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Implementation of Complex Prsopotional Assesment (COPRAS) in Determining Air Conditioning System Traders

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ABSTRACT

Increased global warming and awareness of the need to reduce greenhouse gas emissions have strengthened the focus on energy efficiency in various sectors, including the HVAC (Heating, Ventilation, and Air Conditioning) industry. In this context, the selection of air conditioning (AC) systems becomes crucial in providing thermal comfort. However, decisions regarding air conditioning systems are often complex as they involve considerations of energy efficiency, operational costs, system reliability, and environmental impact. To address this complexity, Complex Proportional Assessment (COPRAS) emerged as an effective multi-criteria analysis method. However, the application of COPRAS in determining AC system traffickers is still limited. This research explores the possible application of COPRAS in this context and identifies key factors to consider. The evaluation results show that Medan Elektronik and Citra Inovasi Prima are the top choices in the selection of AC system traffickers. This research is expected to contribute to the development of more sophisticated analysis methods in the HVAC industry as well as assist decision makers in selecting more appropriate and sustainable air conditioning systems.

Keyword : Traders; Air Conditioning System; Decision Support System; COPRAS.

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1. INTRODUCTION

Global warming and increasing awareness of the need to reduce greenhouse gas emissions have prompted greater attention to energy efficiency in various sectors, including the HVAC (Heating, Ventilation, and Air Conditioning) industry. In this industry, air conditioning systems play an important role in providing thermal comfort in various environments, both indoor and outdoor.

However, decisions regarding the selection of the right air conditioning system are often challenging for decision-makers. Many factors need to be considered, including energy efficiency, operating costs, system reliability and environmental impact. To assist decision-makers in evaluating AC system alternatives, an efficient and effective analysis method is needed.

Complex Proportional Assessment (COPRAS) is one of the multi-criteria analysis methods that has proven effective in addressing alternative selection problems. This method allows decision makers to evaluate complex alternatives by considering a number of different criteria simultaneously. In the context of air conditioning systems, COPRAS can be applied to assess the performance of different types of air conditioning systems based on relevant criteria, such as energy efficiency, investment cost, operational reliability, and environmental impact Goswami et al., 2021; Kustiyahningsih & Aini, 2020; Rizki Tanjung & Siagian, 2021; Sałabun et al., 2020).

Previous research has demonstrated the potential of COPRAS in assisting decision makers in selecting optimal alternatives in various contexts. However, the application of COPRAS in determining the traders of air conditioning systems specifically is still limited. Therefore, this study aims to explore the possible application of COPRAS in this context and identify the key factors to consider in determining the optimal Air Conditioning System Traders.

As such, this research is expected to contribute to the development of more sophisticated and applicable analysis methods in the HVAC industry, as well as assist decision makers in making more informed and sustainable decisions regarding the selection of air conditioning systems.

2. Research Stages

2.1 Data Collecting

The data collection technique is carried out in two stages, including:

1. Observation
   Observation activities in this study were carried out by direct review to PT Mitsubishi Electric Indonesia. At the company, an analysis of the problems and needs faced is carried out by directly observing the process of activities in determining Air Conditioning System Traders so that it can be concluded what problems are faced and what the solution is.
2. Interview
   After that, interviews were conducted with the authorities at PT Mitsubishi Electric Indonesia who had a hand in the history of Determining Air Conditioning System Traders to ask what the obstacles have been and to find and provide solutions to the obstacles faced so far.

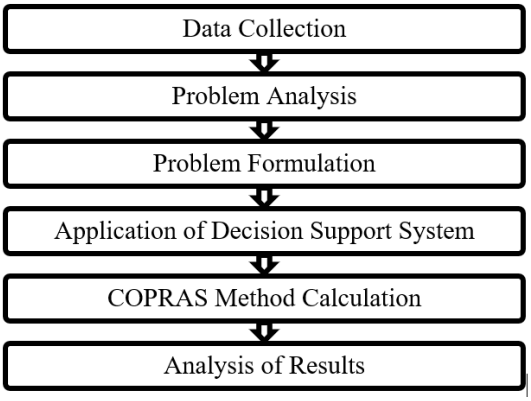
The following is the data obtained from PT. Mitsubishi Electric Indonesia in the form of interview results:

Tabel 1. Data Air Conditioning System Traders

No	Nama	Price	Quality	Services	Location	Reputation
1	Medan Elektronik	Very cheap	Not good	Very good	Very good	Very good
2	Citra Inovasi Prima	Cheap	Not good	Very good	Good	Good
3	PT. Mahadana Mitra Kencana	Cheap	Not good	Good	Good	Good
4	Seltech Utama Mandiri	Cheap	Sangat Not good	Good	Good	Good
5	CV. Multi Mandiri Anugrah Pratama	Very cheap	Cukup	Very good	Very good	Very good
6	CV. Intech Group	Very cheap	Cukup	Good	Very good	Very good
7	AC Sukses Makmur	Very cheap	Cukup	Very good	Very good	Very good
8	Medan AC Toko	Cheap	Not good	Very good	Good	Good
9	CV.Bakarasa Teknik Medan	Very cheap	Not good	Good	Very good	Good
10	CV. Berjaya Ac	Cheap	Not good	Good	Good	Good

2.2 Literature Study

In the literature study, this research uses a lot of journals, both sinta accredited journals, national journals, local journals and books as reference sources. It is hoped that the literature can assist researchers in solving problems that occur at PT Mitsubishi Electric Indonesia related to Determining Air Conditioning System Traders. Because this research uses the concept of an experimental approach, below is the research method, namely as follows:



Picture 1. Research Stages

Based on Figure 1 above, the following stages can be explained:

1. Data Collection
   At this stage, namely collecting data which is carried out directly to the relevant company, namely PT. Mitsubishi Electric Indonesia.

2. Problem Analysis
   At this stage, namely analyzing the problems that occur so that it can be concluded what problems occur at PT. Mitsubishi Electric Indonesia.
3. Problem Formulation
   At this stage, namely formulating every problem that exists at PT. Mitsubishi Electric Indonesia so that solutions and solutions can be found.
4. Application of Decision Support System
   At this stage, namely implementing a Decision Support System to solve existing problems at PT. Mitsubishi Electric Indonesia.
5. Calculation of the COPRAS Method
   At this stage, namely applying the calculation of the COPRAS method to obtain accuracy results on the data processed as a reference for decisions.
6. Analysis of Results
   At this stage, namely analyzing the results of the implementation of the Decision Support System using the COPRAS method related to problems that occur at PT Mitsubishi Electric Indonesia so that a decision reference can be taken from the settlement.

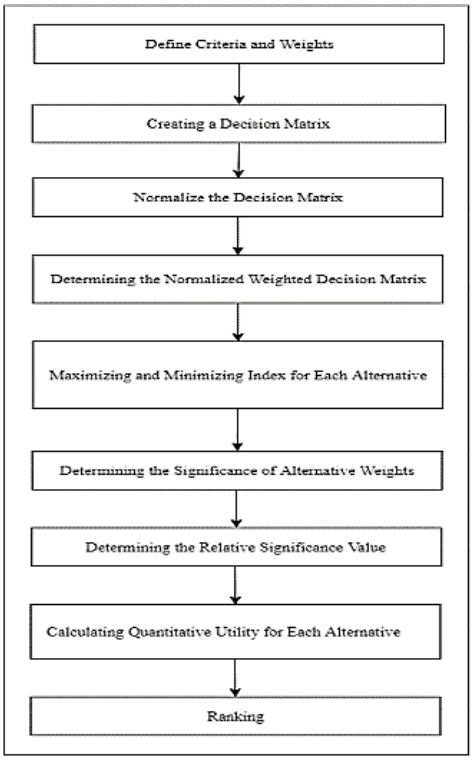
2.3 Application of the COPRAS Method

In determining the Determination of Air Conditioning System Traders using the COPRAS method at PT Mitsubishi Electric Indonesia, the stages in completing the calculation are required as follows (Alkan & Albayrak, 2020; Dhiman & Deb, 2020; Hezer et al., 2021; Hutagalung & Indah R, 2021; Idaman et al., 2023; Pamučar & Savin, 2020; Panjaitan et al., 2023; Roozbahani et al., 2020; Tira Wulandari et al., 2024; Triayudi et al., 2022; Yolanda & Sihite, 2020):

1. Define Criteria and Weights
2. Creating a Decision Matrix
3. Normalizing the Decision Matrix
4. Determining the Normalized Weighted Decision Matrix
5. Maximizing and Minimizing the Index for Each Alternative
6. Determining the Significance of Alternative Weights
7. Determining the Relative Significance Value
8. Calculating Quantitative Utility for Each Alternative
9. Ranking

2.4 Framework

Framework is a basic conceptual structure used to solve or handle a complex problem. This term is often used, among others, in the field of reusable software, as well as in the field of management to describe a concept that allows handling various types or business entities homogeneously, this framework is a step that will be taken in solving the problem to be discussed.



Picture 2. Research Stages

3. RESULTS AND DISCUSSION (10 PT)

3.1 Define Criteria and Weights

Define in advance the criteria that will be used as benchmarks for problem solving. The criteria used in determining Air Conditioning System Traders are as follows:

Table 2. Criteria Description

No	Code	Criteria Name	Type	Weight
1	C1	Price	Cost	35%
2	C2	Quality	Benefit	25%
3	C3	Services	Benefit	20%
4	C4	Location	Cost	15%
5	C5	Reputation	Benefit	5%

Based on the data obtained, it is necessary to convert each criterion to be processed into the COPRAS method. The following are the conversion results of the criteria used in solving problems related to the feasibility of determining the Air Conditioning Systems Trafficker:

Table 3. Alternative Data Conversion Results

Alternative	C1	C2	C3	C4	C5
A1	5	2	5	5	5
A2	4	2	5	4	4
A3	4	2	4	4	4
A4	4	1	4	4	4
A5	5	3	5	5	5
A6	5	3	4	5	5
A7	5	3	5	5	5
A8	4	2	5	4	4
A9	5	2	4	4	5
A10	4	2	4	4	4
	COST	**BENEFIT**	**BENEFIT**	**COST**	**BENEFIT**

3.2 Creating a Decision Matrix

From the alternative conversion that has been done, the next step is to form a decision matrix based on each criterion. Then the decision matrix is obtained as follows:

$$X = \begin{matrix} \begin{pmatrix} 5 & 2 & 5 & 5 & 5 \\ 4 & 2 & 5 & 4 & 4 \\ 4 & 2 & 4 & 4 & 4 \\ 4 & 1 & 4 & 4 & 4 \\ 5 & 3 & 5 & 5 & 5 \\ 5 & 3 & 4 & 5 & 5 \\ 5 & 3 & 5 & 5 & 5 \\ 4 & 2 & 5 & 4 & 4 \\ 5 & 2 & 4 & 4 & 5 \\ 4 & 2 & 4 & 4 & 4 \end{pmatrix} \\ \hline 45 \quad 22 \quad 45 \quad 44 \quad 45 \end{matrix}$$

3.3 Normalize the Decision Matrix

Criteria 1 (C1)
A11 = 5 / 45 = 0.1111
A21 = 4 / 45 = 0.0889
A31 = 4 / 45 = 0.0889
A41 = 4 / 45 = 0.0889
A51 = 5 / 45 = 0.1111
A61 = 5 / 45 = 0.1111
A71 = 5 / 45 = 0.1111
A81 = 4 / 45 = 0.0889
A91 = 5 / 45 = 0.1111
A101 = 4 / 45 = 0.0889
Criteria 2 (C2)
A12 = 2 / 22 = 0.0909
A22 = 2 / 22 = 0.0909
A32 = 2 / 22 = 0.0909
A42 = 1 / 22 = 0.0455
A52 = 3 / 22 = 0.1364
A62 = 3 / 22 = 0.1364
A72 = 3 / 22 = 0.1364
A82 = 2 / 22 = 0.0909
A92 = 2 / 22 = 0.0909
A102 = 2 / 22 = 0.0909
Criteria 3 (C3)
A13 = 5 / 45 = 0.1111
A23 = 5 / 45 = 0.1111
A33 = 4 / 45 = 0.0889
A43 = 4 / 45 = 0.0889
A53 = 5 / 45 = 0.1111
A63 = 4 / 45 = 0.0889
A73 = 5 / 45 = 0.1111
A83 = 5 / 45 = 0.1111
A93 = 4 / 45 = 0.0889
A103 = 4 / 45 = 0.0889
Criteria 4 (C4)
A14 = 5 / 44 = 0.1136
A24 = 4 / 44 = 0.0909
A34 = 4 / 44 = 0.0909
A44 = 4 / 44 = 0.0909
A54 = 5 / 44 = 0.1136

A64 = 5 / 44 = 0.1136
A74 = 5 / 44 = 0.1136
A84 = 4 / 44 = 0.0909
A94 = 5 / 44 = 0.1136
A104 = 4 / 44 = 0.0909
Criteria 5 (C5)
A15 = 5 / 45 = 0.1111
A25 = 4 / 45 = 0.0889
A35 = 4 / 45 = 0.0889
A45 = 4 / 45 = 0.0889
A55 = 5 / 45 = 0.1111
A65 = 5 / 45 = 0.1111
A75 = 5 / 45 = 0.1111
A85 = 4 / 45 = 0.0889
A95 = 5 / 45 = 0.1111
A105 = 4 / 45 = 0.0889

From the above calculations, the $\boldsymbol{X_{ij}}$ matrix is obtained as follows:

$$X_{ij} = \begin{Bmatrix} 0.1111 & 0.0909 & 0.1111 & 0.1136 & 0.1111 \\ 0.0889 & 0.0909 & 0.1111 & 0.0909 & 0.0889 \\ 0.0889 & 0.0909 & 0.0889 & 0.0909 & 0.0889 \\ 0.0889 & 0.0455 & 0.0889 & 0.0909 & 0.0889 \\ 0.1111 & 0.1364 & 0.1111 & 0.1136 & 0.1111 \\ 0.1111 & 0.1364 & 0.0889 & 0.1136 & 0.1111 \\ 0.1111 & 0.1364 & 0.1111 & 0.1136 & 0.1111 \\ 0.0889 & 0.0909 & 0.1111 & 0.0909 & 0.0889 \\ 0.1111 & 0.0909 & 0.0889 & 0.0909 & 0.1111 \\ 0.0889 & 0.0909 & 0.0889 & 0.0909 & 0.0889 \end{Bmatrix}$$

3.4 Determining the Normalized Weighted Decision Matrix

Weighted decision matrix
Criteria 1 (C1) :
A11 = 0.1111 x 35 = 3.8889
A21 = 0.0889 x 35 = 3.1111
A31 = 0.0889 x 35 = 3.1111
A41 = 0.0889 x 35 = 3.1111
A51 = 0.1111 x 35 = 3.8889
A61 = 0.1111 x 35 = 3.8889
A71 = 0.1111 x 35 = 3.8889
A81 = 0.1111 x 35 = 3.1111
A91 = 0.1111 x 35 = 3.8889
A101 = 0.0889 x 35 = 3.1111
Criteria 2 (C2)
A12 = 0.0909 x 25 = 2.2727
A22 = 0.0909 x 25 = 2.2727
A32 = 0.0909 x 25 = 2.2727
A42 = 0.0455 x 25 = 1.1364
A52 = 0.1364 x 25 = 3.4091
A62 = 0.1364 x 25 = 3.4091
A72 = 0.1364 x 25 = 3.4091
A82 = 0.0909 x 25 = 2.2727
A92 = 0.0909 x 25 = 2.2727
A102 = 0.0909 x 25 = 2.2727
Criteria 3 (C3)
A13 = 0.1111 x 20 = 2.2222
A23 = 0.1111 x 20 = 2.2222
A33 = 0.0889 x 20 = 1.7778

A43 = 0.0889 x 20 = 1.7778
A53 = 0.1111 x 20 = 2.2222
A63 = 0.0889 x 20 = 1.7778
A73 = 0.1111 x 20 = 2.2222
A83 = 0.1111 x 20 = 1.7778
A93 = 0.0889 x 20 = 1.7778
A103 = 0.0889 x 20 = 1.7778
Criteria 4 (C4)
A11 = 0.1136 x 15 = 1.7045
A21 = 0.0909 x 15 = 1.3636
A31 = 0.0909 x 15 = 1.3636
A41 = 0.0909 x 15 = 1.3636
A51 = 0.1136 x 15 = 1.7045
A61 = 0.1136 x 15 = 1.7045
A71 = 0.1136 x 15 = 1.7045
A81 = 0.0909x 15 = 1.3636
A91 = 0.0909x 15 = 1.3636
A101 = 0.0909x 15 = 1.3636
Criteria 5 (C5)
A11 = 0.1111 x 5 = 0.5556
A21 = 0.0889 x 5 = 0.4444
A31 = 0.0889 x 5 = 0.4444
A41 = 0.0889 x 5 = 0.4444
A51 = 0.1111 x 5 = 0.5556
A61 = 0.1111 x 5 = 0.5556
A71 = 0.1111 x 5 = 0.5556
A81 = 0.0889 x 5 = 0.4444
A91 = 0.1111 x 5 = 0.5556
A101 = 0.0889 x 5 = 0.4444

From the above calculations, the matrix D_{ij} is obtained:

$$D_{ij} = \begin{Bmatrix} 3.8889 & 2.2727 & 2.2222 & 1.7045 & 0.5556 \\ 3.1111 & 2.2727 & 2.2222 & 1.3636 & 0.4444 \\ 3.1111 & 2.2727 & 1.7778 & 1.3636 & 0.4444 \\ 3.1111 & 1.1364 & 1.7778 & 1.3636 & 0.4444 \\ 3.8889 & 3.4091 & 2.2222 & 1.7045 & 0.5556 \\ 3.8889 & 3.4091 & 1.7778 & 1.7045 & 0.5556 \\ 3.8889 & 3.4091 & 2.2222 & 1.7045 & 0.5556 \\ 3.1111 & 2.2727 & 2.2222 & 1.3636 & 0.4444 \\ 3.8889 & 2.2727 & 1.7778 & 1.3636 & 0.5556 \\ 3.1111 & 2.2727 & 1.7778 & 1.3636 & 0.4444 \end{Bmatrix}$$

3.5 Maximizing and Minimizing the Index for Each Alternative

S_{+i} = (C2 + C3 + C4)
A1 = 2.2727 + 2.2222 + 0.5556 = 5.0505
A2 = 2.2727 + 2.2222 + 0.4444 = 4.4949
A3 = 2.2727 + 1.7778 + 0.4444 = 4.0505
A4 = 1.1364 + 1.7778 + 0.4444 = 2.9141
A5 = 3.4091 + 2.2222 + 0.5556 = 5.6313
A6 = 3.4091 + 1.7778 + 0.5556 = 5.1869
A7 = 3.4091 + 2.2222 + 0.5556 = 5.6313
A8 = 2.2727 + 2.2222 + 0.4444 = 4.4949
A9 = 2.2727 + 1.7778 + 0.5556 = 4.0505
A10 = 2.2727 + 1.7778 + 0.4444 = 4.0505
S_{-i} = C1 + C4
A1 = 3.8889 + 1.7045 = 5.5934
A2 = 3.1111 + 1.3636 = 4.4747

A3 = 3.1111 + 1.3636 = 4.4747
A4 = 3.1111 + 1.3636 = 4.4747
A5 = 3.8889 + 1.7045 = 5.5934
A6 = 3.8889 + 1.7045 = 5.5934
A7 = 3.8889 + 1.7045 = 5.5934
A8 = 3.1111 + 1.3636 = 4.4747
A9 = 3.8889 + 1.3636 = 5.2525
A10 = 3.1111 + 1.3636 = 4.4747
Total = 50

3.6 Determining the Significance of Alternative Weights

Then calculate the relative weight of each alternative using the equation 1 S-1 and S-1 * Total 1 S-1 as below:

Table 4. Calculation of Relative Weight of Each Alternative

Alternative	(1/S-i)	S-i*TOTAL(1/S-i)
A_1	1/5.5934 = 0.1788	5.5934 * 2.0229 = 11.3149
A_2	1/4.4747 = 0.2235	4.4747 * 2.0229 = 9.0519
A_3	1/4.4747 = 0.2235	4.4747 * 2.0229 = 9.0519
A_4	1/4.4747 = 0.2235	4.4747 * 2.0229 = 9.0519
A_5	1/5.5934 = 0.1788	5.5934 * 2.0229 = 11.3149
A_6	1/5.5934 = 0.1788	5.5934 * 2.0229 = 11.3149
A_7	1/4.4747 = 0.1788	5.5934 * 2.0229 = 11.3149
A_8	1/5.2525 = 0.2235	4.4747 * 2.0229 = 9.0519
A_9	1/4.4747 = 0.1904	5.2525 * 2.0229 = 10.6253
A_{10}	1/1,5385 = 0.2235	4.4747 * 2.0229 = 9.0519
Total	**2.0229**	

3.7 Determining the Relative Significance Value (Q_i)

$$Q_i = S_{+i} + \frac{S_{-i\ min \sum_{i=1}^{m} s_{-1}}}{S_{-i \sum_{i=1}^{m} (S_{-min}/S_{-i})}} = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i} \sum_{i=1}^{m} (1/S_{-i})} (i = 1,2, \dots, m)$$

$$Q1 = 5.0505 + \frac{50}{11.3149} = 5.0505 + 4.4190 = 9.4695$$

$$Q2 = 4.4949 + \frac{50}{9.0519} = 4.4949 + 5.5237 = 10.0186$$

$$Q3 = 4.4949 + \frac{50}{9.0519} = 4.4949 + 5.5237 = 9.5742$$

$$Q4 = 2.9141 + \frac{50}{9.0519} = 2.9141 + 5.5237 = 8.4378$$

$$Q5 = 5.6313 + \frac{50}{11.3149} = 5.6313 + 4.4190 = 10.0503$$

$$Q6 = 5.6313 + \frac{50}{11.3149} = 5.6313 + 4.4190 = 9.6058$$

$$Q7 = 5.6313 + \frac{50}{11.3149} = 5.6313 + 4.4190 = 10.0503$$

$$Q8 = 4.4949 + \frac{50}{9.0519} = 4.4949 + 5.5237 = 10.0186$$

$$Q9 = 4.0505 + \frac{50}{11.3149} = 4.0505 + 4.4190 = 8.7563$$

$$Q10 = 4.0505 + \frac{50}{9.0519} = 4.0505 + 5.5237 = 9.5742$$

Value Max Q_i = 10.0503

3.8 Calculating Quantitative Utility for Each Alternative U_i

$$U_i = \left[\frac{Q_i}{Q_{max}}\right] x100\%$$

U_1 = 9.4695 / 10.0503 * 100 = 94.2210
U_2 = 10.0186 / 10.0503 * 100 = 99.6853
U_3 = 9.5742 / 10.0503 * 100 = 95.2631
U4 = 4.2013 / 10.0503 * 100 = 83.9563
U_5 = 10.0503 / 10.0503 * 100 = 100.0000
U_6 = 9.6058/ 10.0503 * 100 = 95.5778
U_7 = 10.0503 / 10.0503 * 100 = 100.0000
U_8 = 10.0186 / 10.0503 * 100 = 99.6853
U_9 = 8.7563 / 10.0503 * 100 = 87.1247
U_{10} = 9.5742 / 10.0503 * 100 = 95.2631

3.9 Perform Ranking

The calculation results of the COPRAS method can be seen in the table below:

Table 5. Calculation results of each alternative

No	Code	Name	Final Grade
1	A1	Medan Elektronik	94.2210
2	A2	Citra Inovasi Prima	99.6853
3	A3	PT. Mahadana Mitra Kencana	95.2631
4	A4	Seltech Utama Mandiri	83.9563
5	A5	CV. Multi Mandiri Anugrah Pratama	100.0000
6	A6	CV. Intech Group	95.5778
7	A7	AC Sukses Makmur	100.0000
8	A8	Medan Ac Toko	99.6853
9	A9	CV.Bakarasa Teknik Medan	87.1247
10	A10	CV. Berjaya Ac	95.2631

Based on the results of the above calculations, the ranking results in determining Air Conditioning System Traders are as follows:

Table 6. Ranking of Alternatives

No	Code	Name	Final Grade	Ranking
1	A5	Medan Elektronik	100.0000	1
2	A7	Citra Inovasi Prima	100.0000	2
3	A2	Pt. Mahadana Mitra Kencana	99.6853	3
4	A8	Seltech Utama Mandiri	99.6853	4
5	A6	Cv. Multi Mandiri Anugrah Pratama	95.5778	5
6	A3	Cv. Intech Group	95.2631	6
7	A10	Ac Sukses Makmur	95.2631	7
8	A1	Medan Ac Toko	94.2210	8
9	A9	Cv.Bakarasa Teknik Medan	87.1247	9
10	A4	Cv. Berjaya Ac	83.9563	10

4. CONCLUSION

Global warming and awareness of the need to reduce greenhouse gas emissions have prompted greater attention to energy efficiency in the HVAC industry, where air conditioning (AC) systems play an important role in providing thermal comfort. However, selecting the right air conditioning system is often challenging due to the various factors that need to be considered, such as energy efficiency, operational costs, system reliability and environmental impact. To address this complexity, Complex Proportional Assessment (COPRAS) emerges as an effective multi-criteria analysis method in evaluating AC system alternatives by considering a number of criteria simultaneously. Although the potential of COPRAS has been demonstrated in various contexts, its application in determining AC system traffickers is still limited. Therefore, this study aims to explore the possible application of COPRAS in this context and identify key factors to consider in determining the optimal AC system trafficker. The evaluation results using the COPRAS method show that Medan Elektronik with a score of 100 and Citra Inovasi Prima with a score of 100 are the top choices in the selection of AC system traffickers that can be used as a reference in the selection. It is hoped that this research will contribute to the development of more sophisticated and applicable analysis methods in the HVAC industry and assist decision makers in making more informed and sustainable decisions regarding the selection of air conditioning systems.

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