Available online at www.CivileJournal.org

Civil Engineering Journal

(E-ISSN: 2476-3055; ISSN: 2676-6957)

Vol. 7, Special Issue, 2021

"Innovative Strategies in Civil Engineering Grand Challenges"

Implementing the Calculations and Characterization of Underground Coal Gasification using Data Analytic Method

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Received 24 April 2022; Revised 24 July 2022; Accepted 11 August 2022; Published 22 August 2022

Abstract

Indonesian coal production nowadays has reached 63% of total production, which means this high demand will also produce a lot of data. This high demand needs to be innovated as a new alternative energy based on coal production, Underground Coal Gasification (UCG). The coal in this alternative energy source is used to turn the solid coal into gas. Coal mining data has a lot of variables that might be difficult to process manually. Our automatic system will help the users, especially the geologists, identify which coal seams have the potential to be developed as the UCG. We developed the system using a python-based coding system and required data standardization to ease the built-in code reading and process all the required steps to identify the UCG. We implemented the calculation and characterization regarding the calorific value (ADB), proximate, and ultimate analysis from the provided data to find the needed variables for the UCG analytics system. The automatic system will allow the user to choose the interesting borehole that they want to identify. Our system then shows the initial UCG recommendation layer for the next analysis. From our experiment, our system finally found that at the depth of 260 meters, Borehole MJ02 has the potential as the initial guest of the recommendation layer of the UCG development.

Keywords: Underground Coal Gasification; Data Analytic; Characterization; Calculation; Geological.

1. Introduction

Coal production in Indonesia has significantly increased during 2009–2018 and is predicted to increase in the future due to fulfilling domestic and export demand. As of 2018, total production reached about 557 million tons, and 63% of total production was mostly exported to China and India. This high percentage of Indonesia's coal exports records Indonesia as one of the biggest coal exporters in the world besides Australia [1, 2]. This big demand that might globally increase Indonesian coal production should be a concern and studied comprehensively.

Geologically, PSDMBP (the Center of Mineral, Coal, and Geothermal Resources) classifies coal resources into four types: surface coal, subsurface coal, coalbed methane, and peat. "*Surface Coal*" is defined as coal that is exposed on the surface to a depth of approximately 100 meters beneath the surface. This kind of coal resource is usually recommended as open pit mining. As of December 2020, PSDMBP reported that there are about 143,730.90 billion tons of total coal resources and 38,805.48 billion tons of total coal reserves distributed over the islands of Indonesia. Meanwhile, subsurface coal is defined as coal that is exposed at a depth of greater than 100 meters. This classification needs a more detailed method and analysis regarding Underground Coal Gasification. According to the yearly report of PSDMBP

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http://dx.doi.org/10.28991/CEJ-SP2021-07-012

(2020) [3], subsurface coal has been reported at around 43,533.34 billion tons of coal resources and 173.51 million tons of coal reserves. Another classification is coalbed methane and peat, which are still in the early stages of exploration.

Conventional coal mining has been documented from thousands of years ago until today in an open pit method. This open-pit method requires opening the mining area on a large scale, which might require removing the land use of the prospected area. Another negative effect of open-pit coal mining contributes to global warming and environmental issues. The UCG is one of the new clean energy technologies in coal exploration that has fewer environmental issues. This method utilizes coal gasification by converting the solid coal to gas in situ, which will process the gasification underground. The UCG can recover the low rank of coal, lignite, or sub-bituminous, which, by the characteristics of Indonesian coal, might not be economically [4, 5] or technically feasible due to its seam thickness, depth, overburden properties, large dip angle, or high ash and excessive moisture content. The UCG process also produces less atmospheric pollution than the conventional one since the coal is not mined, which means that no surface needs to be dislocated or do reclamation. The UCG only uses less water since we have to keep the ratio of steam to air high to avoid slagging [6].

Under Law (UU) No. 3 of 2020, Indonesia is responsible for coal and mineral management, including UCG prospecting and utilization, through PSDBMP [3]. PSDMBP already calculated the UCG potential all over Indonesia and discovered about 11 coal basins, and around 5 basins are prospected to be utilized for the UCG. Coal resources for the utilization of the UCG in Indonesia are calculated to be 796 billion tons (Table 1). We could convert by assuming that 1 kg of coal might produce 3 Nm^3 (1 Nm^3 = 35.315 SCF) with a heating value of less than 200 BTU/ft^3, the total UCG resource will reach 84,354 TSCF, which is 35 times the coalbed methane or natural gas potential. That huge amount should be able to be implemented through this clean technology.

Table 1. UCG Resources in Indonesia (PSDMBP, 2020) [3]

No.	Basin	Formation	Number of Seams	Total Thickness (m)	Area Distribution for UCG (m^2)	Correction Factor	UCG Resources (ton)
1.	South Sumatera	Muara Enim	5	61.47	9,400,000,000	0.5	375,581,700,000
2.	Ombilin	Ombilin	3	17.4	60,750,000	0.5	687,082,500
3.	Barito	Warukin-Tanjung	7	48.55	8,100,000,000	0.5	255,615,750,000
4.	Pasir/Asam2	Warukin-Tanjung	2	14.87	502,500,000	0.5	4,856,913,750
5.	Kutai	Prangat	5	31.55	7,776,000,000	0.5	159,466,320,000
		Total			25,839,250,000		796,207,766,250

Our preliminary study aims to figure out where the UCG is in Indonesia. We started to analyze the UCG potential around the Mangunjaya area as one of the potential areas in the South Sumatera Basin (Figure 1). We used the exploration data provided by PSDMBP. In this paper, we try to implement automatic calculation and characterization using Python. This automatic calculation and characterization are followed by manual calculation and characterization to validate whether our coding system is proven. So, once in the future, we have a lot of data to be used, we can easily apply this automatic system.

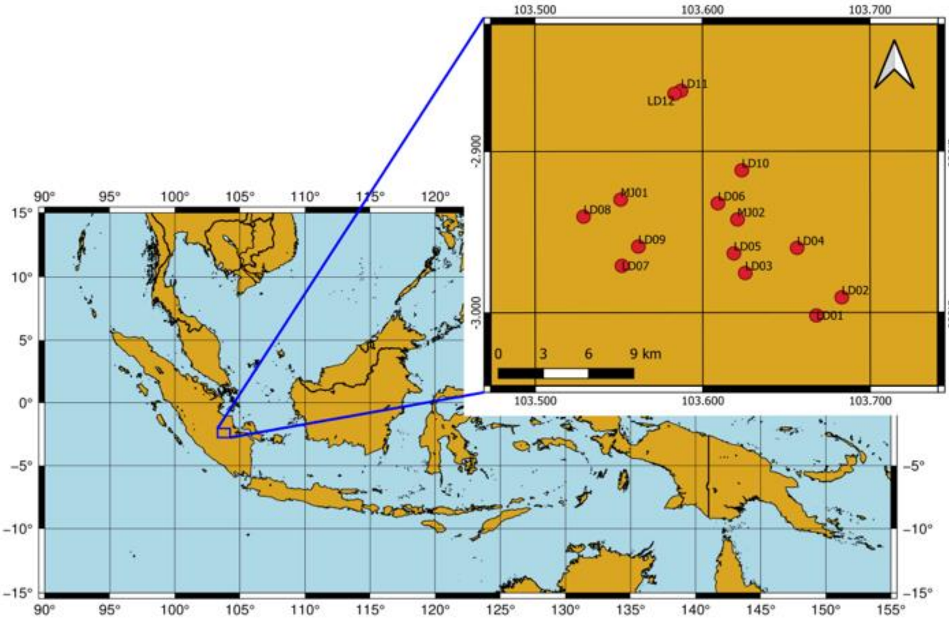

Figure 1. Mangunjaya Map, Indonesia

2. Underground Coal Gasification and Characterization

To find the UCG potential deep inside the subsurface, we cannot judge that all the coal seams inside meet the UCG requirements. Site selection is something very important in the UCG analysis by considering the thickness and depth of the coal seam, coal rank and other properties [7], roof and floor rock, structural geology of the area, calorific value, depth to thickness ratio, and the dip angle of the seam itself. Our study refers to Dwitama et al. (2021) [8] which summarized the UCG criteria as shown in Table 2.

Table 2. Variables Used for the UCG Characterization

No.	Criteria	Code Naming	Minimum Condition
1	Calorie Value (in ADB) according to PSDMBP classification	CV(ADB)	< 6,100 cal/g (low – medium calorie) > 6,100 cal/g, need to do coking analysis
2	Coal Thickness	Thickness	> 2 meters > 3.5 meters for lignite
3	Coal depth	From	> 120 meters
4	Depth to Thickness Ratio	D/T Ratio	For depth: 120 – 200 = minimum ratio 22 200 – 300 = minimum ratio 18 300 – 400 = minimum ratio 15 > 400 = minimum ratio 15
5	Roof and Floor Rock Type	Roof | Floor	Impermeable rock
6	Roof and Floor Thickness	Roof Thickness Floor Thickness	Roof = 2 times of the coal seam Floor = 1 time of the coal seam
7	Dip of the Seam		Recommended < 20˚, maximum 65˚
8	Hydrogeological Condition		> 30 meters or 25 times of the coal thickness
9	Structural Geology		A simple structure, no fractures or faults nearby/influenced. Recommended in syncline
10	Coal Resources		Minimum 2.5 million tons in 1 km^2
11	Distance to open pit mine area		300 meters following seam dip

The UCG technology will convert the solid coal into gas in situ by injecting air or oxygen. This injection will ignite the coal and flows in the targeted coal seam or surrounding rocks that increase temperature, pressure, and gas content as the oxygen is continuously injected and let the high-pressure gas ascend along the borehole which is known as the gasification process [7-10]. This gasification process can be optimal if we gasify the low-rank coal as it will assist in the reduction of carbon emissions due to the chemical and physical transformation [9, 11-13]. This statement is in agreement with our study that found lignite to sub-bituminous are dominating the coal rank distribution. According to PSDMBP classification (Table 3) for the calorific value (in ADB), we selected the type of coal with the above rating, the initial sorting is done by recording coal with a calorific value of less than 6,100 cal/gr (<6,100 cal/gr, ADB).

Table 3. Caloric Value According to Borehole Mapping

Group	Calorific Value (kal/g) (ADB)	Description
Low Calorie	< 5100	Hard-soft, easy to squeeze, high water content, the wooden-structure still can be seen
Medium Calorie	5100 - 6100	Hard, easy to hard to squeeze, less water content, wooden-structure still can be seen
High Calorie	6100 - 7100	Less water content, wooden-structure cannot be seen
Very High Calorie	>7100	very less water content, might be influenced by another intrusion or structure

Another sorting that we need to do for finding the UCG prospecting seam is considering the thickness of the coal seam itself. We put the threshold value in the computation system according to several studies that have been done and summarized in Dwitama et al. (2021) [8]. For lignite rank coal, the thickness of the coal should be 3.5 meters. For non-lignite rank coal, 2 meters of thickness can be examined for the next characterization. For depth characterization, we put a minimum threshold value of depth of around 120 meters which then needs to be calculated as the ratio of its depth to thickness as shown in Table 2.

We then put the type of roof and floor in the coding system to be automatically selected. We selected the type of roof and floor that is impermeable as the UCG characterized. We found like claystone, siltstone, shale, tuff, etc. are distributed in each borehole. These rocks might be characterized as impermeable rocks. Our system traced as much as possible to find the roof and floor and sum in into one layer either roof or floor. Once the system finds the permeability zone (layer), the system will stop to sum in as we do not need it. According to Dwitama et al. (2021) [8], we used the minimum thickness of both layers to be twice the thickness of the coal for the roof and once the thickness of the coal for the floor.

We still have more characterization that needs to be considered. However, some of the coal data is preferable to manually checked and it is quite difficult to implement it in the coding system, such as the geological structure condition, the distance between the target coal and active aquifer layer, and the minimum distance of the targeted field to the ex-mining or mining area. These two conditions might need to be manually checked. If it is possible to put it in the coding system, we might only put the term, such as simple geology or 300 meters. For identification itself, it might be complicated if it is applied to the coding system.

However, there is still some characterization that might be possible to be put into the coding system. Dwitama et al. (2021) [8] reviewed the good dip in selected seam for developing the UCG are determined in less than 65˚ according to some successful projects around the world. The coal resources are still considered for the UCG development. The minimum coal resources are adjusted to the utilization of gas for industry or the capacity of the power plant and the length of operating time [15]. To ease the UCG characterization process, we summarized the process into a flowchart as shown in Figure 2.

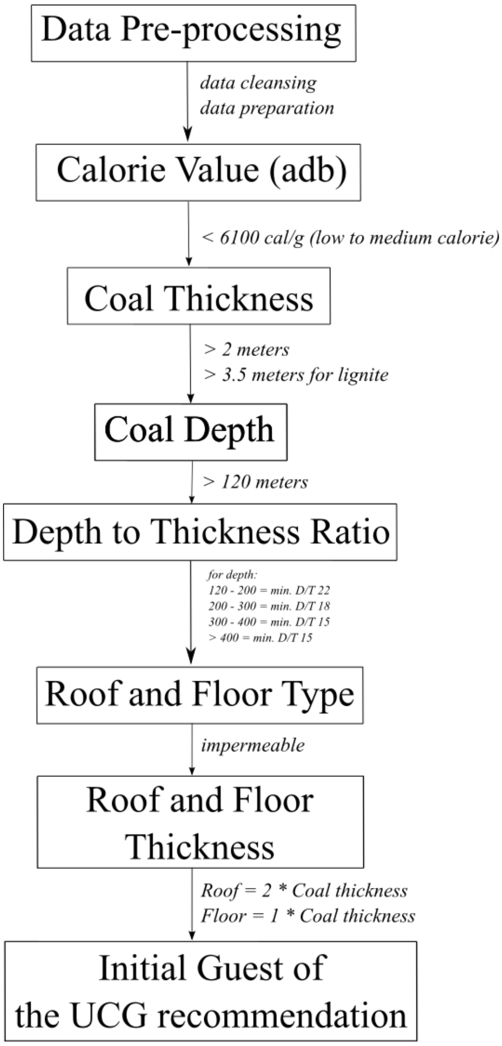

Figure 2. UCG Characterization Process through Data Analytic

3. Analytic Approach

A high rate of coal demand especially Indonesian Coal now has forced us to do an automatization process to ease our work. In this study, we attempt to involve in a coal database to automatically calculate and characterize the target analysis, the UCG analysis. We utilized the coal data provided by PSDMBP as our first experiment in implementing the automatic calculation and characterization. We also did the manual analysis, examined by the geologists to validate our work. We first created the data standardization for each calculation. This standardization was made to ease the python-based code to read and calculate the data according to the coding system since some people might not be familiar with the form of the data.

The UCG analysis needs some data have been calculated before it goes to the UCG analysis. Our first step is calculating and characterizing the data according to the Calorific Value (in ADB) and ASTM analysis. ASTM analysis will inform you in what rank of coal your data is. This calculation and characterization are provided as one python-based code. We then go to the UCG analysis to trace each data and calculate the variables needed such as the D-T ratio and the type of the Roof and Floor rock and its thickness. Once the UCG code gets the results, we then go to the UCG analysis that will filter all the whole things inside your data and automatically choose and find out which seam is recommended for the initial guest of the UCG development. Figure 3 is the pseudocode of the coding system in filtering the data. However, we mention that our python-based code is only for the initial guest since there might be some data that need to be manually interpreted by the experts, such as the structural geology condition. We also found that one coal seam might contain more than one data as laboratory samples which is not consistent with one another. So, this might allow you to do manual-checked and data cleansing before it goes to the automatic system. Our automatic system has provided data standardization in each coding system that will allow you to first clean and arrange the data before you use our system. To ease your depiction, we illustrated our automatic system in Figure 4.

```
Pseudocode of the UCG Characterization:

Step 1: if 'CV (adb)' < 6100: continue
   if 'CV (adb)' > 6100: delete

Step 2: if 'ASTM' == 'Lignite A' or 'Lignite B': continue to check the 'Thickness' == > 3.5 meter
   if 'ASTM' != 'Lignite A' or 'Lignite B': continue check 'Thickness' == > 2 meter
   for data except those criteria: delete

Step 3: if 'From' == 120 - 200 meter with 'D/T Ratio' <= 22 (more is recommended): continue
   if 'From' == 200 - 300 meter with D/T Ratio' <= 18 (more is recommended): continue
   if 'From' == 300 - 400 meter with 'D/T Ratio' <= 15 (more is recommended): continue
   if 'From' > 400 meter dengan 'D/T Ratio' == 15 (more is recommended): continue
   if 'From' < 120 meter == do not execute, data will be kept as open pit mining recommendation

Step 4: If 'Roof' and 'Floor' == impermeable rock: continue
   if 'Roof' and 'Floor' != impermeable rock: delete

Step 5: if 'Roof Thickness' >= 2 * 'Thickness' and 'Floor Thickness' = 1 * 'Thickness': continue
   if <= 2 * 'Thickness' and 'Floor Thickness' = 1 * 'Thickness' : delete
```

Figure 3. UCG Characterization Pseudocode

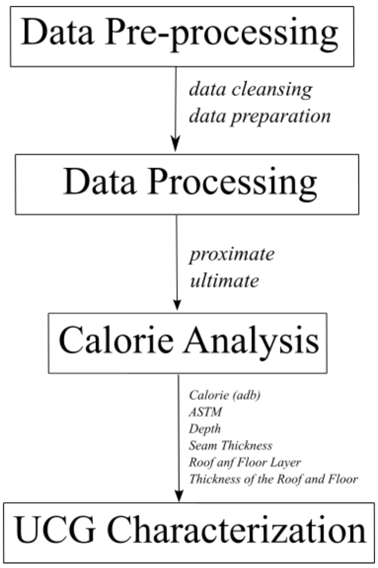

Figure 4. The UCG Automation Process

4. Discussion and Result

We aim to determine the UCG potential location as we want to develop the UCG as our alternative energy. The implementation of the automatic process by python-based analysis helps us once we work for big data. We used 14 boreholes to do the analysis. We implemented those 14 boreholes to the system required to find which borehole and the seam are qualified and potential for developing the UCG.

According to the lithology of each borehole, we figured out that each borehole has more than one coal seam. Dwitama et al. (2021) [8] suggested finding the most potential coal seam if in an area there is more than one coal seam. This is obvious as we consider the effect on the surrounding environment and the possibility of subsidence that might occur once we are exploitative the seam since we would convert the solid coal into gas. If we get too many layers or seams that will be exploited, subsidence on a large scale might occur. To depict the borehole distribution in the study area, we implemented the "Borehole Mapping" feature in the system. This feature allows the user to be able to identify the distribution of the borehole in a map displayed by the system according to its calorific value (ADB). Table 4 describes an example of the dataset that was used in this feature.

Table 4. Data Standardization for Borhole Mapping

No.	AreaName	BoreholeName	Calories	From	To
1	Mangunjaya	MJO1	5540.0	74.0	74.50
2	Mangunjaya	MJO1	5574.0	74.50	75.00
3	Mangunjaya	MJO1	5349.0	76.00	76.50
4	Mangunjaya	MJO1	5360.0	79.00	79.40
…	….	….	….	…	….
116	Mangunjaya	LD12	4910.0	47.00	49.25
117	Mangunjaya	LD12	Nan	74.05	74.85
118	Mangunjaya	LD12	5240.0	77.15	77.35
119	Mangunjaya	LD12	5240.0	77.38	78.82
120	Mangunjaya	LD12	5240.0	78.85	82.60

We implemented the steps in Table 2 to determine which coal seam in a borehole that is the potential for UCG development. Our system is a python-based system by filters the dataset to finally characterize the initial guest of the UCG development. From the experimental results, the data feature extraction is used as the input data to achieve the borehole distribution. The results of data standardization for the borehole mapping process are described in Table 5. In this feature, we can easily choose and filter which we want to use such as low, medium, high, and very high calories. We then can see which borehole has our desired filter, such as the low-calorie distribution.

Table 5. Variables Used for the UCG Characterization

Variable	Explanation	Example
Area Name	The name of the area where the borehole is located	Mangunjaya
Borehole Name	Borehole Code	LD01
Calories	Calorie content in borehole	5540
From	Initial depth of borehole contents	75.5
To	Initial depth of borehole contents	85

An automatic lithology depiction to assist the user in identifying the layer content in each borehole has been developed. To implement this code, we require the data standardization shown in Tables 6 and 7. This feature will easily filter the lithology of the borehole you want to see, such as MJ01. The user can easily see and identify the coal seam distribution (Figure 5) according to the color and pattern that we have provided in the system (Figure 6). As an example, we used Borehole MJ01 and found around 17 coal seams in Borehole MJ01, just easily identify since coal is depicted as plain black.

Table 6. Data Standardization for Lithology

	Borehole Name	Lithology	From	To	Thickness
0	MJO1	Soil	0.00	10.45	10.45
1	MJO1	Claystone	10.45	10.92	0.47
2	MJO1	Fine Grained Sandstone	10.92	23.00	12.08
3	MJO1	Core Loss	23.00	25.00	2.00
4	MJO1	Coarse Grained Sandstone	25.00	28.08	3.08
…	….	….	….	….	….
437	LD12	Claystone	77.35	77.38	0.03
438	LD12	Coal	77.38	78.82	1.44
439	LD12	Claystone	78.82	78.85	0.03
440	LD12	Coal	78.82	82.60	3.75
441	LD12	Claystone	82.60	83.00	0.40

Table 7. Variables Used for the UCG Characterization

Variable	Explanation	Example
Borehole Name	Borehole Code	LD01
Lithology	Type of coal content	Soil, Coal, etc.
From	Initial depth of borehole contents	75.5
To	Initial depth of borehole contents	85
Thickness	Borehole Content Layer Thickness	10.5

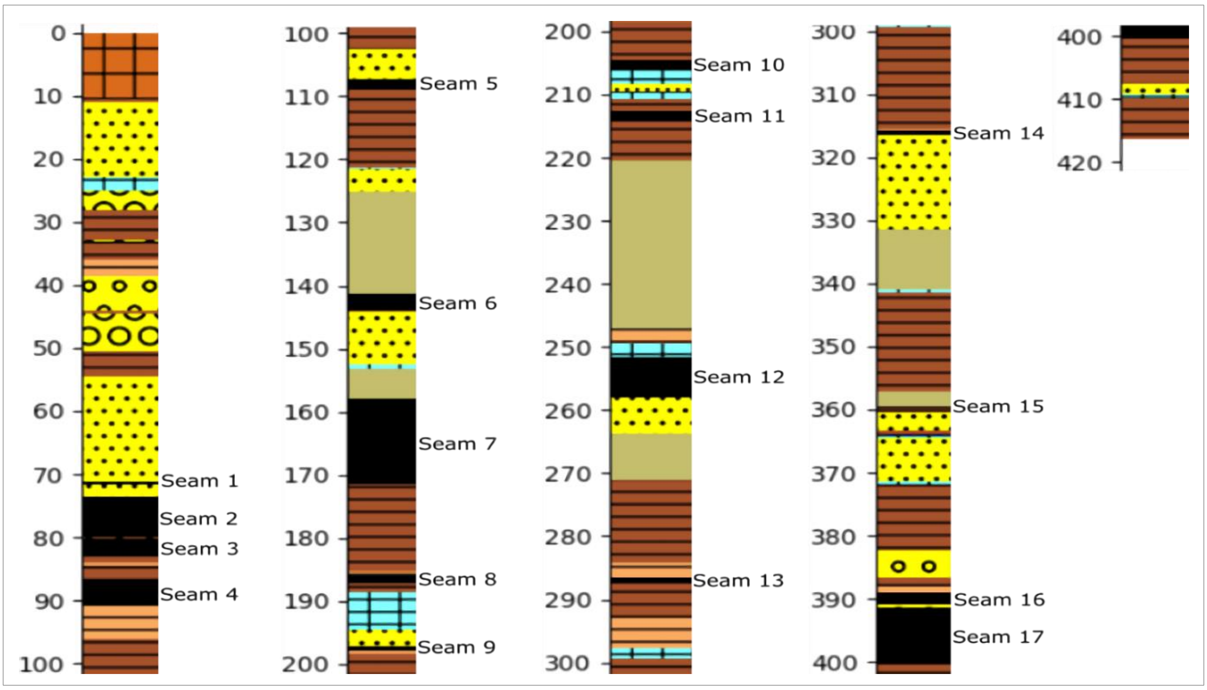

Figure 5. Lithology Log of Borehole in MJ01 Sample

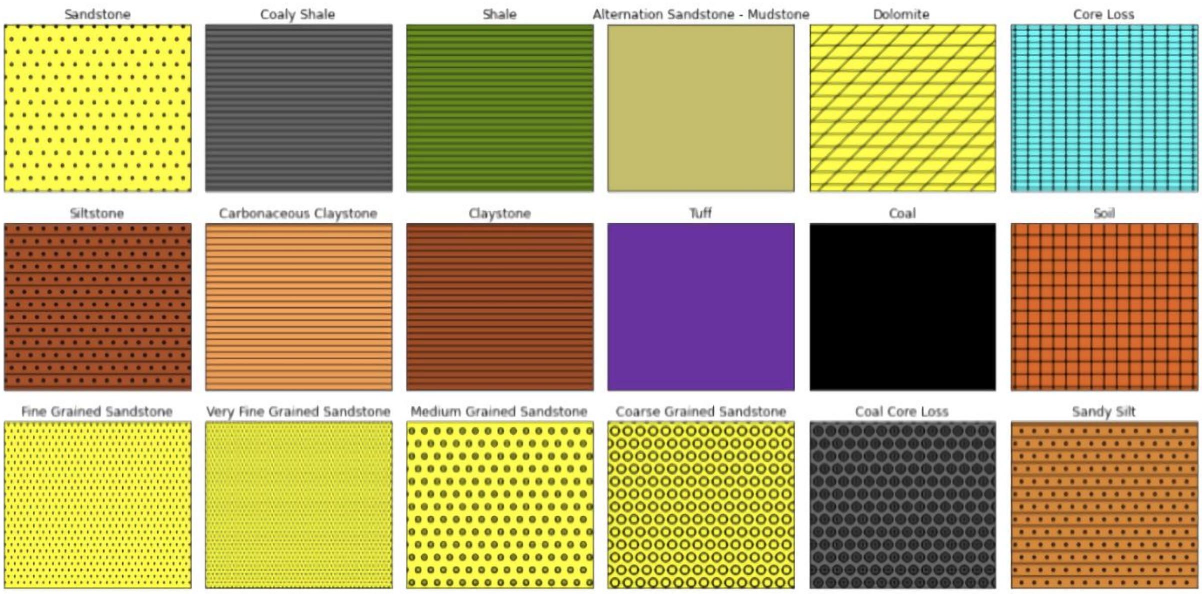

Figure 6. Lithology Legend

As an example, our data in Borehole MJ01 contains 17 coal seams. However, we could not proceed with all those 17 layers in the calculation since the proximate and ultimate data provided is not available. We might somehow find that in layer 1, no data is provided for the variables needed. So, we have to check it manually to make sure that the system calculates the right data. Another thing to be manually checked is the amount of sampling data in each layer since it has inconsistency in its amount. As an example, we might find out that the amount of sampling data in layers 2 and 3 (Figure 5) is not the same. It is obvious since the coal seam thickness is not the same. In layer 2, we have sampling data of 6, while layer 3 only has 2 sampling data. This inconsistency can be found in other layers. We then have to calculate the average value of one layer to find the variable value for a layer for the UCG analysis.

Another feature that we developed is the coal rank distribution. This feature allows the user to identify the coal rank analysis (ASTM analysis). Again, we then require a data standardization to calculate it automatically (Tables 8 and 9). We also developed a graphic if the user wants to see the coal rank and calorific value (in ADB) distribution in each borehole, just by filtering the borehole name, the output will show you the coal rank distribution in the chosen borehole (Figure 7). From our identification, our coal rank data distribute as lignite to sub-bituminous and calorific values are less than 6,100 cal/g (ADB) which are quite recommended for the UCG development since the high-rank coal might have caking/coking properties. If your data might have those high ranks, then you should do coking analysis.

Table 8. Coal Data Standardization

	Borehole	CV (ADB)	A (%)	M (%)	C (%)	O (%)	H (%)
0	MJ01	5540.0	3.47	11.80	69.10	25.08	5.09
1	MJ01	5574.0	2.90	11.98	69.59	24.44	5.06
2	MJ01	5349.0	3.94	12.61	68.54	25.63	4.91
3	MJ01	5360.0	4.47	12.17	68.75	25.30	5.00
4	MJ01	5330.0	6.82	11.96	69.30	24.36	5.28

Table 9. Data Dictionary of Coal Rank Analysis Features

Variable	Explanation	Example
Borehole	Borehole Code	MJ01
CV	calorific value in ADB (unit kcal/kg) in proximate analysis	5540
A	Ash content in ADB in proximate analysis	3.47
M	Moisture content in ADB in proximate analysis	11.80
C	carbon content in DAF in ultimate analysis	69.10
O	oxygen content in DAF in ultimate analysis	25.08
H	hydrogen content in DAF in ultimate analysis	5.09

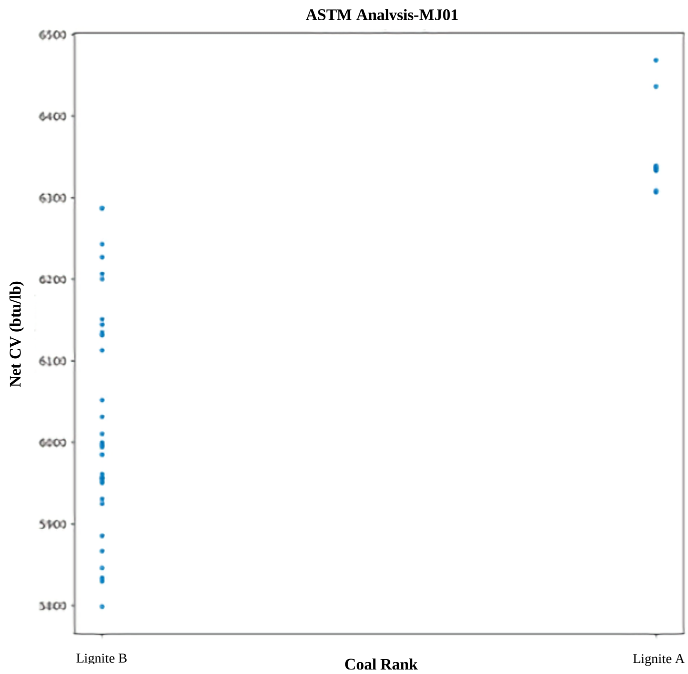

Figure 7. Coal Rank Data Distribution Result for MJ01 Sample

For the UCG Calculation feature, the user can automatically calculate the needed variables in characterizing the UCG development, such as D/T Ratio, roof and floor thickness, and roof and floor type. The data standardization of the required dataset is similar to the lithology data (Tables 6 and 7). This feature is an automatic filter for UCG development.

Since many variables are used for this analysis, it might be difficult for us to manually check each layer. We developed this feature to ease your initial interpretation of the UCG analysis. We developed those five steps and required the users to standardize their data to use this feature. The data standardization format is shown in Table 10. Once the user inputs all the data, the output will automatically appear as the UCG initial recommendation layer for the interest area. All those used criteria were summarized according to some studies in the development of the UCG.

Table 10. Data Dictionary of the Needed Variables for the UCG Analysis Features

Variable	Explanation	Example
Borehole Name	Borehole Code	LD01
Lithology	Type of coal content	Soil, Coal, etc.
From	Initial depth of borehole contents	75.5
To	Initial depth of borehole contents	85
Thickness	Borehole Content Layer Thickness	10.5
Coal seam	Name of coal layer	Benakat
CV	Calorific Value in ADB	5430.5
Net CV	Net Calorific Value in btu/lb for ASTM characterization	5908.5
PSDMBP	Center of Mineral, Coal, and Geothermal Resources Indonesia that classify coal rank according to its Calorific Value in ADB	Medium
ASTM	Coal Rank analysis	Lignite B
DT Ratio	Depth to Thickness Ratio of the coal seam	11.45
Roof	Type of roof, type of rocks above the coal	Siltsone
Floor	Type of floor, type of rocks under the coal	Claystone
Roof Thickness	Thickness of rocks above the coal	20.4
Floor Thickness	Thickness of rocks under the coal	10.2

The threshold value for the UCG characterization, such as for its coal thickness criteria, was obtained according to some studies. They mentioned that the thickness might be around 10 meters (Gastech, 0.50 meters, Ergo Exergy, 2 meters "Former Soviet" [7], preferably 5–10 meters [16, 17]), the optimal thickness assessed at around 2-4 meters [14]. In this study, we used the minimum value in the range of 2 to 3.5 meters by considering the rank of the coal. According to Dwitama et al. (2021) [8] that has personal communication with the experts, for lignite rank coal (assumed to have a calorific value of less than 5,100 cal/gr), for non-lignite, it is okay to use a minimum thickness of 2 meters.

The depth of the coal seam ranges from 12 to 1,200 meters [7, 18]. Burton et al. (2006) [18] recommended a good depth for UCG development that is deeper than 200 meters. This suggestion considers the risk of subsidence, which will be risky if the depth is shallower. The UGC development is not recommended if the seam depth is more than 800 meters due to the economic aspect and difficulty. Dwitama et al. (2021) [8] had personal communication with the UCG experts and concluded the minimum depth of the UCG development was in a range of 120 meters, which we used in this study. This minimum depth also takes into account the minimum value of the coal depth and thickness ratio. The minimum ratio of depth and thickness of coal is useful to avoid subsidence due to the loss of part of the coal seam during the gasification process. The minimum ratio value can generally be described as inversely proportional to its depth. Once the coal depth is deeper, the smaller the required ratio value should be (Table 2). It would be better if the ratio value was larger than required, but the minimum value of thickness required also needs to be considered.

To prevent any gas leakage or contamination of groundwater, the type of roof and floor rock should be low permeability or preferably impermeable [19]. In this study, rock types that have low permeability or are impermeable, such as claystone, siltstone, shale, tuff, carbonaceous claystone, etc., were considered. The thickness of the roof and floor rock is also an important thing to be considered. As it gets thicker, the fluids would not easily escape if there was any gas leakage or water contamination. Bielowicz and Kasinski (2014) [14] suggest that the minimum thickness of the impermeable roof is 15 meters. According to Dwitama et al. (2021) [8] who had personal communication with the UCG expert, we used the minimum thickness of both layers to be twice the thickness of the coal for the roof and once the thickness of the coal for the floor.

5. Conclusion

Our study is aimed at developing an automatic coding system in the UCG analysis for coal mining data. The data is provided by PSDMBP as the legal institution for coal development in Indonesia. We developed an automatic system for 14 boreholes data distributed in the area of Mangunjaya. According to the coding system, we can conclude our study as follows.

The high demand for Indonesian coal might produce a lot of data that needs to be analyzed automatically. By implementing the calculation of calorific value, D/T ratio, and roof and floor thickness, we can ease and save our time to utilize our potential as human resources. This automatic system also minimizes human error. Our sampling data can be implemented in a python-based automatic system. This system will automatically calculate and characterize the variables according to the given criteria, in this case, the UCG analysis. The UCG analysis itself might not be able to implement all the given criteria since it has to be manually checked by the user. Our coding system will assist the user as the initial guest of the Underground Coal Gasification (UCG) development.

6. Declarations

6.1. Author Contributions

Conceptualization, M.R. and F.A.; methodology, M.R. and F.A.; software, V.S.; validation, M.R. and F.A..; formal analysis, V.S.; resources, M.R.; data curation, F.A.; writing—original draft preparation, M.R., F.A., and V.S.; writing—review and editing, M.R., F.A., and V.S.; visualization, V.S.; supervision, M.R..; project administration, M.R.; funding acquisition, M.R. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

6.3. Funding

This research was funded by the Ministry of Cultural, Education, Research and Higher Education, the Republic of Indonesia, Grant PPUPT 2020-2023. The research has been supported by the PRN BOPTN 2021 Program by the Ministry of Education, Cultural, Research and Technology, Republic of Indonesia. The research in collaboration with the Center for Mineral, Coal, and Geothermal Resources, Geological Agency, Ministry of Energy and Natural Resources, the Republic of Indonesia has provided the field data. The research is also supported by Computer System and Network Research labs, Department of Computer Sciences and Electronics, Faculty of Mathematics and Natural Sciences, Universitas Gadjah Mada, also in collaboration with Cloud and Grid Technology Working Group (GamaBox).

6.4. Conflicts of Interest

The authors declare no conflict of interest.

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