



## ANALYSIS OF THE EFFECT OF TOTAL MOISTURE (TM), ASH CONTENT (ASH), AND TOTAL SULFUR (TS) ON THE GROSS CALORIFIC VALUE OF COAL SEAM 16 AT PT UNGGUL NUSANTARA

### ANALISIS PENGARUH KADAR AIR TOTAL (TM), KADAR ABU (ASH), DAN TOTAL SULFUR (TS) TERHADAP NILAI KALOR KOTOR LAPISAN BATUBARA 16 DI PT UNGGUL NUSANTARA

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#### Abstract

This study aims to analyze the relationship and influence of coal quality parameters which include Total Moisture (TM), Ash Content (ASH), and Total Sulfur (TS) on Gross Calorific Value (GCV). The data used in this study is data from laboratory tests on 23 samples of Run Of Mine (ROM) coal at seam 16 at PT Unggul Nusantara, North Barito Regency, Central Kalimantan. Data analysis was performed statistically using the help of SPSS software through Pearson correlation test and multiple linear regression analysis. The results of the correlation test showed that simultaneously, the TM, ASH, and TS parameters had a very strong relationship with the GCV value with a correlation coefficient (R) of 0.893 and contributed an influence of 76.5%. Partially, Ash Content (ASH) had a very strong negative relationship ( $r = -0.881$ ) and had a significant effect on calorie values ( $p = 0.000$ ). Each 1% increase in ash content would decrease the GCV value by 68.249 Kcal/Kg. Meanwhile, Total Moisture had a significant positive relationship by simple correlation ( $r = 0.506$ ,  $p = 0.014$ ), but showed no partial significant effect in multiple regression models ( $p = 0.364$ ). Total Sulfur was found to have a very weak negative relationship ( $r = -0.182$ ) and had no significant effect on GCV values ( $p = 0.406$ ). This study concludes that Ash Content is the most dominant parameter that affects the reduction of the caloric value of coal seam 16 at PT Unggul Nusantara.

**Keywords :** Coal, Total Moisture, Ash Content, Total Sulfur, Gross Calorific Value.

#### Abstrak

Penelitian ini bertujuan untuk menganalisis hubungan dan pengaruh parameter kualitas batubara yang meliputi Kadar Air Total (TM), Kadar Abu (ASH), dan Kadar Sulfur Total (TS) terhadap Nilai Kalor Bruto (GCV). Data yang digunakan dalam penelitian ini adalah data dari uji laboratorium pada 23 sampel batubara Run Of Mine (ROM) di lapisan 16 PT Unggul Nusantara, Kabupaten Barito Utara, Kalimantan Tengah. Analisis data dilakukan secara statistik dengan bantuan perangkat lunak SPSS melalui uji korelasi Pearson dan analisis regresi linier berganda. Hasil uji korelasi menunjukkan bahwa secara simultan, parameter TM, ASH, dan TS memiliki hubungan yang sangat kuat dengan nilai GCV



dengan koefisien korelasi (R) sebesar 0,893 dan memberikan pengaruh sebesar 76,5%. Secara parsial, Kadar Abu (ASH) memiliki hubungan negatif yang sangat kuat ( $r = -0,881$ ) dan berpengaruh signifikan terhadap nilai kalori ( $p = 0,000$ ). Setiap peningkatan 1% pada kadar abu akan menurunkan nilai GCV sebesar 68,249 Kkal/Kg. Sementara itu, Kadar Air Total memiliki hubungan positif yang signifikan berdasarkan korelasi sederhana ( $r = 0,506$ ,  $p = 0,014$ ), tetapi tidak menunjukkan pengaruh signifikan parsial pada model regresi berganda ( $p = 0,364$ ). Kadar Sulfur Total ditemukan memiliki hubungan negatif yang sangat lemah ( $r = -0,182$ ) dan tidak memiliki pengaruh signifikan terhadap nilai GCV ( $p = 0,406$ ). Studi ini menyimpulkan bahwa Kadar Abu merupakan parameter paling dominan yang mempengaruhi penurunan nilai kalor batubara lapisan 16 di PT Unggul Nusantara.

**Kata Kunci :** Coal, Total Moisture, Ash Content, Total Sulfur, Gross Calorific Value.

## 1. INTRODUCTION

Indonesia has a huge wealth of coal resources, as evidenced by the latest data based on the Performance Report of the Directorate General of Minerals and Coal and Energy and Mineral Resources in 2024, the realization of proven reserves until the end of 2023 was recorded at 31.713 billion tons (ESDM, 2024). Coal is one of the main sources of fossil energy that is widely used as fuel for power generation and industry in Indonesia. In the industrial world, the use of coal as fuel is highly dependent on its quality. Calorific value of coal (Gross

Calorific Value) is the main parameter in determining the quality and efficiency of combustion which is greatly influenced by various chemical and physical parameters contained in coal, such as Total Moisture, Ash Content, and Total Sulfur (Munawar, 2020). The problem that arises from the quality of coal is that there is a difference in the calorific value of coal every time a test is carried out, in sample one location or one seam of coal. This proves that in one location or one seam that does not necessarily have the same coal quality test results.

Various problems that arise due to unknown or uncontrolled characteristics of coal include: decreased combustion efficiency due to high coal water content, corrosion in industrial equipment that experiences direct contact with coal combustion products and environmental pollution caused by ash and sulfur content from coal combustion products. It is important to analyze the influence of several important parameters that must be considered by the industry in the use of coal as fuel, namely total moisture content, total sulfur, ash content and gross calorific value in order to carry out industrial work effectively and efficiently (Lestari et al., 2016).

Therefore, changes in the value of coal quality parameters need to be controlled to meet the specifications that have been agreed between the company and consumers. The relationship between other coal quality parameters and the calorific value of coal became the basis for the author to raise the research with the title "Analysis of Coal Laboratory Data on the Calorific Value of Coal at PT Unggul Nusantara.

## 2. RESEARCH METHOD

The type of research used in this is quantitative research that aims to describe or describe numbers that have been processed according to certain standards. The data that will be displayed in this study is quantitative data. Quantitative research is research in the form of numbers and is analyzed statistically and using a correlational approach. Therefore, this study aims to analyze the relationship and influence between TM, ASH, TS parameters on calorie values (GCV). The data used are sourced from laboratory results, then statistically analyzed using linear correlation and regression methods.

## 3. RESULT AND DISCUSSION

### 1. Laboratory results on coal samples



The results of laboratory analysis of coal samples in seam 16 Run Of Mine (ROM) of PT Unggul Nusantara, there were 23 samples tested at the PT IOL Indonesia Laboratory, Banjarbaru. As shown in the following table:

**Table 1. Data from Coal Sample Analysis (ROM)**

No	Sampel ID	<i>As Received</i>		<i>Air Dried Basis</i>		GCV
		TM	ASH	TS	Kcal/kg	
		%	%	%		
1	ROM-HS-HA-A16-JETTY LHL-LOT 27	30,39	13,84	2,41	4864	
2	ROM-HSHA-A16-JETTY LHL-LOT 44	30,98	11,55	2,46	5212	
3	ROM-HSHA-A16-JETTY.LHL-LOT 30	30,5	11,78	2,64	4890	
4	ROM-HSHA-A16-JETTY.LHL-LOT 10	31,38	13,52	2,69	4957	
5	ROM-HSHA-A16-JETTY.LHL-LOT 12	30,77	14,40	2,47	4671	
6	ROM-HS HA-A16-JETTY.LHL-LOT.5	30,00	13,61	3,87	4912	
7	ROM-HS HA-A16-JETTY.LHL-LOT.16	28,25	20,01	4,66	4346	
8	ROM-HS HA-A16-JETTY.LHL-LOT.22	29,17	16,93	4,54	4654	
9	ROM-HS HA-A16-JETTY.LHL-LOT.23	30,81	12,89	3,87	4930	
10	ROM-HS HA-A16-JETTY.LHL-LOT.3	32,26	13,86	3,89	4894	
11	ROM-HS HA-A16-JETTY.LHL-LOT.5	31,88	11,27	4,37	5073	
12	ROM-HS HA-A16/JETTY.LHL-LOT.10	30,14	15,50	3,46	4560	
13	ROM-HS HA-A16/JETTY.LHL-LOT.16	30,95	9,01	2,39	5042	
14	ROM-ULTRA-HS HA-A16-JETTY.LHL-LOT	30,78	17,06	2,09	4567	
15	ROM-UHS HA-A16-JETTY.LHL-LOT.20	31,35	11,93	1,77	4950	
16	ROM-UHS HA-A16/JETTY.LHL-LOT.11	30,16	12,12	3,97	4902	
17	ROM-UHS HA-A16-JETTY.LHL-LOT.16	31,02	14,39	3,02	4741	
18	ROM-UHS HA-A16-JETTY.LHL-LOT.19	30,80	11,85	2,21	4876	
19	ROM-UHS HA-A16-JETTY.LHL-LOT.5	30,66	16,65	2,23	4628	
20	ROM-UHS HA-A16-JETTY.LHL-LOT.6	31,62	16,24	2,93	4720	
21	ROM-A16-UHS-HA-JETTY LHL-LOT 11	30,84	12,59	2,34	4837	
22	ROM-DCHS-A16-JETTY LHL-LOT 42	32,02	12,40	2,38	4811	
23	ROM-DCHS-A16-JETTY.LHL-LOT 27	32,47	12,96	2,27	4805	

Sumber: PT Unggul Nusantara

## 2. Simple Correlation Analysis

Simple correlation analysis is a data analysis technique used to measure and see the approximate direction of the linear relationship between two variables.

**Table 2. Pearson Correlation Test Results**

		Correlations			
		TM	ASH	TS	GCV
TM	Pearson Correlation	1	-0,524	-0,446	0,506
	Sig. (2-tailed)		0,010	0,033	0,014
	N	23	23	23	23
ASH	Pearson Correlation	-0,524*	1	0,326	-0,881**
	Sig. (2-tailed)	0,010		0,128	0,000
	N	23	23	23	23
TS	Pearson Correlation	-0,446*	0,326	1	-0,182
	Sig. (2-tailed)	0,033	0,128		0,406
	N	23	23	23	23
GCV	Pearson Correlation	0,506*	-0,881	-0,182	1
	Sig. (2-tailed)	0,014	0,000	0,406	



N	23	23	23	23
*. Correlation is significant at the 0.05 level (2-tailed).				

Based on the table above, based on the results of the discussion, the relationship between coal quality parameters and Gross Calorific Value (GCV) in seam 16 coal samples (ROM) shows different tendencies, both in terms of the direction of the relationship, the strength of the correlation, and the level of significance. Total Moisture (TM) had a positive relationship with GCV with a Pearson correlation value of 0.506, which is in the medium relationship category, as well as a p-value of 0.014 which indicates a significant relationship because it is smaller than 0.05. This means that in the data of this study, an increase in TM tends to be followed by an increase in GCV, although these results are different from the general theory of coal which states that high moisture content usually lowers the calorific value because part of the energy is used to evaporate water. The contribution of TM to the change in GCV is shown by the R<sup>2</sup> value of 25.62%, so there are still other factors that also affect the calorific value. Meanwhile, ASH showed a very strong negative relationship with GCV with a Pearson correlation of -0.881 and a p-value of 0.000, so this relationship is significant. The R<sup>2</sup> value of 77.15% indicates that ASH is the most dominant factor in reducing the calorific value of coal. The higher the ash content, the lower the GCV because mineral matter does not burn and inhibits the combustion process, so the heat energy produced becomes smaller. Total Sulfur (TS) has a very weak negative relationship with GCV with a Pearson correlation of -0.182 and a p-value of 0.406, so it is not statistically significant. The R<sup>2</sup> TS value is only 3.31%, which means that its effect on GCV is very small compared to ASH. Thus, it can be concluded that ASH is the main parameter that influences the decrease in the calorific value, TM shows a positive relationship that needs to be studied further, while TS is more related to environmental aspects and combustion emissions than a direct determinant of the calorific value of Coal.

**2. Multiple Correlation Analysis**

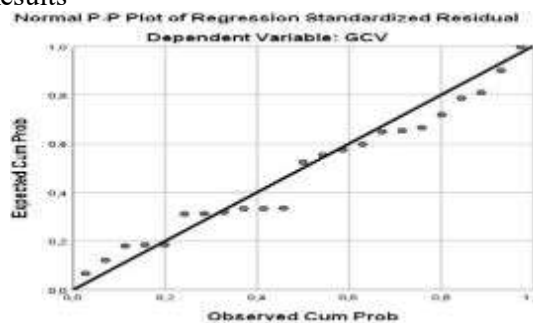
Multiple correlation analysis aims to see the relationship between *independent* variables together and *dependent variables*.

**Table 3. Multiple Correlation Test Results**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	0,893	0,797	0,765	92,69013	1,817
Predictors: (Constant), TS, ASH, TS					
Dependent Variabel: GCV					

Based on the results of the correlation test in the table above, it was obtained that the R value of 0.893 means that TM, ASH, TS together have a very strong relationship with the GCV value, while the adjusted R square of 0.765 which means that TM, ASH, TS together have an influence of 76.5% on the caloric value (GCV) while the remaining 23.5% is influenced by other variables.

**Residual Normality Test Results**



**Figure 1. Residual Normality Test Results**

Based on the image above, it can be seen that the dots are spread around the line and follow a diagonal line, then it can be concluded that the residual value is normally distributed.



Multicollinearity Test Results

**Table 4. Multicollinearity Test Results**

Model		Unstandardized Coefficients		Standardized Coefficients	Collinearity Statistics	
		B	Std. Error	Beta	Tolerance	VIF
1	(Constant)	4911,006	893,809			
	TM	24,179	25,972	0,120	0,640	1,561
	ASH	-68,249	9,606	-0,868	0,715	1,400
	TS	33,839	25,386	0,155	0,789	1,267

a. Dependent Variable: GCV

Based on the table above, it can be seen that the *tolerance value* of the three variables is more than 0.100 and the VIF is less than 10. So it can be concluded that there is no multicollinearity between independent variables. It is concluded that there is no multicollinearity between independent variables.

Autocorrelation Test Results

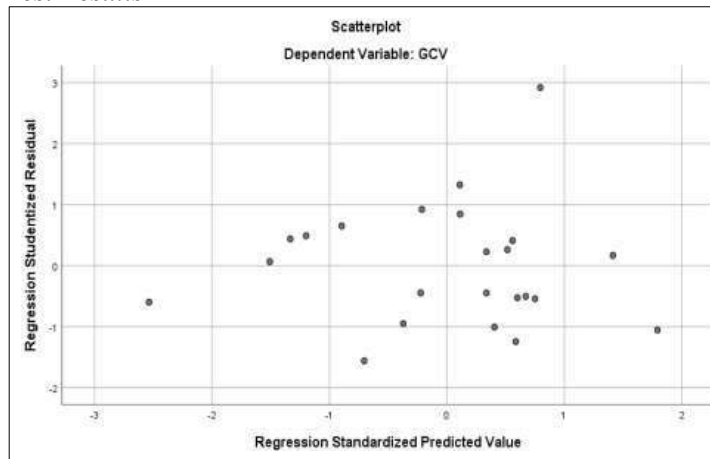
**Table 5. Autocorrelation Test Results**

Model	R	R Square	Durbin-Watson
1	0,893 <sup>a</sup>	0,797	1,817

Predictors: (Constant), TS, ASH, TS  
Dependent Variabel: GCV

Based on the table above, it can be seen that the DW *test value* is 1.817 with a DU value of 1.660 and a value of  $4 - DU = 2.340$  which means that the DW value (1.817) between  $DU$  and  $4 - DU$  or  $DU < DW < 4 - DU$  then  $H_0$  is accepted, meaning that there is no *autocorrelation* in the regression model.

Heteroscedasticity Test Results



**Figure 2. Heteroscedasticity Test Results**

Based on the image above, the data points are randomly scattered around the zero on the residual axis, without forming a specific pattern such as a widening (fan) or narrowing (cone) pattern, or a curvilinear pattern. This evenly distributed and unpatterned data indicates that the residual variance is constant for each level of the prediction value, so that the homoskedasticity assumption is met. This shows that the constructed linear regression model has a residual that has a uniform *variance*, making it a valid and efficient model.

Deviation of Total Moisture (TM) to Gross Calorific Value (GCV).

The findings of irregularities in the study were that there was a significant positive relationship between Total Moisture (TM) and Gross Calorific Value (GCV) in seam 16 coal (ROM). These results deviate from the general principles of coal and can be explained by specific geological factors during the period of their formation. The results of Pearson's correlation analysis showed a significant positive



relationship between TM and GCV ( $r = 0.506$ ,  $p < 0.05$ ). This finding is a departure from the general theory of coal quality, where theoretically increased moisture usually leads to a decrease in calorific value because part of the combustion energy is used to evaporate the water content in the coal. According to Speight, high moisture content will reduce combustion efficiency and reduce the effective heating value of coal. This deviation cannot be explained by the normal coalification process alone, where along with the increase in the rank of coal and GCV, the moisture content should decrease. This deviation is most likely related to the geological factors of the formation of seam 16 coal as allotonic coal formed in the delta environment, as well as the conditions of paleogeography and ancient paleoclimate as in the drift theory. The concept states that coal-forming plant material does not grow and decompose at the site of its discovery. The plant comes from elsewhere, is washed away or transported by a stream of water (river), and accumulates in a sedimentation site (such as a swamp or delta) before eventually being buried in sediment

#### 4. CONCLUSION

1. Ash content is the quality parameter that most dictates the calorific value of coal in Seam 16. With a very strong negative correlation ( $r = -0.881$ ) and the largest regression coefficient ( $B = -68.249$ ), any increase in ash content will be linearly and significantly reduced the Gross Calorific Value (GCV). This proves that the existence of non-organic matter (mineral matter) is the main limiting factor for the heat energy produced.
2. This study succeeded in uncovering an anomaly or unique phenomenon in which Total Moisture (TM) partially showed a significant positive correlation with GCV ( $r = 0.506$ ). Theoretically, water is supposed to lower the caloric value. However, in Seam 16, this condition is explained through an allotonic geological historical approach in the extreme wet Tertiary equatorial delta environment. The very wet condition of the anoxic swamp actually triggers the growth of high-energy fertile ancient vegetation while preserving it very efficiently, thus producing coal with a high moisture content but still having a high caloric value.
3. Total Sulfur (TS) was shown to have no significant influence or contribution to the rise and fall of coal caloric values at the study site ( $r = -0.182$ ;  $p = 0.406 > 0.05$ ). This indicates that the variation in sulfur content in the Seam 16 coal sample is relatively homogeneous and small, so statistically the change does not have a direct impact on the calorific value, but rather has implications for the quality aspect of environmental emissions.
4. Simultaneously (together), the combination of the parameters Total Moisture, Ash Content, and Total Sulfur had a very strong relationship ( $R = 0.893$ ) and was able to explain the 76.5% variation in the Gross Calorific Value (GCV) in Seam 16 coal. This high representation figure, coupled with the passing of the model from all classical assumption tests (normality, multicollinearity, autocorrelation, heteroscedasticity), confirms that this regression model is very valid and reliable to predict the calorific value of ROM coal (Run Of Mine) at PT Unggul Nusantara
5. Overall, this study proves that controlling coal quality parameters, especially ash content (ASH), is very important in maintaining the stability of the caloric value and quality of coal products marketed.

#### 5. REFERENCES

- Aksehira, M., & Şaşman-Kaylı, D. (2021). The Influence Of Motherhood In The Construction Of Female Identity: A Subversive Approach To Motherhood In Erendiz Atasü's Novels. *Journal of European Studies*, 51(2), 139–150. <https://doi.org/10.1177/004724412111010891>
- Adams, P., & Baker, Q. (2020). *Elemental Composition and Environmental Impact of Coal Combustion*. *Journal of Energy Resources*, 12(3), 85- 98.
- Anggreini, D., Bahtiar, S., Widyawati, F., & Hidayat, S. (2021). *Analisis hubungan kandungan total moisture, total sulphur dan ash content terhadap gross calorific value pada batubara*. *Jurnal Tambora*, 5(3), 50–55.



- Fadhili, M. A., & Ansosry. (2021). *Analisis Pengaruh Perubahan Total Moisture, Ash Content, dan Total Sulphur terhadap Nilai Kalori Batubara BB-50 di Tambang Banko Barat PT Bukit Asam, Tbk.* Jurnal Bina Tambang, 4(3).
- Ghozali, Imam. 2018. *Aplikasi Analisis Multivariate Dengan Program IBM SPSS 25*. Semarang: Badan Penerbit Universitas Diponegoro.
- Green, A., & Black, B. (2022). *Fixed Carbon Contribution to Coal's Energy Density*. Coal Quality Assessment Journal, 15(1), 30-40.
- Kementerian Energi dan Sumber Daya Mineral, Direktorat Jenderal Mineral dan Batubara. (2024). *Laporan Kinerja Ditjen Mineral dan Batubara ESDM Tahun 2024* (hlm. data cadangan Batubara 2023). Jakarta: Kementerian ESDM.
- Komaridah, W. E. (2012). *Peningkatan Kualitas Batubara Indonesia Peringkat Rendah Melalui Penghilangan Moisture Dengan Pemanasan Gelombang Mikro*, skripsi. Depok: Universitas Indonesia.
- Lestari, D., Asy'ari, M. A., Hidayatullah, R. (2016). *Geokimia Batubara Untuk Beberapa Industri*. Jurnal POROS TEKNIK Vol. 8 (1), p. 48-54.
- Mahreni & Puspitasari, M. (2019), *Pencucian Batubara*, LPPM UPN "Veteran" Yogyakarta, Yogyakarta.
- Pasyimi. (2008). *Analisis Proksimat dan Ultimat Batubara*. Jakarta: Direktorat Jenderal Mineral dan Batubara, Departemen Energi dan Sumber Daya Mineral.
- Sukandarrumidi. (1995). *Batubara dan Pemanfaatannya*. Gadjah Mada University.
- Sun, R., Liu, J., & Liu, H. (2012). "Effect of moisture and ash on the calorific value of coal." Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 34(20), 1911–1917.
- Suratno, Iphan Fitriani Radam, & Yasruddin. (2023). *Pengaruh Tanah Existing terhadap Nilai Kuat Tekan Bebas (Ucs) Pada Perkerasan Lentur Tipe Cement Treated Recycling Base (CTRB)*. Prosiding Seminar Nasional Tahun X
- Suratno, Wahidah, N., & Nikolus, R. (2025). *Quality Control Batubara Dari Channel-pit Menuju Rom Stockpile di PT Mega Multi Energi*. Journal Scientific of Mandalika (JSM) e-ISSN 2745-5955 | pISSN 2809-0543, 6(4), 904-916.
- Western Climate Initiative, Inc. (2012). *Final Essential Requirements for Mandatory Reporting – Canadian Harmonization: Quantification Methods* (lampiran bagian "General Stationary Combustion" & "Coal Storage"). Western Climate Initiative, Inc.
- Yakub Arbie. (2011). *Pengambilan, Preparasi, dan Pengujian Contoh Batubara*.