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Applying the CURLI Method to Select Small-Scale Generators

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Abstract
In all fields, the selection of one option among many available alternatives must be based on multiple parameters (known as criteria). Multi-criteria decision-making (MCDM) methods are increasingly used to solve these types of problems. Common difficulties encountered when using MCDM methods are choosing a data normalization method and a method for calculating criteria weights, as these two factors significantly affect the ranking of alternatives. This study applies the CURLI method to the selection of small-scale generators. CURLI is a unique MCDM method that does not require users to normalize data or calculate criteria weights. Seven types of small-scale generators commonly sold in the Vietnamese market were surveyed in this study, including the Hyundai HY30CLE, Hyundai HY9000LE, Hyundai HY7000LE, Hyundai HY3100LE, Hyundai DHY6000SE, Hyundai DHY6000LE, and Hữu Toàn HG3100. The application of the CURLI method confirmed that the Hyundai HY7000LE is the best option, while the Hữu Toàn HG3100 is the least effective. The limitations and directions for future research are also discussed in the final section of this paper.
Keywords: *small-scale generator selection, MCDM, CURLI method*

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I. Introduction

Small-scale generators, also known as mini generators, play a crucial role in daily life, especially for household activities, livestock farming, and crop production. They serve as an effective solution when the national power grid fails, ensuring that essential appliances like refrigerators, water pumps, lighting systems, and fans continue to operate. In animal husbandry, generators help maintain ventilation and heating systems for barns, protecting livestock from sudden weather changes. For crop farming, generators can power automatic irrigation systems, water pumps, or other agricultural equipment, ensuring uninterrupted production [1].

The current market for mini generators is incredibly diverse, with various models and brands available. Consumers can easily find generators that run on gasoline, diesel, or even gas. To select a suitable generator, it's essential to consider several key criteria. Power output is a primary factor, as it determines if the generator is strong enough to run all the appliances you need. The type of fuel used affects operating costs and environmental impact [2]. Furthermore, origin and price are also significant factors. A reputable brand from a well-known manufacturer often guarantees higher quality and durability, though it may come with a higher price tag. Carefully considering these criteria is crucial for making an informed decision and finding the best product for your needs, which is an urgent but challenging task. Multi-criteria decision-making (MCDM) methods are techniques applied to solve these difficult situations [3, 4].

MCDM techniques have developed rapidly in recent years, with hundreds of different methods being used across all fields, including economics, engineering, management, and education [5-8]. Generally, most MCDM methods, despite their algorithmic differences, require users to perform data normalization and calculate criteria weights [9-12]. However, data normalization can compromise the originality of the data, as it converts criteria with different units into a single, unitless type. Therefore, data normalization can, to some extent, affect the accuracy of the final results [13, 14]. On the other hand, selecting a method for calculating criteria weights is also a complex task. Using objective weighting methods to calculate criteria weights does not account for user opinions, which can sometimes lead to results that do not meet their requirements [15]. Conversely, if a subjective weighting method is used, the criteria weights might be influenced by the decision-maker's lack of knowledge [16].

Therefore, using an MCDM method that doesn't require data normalization or criteria weighting would yield more reliable results for ranking small-scale generators. CURLI is the only method that, when used, does not require users to normalize data or calculate criteria weights [17, 18]. For this reason, this study utilizes the CURLI method to select a small-scale generator.

II. Materials and Methods

2.1. The CURLI Method

To rank alternatives using the CURLI method, the following sequence should be executed [17, 18]:

Step 1: For each criterion, create a square matrix of size *m* and score the alternatives.

Scoring the alternatives (for each criterion) is done as follows: For example, in the cell corresponding to column 1 and row 2, if the value of alternative 1 is better than alternative 2, a score of 1 is assigned. In another example, if the cell corresponding to column 2 and row 1 shows that the value of alternative 2 is worse than alternative 1, a score of -1 is assigned. A score of 0 is assigned in the cell for column 2 and row *m* if the value of alternative 2 is equal to alternative *m*. A score of 0 is also entered into all cells along the main diagonal of the matrix.

Step 2: The scoring matrix for all criteria (referred to as matrix Q) is formed by adding all the individual scoring matrices for each criterion together.

Step 3: The Q matrix is sorted by re-arranging the rows and columns so that the number of non-positive values above the main diagonal is maximized. After sorting, the top-to-bottom order of the rows represents the ranking of the alternatives.

2.2. Small-Scale Generators

An appliance store offers seven types of generators for sale. Of these, only one is manufactured in Vietnam, with the rest being imported from South Korea. According to the product documentation, the list of criteria used to describe each generator includes: price, fuel type (gasoline or diesel), continuous runtime, cylinder capacity, rated power, maximum power, length, width, height, noise level, weight, and origin.

While the selection of a generator should ideally consider more than these twelve parameters—such as warranty period, maintenance costs, and customer service—these specific factors happen to have the same values across all seven models under consideration. Therefore, the decision-making process only needs to focus on the parameters whose values differ among the seven alternatives. The units and types of these criteria are shown in the last two rows of Table 1.

When asked for their opinion, most respondents indicated a preference for gasoline-powered generators over diesel models. Their reasoning is that gasoline engines operate based on compression and spark plug ignition, making the starting process as simple as starting a motorbike. In contrast, diesel engines use fuel injectors, where fuel is sprayed into a combustion chamber and mixed with highly compressed, high-temperature air before igniting spontaneously to generate power. This operational principle makes starting a diesel generator more difficult, especially in low-temperature conditions. Regarding brand origin, the general sentiment among Vietnamese consumers is a preference for imported goods over domestic products. Consequently, generators from South Korea are viewed more favorably than those made in Vietnam.

Table 1. Generator Models (Source: The authors' compilation)

Type	price	fuel type	continuous runtime	cylinder capacity	rated power	maximum power	length	width	height	noise level	weight	brand origin
Hyundai HY30CLE	8.99	asoline	10	96	2.3	2.6	610	490	490	74	54	Korea
Hyundai HY9000LE	23.9	asoline	16	420	2.5	2.8	670	540	555	75	86	Korea
Hyundai HY7000LE	21.9	asoline	22	389	5	5.5	670	540	555	75	82	Korea
Hyundai HY3100LE	11.9	asoline	22	196	2.5	2.8	610	490	490	68	43	Korea
Hyundai DHY6000SE	38.9	diesel	16	212	5	5.5	920	520	760	68	160	Korea
Hyundai DHY6000LE	35.45	diesel	13	456	5	5.8	720	480	600	79	116	Korea
Hữu Toàn HG3100	17.31	asoline	12	163	2	2.3	635	425	475	65	34	Viet Nam
Criteria type	Min	-	Max	Max	Max	Max	Min	Min	Min	Max	Max	-
Unit of criteria	Vietnam million dong	-	giờ	cc	kW	kW	mm	mm	mm	dbA	kg	-

Based on the data in Table 1, if a buyer only chooses the generator with the lowest price (Hyundai HY30CLE), they will end up with a model that has a short continuous runtime, small cylinder capacity, and a relatively high noise level. In another example, if a buyer selects a generator with high power output (like the Hyundai HY7000LE), their product will have a high price and also be quite noisy. Similarly, if a buyer only

considers products made in South Korea and disregards the Vietnamese-made model (Hữu Toàn HG3100), they would miss out on the generator with the lowest noise level.
This shows that if a purchase decision is based on a single parameter, the best possible generator will not be chosen. To select the best generator, all twelve criteria in Table 1 must be considered. This means that choosing a generator is an act of multi-criteria decision-making. This action will be carried out with the help of the CURLI method, as detailed in the next section of this paper.

III. Results and Discussion

Step 1 of the CURLI method was applied to score the generator models for each criterion. The scoring results for these criteria are presented in Tables 2 through 13.

Table 2. Scoring of generator models for the criterion price

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	-1	-1	-1	-1	-1	-1
Hyundai HY9000LE	1	0	1	1	-1	-1	1
Hyundai HY7000LE	1	-1	0	1	-1	-1	1
Hyundai HY3100LE	1	-1	-1	0	-1	-1	-1
Hyundai DHY6000SE	1	1	1	1	0	1	1
Hyundai DHY6000LE	1	1	1	1	-1	0	1
Hữu Toàn HG3100	1	-1	-1	1	-1	-1	0

Table 3. Scoring of generator models for the criterion fuel type

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	0	0	0	-1	-1	0
Hyundai HY9000LE	0	0	0	0	-1	-1	0
Hyundai HY7000LE	0	0	0	0	-1	-1	0
Hyundai HY3100LE	0	0	0	0	-1	-1	0
Hyundai DHY6000SE	1	1	1	1	0	0	1
Hyundai DHY6000LE	1	1	1	1	0	0	1
Hữu Toàn HG3100	0	0	0	0	-1	-1	0

Table 4. Scoring of generator models for the criterion continuous runtime

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	1	1	1	1	1	1
Hyundai HY9000LE	-1	0	1	1	0	-1	-1
Hyundai HY7000LE	-1	-1	0	0	-1	-1	-1
Hyundai HY3100LE	-1	-1	0	0	-1	-1	-1
Hyundai DHY6000SE	-1	0	1	1	0	-1	-1
Hyundai DHY6000LE	-1	1	1	1	1	0	-1
Hữu Toàn HG3100	-1	1	1	1	1	1	0

Table 5. Scoring of generator models for the criterion cylinder capacity

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	1	1	1	1	1	1
Hyundai HY9000LE	-1	0	-1	-1	-1	1	-1
Hyundai HY7000LE	-1	1	0	-1	-1	1	-1
Hyundai HY3100LE	-1	1	1	0	1	1	-1
Hyundai DHY6000SE	-1	1	1	-1	0	1	-1
Hyundai DHY6000LE	-1	-1	-1	-1	-1	0	-1
Hữu Toàn HG3100	-1	1	1	1	1	1	0

Table 6. Scoring of generator models for the criterion rated power

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	1	1	1	1	1	-1
Hyundai HY9000LE	-1	0	1	0	1	1	-1
Hyundai HY7000LE	-1	-1	0	-1	0	0	-1
Hyundai HY3100LE	-1	0	1	0	1	1	-1
Hyundai DHY6000SE	-1	-1	0	-1	0	0	-1
Hyundai DHY6000LE	-1	-1	0	-1	0	0	-1
Hữu Toàn HG3100	1	1	1	1	1	1	0

Table 7. Scoring of generator models for the criterion maximum power

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	1	1	1	1	1	-1
Hyundai HY9000LE	-1	0	1	0	1	1	-1
Hyundai HY7000LE	-1	-1	0	-1	0	1	-1

Hyundai HY3100LE	-1	0	1	0	1	1	-1
Hyundai DHY6000SE	-1	-1	0	-1	0	1	-1
Hyundai DHY6000LE	-1	-1	-1	-1	-1	0	-1
Hữu Toàn HG3100	1	1	1	1	1	1	0

Table 8. Scoring of generator models for the criterion length

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	-1	-1	0	-1	-1	-1
Hyundai HY9000LE	1	0	0	1	-1	-1	1
Hyundai HY7000LE	1	0	0	1	-1	-1	1
Hyundai HY3100LE	0	-1	-1	0	-1	-1	-1
Hyundai DHY6000SE	1	1	1	1	0	1	1
Hyundai DHY6000LE	1	1	1	1	-1	0	1
Hữu Toàn HG3100	1	-1	-1	1	-1	-1	0

Table 9. Scoring of generator models for the criterion width

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	-1	-1	0	-1	1	1
Hyundai HY9000LE	1	0	0	1	1	1	1
Hyundai HY7000LE	1	0	0	1	1	1	1
Hyundai HY3100LE	0	-1	-1	0	-1	1	1
Hyundai DHY6000SE	1	-1	-1	1	0	1	1
Hyundai DHY6000LE	-1	-1	-1	-1	-1	0	1
Hữu Toàn HG3100	-1	-1	-1	-1	-1	-1	0

Table 10. Scoring of generator models for the criterion height

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	-1	-1	0	-1	-1	1
Hyundai HY9000LE	1	0	0	1	-1	-1	1
Hyundai HY7000LE	1	0	0	1	-1	-1	1
Hyundai HY3100LE	0	-1	-1	0	-1	-1	1
Hyundai DHY6000SE	1	1	1	1	0	1	1
Hyundai DHY6000LE	1	1	1	1	-1	0	1
Hữu Toàn HG3100	-1	-1	-1	-1	-1	-1	0

Table 11. Scoring of generator models for the criterion noise level

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	1	1	-1	-1	1	-1
Hyundai HY9000LE	-1	0	0	-1	-1	1	-1
Hyundai HY7000LE	-1	0	0	-1	-1	1	-1
Hyundai HY3100LE	1	1	1	0	0	1	-1
Hyundai DHY6000SE	1	1	1	0	0	1	-1
Hyundai DHY6000LE	-1	-1	-1	-1	-1	0	-1
Hữu Toàn HG3100	1	1	1	1	1	1	0

Table 12. Scoring of generator models for the criterion weight

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	1	1	-1	1	1	-1
Hyundai HY9000LE	-1	0	-1	-1	1	1	-1
Hyundai HY7000LE	-1	1	0	-1	1	1	-1
Hyundai HY3100LE	1	1	1	0	1	1	-1
Hyundai DHY6000SE	-1	-1	-1	-1	0	-1	-1
Hyundai DHY6000LE	-1	-1	-1	-1	1	0	-1
Hữu Toàn HG3100	1	1	1	1	1	1	0

Table 13. Scoring of generator models for the criterion brand origin

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	0	0	0	0	0	-1
Hyundai HY9000LE	0	0	0	0	0	0	-1
Hyundai HY7000LE	0	0	0	0	0	0	-1
Hyundai HY3100LE	0	0	0	0	0	0	-1
Hyundai DHY6000SE	0	0	0	0	0	0	-1
Hyundai DHY6000LE	0	0	0	0	0	0	-1
Hữu Toàn HG3100	1	1	1	1	1	1	0

Step 2 of the CURLI method was then used to construct the **Q** matrix, as shown in Table 14.

Step 3 of the CURLI method was applied to reorder the rows and columns of the **Q** matrix. The results are presented in Table 15.

Table 14. The **Q** matrix

Type	S1	S2	S3	S4	S5	S6	S7
Hyundai HY30CLE	0	2	2	1	-1	3	-3
Hyundai HY9000LE	-2	0	2	2	-2	1	-3
Hyundai HY7000LE	-2	-2	0	-1	-5	0	-3
Hyundai HY3100LE	-1	-2	1	0	-2	1	-7
Hyundai DHY6000SE	1	2	5	2	0	5	-2
Hyundai DHY6000LE	-3	-1	0	-1	-5	0	-2
Hữu Toàn HG3100	3	3	3	7	2	2	0

Table 15. The reordered **Q** matrix

Type	S3	S6	S4	S2	S1	S5	S7
Hyundai HY7000LE	0	0	-1	-2	-2	-5	-3
Hyundai DHY6000LE	0	0	-1	-1	-3	-5	-2
Hyundai HY3100LE	1	1	0	-2	-1	-2	-7
Hyundai HY9000LE	2	1	2	0	-2	-2	-3
Hyundai HY30CLE	2	3	1	2	0	-1	-3
Hyundai DHY6000SE	5	5	2	2	1	0	-2
Hữu Toàn HG3100	3	2	7	3	3	2	0

Based on the results in Table 15, the ranking of the generators, in order of preference from top to bottom, is clearly defined. The Hyundai HY7000LE is identified as the best model, while the Huu Toan HG3100 is the least suitable. Thus, by applying the CURLI method, the conclusion is that the Hyundai HY7000LE is the best choice, and the Huu Toan HG3100 is the worst.

IV. Conclusion

For the first time, the CURLI method was used in this study to rank generator models. Among the seven models provided by the supplier—the Hyundai HY30CLE, Hyundai HY9000LE, Hyundai HY7000LE, Hyundai HY3100LE, Hyundai DHY6000SE, Hyundai DHY6000LE, and Hữu Toàn HG3100—the Hyundai HY7000LE was identified as the best option.

For a more comprehensive evaluation of small-scale generators, future research should consider a wider range of criteria for each product. Additionally, exploring improvements to the CURLI method to incorporate the importance of each criterion would help ensure the results more closely align with user requirements.

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