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DECISION SUPPORT SYSTEM FOR SELECTION OF THE BEST FUEL FOR HOUSEHOLDS USING THE WEIGHTED PRODUCT (WP) METHOD

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Abstract

Fuel is one of the most critical needs for the community in carrying out various household activities dominated by fuel oil. Meanwhile, the availability of fuel is increasingly running low. Most people in the Botumoito area in Gorontalo province work in the agricultural sector with low local income. Availability of fuels such as kerosene and gas there is quite challenging because there is no source or supply of gas either directly from the gas field or terminal. The government needs to make the right policy on fuel selection according to the problems in the region. This research aims to design and build a decision support system for selecting the best fuel and implementing the Weighted Product (WP) method into the system. The method used in designing and manufacturing this system is the waterfall method. This research results in a decision support system that can help fuel ranking. The ranking results are based on the magnitude of the Vector (V) value obtained from testing ten alternative fuels. Bioethanol occupies the top priority with a vector value of 0.152. This research can help consultants, fuel experts, and local governments speed up their work in determining the best household fuel according to their respective regions.

Keywords: Fuels; Decision Support Systems; Weighted Products.

Abstrak

Bahan bakar merupakan salah satu kebutuhan yang paling penting bagi masyarakat dalam melakukan berbagai aktivitas rumah tangga yang didominasi oleh bahan bakar minyak (BBM). Sementara itu, ketersediaan BBM semakin lama semakin menipis. Sebagian besar penduduk di daerah Botumoito di provinsi Gorontalo bekerja di sektor pertanian dengan pendapatan warga setempat tidak terlalu tinggi. Ketersediaan bahan bakar seperti minyak tanah dan gas disana cukup sulit diperoleh karena belum terdapat sumber atau pasokan gas baik secara langsung dari lapangan gas maupun terminal. Pemerintah perlu membuat kebijakan yang tepat pada pemilihan bahan bakar sesuai dengan masalah yang ada di daerah. Tujuan dari penelitian ini yaitu merancang dan membangun sistem pendukung keputusan dalam pemilihan bahan bakar terbaik serta mengimplementasikan metode Weighted Product (WP) kedalam sistem. Metode yang digunakan dalam perancangan dan pengembangan sistem ini yaitu menggunakan metode waterfall. Hasil dari penelitian ini yaitu sebuah sistem pendukung keputusan yang dapat membantu perankingan bahan bakar. Hasil perankingan berdasarkan besarnya nilai Vektor (V) yang didapatkan dari pengujian 10 alternatif bahan bakar, Bioetanol menempati prioritas utama dengan nilai vektor 0,152. Penelitian ini membantu konsultan, pakar bahan bakar dan pemerintah daerah dalam menentukan bahan bakar rumah tangga terbaik sesuai dengan wilayahnya masing-masing.

Kata kunci: Bahan Bakar; Sistem Pendukung Keputusan; Weighted Products.

INTRODUCTION

Fuel is a material that can be converted into energy and is one of the most essential needs for society. Most of the fuel is used in various household activities such as lighting, cooking, heating, cooling, and other household activities (Rohim & Triani, 2021). Generally, the fuel used by Indonesians for household activities is still dominated by fuel oil (Ridlo Al Hakim, 2020). Meanwhile, the availability of fuel is getting less and less along with the increasing population, accompanied by increasing demand and energy consumption. This is a concern in the context of

energy security, given that Indonesia's oil production continues to decline (Umam et al., 2018). Therefore, the government places restrictions on fuel subsidies as an essential step to increase efficiency in fuel use (Afriyanti et al., 2018).

The government needs to make the right policies on fuel selection for their respective regions. This decision is hoped to benefit the local community regarding price, environmental friendliness, availability, infrastructure, safety, and ease of use. Many household fuel choices exist, such as LPG, Kerosene, Biogas, City Gas, Bioethanol, and others. Each of these fuels has its advantages and disadvantages according to local conditions. Therefore, the local government must be selective in choosing fuel according to the conditions of each area.

The Botumoito area in the province of Gorontalo is the area that will be used in this study. This sub-district has an area of 486.23 km2, and the distance between the village of Botumoito and the capital is about 2.5 km. The total population of Botumoito itself is around 2,685 people, and from the employment perspective, most of the population of Botumoito works in the agricultural sector. Residents' income in this area is low, around 500,000 to 1 million monthly rupiahs per capita. The availability of fuels such as kerosene and gas there is quite challenging because there is no source or supply of gas either directly from the gas field or terminal. Another cause is that national production has been reduced and sold in certain places (BPS, 2018).

In order to decide to choose the best fuel for an area, it is necessary to consult with experts. The expert needs to have a system that can help provide calculation output for fuel selection. Decision Support Systems (DSS) are interactive computer-based systems that help decision-makers utilize data and models to solve unstructured and semi-structured problems (Limbong et al., 2020). DSS requires a method to find alternative solutions to problems that occur. The DSS method used in this study is Weighted Product (WP).

The WP method is calculated based on the level of importance. This method is more efficient because the time needed in the calculation is shorter (Susliansyah et al., 2019). The WP method is a settlement method that uses multiplication to connect attribute ratings where the rating must be raised to the first power along with the weight of the attribute in question (Aldo, 2019). So the WP method does not allow for the same vector values for different criteria (Anggraeni, 2017). The use of the WP method is expected to answer the needs of policymakers in determining the most appropriate type of fuel to use in an area. Making the right decision can be one of the efforts to ensure energy security to support economic growth. This study applies the WP method because of the simple calculation concept for determining the weights of almost the same value criteria.

RESEARCH METHODS

Types of research

This research uses a quantitative method that is systematic and uses mathematical models.

Time and Place of Research

The research starts from June 2021 to May 2022. The research location is at the Center for Research and Development of Oil and Gas Technology "LEMIGAS," at Jl. Ciledug Raya, Kav. 109, Cipulir, Kebayoran Lama, South Jakarta.

Research Target

This study aims to design and build a decision support system for choosing the best fuel for households using the Weighted Product (WP) method. Therefore, it is hoped that this will help consultants, fuel experts, and local governments speed up work in determining the best household fuel according to their respective regions. Then, the interview stages are carried out to collect alternative data, criteria, and weights.

Procedure

This research uses the waterfall method, one of the SDLC models often used in developing information systems or software. This method uses a systematic and sequential approach (Wahid, 2020). The early stage of this research method is analysis consisting of data collection and weighted product method. Data collection begins with the stages of observation, interviews, and the application of literary studies to produce output in the form of criteria data, data on alternative fuels, and their weights which are then calculated using the weighted product method to produce recommendation values.

The next step is System Design, which is to build a program applying object-oriented programming through the Unified Modeling Language (UML) design process to produce use cases, activities, sequences, and class diagrams. The next stage is coding in implementing web-based programs using HTML programming languages, PHP, MySQL databases, and web browsers using Chrome. Furthermore, black box testing is carried

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out at the testing stage so that the system can run properly.

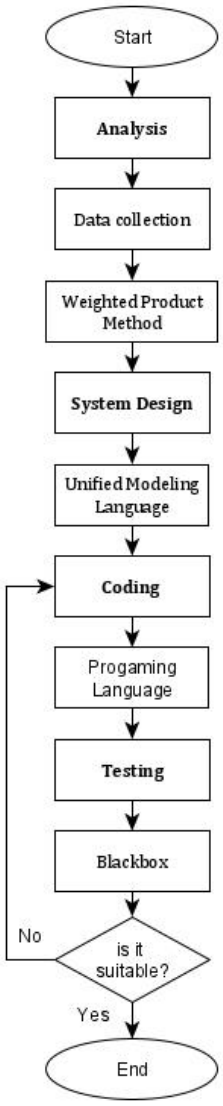


Figure 1. Research Method

Data, Instruments, and Data Collection Techniques

Based on the results of interviews conducted with a fuel expert at Lembaga Minyak dan Gas (LEMIGAS), data that will be used in calculating the weighted product method can be compiled.

This study will use ten alternative fuels as samples, as shown in Table 1.

Table 1. Alternative Data

Alternative Code	Alternative Name
A_1	Gas City
A_2	LPG
A_3	Biogas
A_4	Bioethanol
A_5	kerosene
A_6	Dimethyl Ether (DME)
A_7	Coal Briquettes
A_8	Coconut Shell Briquettes
A_9	Rice Husk Briquettes
A_{10}	Electricity

Criteria values and weights were obtained from fuel experts. In the weighted product method, there are two types of criteria, namely price and benefits criteria. The benefit criterion is that the greater the value, the more selected, and the price criterion, namely, the smaller the value, the more selected (Widaningsih & Manggala, 2020). The criteria, weight, and type can be seen in Table 2.

Table 2. Criteria Data and weight

Code	Criteria	Weigh t	Type
K_1	Price	30	Cost
K_2	Availability	25	Benefit
K_3	Infrastructure	10	Benefit
K_4	Safety	15	Benefit
K_5	Ease of use	15	Benefit
K_6	Pollution Level	5	Benefit
	Total	100	

The quantitative values of the criteria for each of the alternatives used are as follows ;

The price criterion (K_1) is obtained based on the price consumers must pay for the fuel if the fuel is available in the area. If the fuel is unavailable, then the price obtained is based on market prices.

The Availability criteria (K_2) are obtained based on the ease with which the community obtains fuel in the area. The ease is measured based on the amount of fuel compared to the needs and mileage of taking the fuel from sources available in the area. The rating is in Table 3.

Table 3. Availability criteria (K_2)

Description	Value
Very difficult	1
Difficult	2
Easy	3
Quite easy	4
Very easy	5

The Infrastructure criteria (K_3) are measured based on fuel facilities or infrastructure to reach the consumer. The rating is in Table 4.

Table 4. Infrastructure criteria (K_3)

Description	Value
Very difficult	1
Difficult	2
Easy	3
Quite easy	4
Very easy	5

The Safety criteria (K_4) are measured based on the flammability of the fuel and the ease of detecting the presence of the fuel. The rating is in Table 5.

Table 5. Safety criteria (K_4)

Description	Value
Not safe	1
Less Safe	2
Safe	3
Safe Enough	4
Very safe	5

The criteria for convenience (K_5) are measured by consumers or the community, starting from turning on the stove to turning it off. The rating is in Table 6.

Table 6. Convenience criteria (K_5)

Description	Value
Very difficult	1
Difficult	2
Easy	3
Quite easy	4
Very easy	5

The Criteria level of pollution (K_6) is measured by the results of burning these fuels, which damage human health. The rating is in Table 7.

Table 7. Criteria The level of pollution (K_6)

Description	Value
Very high	1
High	2
Medium	3
Low	4
Very low	5

If the value of each criterion has been determined, a matching rating table, as in Table 8, is created.

Table 8. Matching rating for each alternative

Alternative	Criteria					
	K_1	K_2	K_3	K_4	K_5	K_6
A_1	50000	1	1	1	5	5
A_2	90000	3	3	3	5	4
A_3	110000	2	2	2	4	5
A_4	56000	5	4	4	2	4
A_5	90000	3	3	4	3	3
A_6	60000	1	3	2	5	5
A_7	100000	2	4	5	1	1
A_8	300000	2	4	5	1	1
A_9	360000	2	4	5	1	1
A_{10}	110000	3	3	4	3	5

Data analysis technique

Weighted Product (WP) calculates based on the level of importance and can evaluate a collection of attributes by multiplying all criteria with alternative results and ranking between weights and alternative multiplication results. The data from the conformity assessment results in Table 8. that have been obtained will be processed using the Weighted Product Method to produce the best alternative fuel recommendations.

First, make improvements to the value of the weight of the criteria by adding up the weight of each criterion, then each initial weight of the criteria is divided by the sum of the weights of the

Criteria using the following formula 1.

$$W_j = \frac{w_j}{\Sigma w_j} \quad \text{.....(1)}$$

Description:
W : Criteria weight
j : Criteria

Next, calculate the S Vector for each fuel alternative by multiplying all the attributes for an alternative with the weight as a positive exponent for the benefit attribute and a negative exponent for the cost attribute using formula 2.

$$S_i = \prod_{j=1}^{n} {X_{ij}}^{w_j} \quad \text{.....(2)}$$

Description:
i : Alternative 1,2,...,m.

S : Vector S
X : Criteria value
W : Criteria weight
j : Criteria
n : The number of criteria

After obtaining the value of Vector S, calculate Vector (V). That is, divide the preferences of each alternative by the total number of Vectors (S) with the following formula 3.

$$V_i = \frac{S_i}{\sum S_i} \quad \text{..... (3)}$$

Description:
i : Alternative 1,2,…,m.
V : Vector V
S : Vector S
X : Criteria value
W : Criteria weight
j : Criteria
n : The number of criteria
* : The number of criteria that have been assessed on the S vector

After the value of the vector V is obtained, sort it based on the most significant value of V. A sequence of the best alternative fuels is found, which will be the decision.

RESULTS AND DISCUSSION

The weighted product method calculates the best alternative fuel recommendation value for households. The process begins with alternative data, criteria, and weights as input. Then, it calculates the improvement of the criterion weights. At this stage, the criterion weights from K_1 to K_6 will be corrected for the weight values. The result table can be seen in Table 9.

Table 9. The improvement weights

Code	Old Weight	New Weight
K_1	30	0,3
K_2	25	0,25
K_3	10	0,1
K_4	15	0,15
K_5	15	0,15
K_6	5	0,05

Furthermore, the next step is to run the program using a web-based programming language, PHP, with a MySQL database. The code can be seen in pseudocode_ improvement weights.

Pseudocode_ improvement weights

```
$numb = 1; foreach ($kriteria as $k) :
$numb++
$k['normalisasi_bobot']
$bobot = 0; $no = 1; foreach ($kriteria as $kb) :
$bobot = $bobot + $kb['normalisasi_bobot']
if ($no++ == sizeof($kriteria)) :
        $kb['normalisasi_bobot']
else
        $kb['normalisasi_bobot']
endif
endforeach
$k['normalisasi_bobot']
$bobot
$k['normalisasi_bobot']
if ($k['jenis_kriteria'] == 'Benefit') : $hasil =
$k['normalisasi_bobot'] * 1
$k['normalisasi_bobot'] * (1)
else : $hasil = $k['normalisasi_bobot'] * -1
$k['normalisasi_bobot']  ?> * (-1)
endif
$hasil
$this->db->where('id', $k['id']);
$this->db->update('kriteria', ['hasil' => $hasil]);
endforeach
```

Next calculates Vector S At this stage, and it calculates the value of Vector S from alternative fuels A_1 to A_{10}. The result table can be seen in Table 10.

Table 10. Vector S

S_i	W_1	W_2	W_3	W_4	W_5	W_6	Result
S_1	0,039	1	1	1	1,27	1,08	0,054
S_2	0,033	1,32	1,12	1,18	1,27	1,07	0,077
S_3	0,030	1,19	1,07	1,11	1,23	1,08	0,057
S_4	0,038	1,50	1,15	1,23	1,11	1,07	0,095
S_5	0,033	1,32	1,12	1,23	1,18	1,06	0,074
S_6	0,037	1	1,12	1,23	1,18	1,06	0,063
S_7	0,032	1,19	1,15	1,27	1	1	0,055
S_8	0,023	1,19	1,15	1,27	1	1	0,040
S_9	0,022	1,19	1,15	1,27	1	1	0,037
S_{10}	0,031	1,32	1,12	1,23	1,18	1,08	0,071
Total							0,622

The code that calculates vector S can be seen in pseudocode_ vectorS.

```
Pseudocode_ vectorS
foreach ($kriteria as $krt) : ?>
    100 / (sizeof($kriteria))
    $krt['nama_kriteria']
    $krt['normalisasi_bobot'] ?>)
endforeach ?>
foreach ($nilai_kriteria_alternatif as $alt => $value):
    $no =1 ;  $hasil = 1;
    foreach ($value['nilai'] as $nilai_kriteria):
        100 / (sizeof($value['nilai'])) %
    print_r($this->uri->segment(4) . ' here');die;
            // $getNilai = $this->db-
>get_where('nilai_kriteria_alternatif', ['wilayah_id' =>
$this->uri->segment(2), 'kriteria_id' => $krit['id'],
'alternatif_id' => $alt['id']])->row_array();
```

```
            $hasil = $hasil * (pow($nilai_kriteria['nilai'],
$nilai_kriteria['kriteria_hasil']));
$nilai_kriteria['nilai'] $nilai_kriteria['kriteria_hasil']
if ($no++ < sizeof($value['nilai'])):
else:
endif ?>
if (is_infinite($hasil) || is_nan($hasil)) $hasil = 0;
$where = ['wilayah_id' => $this->uri->segment(4),
'alternatif_id' => $nilai_kriteria['alternatif_id']];
$cekHasil = $this->db->
get_where('hasil_normalisasi', $where)->
row_array();
if ($cekHasil) $this->db-> update('hasil_normalisasi',
['hasil' => $hasil], $where);
else {
$where['hasil'] = $hasil;
$this->db->insert('hasil_normalisasi', $where);
}
endforeach
$hasil = number_format($hasil, 3)
endforeach
```

After obtaining the value of Vector S_1 to S_{10}, calculate Vector (V). From the results of the V vector, the recommendations are ranked from the largest to the smallest. The ranking table can be seen in Table 11.

Table 11. The ranking table

Vi	Fuel	Score	Rank
V_4	Bioethanol	0,152	1
V_2	LPG	0,124	2
V_5	kerosene	0,118	3
V_{10}	Electricity	0,114	4
V_6	Dimethyl Ether (DME)	0,101	5
V_3	Biogas	0,092	6
V_7	Coal Briquettes	0,088	7
V_1	Gas City	0,086	8
V_8	Coconut Shell Briquettes	0,064	9
V_9	Rice Husk Briquettes	0,060	10

Then the recommended result is bioethanol fuel with the most significant vector V value of 0.152. The code calculates vector V can be seen in the pseudocode_ vector.

```
Pseudocode_ vectorV

$alternatif = $this->db->select("
alternatif.nama_alternatif, hasil_normalisasi.*")-
>join("alternatif", "alternatif.id =
hasil_normalisasi.alternatif_id")-
>get_where('hasil_normalisasi', ['wilayah_id' => $this-
>uri->segment(4)]);
$num = 1; foreach ($alternatif->result() as $rank) :
rank->nama_alternatif
number_format($rank->hasil, 3)
$jumlah = 0; $no = 1; foreach ($alternatif->result() as
$ar) : $jumlah = $jumlah + $ar->hasil ?>
```

```
if ($no++ == $alternatif->num_rows())
      number_format($ar->hasil, 3) ?>
else :
      number_format($ar->hasil, 3) ?>+
endif
endforeach
$hasil = $rank->hasil <= 0 ? 0 : $rank->hasil / $jumlah
number_format($rank->hasil, 3
number_format($jumlah, 3)
number_format($hasil, 3)
$this->db->where('id_hasil', $rank->id_hasil);
if (is_infinite($hasil) || is_nan($hasil)) $hasil = '0';
    $this->db->update('hasil_normalisasi', ['hasil_wp'
    => $hasil]);
endforeach ?>
```

System Displays

This displays the calculation results and ranking of the best fuel priorities. The Chart Results of the Method can be shown in Figure 11.

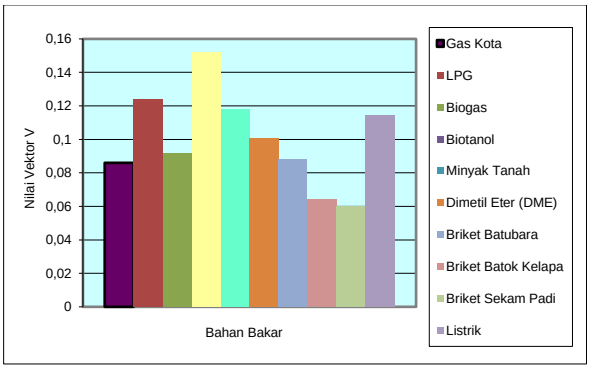
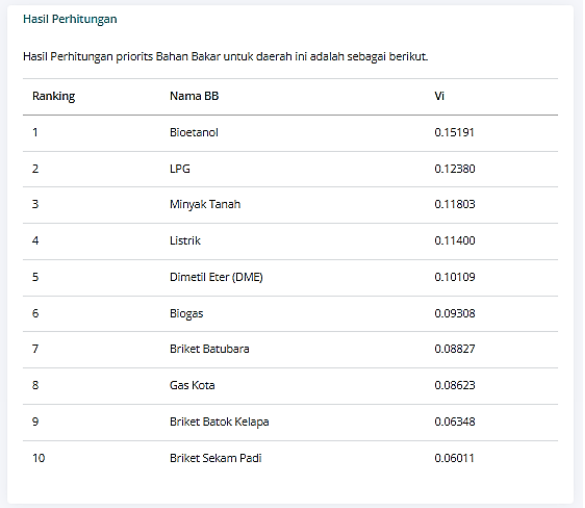


Figure 11. Chart Results page

The ranking of the best fuel priorities page can be shown in Figure 12.



Hasil Perhitungan

Hasil Perhitungan priorits Bahan Bakar untuk daerah ini adalah sebagai berikut.

Ranking	Nama BB	Vi
1	Bioetanol	0.15191
2	LPG	0.12380
3	Minyak Tanah	0.11803
4	Listrik	0.11400
5	Dimetil Eter (DME)	0.10109
6	Biogas	0.09308
7	Briket Batubara	0.08827
8	Gas Kota	0.08623
9	Briket Batok Kelapa	0.06348
10	Briket Sekam Padi	0.06011

Figure 12. The ranking page

CONCLUSIONS AND SUGGESTIONS

Conclusion

This study concludes that the WP system has been successfully developed to assist consultants, experts, and local governments in determining fuel in their regions. The Weighted Product method using five criteria of price, pollution level, availability, infrastructure, safety, and ease of use produces a ranking according to the magnitude of the Vector (V) value obtained from testing ten alternative fuels, namely: (1) Bioethanol (2) LPG (3) Kerosene, (4) Electricity, (5) Dimethyl Ether, (6) Biogas, (7) Coal Briquettes, (8) City Gas (9) Coconut Shell Briquettes, and (10) Rice Husk Briquettes. The system is designed using UML Diagrams and built using a web programming language, PHP. System testing uses the Black Box method so that the system can run properly.

Suggestion

This decision support system can be developed by comparing it with other methods, such as Topsis or Fuzzy logic, to support the accuracy of the data. The WP method can also support policymakers in making a policy for the best product among many products in some criteria.

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