision maker then assigns a numerical value to the importance of each criterion. Then, the decision maker uses the experience of the analysis results as a consideration to determine the criteria to be used, of course by choosing the criteria that have the highest priority and have a high influence on the results. The AHP method has characteristics or properties that involve quantitative and qualitative elements.

AHP is a decision support paradigm that was created by Thomas L. Saaty. The intricate multifactor or multicriteria problem will be broken down into a hierarchy of decision support models. Saaty (2004) defines a hierarchy as a multi-level structure that represents a complex problem. The initial level of the hierarchy is the aim, followed by tiers of factors, criteria, sub-criteria, and finally options at the last level.

The AHP is utilised to determine the relative importance of criteria that have been derived from expert opinions through pairwise comparisons (Dachyar & Purnomo, 2018). Analytic Hierarchy Process (AHP) is employed to elucidate intricate and disorganised scenarios. There are multiple criteria that need to be resolved into various components, which will then be organised into a hierarchy. With hierarchy, a complex problem can be broken down into groups which are then arranged into a form of hierarchy so that the problem will appear more structured and systematic.

MCDM, including AHP and TOPSIS, is crucial for selecting optimal locations and technology for solar power plants (Ghasempour et al, 2019). These approaches consider factors like geography, economics, accessibility, electrical network, maintenance expenses, and operational costs. Efficient solar power generation is essential for electricity generation, but the choice of technology is equally important. Comprehensive research is needed to fully understand these factors.

2.4. Technique for Order of Preference by Similarity to Ideal Solutions (TOPSIS)

The TOPSIS method is a technique for making decisions based on several factors. It was initially developed by Yoon and Hwang in 1981. This strategy is commonly employed to facilitate practical decision-making. TOPSIS is a technique used for multi-criteria decision-making (MCDM) that rates options based on their proximity to an ideal answer (Dachyar & Maharani, 2019). The TOPSIS methodology entails assessing a solution by measuring its proximity to both the positive and negative ideal solutions. The TOPSIS method employs the notion that the chosen option should be the most distant from a negative solution and the closest to a positive ideal solution, as determined by Euclidean distance in a geometric context. The TOPSIS optimal solution is achieved by evaluating the proximity of an alternative to the positive ideal solution. TOPSIS is a method that assigns rankings to different options based on their relative closeness to the positive ideal solution, which is determined by a priority value. The ranking alternatives serve as a reference for decision making in order to select the most optimal option (Jain, 2011). In the TOPSIS technique, the selected alternative should have the minimum distance from the positive ideal solution and the most distance from the negative ideal solution.

In this research TOPSIS is applied to assess an alternative choice. The set that will be carried out in TOPSIS is the set of alternatives expressed as A = {A1, A2, ... , Am}, and the set of criteria expressed as C = {C1, C2, ... , Cn}, the TOPSIS method construction process is weighted entrop – AHP can be demonstrated through several stages. MCDM techniques, such as AHP and TOPSIS, are being explored for their effectiveness in making sustainable development decisions (Rane et al, 2023). These techniques are used in various sectors, including construction, business, finance, accounting, and more. The study emphasizes the need for hybrid MCDM techniques, which combine the advantages of multiple decision-making processes for more precise and resilient outcomes. The ultimate goal is to enhance the creation of a robust decision-making framework for sustainable development, providing valuable perspectives for policy makers, academics, and practitioners.

MCDM, including AHP and TOPSIS, is a critical tool in managing energy resources, particularly in renewable energy (Bohra et al, 2021). It helps in identifying sensitive factors controlling energy-intensive applications and determining suitable locations for solar, wind, and hydroelectric power plants. This research aims to identify MCDM domains and approaches in the energy sector, enabling engineers, decision-makers, academics, and researchers to plan, manage, and select renewable resources, thereby enhancing the development of civilization.

3. Research Methodology

The case study taken in this research is the Buspro and Goosepro protection system. The data taken is primary data using a questionnaire given to Experts at National Elctricity Company as users of the protection system. The proposed decision-making model in this work comprises several key components. These actions involve determining the selection criteria, assigning weights to each criterion, and utilizing them to rank the available options. These procedures are supplemented with four further subprocesses: criterion validation, criteria weighting, and priority determination utilizing AHP and TOPSIS.

First, analyze the reference material to determine the criteria used for selection. Experts recommend incorporating other supplementary criteria into the selection process. The individuals referred to as "experts" are employees of the state power company who possess different levels of experience and diverse professional backgrounds. The criteria, derived from a range of literature sources and expert judgments, have not been demonstrated to be relevant to the research context. To achieve the research objectives, it is necessary to validate the collected criteria, as most of the literature does not specifically discuss the selection of a protective system framework.

Prior to establishing the selection criteria, a comprehensive examination of the pertinent literature is undertaken. Moreover, experts recommend including certain criteria in the selecting process. The individuals referred to as experts are employees of the state electrical business who have a wide range of professional qualifications, different levels of seniority, and significant work experience. The validity of the criteria, which were determined through expert consultation and extensive literature review, has not yet been confirmed within the research environment. Considering that most of the existing literature does not expressly discuss the selection of a protective system framework, it is crucial to verify the collected criteria in order to ensure that the research objectives are achieved.

A Likert scale questionnaire ranging from one to five was used to validate the criteria. Where 1 denotes the least significant value and 5 denotes the most significant value. Experts will determine the essential factors that should be considered when selecting a framework for a security system. After analyzing the questionnaire responses, the geometric mean of the experts' answers for each criterion was calculated. The geometric mean is used instead of the arithmetic mean because it reduces the influence of large differences in values within the dataset. As a result, it reduces computational inaccuracies compared to the arithmetic mean.

After establishing the criteria for selection, the next step is to utilize the Analytic Hierarchy Process (AHP) approach to calculate the weight of each criterion. AHP is considered a method for defining and evaluating priority criteria since it utilizes rigorous tests to confirm the legitimacy of expert opinions. The manual calculation of pairwise comparisons for each criterion and sub-criteria is carried out using the Excel software and the Expert Choice application. The framework selection and ranking method utilizes the weight of the collected criteria and sub-criteria as input. In addition, the TOPSIS technique requires the expert to evaluate each possibility based on the provided criteria and sub-criteria. Consequently, a survey is used to get the expert's ideas by employing an additional survey. On the Likert scale, ratings range from 1 to 4, with 4 being the highest and 1 being the lowest. Afterwards, the TOPSIS algorithm will use the questionnaire replies as input to determine the ranking of the frameworks.

4. Result and Discussion

Researchers have collected several lists of criteria based on literature studies that have been carried out, then researchers carried out assessments from experts to confirm the list of criteria from the sub-criteria listed. Experts are needed to confirm several lists of criteria that will be determined in research to determine the protection system. The experts in this questionnaire are respondents from within the company. The selection of experts is based on the experts' expertise in managing protection systems in the company and based on length of work experience. According to the above criteria, the selection of protection systems will be divided into many sub-criteria that will be evaluated by experts. The sub-criteria presented in this table are derived from several literature sources.

Table 1. Main Criteria and Sub-Criteria for Protection System Selection

No.	Main Criteria	Sub-Criteria	References
1.	Usefullness	Use of the protection system	Davis et. al., 1989; Pu et al., 2020; Sharma et al. 2019; dan Williams., 2021.
		Technology Features	
2.	Ease of Use	System Usability	Naysary et al., 2022; Hussain et al., 2019 dan Singth et al., 2020.
		Ease of Operation	
3.	Risk	System Failure	Naysary et al., 2022; dan Yang et al., 2015.
		Off / Not Off	
4.	User Interface	Feature Development	Naysary et al., 2022, Pu et al., 2020; dan Kim et al., 2010).
		Technology Use Satisfaction	
5.	Security	System Security	Naysary et al., 2022; dan Amaloo., 2022.
		Technology Systems	
6.	Interoperability	National Elctricity Company Maintenance System Policy	Naysary et al., 2022; dan Gomes., 2018.

No.	Main Criteria	Sub-Criteria	References
		Disruption Duration Resolution Speed	
		Connection System	
7.	Associated Cross	Implementation Costs	Naysary et al., 2022; dann Rogers., 2003.
		Use of Technology	
8.	Trust	Interference Susceptibility	Naysary et al., 2022; dan Pu et al., 2020.
		User Trust	

After an assessment has been carried out by experts, the average value for each criterion that has been identified is then calculated. In carrying out the evaluation carried out by experts, the geometric mean method was used. Activities that have an average value smaller than the table will be eliminated because they are considered inappropriate. The following are the survey results obtained from experts which have been processed by researchers:

Table 2. Acceptance of Criteria and Sub-Criteria for Protection System Selection

No.	Main Criteria	Sub-Criteria	Weight Geomean	Geomean	Decision
1	Usefullness	Use of the protection system	4.57	4.57	Accepted
		Technology Features	4.57		Accepted
2	Ease of Use	System Usability	4.13	4.13	Accepted
		Ease of Operation	4.13		Accepted
3	Risk	System Failure	4.57	4.57	Accepted
		Off / Not Off	4.57		Accepted
4	User Interface	Feature Development	3.95	3.95	Accepted
		Technology Use Satisfaction	3.95		Accepted
5	Security	System Security	3.95	3.95	Accepted
		Technology Systems	3.95		Accepted
6	Interoperability	National Elctricity Company Maintenance System Policy	3.57	4.07	Not Accepted
		Disruption Duration Resolution Speed	4.57		Accepted
		Connection System	4.13		Accepted
7	Associated Cross	Implementation Costs	4.13	4.13	Accepted
		Use of Technology	4.13		Accepted
8	Trust	Interference Susceptibility	4.37	4.37	Accepted
		User Trust	4.37		Accepted

In the process of selecting a protection system, weighting is carried out using local weights and global weights for each selected criterion and sub-criteria using the AHP method. The weighting results can later be used in the next stage of data processing using the TOPSIS method.

Table 3. Pairwise Comparison Weighting Scale

Scale	Definition
1	Both criteria are equally important
3	One criterion is slightly more important than the others
5	One criterion is more important than the other
7	One criterion is clearly more important than the other
9	One criterion is absolutely more important than the other
2, 4, 6, 8	The values between two adjacent considerations

The questionnaire in this research will contain questions regarding the level of importance between one criterion and another criterion and one sub-criterion with another sub-criterion. Within the same criteria, experts will be assessed using an Pairwise Comparison weighting scale of 1 to 9.

Based on the results of pairwise comparisons that have been assessed by experts, data processing will be carried out using the AHP method. Weighting assessment by experts requires making a combined weight calculation taking into consideration the amount of weight for each expert so that the final weight results for each criterion and sub-criteria can be obtained.

The local weights of the criteria are obtained from normalized wight calculations. As for the pairwise comparison matrix, each sub-criteria is calculated the same way. The calculation of the global weight is the product of the local weight for the criteria and the local weight for the sub-criteria. After calculating the global weight, ranking of all sub-criteria based on the global weight can be seen in the following table.

Table 4. Local Weights and Global Weights for Criteria and Sub-Criteria

No.	Main Criteria	Local Weight	Sub-Criteria	Local Weight	Global Weight	Ranking
1	Usefullness	0.19	Use of the protection system	0.78	0.15	2
			Technology Features	0.22	0.04	9
2	Ease of Use	0.10	System Usability	0.88	0.09	4
			Ease of Operation	0.12	0.01	16
3	Risk	0.11	System Failure	0.73	0.08	5
			Blackout	0.27	0.03	13
4	User Interface	0.06	Feature Development	0.58	0.03	11
			Technology Use Satisfaction	0.42	0.03	14
5	Security	0.15	System Security	0.88	0.14	3
			Technology Systems	0.12	0.02	15
6	Interoperability	0.21	Disruption Duration Resolution Speed	0.78	0.16	1
			Connection System	0.22	0.05	8
7	Associated Cross	0.08	Implementation Costs	0.59	0.05	7
			Use of Technology	0.41	0.03	12
8	Trust	0.10	Interference Susceptibility	0.42	0.04	10
			User Trust	0.58	0.06	6

Weighting according to the level of importance and priority in determining criteria and sub-criteria based on the highest weight is the sub-criterion Speed of Resolving the Duration of Disturbances with a global weight of 0.16. Meanwhile, the sub-criteria that has the lowest global weight value is Ease of Operation with a value of 0.01. The order in weighting the calculation of priority criteria in selecting a protection system is shown in the following table.

Table 5. Priority and Ranking of AHP Final Results from Criteria and Sub-Criteria

Sub-Criteria	Local Weight	Global Weight	Ranking
Disruption Duration Resolution Speed	0.78	0.16	1
Use of the Protection System	0.78	0.15	2
System Security	0.88	0.14	3
System Usability	0.88	0.09	4
System Failure	0.73	0.08	5
User Trust	0.58	0.06	6

Sub-Criteria	Local Weight	Global Weight	Ranking
Implementation Costs	0.59	0.05	7
Connection System	0.22	0.05	8
Technology Features	0.22	0.04	9
Interference Susceptibility	0.42	0.04	10
Feature Development	0.58	0.03	11
Use of Technology	0.41	0.03	12
Off / Not Off	0.27	0.03	13
Technology Use Satisfaction	0.42	0.03	14
Technology Systems	0.12	0.02	15
Ease of Operation	0.12	0.01	16

Calculation of the Consistency Ratio is one of the requirements in carrying out AHP method calculations. This calculation is carried out from the results of the data processing carried out. The Consistency Ratio value that is required is below 10% or (CR<0.1) is declared consistent. Meanwhile, a Consistency Ratio value above 10% or (CR>0.1) indicates that data collection must be carried out again or it is inconsistent. Based on the combination of the Pairwise Comparison Matrix from the distribution of questionnaires on the Sub-Criteria for selecting a protection system using Expert Choice, a consistent value of 0.05 was obtained. This value is below 0.1, meaning that the combined AHP calculation is acceptable.

The results of the calculations for pairwise comparisons of criteria and sub-criteria can be summarized and shown in the following table.

Table 6. AHP Consistency Ratio Assessment Results

Matrix	Consistency Ratio	Result
Kriteria Utama	0.05	Consistent
Sub-Criteria Usefullness	0.00	Consistent
Sub-Criteria Ease of Use	0.00	Consistent
Sub-Criteria Risk	0.00	Consistent
Sub-Criteria User Interface	0.00	Consistent
Sub-Criteria Security	0.00	Consistent
Sub-Criteria Security	0.00	Consistent
Sub-Criteria Interoperability	0.00	Consistent
Sub-Criteria Associated Cross	0.00	Consistent
Sub-Criteria Trust	0.00	Consistent

The classification of criteria and sub-criteria will be assessed using TOPSIS from the AHP results, and a description will be made for selecting a protection system from 2 alternatives which are the main priority.

The protection system selection criteria are assessed using 8 criteria including Usefulness, Ease of Use, Risk, User Interface, Security, Interoperability, Associated Cross and Trust. Of all the criteria obtained by the AHP value with local weights in the image below, based on the graph the highest local weight value is related to Interoperability. This shows that the most important criterion is Interoperability with a value of 0.21, followed by Usefulness with a value of 0.19. The weighting values for criteria and sub-criteria are dynamic, because the AHP approach assumes the possibility of dependencies between the requirements themselves, so it is hoped that the resulting priorities will be more accurate. If the local weight increases, then a criterion or sub-criterion is more important and becomes a potential criterion so that the company can make the criterion or sub-criterion more important and can be used as a reference or priority for the company as a consideration in selecting a protection system.

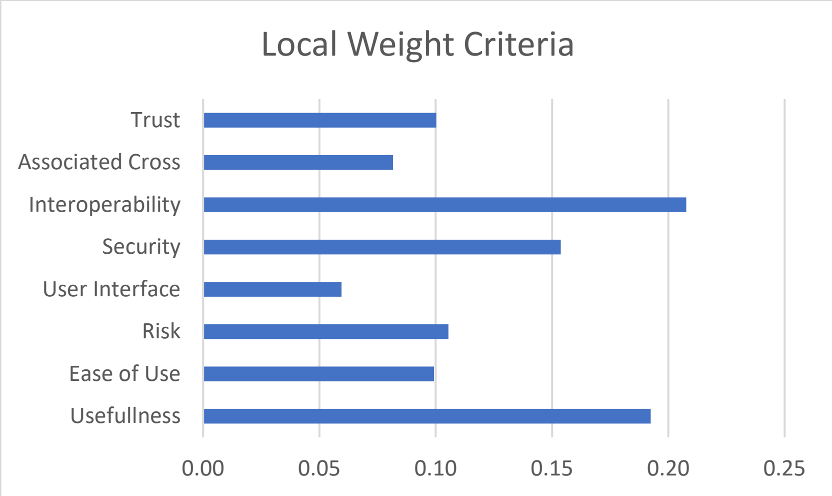

Fig 1. Local Weights for AHP Protection System Criteria

Furthermore, for each criterion there are 8 sub-criteria each, there are 16 sub-criteria for sleep for each criterion. Based on the results of the AHP calculation, we get the pending local weight for the sub-criterion Speed of Completion of Disturbance Duration with a value of 0.19. In selecting a protection system, conditions related to the speed of resolution of the duration of the disturbance are seen as the ability of a protection system to overcome disturbances (trips) in order to mitigate complaints or complaints from customers.

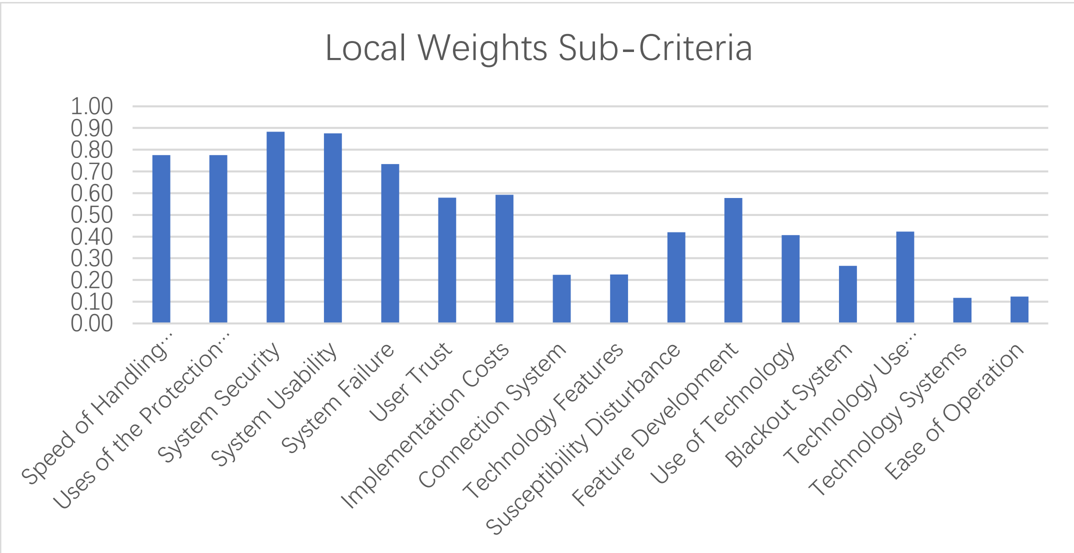

Fig 2 . Local Weights of AHP Protection System Sub-Criteria

Apart from local weighting, global weighting was also carried out for all sub-criteria at the highest rank for AHP calculations, obtaining the sub-criterion Speed of Completion of Disturbance Duration which had a value of 0.16. Next, the Usefulness criterion is the second highest weight with the sub-criterion Usefulness of the Protection System which has a fairly high level of importance for companies in choosing a protection system.

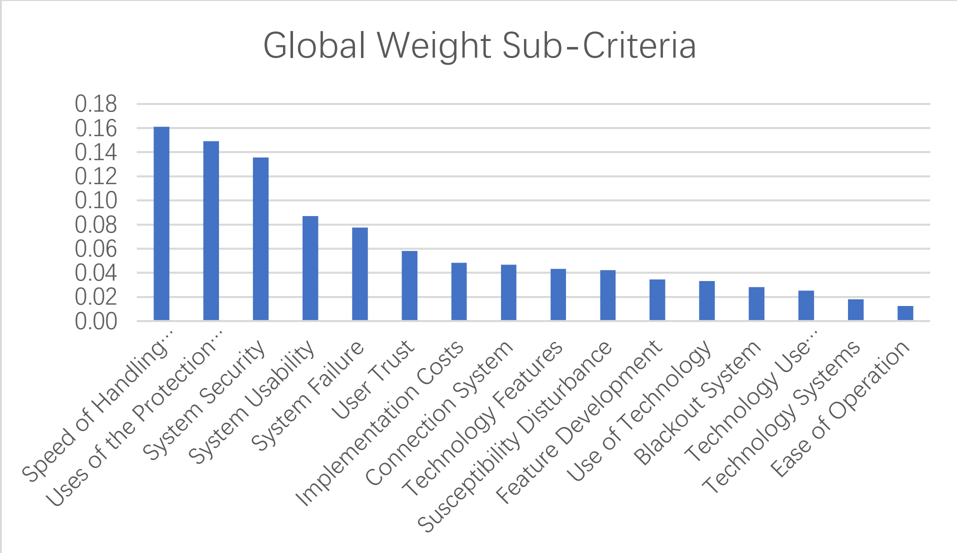

Fig 3. Global Weights of AHP Protection System Sub-Criteria

The design of the third questionnaire was carried out to assess alternative protection system choices between Buspro and Goosepro. After the alternative protection system questionnaire has been completed by experts or respondents, data processing can be carried out on the results of the questionnaire. Data processing for alternative protection system questionnaire results uses the TOPSIS method which consists of several stages of data processing. These stages include creating an initial decision matrix, normalizing the initial decision matrix, creating a weighted normalized decision matrix, determining the positive ideal solution and negative ideal solution, calculating the distance between each alternative protection system to the positive ideal solution and negative ideal solution and calculating the coefficient value. proximity to each alternative protection system.

The initial step of TOPSIS is to combine the results of the expert assessment questionnaire which is an average calculation of all the experts' answers. After getting the questionnaire value from the initial decision matrix, normalization of the matrix is then carried out. After that, it is necessary to normalize the comparison matrix for alternative protection systems and selected sub-criteria. By weighting the calculations obtained, the global weight of the normalized matrix is calculated by multiplying the value of the decision matrix with the normalized weighting. The next step is to calculate the ideal solution for each sub-criterion. Ideal solutions for positive ideal solutions and negative ideal solutions.

Table 7. Initial Decision Matrix of Expert Answers

No.	**Sub-Criteria**	**Protection System Selection**	
		Geomean	
		Buspro	**Goosepro**
1	Use of the protection system	2.93	3.57
2	Technology Features	2.93	2.86
3	System Usability	2.49	3.18
4	Ease of Operation	2.70	2.93
5	System Failure	2.86	2.86
6	Off / Not Off	3.57	2.93
7	Feature Development	2.70	2.86
8	Technology Use Satisfaction	3.57	3.03
9	System Security	2.86	3.10
10	Technology Systems	2.93	3.29

No.	Sub-Criteria	Protection System Selection	
		Geomean	
		Buspro	Goosepro
11	Disruption Duration Resolution Speed	2.64	2.86
12	Connection System	3.10	3.03
13	Implementation Costs	3.10	3.78
14	Use of Technology	2.93	2.93
15	Interference Susceptibility	2.86	3.29
16	User Trust	3.37	2.70

Table 8. Normalized Decision Matrix

No.	Sub-Criteria	Data Normalization	
		Protection System Selection	
		Buspro	Goosepro
1	Use of the protection system	0.63	0.77
2	Technology Features	0.72	0.70
3	System Usability	0.62	0.79
4	Ease of Operation	0.68	0.74
5	System Failure	0.71	0.71
6	Off / Not Off	0.77	0.63
7	Feature Development	0.69	0.73
8	Technology Use Satisfaction	0.76	0.65
9	System Security	0.68	0.74
10	Technology Systems	0.67	0.75
11	Disruption Duration Resolution Speed	0.68	0.74
12	Connection System	0.72	0.70
13	Implementation Costs	0.63	0.77
14	Use of Technology	0.71	0.71
15	Interference Susceptibility	0.66	0.75
16	User Trust	0.78	0.63

Positive ideal solutions and negative ideal solutions were previously grouped based on costs and benefits. Next, the value of the positive ideal solution and negative ideal solution will be calculated using the formula, resulting in the following values.

Table 9. Positive Ideal Solutions and Negative Ideal Solutions Sub-Criteria

No.	Sub-Criteria	Solution A^+	Solution A^-
1	Use of the protection system	0.77	0.63
2	Technology Features	0.72	0.70
3	System Usability	0.79	0.62
4	Ease of Operation	0.74	0.68
5	System Failure	0.71	0.71
6	Off / Not Off	0.77	0.63
7	Feature Development	0.73	0.69
8	Technology Use Satisfaction	0.76	0.65

No.	Sub-Criteria	Solution A+	Solution A-
9	System Security	0.74	0.68
10	Technology Systems	0.75	0.67
11	Disruption Duration Resolution Speed	0.74	0.68
12	Connection System	0.72	0.70
13	Implementation Costs	0.77	0.63
14	Use of Technology	0.71	0.71
15	Interference Susceptibility	0.75	0.66
16	User Trust	0.78	0.63

The next step is to calculate the distance from each alternative protection system to the positive ideal solution and negative ideal solution. After calculating the positive ideal solution and negative ideal solution, we continue with the distance calculation.

Table 10. Positive Ideal Solutions and Alternative Negative Ideal Solutions

No.	Alternatif Sistem Proteksi	Solution A+	Solution A-
1	Buspro	0.31	0.24
2	Goosepro	0.24	0.31

Table 11. Distance for Positive Ideal Solutions and Alternative Negative Ideal Solutions

No.	Alternatif Sistem Proteksi	Result
1	Buspro	0.44
2	Goosepro	0.56

Based on the calculation of the protection system selection process in order to choose a protection system based on the alternatives provided by the company, the result was that the euclidean distance from Goosepro was higher, namely 0.56 compared to Buspro with a value of 0.44. So it can be concluded that Goosepro is an alternative with the highest priority that is worthy of consideration when choosing a protection system.

The graphic below, displays a sensitivity analysis of several system attributes for two alternatives termed "Goosepro" and "Buspro". The graph presents rankings for aspects like Usefulness, Ease of Use, Risk, User Interface, Security, Interoperability, Associated Cost, Trust, and Overall (Goosepro and Buspro).

The Usefulness graph indicates that Goosepro has a superior score compared to Buspro, thus leading to the conclusion that Goosepro is deemed more advantageous than Buspro. The Ease of Use graph clearly indicates that Goosepro has a higher value, thus demonstrating that this system is more user-friendly than Buspro. The Risk graph clearly indicates that Buspro has a lower risk score compared to Goosepro, implying that Buspro is somewhat safer or has a lesser risk in its operations. The User Interface graph indicates that both options have nearly identical scores for user interface. However, Goosepro's score marginally above that of Buspro. The Security graph indicates that Buspro has a greater security score compared to Goosepro, implying that Buspro excels in terms of security. According to the Interoperability graph, Goosepro receives a higher score, indicating that the system has a superior capability to function with other systems or components. The Associated Cost graph indicates that Goosepro has a lower cost value in comparison to Buspro, thus implying that Goosepro is more efficient than Buspro. According to the Trust graph, Goosepro has a relatively high value, suggesting a greater level of trust from users or stakeholders.

In general, Goosepro gets a higher overall rating compared to Buspro. The graph provides a concise depiction of the performance of each system based on established criteria. Goosepro generally outperforms Buspro in various crucial areas, yet there are specific criteria where Buspro excels, particularly in terms of security and risk.

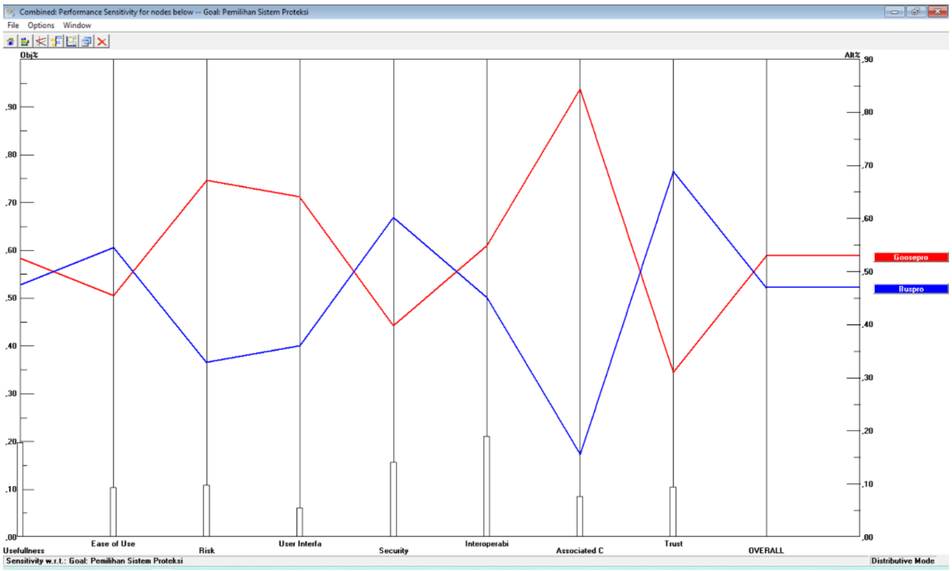

Fig 4. Performance Sensitivity Graph

The dynamic sensitivity graph below indicates that multiple factors have an impact on the selection of a protection system. The elements influencing the selection of protective systems have been evaluated and presented based on their susceptibility to the ultimate decision.

The weight assigned to usefulness is rather high at 19.4%, indicating that the level of usefulness of the system is a significant factor in the selection process. Interoperability holds the greatest significance, accounting for 20.7% of the overall importance. Weight (15.3%) is a subsequent factor to consider after security. When comparing Buspro and Goosepro, it is evident that Goosepro has a higher score of 53.0% compared to Buspro's score of 47.0%. This demonstrates that Goosepro is deemed to be more efficacious or fulfills the established requirements as assessed by sensitivity analysis.

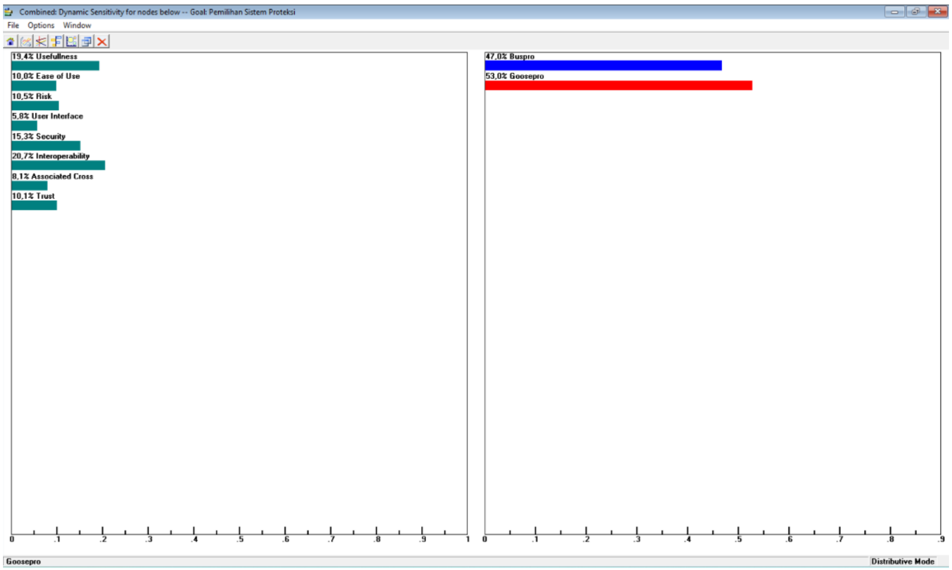

Fig 5. Dynamic Sensitivity Graph

5. Conclusions

The results of research regarding the comparison of protection and goose pro busbars using the AHP method were concluded. The main criteria for selecting the use of busbar protection using the AHP method are Interoperability Criteria with a value of 0.0.21 followed by Usefulness 0.19 and the lowest criteria are User Interface criteria with 0.06. The Duration Completion Speed sub-criterion obtained the highest score with a value of 0.16, followed by the Protection System Usability sub-criterion with a value of 0.15. The main alternative obtained from TOPSIS processing with the choice of using Goosepro Protection shows that the use of Goosepro received a higher priority value with a score of 0.56 compared to Buspro with a score of 0.44.

This study presents a comparative analysis of Buspro and Goosepro protection systems for electrical substations at the National Electricity Company in Indonesia using the AHP and TOPSIS methods. The findings highlight the importance of various criteria, such as interoperability, usefulness, and the speed of resolving disturbance duration, in selecting a protection system. The AHP analysis reveals that the Busbar system outperforms the Goosepro system in several key aspects, such as security, ease of use, and trustworthiness. The TOPSIS analysis further confirms that the Goosepro system is the preferred alternative based on the evaluated criteria. The authors conclude that the conventional Goosepro system is more suitable for protection system at the National Electricity Company substations. However, they also recommend that the company pay more attention to risk, associated costs, and trust factors in future decision-making processes. So that in future research we can add these variables so that it can increase the value of the research. This study contributes to the understanding of protection system selection in electrical substations and provides a framework for future research in this area.

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