LAMPIRAN LAMPIRAN

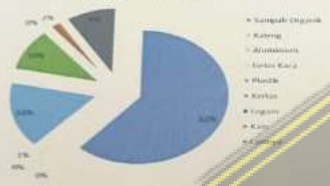
LAMPIRAN LAMPIRAN


PETA LOKASI TPA JATIBARANG
PETA TPA JATIBARANG
PEMERINTAH KOTA SEMARANG
Legend
Jalan TPA
Ex Narpati
Zona Rencana PLTSa
Google Earth
N

Prosentase komposisi sampah dan potensi energy

Uji Komposisi
(dilakukan 3 hari berturut-turut dan sampah pasar)

Komposisi Sampah TPA Jatibarang



Jenis Komposisi	Prosentase (%)
Sampah Organik	61.34
Kaleng	0.10
Alumunium	0.02
Gelas Kaca	0.44
Plastik	16.34
Kertas	10.31
Logam	0.15
Kain	1.67
Lainnya	9.32
Total	100.00

Komposisi Sampah Pasar Kota Semarang

Jenis Sampah	Prosentase (%)
Organik	80.96
Kaleng	0.10
Allumunium	0.00
Gelas Kaca	0.00
Plastik	9.37
Kertas	3.96
Logam	0.00
Kain	0.19
Lain-lain	5.40
Total	100.00

Uji Proximate dan Ultimate

Parameter	Unit	Hasil		
		Sampah RDF	Sampah Pasar	Sampah TPA
Total Moisture	%, ar	54.9	81.4	56.63
Proximate Analysis :				
- Moisture Analyst	%, adb	2.3	4.2	3.76
- Ash Content	%, adb	10.55	29.31	20.08
- Volatile Matter	%, adb	83.53	52.69	66.90
- Fixed Carbon	%, adb	3.61	13.80	12.07
Total Sulfur	%, db	0.29	0.25	0.20
Gross Calorific Value	**Kcal/kg, db**	[illegible]	4018	**4915.00**
Net Caloric Value	**kcal/kg, ar**	**3010.27**	274.92	**1220.51**

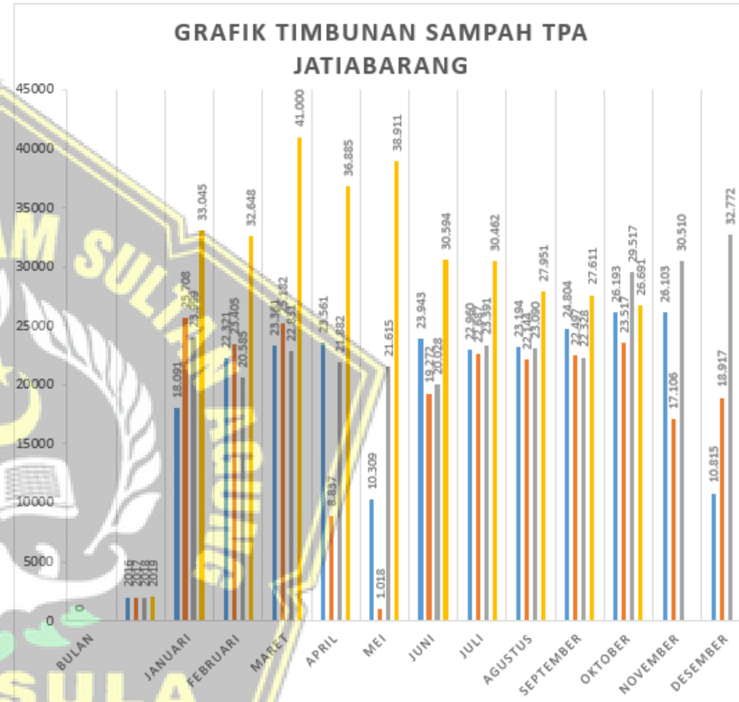
Uji Gas Metan

Parameter	Units	Results
		Rata2
Hydrocarbon Analysis:	%mol	
Carbon Dioxide (CO2)	%mol	34.3746
Nitrogen (N2)	%mol	11.0326
Oxygen (O2)	%mol	5.2376
Methane	%mol	**49.3553**

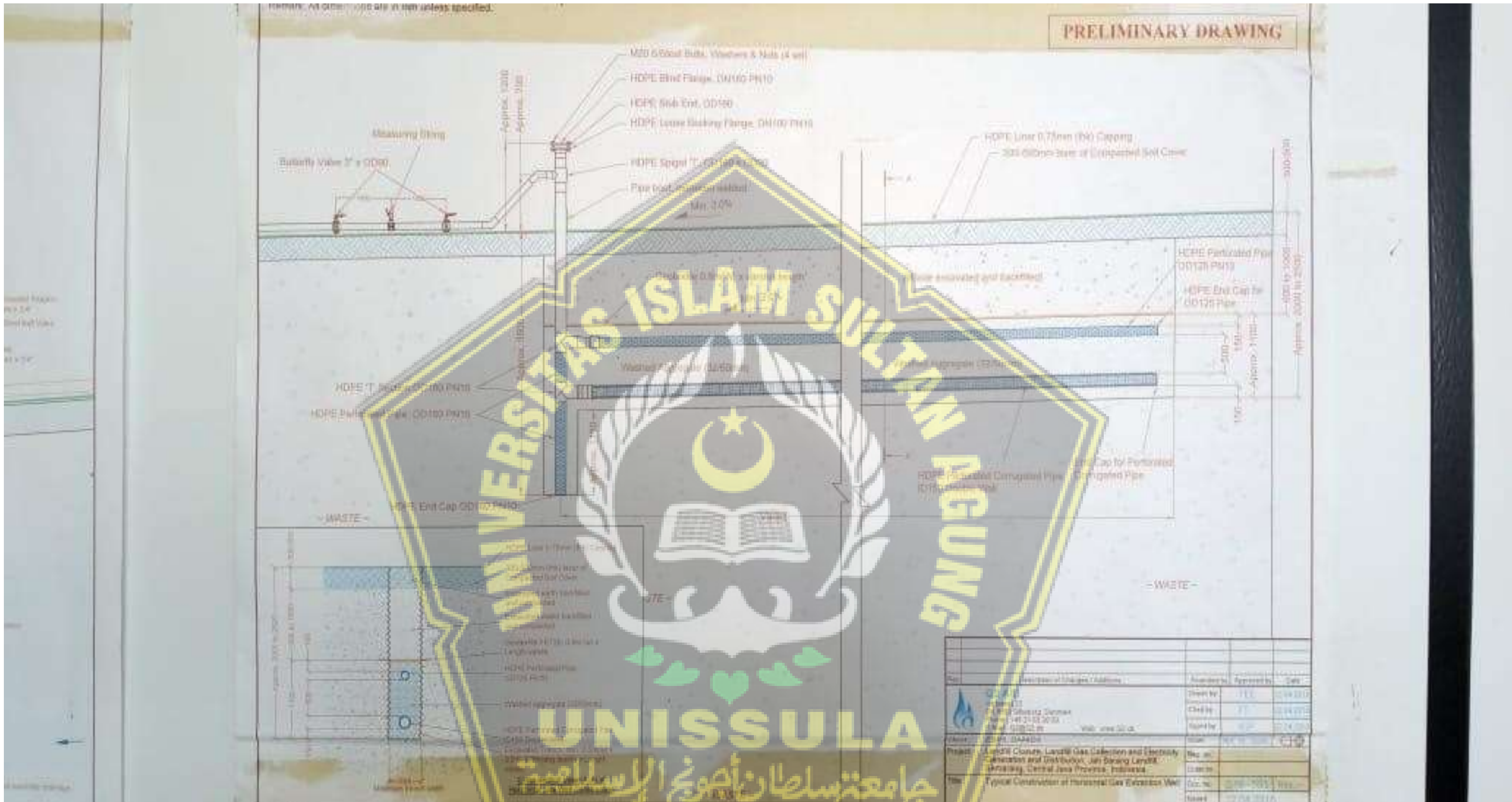
Data : Kementerian ESDM Republik Indonesia

Tabel Grafik Timbunan Sampah Tpa [PLTSa Jatibarang]

bulan	tahun / ton			
	2016	**2017**	**2018**	**2019**
januari	18.091	25.708	23.999	33.045
februari	22.321	23.405	20.585	32.648
maret	23.361	25.182	22.831	41.000
april	23.561	8.837	21.882	36.885
mei	10.309	1.018	21.615	38.911
juni	23.943	19.272	20.028	30.594
juli	22.960	22.687	23.391	30.462
agustus	23.194	22.144	23.090	27.951
september	24.804	22.497	22.328	27.611
oktober	26.193	23.517	29.517	26.691
november	26.103	17.106	30.510	26.404
desember	10.815	18.917	32.772	25.281
jumlah	**255.655**	**230.290**	**292.548**	**377.483**
rata- rata perhari	**700,4247**	**630,9315**	**801,5014**	**1034,2**



Gambar Grafik Timbunan Sampah Tpa [PLTSa Jatibarang]



Gambar Sistem Pemipaan Landfill Gas PLTSa Jati Barang

Table Rules Bases Fuzzy

RULES	PARAMETER					OUTPUT	
	CH4	CO2	O2	H2S	CUACA	LFG	HUB PLN
1	LOW	LOW	DOWN	DOWN	HUJAN	DN	LOSS
2	LOW	LOW	DOWN	DOWN	BERAWAN	DN	LOSS
3	LOW	LOW	DOWN	DOWN	PANAS	DN	LOSS
4	LOW	LOW	DOWN	UP	HUJAN	DN	LOSS
5	LOW	LOW	DOWN	UP	BERAWAN	DN	LOSS
6	LOW	LOW	DOWN	UP	PANAS	DN	LOSS
7	LOW	LOW	UP	DOWN	HUJAN	DN	LOSS
8	LOW	LOW	UP	DOWN	BERAWAN	DN	LOSS
9	LOW	LOW	UP	DOWN	PANAS	DN	LOSS
10	LOW	LOW	UP	UP	HUJAN	DN	LOSS
11	LOW	LOW	UP	UP	BERAWAN	DN	LOSS
12	LOW	LOW	UP	UP	PANAS	DN	LOSS
13	LOW	MEDIUM	DOWN	DOWN	HUJAN	DN	LOSS
14	LOW	MEDIUM	DOWN	DOWN	BERAWAN	DN	LOSS
15	LOW	MEDIUM	DOWN	DOWN	PANAS	DN	LOSS
16	LOW	MEDIUM	DOWN	UP	HUJAN	DN	LOSS
17	LOW	MEDIUM	DOWN	UP	BERAWAN	DN	LOSS
18	LOW	MEDIUM	DOWN	UP	PANAS	DN	LOSS
19	LOW	MEDIUM	UP	DOWN	HUJAN	DN	LOSS
20	LOW	MEDIUM	UP	DOWN	BERAWAN	DN	LOSS
21	LOW	MEDIUM	UP	DOWN	PANAS	DN	LOSS
22	LOW	MEDIUM	UP	UP	HUJAN	DN	LOSS
23	LOW	MEDIUM	UP	UP	BERAWAN	DN	LOSS
24	LOW	MEDIUM	UP	UP	PANAS	DN	LOSS
25	LOW	HIGH	DOWN	DOWN	HUJAN	DN	LOSS
26	LOW	HIGH	DOWN	DOWN	BERAWAN	DN	LOSS
27	LOW	HIGH	DOWN	DOWN	PANAS	DN	LOSS
28	LOW	HIGH	DOWN	UP	HUJAN	DN	LOSS
29	LOW	HIGH	DOWN	UP	BERAWAN	DN	LOSS
30	LOW	HIGH	DOWN	UP	PANAS	DN	LOSS
31	LOW	HIGH	UP	DOWN	HUJAN	DN	LOSS
32	LOW	HIGH	UP	DOWN	BERAWAN	DN	LOSS
33	LOW	HIGH	UP	DOWN	PANAS	DN	LOSS
34	LOW	HIGH	UP	UP	HUJAN	DN	LOSS
35	LOW	HIGH	UP	UP	BERAWAN	DN	LOSS
36	LOW	HIGH	UP	UP	PANAS	DN	LOSS
37	MEDIUM	LOW	DOWN	DOWN	HUJAN	DN	LOSS

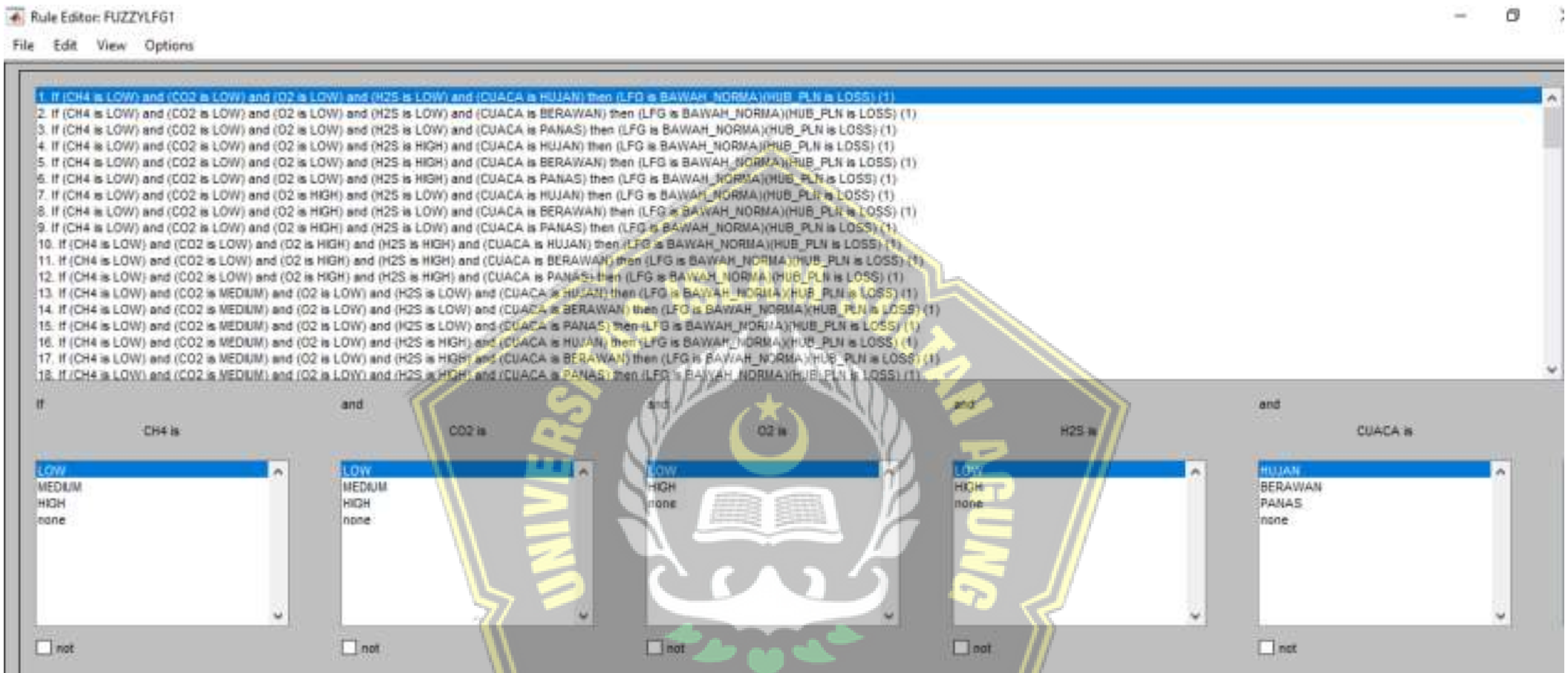
38	MEDIUM	LOW	DOWN	DOWN	BERAWAN	N	SINC
39	MEDIUM	LOW	DOWN	DOWN	PANAS	N	SINC
40	MEDIUM	LOW	DOWN	UP	HUJAN	DN	LOSS
41	MEDIUM	LOW	DOWN	UP	BERAWAN	N	SINC
42	MEDIUM	LOW	DOWN	UP	PANAS	N	SINC
43	MEDIUM	LOW	UP	DOWN	HUJAN	DN	LOSS
44	MEDIUM	LOW	UP	DOWN	BERAWAN	N	SINC
45	MEDIUM	LOW	UP	DOWN	PANAS	N	SINC
46	MEDIUM	LOW	UP	UP	HUJAN	DN	LOSS
47	MEDIUM	LOW	UP	UP	BERAWAN	N	SINC
48	MEDIUM	LOW	UP	UP	PANAS	N	SINC
49	MEDIUM	MEDIUM	DOWN	DOWN	HUJAN	DN	LOSS
50	MEDIUM	MEDIUM	DOWN	DOWN	BERAWAN	N	SINC
51	MEDIUM	MEDIUM	DOWN	DOWN	PANAS	N	SINC
52	MEDIUM	MEDIUM	DOWN	UP	HUJAN	DN	LOSS
53	MEDIUM	MEDIUM	DOWN	UP	BERAWAN	N	SINC
54	MEDIUM	MEDIUM	DOWN	UP	PANAS	N	SINC
55	MEDIUM	MEDIUM	UP	DOWN	HUJAN	DN	LOSS
56	MEDIUM	MEDIUM	UP	DOWN	BERAWAN	N	SINC
57	MEDIUM	MEDIUM	UP	DOWN	PANAS	N	SINC
58	MEDIUM	MEDIUM	UP	UP	HUJAN	DN	LOSS
59	MEDIUM	MEDIUM	UP	UP	BERAWAN	N	SINC
60	MEDIUM	MEDIUM	UP	UP	PANAS	N	SINC
61	MEDIUM	HIGH	DOWN	DOWN	HUJAN	DN	LOSS
62	MEDIUM	HIGH	DOWN	DOWN	BERAWAN	DN	LOSS
63	MEDIUM	HIGH	DOWN	DOWN	PANAS	DN	LOSS
64	MEDIUM	HIGH	DOWN	UP	HUJAN	DN	LOSS
65	MEDIUM	HIGH	DOWN	UP	BERAWAN	DN	LOSS
66	MEDIUM	HIGH	DOWN	UP	PANAS	DN	LOSS
67	MEDIUM	HIGH	UP	DOWN	HUJAN	DN	LOSS
68	MEDIUM	HIGH	UP	DOWN	BERAWAN	DN	LOSS
69	MEDIUM	HIGH	UP	DOWN	PANAS	DN	LOSS
70	MEDIUM	HIGH	UP	UP	HUJAN	DN	LOSS
71	MEDIUM	HIGH	UP	UP	BERAWAN	DN	LOSS
72	MEDIUM	HIGH	UP	UP	PANAS	DN	LOSS
73	HIGH	LOW	DOWN	DOWN	HUJAN	TN	LOSS
74	HIGH	LOW	DOWN	DOWN	BERAWAN	TN	LOSS
75	HIGH	LOW	DOWN	DOWN	PANAS	TN	LOSS
76	HIGH	LOW	DOWN	UP	HUJAN	N	SINC
77	HIGH	LOW	DOWN	UP	BERAWAN	N	SINC
78	HIGH	LOW	DOWN	UP	PANAS	N	SINC

79	HIGH	LOW	UP	DOWN	HUJAN	N	SINC
80	HIGH	LOW	UP	DOWN	BERAWAN	N	SINC
81	HIGH	LOW	UP	DOWN	PANAS	N	SINC
82	HIGH	LOW	UP	UP	HUJAN	N	SINC
83	HIGH	LOW	UP	UP	BERAWAN	N	SINC
84	HIGH	LOW	UP	UP	PANAS	N	SINC
85	HIGH	MEDIUM	DOWN	DOWN	HUJAN	N	SINC
86	HIGH	MEDIUM	DOWN	DOWN	BERAWAN	N	SINC
87	HIGH	MEDIUM	DOWN	DOWN	PANAS	N	SINC
88	HIGH	MEDIUM	DOWN	UP	HUJAN	DN	LOSS
89	HIGH	MEDIUM	DOWN	UP	BERAWAN	N	SINC
90	HIGH	MEDIUM	DOWN	UP	PANAS	N	SINC
91	HIGH	MEDIUM	UP	DOWN	HUJAN	DN	LOSS
92	HIGH	MEDIUM	UP	DOWN	BERAWAN	N	SINC
93	HIGH	MEDIUM	UP	DOWN	PANAS	N	SINC
94	HIGH	MEDIUM	UP	UP	HUJAN	DN	LOSS
95	HIGH	MEDIUM	UP	UP	BERAWAN	N	SINC
96	HIGH	MEDIUM	UP	UP	PANAS	N	SINC
97	HIGH	HIGH	DOWN	DOWN	HUJAN	DN	LOSS
98	HIGH	HIGH	DOWN	DOWN	BERAWAN	N	SINC
99	HIGH	HIGH	DOWN	DOWN	PANAS	N	SINC
100	HIGH	HIGH	DOWN	UP	HUJAN	N	SINC
101	HIGH	HIGH	DOWN	UP	BERAWAN	N	SINC
102	HIGH	HIGH	DOWN	UP	PANAS	N	SINC
103	HIGH	HIGH	UP	DOWN	HUJAN	N	SINC
104	HIGH	HIGH	UP	DOWN	BERAWAN	N	SINC
105	HIGH	HIGH	UP	DOWN	PANAS	N	SINC
106	HIGH	HIGH	UP	UP	HUJAN	N	SINC
107	HIGH	HIGH	UP	UP	BERAWAN	N	SINC
108	HIGH	HIGH	UP	UP	PANAS	N	SINC

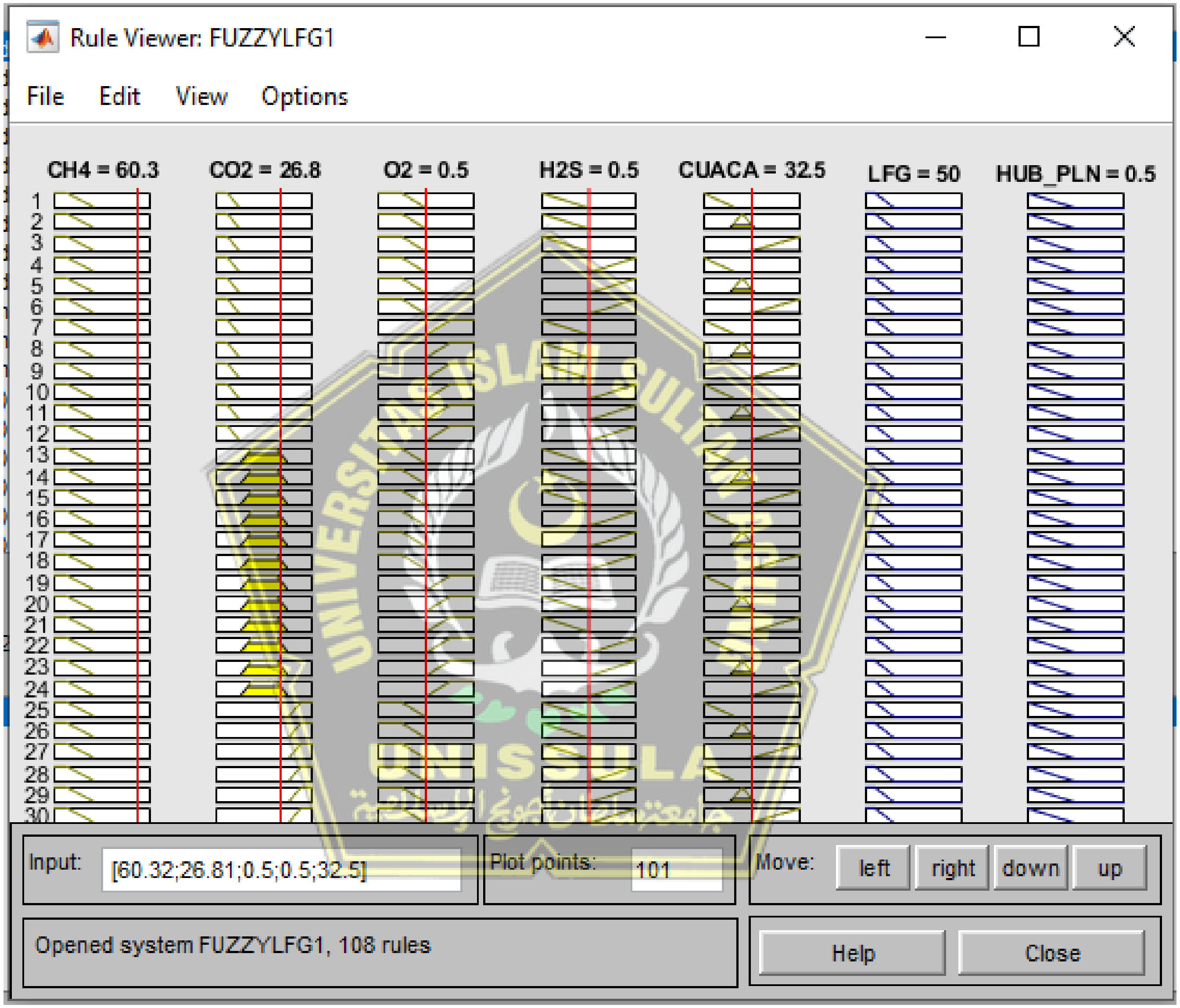
Keterangan: DN : Dibawah Normal

N : Normal

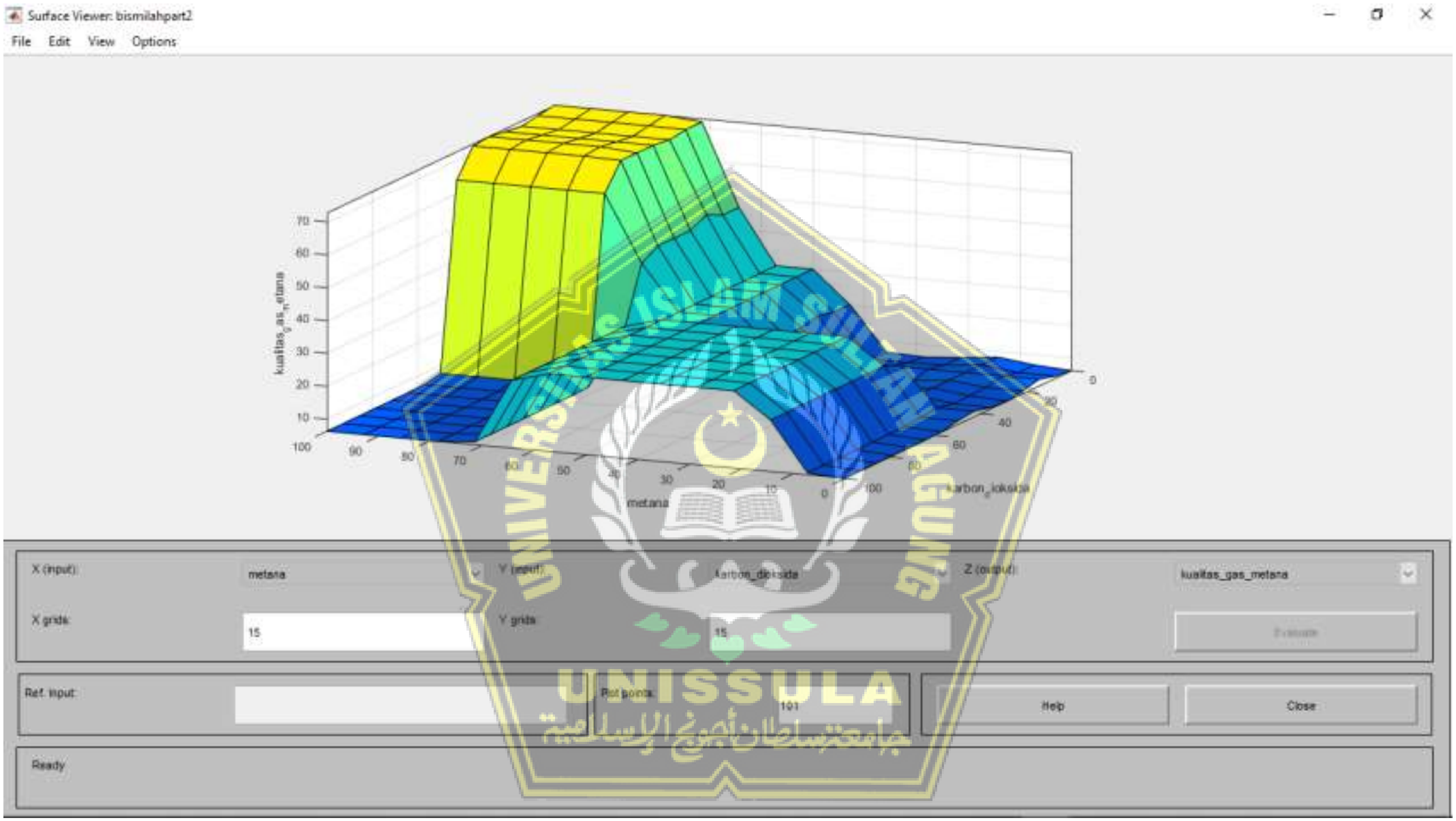
TN : Tidak Normal



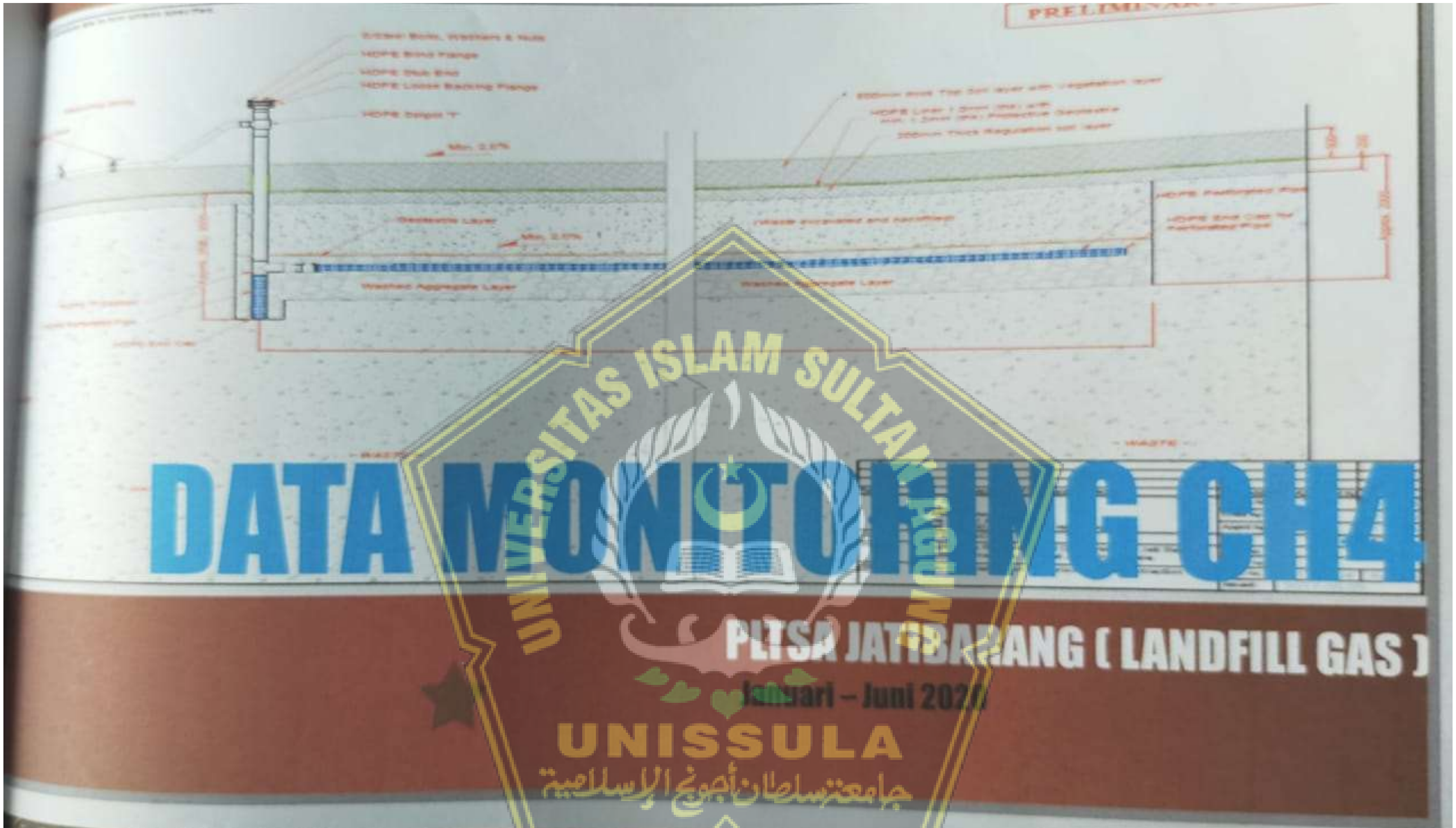
Gambar Inference Model Rules Matlab



Gambar Rules Models



Gambar Surface Rule Metan


PRELIMINARY
DATA MONITORING CH4
PLTSA JATIBARANG (LANDFILL GAS)
Januari – Juni 2020

PT. BHUMI PANDANARAN SEJAHTERA

LFG WELL LOG

Status : Engine On

Date : 17 Januari 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
09.13	1	35,4	32,5	0,5	33,4		2			6		
9-20	2	49	24,5	0,3	21,4		3			28		
09.30	3	38,5	32	0,8	28,4		3			18		
09.38	4	45,3	34,2	0,4	20,1		2	3		33		
09.44	5	18,9	21	1,6	58,1		0			3		
09.46	6	12,5	13,2	10,3	63,9		0			3		
09.16	7	40	35,3	0,9	23,2		0	2		3		
09-18	8	12,7	20,1	3	64,2		0			2		
09.20	9	31	29	0,3	39,8		1			3		
09.29	10	14,1	20,9	1,3	63,7		0			3		
Total		0	0	0	0							

Prepared

maulid

Approved

Status : Engine On

Date : 17 Januari 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
11.47	1	34,6	32,6	0,4	32,7		2			7		
11.54	2	44,9	35,2	0,2	20		3	4		38		
11.58	3	43,3	34,5	0,4	21,3		3			7		
12.02	4	39,4	33,3	0,6	27,9		3			7		
12.05	5	22,3	23,1	0,7	53,8		0			3		
	~~6~~											
11.44	7	39,6	36,2	0,6	23,7		2			21		
11.50	8	12,3	20,2	3,0	64,6		0			1		
11.52	9	38,0	30,8	0,2	31,0		1			16		
11.56	10	13,7	21,2	1,1	64		0			3		
Total		0	0	0	0							

Prepared

Ariza

Approved

Status : Engine On

Date : 17 Januari 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
15.37	1	38,7	34,3	0,3	26,6		2			3		
15.44	2	39,3	33,6	0,5	26,6		4			12		
15.48	3	31,9	31,1	0,6	36,4		3			1		
15.51	4	39,9	31,8	1,8	26,7		3			9		
15.57	5	22,5	20,3	4,8	51,9		0			1		
	6											
15.39	7	44	37,8	0,3	17,9		1			30		
15.41	8	12,5	20,6	3	63,9		0			1		
15.42	9	38,5	31,2	0,3	29,9		1			3		
15.46	10	14	21,6	1,3	63,1		0			2		
Total		0	0	0	0							

Prepared

Eko

Approved

PT BHUMI PANDANARAN SEJAHTERA

LFG WELL LOG

Status : Engine On — Date : [illegible] Januari 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
09.39	1	32,1	32	0,5	35,7		2	1		7	kondensat	
09.45	2	37	32.3	0.5	30.3		4			21		
09.50	3	34.5	27,9	0,3	37.5		1	2		20	kondensat	
9.55	4	27.4	25.2	0.3	47.7		2			31		
9.58	5	8,7	12,7	0,3	73,1		0			6		
	6											
09.37	7	49,2	37,7	0,3	17,8		1			12		
09.41	8	12,7	20,6	2,9	63,8		0			0		
09.43	9	38,6	31,2	0,2	30.3		1			1		
09.47	10	9,5	19,9	0,9	69,8		0			3		
Total		0	0	0	0							

Prepared — Approved

IRSYAD — gilang H.

Status : Engine On — Date : 18. Januari 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
13.50	1	31,6	19,9	0,9	49,6		1	2		10		
13.42	2	35,7	31,6	0,4	32,4		4	3		22		
13.40	3	40,5	35,2	0,7	23,8		3			22		
13.38	4	41,2	34,5	0,4	23,7		3			30		
13.39	5	25,1	25,5	0,7	48,6		0			1		
~~[illegible]~~	6	~~24,8~~	~~17,1~~	~~1~~	~~87,5~~		~~-~~			~~18~~		
13.51	7	24,8	17,1	1	57,5		1	0		18		
13.48	8	8	14,7	4,8	75,1		0			2		
13.46	9	31,5	22,3	0,3	46,7		1			3		
13.41	10	13,5	21,1	1	64,4		0			2		
Total		0	0	0	0							

Prepared — Approved

Bowta — Yoga J.S

Status : Engine On — Date : 18 - 01 - 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
16.25	1	44.4	25.1	0.4	29.7		2			12		
16.21	2	40.5	33.6	0.3	[illegible]		4			48		
16.17	3	38.8	31.5	0.4	29.8		3			20		
16.08	4	37	29.7	0.5	[illegible]		2			24		
16.02	5	34.4	20.1	0.3	46.6		1			3		
	6											
16.27	7	34.9	28.8	0.8	45.5		1			0		
16.29	8	11.5	17,2	2.1	70.5		0			2		
16.11	9	38.3	22.4	0.5	44.3		1			3		
16.32	10	15,8	23.1	1,2	57.2		0			2		
Total		0	0	0	0							

Prepared — Approved

IRSYAD

bps
PT BHUMI PANDANARAN SEJAHTERA

LTSa

LFG WELL LOG

Status : Engine On — Date : 21 Januari 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
06.11	1	34,4	31,8	0,2	33,6		2			2		
06.17	2	40,8	33,6	0,4	25		4			30		
06.20	3	37,2	32,4	0,3	30		3			3		
06.29	4	42,8	33,9	0,4	22,9		3			24		
06.32	5	26,8	26,6	1,3	43,3		0			1		
	6						X					
06.13	7	53,1	44	0,3	6,1		[illegible]	2	1	42		
06.14	8	13,6	21	2,7	62,7		0			1		
06.15	9	36,5	30,7	0,2	32,8		1			11		
06.19	10	14,3	21,4	1,3	63		0			2		
Total		0	0	0	0							

Prepared — Mould.

Approved

Status : Engine On — Date : 21 / 01 / 2020.

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
10.35	1	37,1	32,5	0,5	29,9		2			12		
10.40	2	39,2	33,3	0,9	28,9		4			28		
10.44	3	37,7	33,0	0,5	28,7		3			17		
10.46	4	38,7	32,9	0,6	47,6		3			21		
10.48	5	21,3	24,9	0,3	53,9		0	2		3		
	6											
10.32	7	52,1	39,8	0,5	44		1	2		43		
10.36	8	13,7	21	2,7	62,7		0			8		
10.38	9	36,3	30,4	0,2	33,1		1			1		
10.42	10	14,4	21,6	1,1	62,4		6			1		
Total		0	0	0	0							

Prepared — Dwi Irw

Approved

Status : Engine On — Date : Selasa, 21 / 01 / 2020

Time	Well.	CH_4	CO_2	O_2	Balance	Fan	Status Valve			H2S	Note	Level leachate
15.38	1	42.6	35.3	0,2	21,8		2			24		
15.42	2	45,1	35.4	0,2	19,3		4	3		32		
15.46	3	47,5	36,8	0,3	15,6		3			21	kondensat (DIKURAS)	
15.49	4	44.4	34,5	0,3	20.7		3	2		17		
15.51	5	31,3	30.8	0,3	32,7		2			4		
16.00	6	0.9	1.5	16.4	78.0		X			0		
15.36	7	53.3	40.5	0.3	6.0		2			43		
15.40	8	13,7	20,9	2,5	62.2		0			1		
15.41	9	37.1	30,7	0,2	31,9		1	2	0	10		
15.44	10	14.6	21.6	1	62.8		0			14		
Total		0	0	0	0							

Prepared — IRSYAD

Approved

PT BHUMI PANDANARAN SEJAHTERA

(Unit PLTSa)

Jatibarang Semarang

PENCATATAN KWH METER /JAM

Januari s/d juni 2020

PT. BHUMI PANDANARAN SEJAHTERA

PLTSa

PENCATATAN TIAP JAM PLTSa JATIBARANG SEMARANG

HARI/TANGGAL : Rabu / 1 - 1 - 2020

UNIT 1

			1	2	3	4	5	6	7	8	9	10	11	12
FLOW RATE		Nm³/h	186	175	183	[illegible]	178	191	190	188	[illegible]	195	197	184
KONSENTRASI CH4		%	96.6	47.7	46.5	45.7	45.3	45.6	45.4	45.6	45.8	45.1	45.1	45.8
WAKTU PENCATATAN		JAM	13.00	14.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00
KUBIKEL TEGANGAN	R-N	(V)	11.519	11,587	11,598	11,664	11.797	11,627	11,579	11,764	11.727	11.570	11.590	11.611
	S-N	(V)	11.608	11,671	11.676	11,746	11,861	11,676	11,620	11,674	11.746	11.600	11.661	11.685
	T-N	(V)	11.662	11,743	11,751	11,804	11,949	11,782	[illegible]	11,767	11.847	11.689	11.751	11.763
ARUS	R	(A)	7.465	7.451	7.515	7,417	7.377	7,901	8,034	7,996	7.083	7.223	7632	7688
	S	(A)	6.873	7.011	7.049	6.095	7.226	7,956	[illegible]	[illegible]	[illegible]	7.871	7,146	6.943
	T	(A)	6.673	6.093	6.280	6,641	6.900	6,597	6.375	6,563	[illegible]	6.010	6.947	7.021
FREKUENSI	F	(Hz)	50.10	50.05	50,02	49,97	50.03	50,12	50.10	50,09	50.00	49.89	50,02	49.96
ENERGI	E	(MWh)	89.121	89.265	89.441	89,628	89,829	90,010	90,191	90.373	90.661	90.785	91.020	91.194
DAYA	P	(kW)	203.536	202.174	203.493	[illegible]	203.093	201.739	208.977	202.209	202.226	210.003	204.714	207.242
FAKTOR DAYA (cos PHI)			0,84962	0,82254	0,84506	[illegible]	0,8760	0,79415	0,75123	0,77020	0.79289	0.80196	0.80768	0.80288
OPERATOR JAGA														

Operator:

Kel 1: 1. Niko Riza
2. Eko Yuliyanto
3. Ariza
4. Mould Noma

Kel 2: 1. Yoga SS
2. Dwita
3. Gilang Hari
4. Irsyad Nalial

PLTSa Jatibarang,
Supervisor Unit
PT Bhumi Pandanaran Sejahtera

(Aas Himawan)

bps
PT. BHUMI PANDANARAN SEJAHTERA

PLTSa
Jatibarang Semarang

Putus 23.00 Putus 22.06

PENCATATAN TIAP JAM PLTSa JATIBARANG SEMARANG

UNIT 1

HARI/TANGGAL : Kamis, 2-2-2020

				1	2		4	5	6	7	8	9	10	11	12
FLOW RATE			Nm³/h	230	203	201	190	196	212	210	209	192	199	187	
KONSENTRASI CH4			%	44	45.1	45.6	45.4	45.1	44,6	44,3	44,3	45,0	44,7	44,9	
WAKTU PENCATATAN			JAM	13.00	15.00	16.00	17.00	18.00	19.00	20.00	21.00	22.00	23.00	24.00	
KUBIKEL	TEGANGAN	R-N	(V)	11.669	11.558	11.599	11.817	11.776	11,730	11,805	11.914	11.694	11.668	11.787	
		S-N	(V)	11.746	11.619	11.653	11.854	11.790	11,729	11,803	11.896	11.736	11.666	11.826	
		T-N	(V)	11.831	11.712	11.744	11.951	11.916	11,869	11,946	12.023	11.853	11.795	11.926	
	ARUS	R	(A)	7.548	7.556	7.155	7.156	7.695	7,604	7,306	7,159	7.492	7.032	7.220	
		S	(A)	6.77	7.032	7.219	7.153	7921	8,633	8,749	8,466	7,533	7.883	7.324	
		T	(A)	6.866	6.311	6.832	6.091	6.500	6,426	6,574	6.255	6.811	6.642	6.885	
	FREKUENSI	F	(Hz)	50.01	49.04	50.01	50.01	50.13	50,06	50,01	50.10	49.97	49.91	49.95	
	ENERGI	E	(MWh)	93.802	94.031	94.242	94.471	94.463	94.859	95,064	95.225	95.644	95441	95843	
	DAYA	P	(kW)	204.434	205.666	204.181	202.534	207.168	213,657	215.00	212.508	204.234	210785	203011	
FAKTOR DAYA (cos PHI)				0,8001	0.8274	0.85223	0.8292	0.79284	0,77763	0,75960	0,75294	0,81966	0.75984	0,81474	
OPERATOR JAGA:			Ariza												

↳ 14.00 → CH4 Drop.

Operator:

Kel 1: 1. Niko Riza 3. Ariza
2. Eko Yuliyanto 4. Mould Noma

Kel 2: 1. Yoga SS 3. Gilang Hari
2. Dwita 4. Irsyad Nailul

PLTSa Jatibarang,
Supervisor Unit
PT Bhumi Pandanaran Sejahtera

(Aas Hirnawan)

bps

PT. BHUMI PANDANARAN SEJAHTERA

PLTSa Jatibarang Semarang

UNIVERSITAS ISLAM SULTAN AGUNG UNISSULA

PENCATATAN TIAP JAM PLTSa JATIBARANG SEMARANG

UNIT 1

HARI/TANGGAL : Sabtu / 4 Jan 2020

				1	2	3	4	5	6	7	8	9	10	11	12
FLOW RATE			Nm³/h	179	175	175	179	175	178	173	167	170	174	172	
KONSENTRASI CH4			%	46	46.	46.3	46.0	46.1	46.0	47.2	47,7	47,7	48,3	48,1	
WAKTU PENCATATAN			JAM	01.00	02.00	03.00	04.00	05.00	06.00	07.00	08.00	09.00	10.00	11.00	11.30 → jam
KUBIKEL	TEGANGAN	R-N	(V)	11.668	11.578	11.699	11.666	11.684	11.771	11.841	11.756	11.583	11.736	11,716	
		S-N	(V)	11.710	11.633	11.752	11.717	11.740	11.830	11.887	11.806	11.645	11.797	11,771	
		T-N	(V)	11.801	11.720	11.832	11.798	11.842	11.917	11.979	11.890	11.733	11.895	11,863	
	ARUS	R	(A)	7.114	7.118	7.281	7.359	7.502	7.432	6.733	7.119	7.381	7,322	7,252	Lepas singkron. Kehabisan Oli
		S	(A)	6.919	6.781	6.960	7.096	7.125	7.032	7.026	6.752	6.849	6,894	6,9[illegible]	
		T	(A)	6.605	6.327	6.618	6.660	6.292	6.106	6.229	6.259	6.261	6,250	6.279	
	FREKUENSI	F	(Hz)	50.05	50.03	50.13	49.94	50.07	50.08	50.03	48.97	49.97	50	49,98	
	ENERGI	E	(MWh)	100.89	101.09	101.24	101.46	101.66	101.84	102.5	102,25	102,47	102,62	102,82	
	DAYA	P	(kW)	202.050	209.136	206.142	208.505	204.023	204.327	202.680	203.013	203.090	205,104	204,839	
FAKTOR DAYA (cos PHI)				0.82934	0.83908	0.83319	0.83906	0.82404	0.83259	0.85074	0.83316	0,84379	0,8516	0,84568	
OPERATOR JAGA:															

Operator:

Kel 1: 1. Niko Riza
2. Eko Yuliyanto
3. Ariza
4. Mould Noma

Kel 2: 1. Yoga SS
2. Dwita
3. Gilang Hari
4. Irsyad Naflul

PLTSa Jatibarang,

Supervisor Unit

PT Bhumi Pandanaran Sejahtera

(Aas Hirnawan)

LAMPIRAN LAMPIRAN

DETERMINASI LFG QUALITY FOR OPTIMAZION PRODUCTION WASTE POWER PLANT (WPP) USING FUZZY AHP

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ABSTRACT

This research discusses the determination of the quality of production of landfill gas PLTSa Jatibarang. The model is determined as a WPP with the volume of waste input which is directly proportional to the number of population which continues to increase every year and the parameters used are: waste volume; landfill area; concentration gas : CH_4; CO_2; O_2; H_2S and weather. With a constant average condition of waste methane decomposes 64% fast, 14% decomposes slowly and 22% slowly decomposes. Fuzzy logic is used to determine the value of LFG production quality and fuzzy ahp is used for decision support systems to determine the priority weight of the LFG criteria. The results show that the Fuzzy-AHP is able to provide a gas quality output value with an accuracy rate of 79% with the sanitary landfill model resulting in a maximum potential electrical energy produced by 2,6 MW. Meanwhile, gas emissions released to the air in 2021 are 24,780 tons/ year CH_4 with 1,425 tons/year of CO_2, while the factors that most influence the quality of LFG gas are: methane gas content, carbon dioxide and weather conditions.

***Keyword**: LFG Quality, Waste Power Plant, Fuzzy AHP*

1. INTRODUCTION

The increase in population is directly proportional to the increase in the amount of population consumption, so the amount of waste pile produced will continue to increase every year. This of course raises a number of problems including the continuous increase in waste production, management of large areas of land, transportation of waste management and the environmental impact of the resulting pollutant [1]. Waste that is not managed properly will cause pollution in the environment [2]. One solution to this problem is to make the waste to be processed into alternative energy in the form of Waste Power Plant (WPP). In this study, the results of gas output and the quality of LFG gas production will be known [3].

In line with the Government's program on the use of New and Renewable Energy (EBT) with a target of 23% by 2025, which later on, waste-based power plants (WPP) are targeted to be built and developed in 9 provinces, spread throughout Indonesia [4]. One of the potential sources of EBT to be developed is biomass, biogas, and municipal solid waste. The final disposal site contains organic waste that can emit LFG (Landfill Gas) which is generated continuously by microbes under anaerobic conditions [5]. LFG contains the most methane and carbon dioxide gas, both of which are greenhouse gases. In addition, the presence of methane gas in the landfill can cause fires and even explosions. The principle in gas utilization design is the quality of the gas in accordance with the usage requirements and the capacity of the system planning, where the system design capacity is calculated based on: projection of gas that can be produced, gas productivity rate, and estimated percentage of gas that can be utilized [6]. Generators with discontinuous supply will reduce engine efficiency and result in engine damage. The LFG generation predicted by the model can be multiplied by the percent collection efficiency to estimate the volume of LFG that can be recovered for combustion or use in an LFG energy conversion project [7].

Several studies on LFG quality for optimazion production waste power plant (WPP) determination, among others: research with the LandGEM software simulation method [8] with input of waste revenue per year and ebsilon professional to see output power as well as increase in efficiency and power systems to obtain flow mass with operational time creates real conditions. Research with the method of processing waste without waste [9] obtained a permit for an alternative source of electricity based on renewable energy with the potential for gas and energy produced. Research with the SWOT-FAHP analysis method (hierarchy of fuzzy analysis) [10] analysis for sustainable energy management with waste from the results of research and supervision of the problem criteria in selecting the appropriate method. Research with multi-criteria decision making (MCDM) for energy management and efficiency of waste water treatment resources [11] results show that biogas is chosen as the ideal gas fuel, natural gas is second, liquefied natural gas is third, compressed natural gas is fourth and Landfill gas is the fifth gas fuel on the number at waste power plant in Turkey. This research study only focuses on one of the potential parameters of waste power plant, but no one has discussed the quality of landfill gas. This research focuses on the problem of determining the quality of gas emissions produced by Landfill Gas Emissions using Fuzzy-AHP, where the quality of landfill gas production is influenced by levels of methane, carbon dioxide, oxygen and sulfur dioxide which are affected by weather conditions.

This research study only focuses on one of the potential parameters of WPP, but no one has discussed the quality of landfill gas. This research focuses on the problem of determining the quality of gas emissions produced by landfill gas emissions using fuzzy AHP, where the quality of landfill gas production is influenced by levels of methane, carbon dioxide, oxygen and sulfur dioxide which are affected by weather conditions.

2. Methodology

WPP is a thermal power plant with supercritical steam and fueled by waste or methane gas. The use of gas obtained from waste is carried out using sanitary landfill method, making use of gas produced from waste power plant. The sanitary landfill system is carried out by inserting waste into hole, then leveling and compacting it, and lastly covering it with loose soil, resulting in layers. In order to make use of the gas that has been formed, the next step is to install pipes to release LFG in order to be used as fuel.

A waste power plant is a generator of electrical energy using waste as the main fuel. The principle of generating PLTSa is carried out in 2 ways, namely the Incineration process, namely by burning waste and Gasification, namely by collecting gas which is then converted to electrical energy. Incinerator technology is a waste treatment method by burning waste at high temperatures. The combustion system with high temperature is also known as heat treatment. In the process of burning waste, the fuel used must be of good quality [12]. Incineration method as shown in Figure 1.

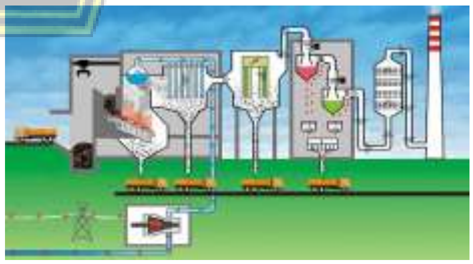

***Fig.1.** Incineration method [12]*

Incineration is a thermal waste treatment technique that can be understood as a controlled combustion process. Incineration is the most popular WTE technique, whereby the heat generated from combustion can be converted into electric power. The organic content of the waste is burned and heat is generated, while the inorganic content contributes to the formation of ash. The end products of incineration include ash, heat, and combustion gases [13]. The advantages of this technique are the following: it results in an almost complete reduction of toxic organic matter if strict monitoring procedures are emphasized, it is low treatment technology if operated properly, and removes liquids, resulting in solid and easy-to-transport waste. Some of the important drawbacks of incineration include the relatively high cost, and potential for the release of radioactive material into the environment, and ultimately the direct re-release of carbon dioxide back into the atmosphere [14].

Gasification is a thermochemical process that involves heating the waste plastic at 700–1100°C with a controlled amount of oxygen, air, oxygen-enriched air, and/or steam to produce industrial gas mixtures called "synthesis gas," or syngas. Syngas is a gas mixture, the main components of which are hydrogen (H2) and carbon monoxide (CO), with lower concentrations of other gases such as carbon dioxide (CO2) and hydrocarbons, for example, methane (CH4) [15]. A gasification plant generally consists of processes of gasification reaction, catalytic conversion of syngas, and gas separation and purification. The main gasification products are CO, CO2, H2, and CH4. The gas yield and composition are dependent on the feedstock characteristics, catalyst types, gasifier types, and operating conditions. For example: temperature, pressure, and residence time. Gasification Method as shown in Figure 2.

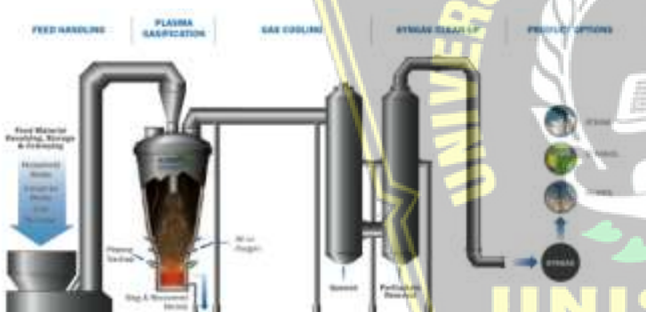

Fig.2. *Gasification Method [15]*

This research has several steps, as shown in Figure 3 the steps that must be taken:

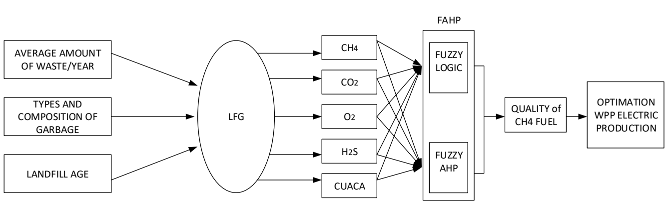

Fig.3. *Research System Model*

In Figure 3. The potential for electrical energy production in solid waste power plants is obtained through prediction using moving averange, where the data is obtained from historical data the previous year.Then after obtaining the waste data, the potential for gas emission and potential LFG can be calculated to produce electrical energy. After obtaining the output of electrical energy conversion, it will then optimize using the AHP fuzzy method which will obtain maximum results for the optimum month output to optimize the output of electrical energy from the waste power plant.

2.1. LFG Potential

The result showed a very promising potential, with methane gas contained in LFG is available in large amount, which is around 50%. The LFG potential produced in sanitary landfill was calculated using the U.S Environmental Protection Agency (EPA) model which has used in various sanitary landfill scenarios in the United States. According to a research [8], the formula used to de-normalize data is shown in Eq.(1).

$$Qt = 2\ Lo\ Mo\ (e^{Kt} - 1)\ e^{-kt} \qquad (1)$$

where: Qt is amount of gas produced (m^3/years), Lo is potential of methane produced (m^3/year), mo is solid amount received, (ton/year), k is Average methane constant (years) and t is landfill age, (year).

Collection efficiency for sites with operating gas collection and control systems is usually based on information on the current conditions of the calculation looking for the efficiency of gas collection to capture LFG generated by waste is shown in the Eq.(2).

$$\text{Production gas (m3 / year)} = 75\% \times \text{The amount of gas produced} \qquad (2)$$

From the amount of methane gas with a percentage of 45-60% in the landfill, the amount of methane gas uses 50% as the average suggested by the EPA is shown in the Eq.(3).

$$\text{Methane gas (m3 / year)} = 50\% \times \text{gas recovery} \qquad (3)$$

To calculate the amount of electricity generated, is shown in the Eq.(4).

$$\sum = \text{Methane} \times 9.39\ \text{kWh} \times \text{Engine Efficiency} \qquad (4)$$

The conversion of methane gas energy into electrical energy is based on the heat potential possessed by 1 Kg of methane gas which is equivalent to 6.13 x 107 J, and 1 kWh of electricity is equivalent to 3.6 x 106 J, 1 m^3 of methane gas is equivalent to 9,39 kWh.

The conversion of methane gas energy into electrical energy is based on the heat potential possessed by 1 kg of methane gas which is equivalent to 6.13 x 107 J, and 1 kWh of electricity is equivalent to 3.6 x 106 J, 1 m3 of methane gas is equivalent to 9.39 kWh can be seen in Table 1 Methane Conversion.

Table 1. Methane Conversion

Energy Convertion	
1 Kg Gas Methane	6,13 x 10^7J
1 kWh	3,6 x 10^6J
1 m3 gas Methane	9,39 kWh

2.2. Gas Emissions Calculation

The calculation of GHG emissions from biological waste management is shown in Eq. (5) and (6).

$$CH_4 \text{ emissions} = \sum(((Mi \times EF) * 10^{-3}) - R) \times GWP \quad (5)$$

$$CO_2 \text{ emissions} = \sum(((Mi \times EF) * 10^{-3}) - R.) \times GWP \quad (6)$$

Where Mi is Gas massa (Gg/years); EF is gas emission factors (g); EF CH_4 is value CH_4 4 g CH_4/kg; EF CO is value CO 0,90 g CO_2/kg; R is amount of gas recovery; and GWP is Global Warming Potensial.

2.3. Moving Everange (ME)

This method is by taking a group of observed values from the PLTSa Jatibarang data and then looking for the average value. Then after that the average will be used for the next period. Table 2 is the result of prediction calculations using moving average where the input used is data from 2011 to 2020 which produces predictive output for the next 10 years, namely 2021 to 2030 shown in Table 2.

Table 2. Moving Average Forecasting results 2021- 2030

Years	**QUANTITY (ton/day)**	**QUANTITY (ton/year)**
2021	1028	375.220
2022	1070	390.587
2023	1089	397.303
2024	1105	403.325
2025	1119	408.508
2026	1131	412.706
2027	1139	415.845
2028	1145	417.743
2029	1146	418.254
2030	1143	417.195

2.4. Fuzzy AHP (Analytical Hierarchy Process)

The analytical method developed from traditional AHP is a combination of the AHP method with the Fuzzy concept approach. Where fuzzy AHP is better at describing vague decisions than traditional AHP [5].

The steps for Fuzzy AHP are: Creating a hierarchical structure; determine the pairwise interest comparison matrix between criteria with the Fuzzy Triangular Number scale; To determine the value of the fuzzy synthesis (Si) to obtain the relative weights for the decision-making elements show in Eq.(7).

$$\tilde{S}i = \sum_{j=1}^{m} \breve{M}_{ci}^{j} \left[\sum_{i=1}^{n} \quad \sum_{i=1}^{n} \breve{M}_{ci}^{j}\right]^{-1} \quad (7)$$

Where Si is fuzzy synthesis; $\sum_{j=1}^{m} \breve{M}_{ci}^{j}$ is operation for the addition of fuzzy extent analysis M values for a partial matrix using the addition operation for each triangular fuzzy number in each row.

Calculating the degree of membership from the comparison of fuzzy synthesis values to obtain a vector is used Eq. (8).

$$V(M_2 \geq M_1) = \begin{cases} 1 & \text{if } m2 \geq m1 \\ 0 & \text{if } l1 \geq u2 \\ \frac{(l1-u2)}{(m2-u2)-(m1-l1)}, & \text{other .} \end{cases} \quad (8)$$

The normalization of the vector weight or the priority value of the criteria that has been obtained is used Eq.(9).

$$W' = (d'(A_1), (d'(A_2), \ldots (d'(An))T \quad (9)$$

Where A1 (i = 1,2,… n) is n the elements; and d '(Ai) is a value that describes the relative choice of each decision attribute.

After normalizing the vector weights, the vector obtained is no longer a fuzzy number, so that the next decision making is to rank the vector weights, the total ranking is obtained by multiplying the evaluation vector of each beneficiary with the priority vector. Making decisions by selecting the highest total ranking.

3. SYSTEM MODEL

The LFG production mitigation flowchart and research procedure algorithm will explain the steps for calculating lfg gas quality. Is shown in Figure 4 *Flowchart of LFG Production determination* .

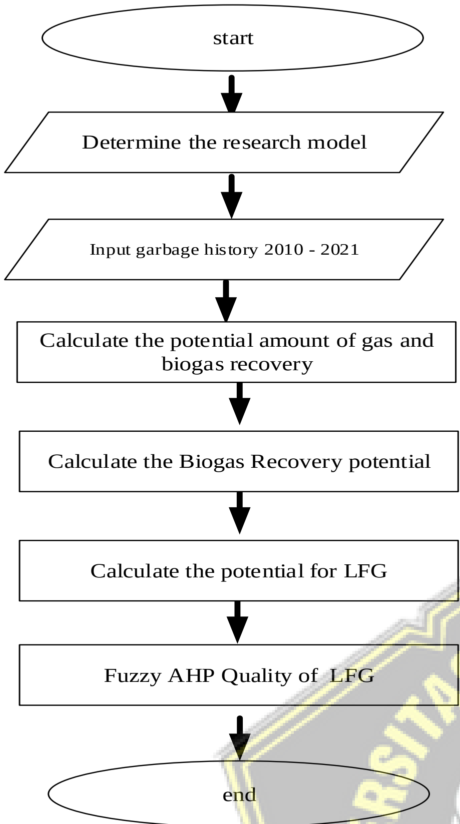

Fig.4. *Flowchart of LFG Production determination*

Figure 4 shows that to determine the quality of LFG, it is necessary to input some data concerning 5 parameters, namely: methane gas CH4 %mmol; carbon dioxide gas CO_2 %mmol; oxygen gas O_2 %mmol; hydrodioxide sulfur H2S %mmol, and weather. The selection of these 5 parameters was based on information and data obtained from the Environmental Office of Semarang and PT. BPS JATI BARANG who manages and operates PLTSa Jatibarang. The system processed the data using fuzzy mamdani and fuzzy AHP to determine the quality of WPP. Is shown in Figure 5. Flowchart of fuzzy ahp quality production landfill gas.

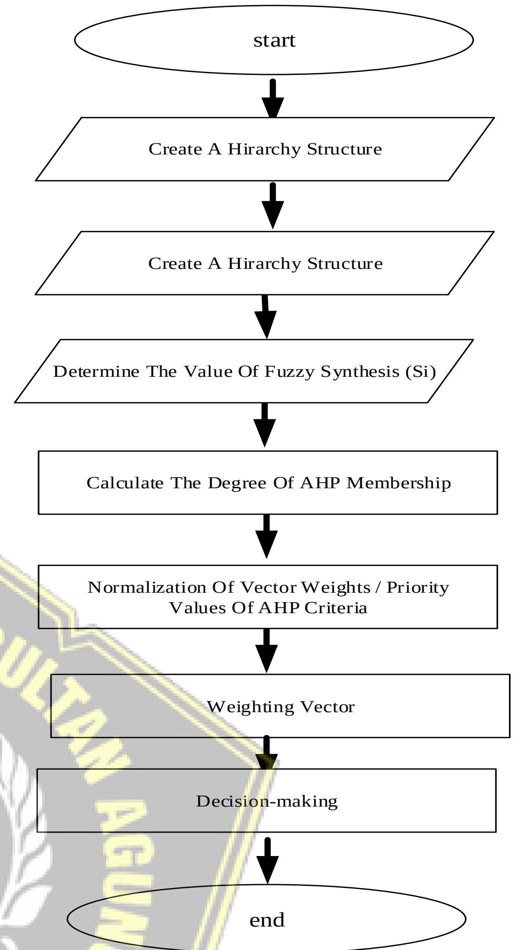

Fig.5 *Flowchart of Fuzzy AHP*

Figure 5 shows the flowchat of AHP fuzzy design for LFG determination. The steps for Fuzzy AHP's work steps in determining the quality of gas production: Create a hierarchical structure of the problem; Determine the pairwise interest comparison matrix between criteria with the Fuzzy Triangular Number scale; Determine the fuzzy sitesis value (Si) to obtain relative weights; Calculating the degree of membership from the comparison of fuzzy synthesis (Si) values; Normalize vector weights or criteria priority values; Perform vector weight ranking; decision making by choosing the highest total ranking

4. RESULTS AND ANALYSIS

Referring to the research model in Figure 1 and the data on landfills in Table 2. The potential results are obtained: Table 3. *Calculation of Potential Gas*

__Table 3.__ Calculation of Gas Potential and Electrical Energy

No	Recoverable Biogas (m^3/years)	Amount of Methane Gas Collected (m^3/years)
1	5.733.294	2.866.647
2	5.968.092	2.984.046
3	6.070.711	3.035.356
4	6.162.734	3.081.367
5	6.241.929	3.120.965
6	6.306.066	3.153.033
7	6.354.029	3.177.015
8	6.383.031	3.191.515
9	6.390.839	3.195.419
10	6.374.665	3.187.332

Table 3 is the result of calculating the potential for gas to be generated for the next 10 years. By knowing the above results are in accordance with the calculation of the data that has been obtained, it can be analyzed that in the second to eight years it has increased every year.

Referring to Tables 3 and equations 3 and 4, the results of the potential for electrical energy will be obtained. Presented in Table 4.

__Table 4.__ Energy Potential Results

No	Energy (Kwh/year)	Power (Kwh/hour)	Mega Watt (MW)
1	23.203.158	2.648,76	2,6
2	24.153.405	2.757,24	2,8
3	24.568.714	2.804,65	2,8
4	24.941.138	2.847,16	2,8
5	25.261.649	2.883,75	2,9
6	25.521.217	2.913,38	2,9
7	25.715.329	2.935,54	2,9
8	25.832.699	2.948,94	2,9
9	25.864.299	2.952,55	2,9
10	25.798.842	2.945,07	2,9

Table 4 is the result of calculating the potential conversion of gas to electrical energy generated for the next 10 years. By knowing the above results are in accordance with the calculation of the data that has been obtained, it can be analyzed that in the second to eight years it has increased every year. Furthermore, the determination of the quality of LFG gas will be determined using the Fuzzy AHP method.

4.1. Potential gas emissions

Refers to equations 5, 6 and Table 2. Calculation of Gas Potential and Electrical Energy. Greenhouse gas emissions obtained are presented in Table 5. Potential gas emissions

__Table 5.__ Potential gas emissions

NO	GAS EMISSIONS	
	CH4	**CO2**
1	24943,99	1425,37
2	30433,8	1739,07
3	31754,77	1814,56
4	33111,17	1892,07
5	34503,71	1971,64
6	35933,8	2053,36
7	37401,78	2137,24
8	31236,91	1784,97
9	23103,41	1320,19
10	27170,16	1552,58

Table 5. is the result of the calculation of potential greenhouse gas emissions, which is deduced annually. The emission reduction in the first year is very large with the resulting emissions. for CH4 which has a content of 40-60% in LFG, the remaining in the first year is only 24,780 tons / year, and for CO2 which has a 40% content in LFG 1,425 tons / year.

4.2. Membership Function

The membership function is a curve that shows the mapping of data input points into membership degrees that have intervals between 0 and 1. The function used to determine the quality of the biogas is the gaussian trapezoid function. The set of membership functions for each gas is determined based on field data. shown in Table 6 the percentage of the content of the elements in the substances in the field.

__Table 6.__ Percentage of Substance Content

Chemical Content	Percentage
CH_4	50-70 %
CO_2	30-40 %
O_2	1 – 10 %
H_2S	< 0,1 %

Table 6. it is known that the ch4 content is 30-70%; carbon dioxide content of 30-40%; oxygen of 1-10% and hydrogen sulfide of 1-10% of the gas element content in the field.

4.2.1. Membership Function Of Methane

The variable CH4 which consists of 3 fuzzy sets, namely LOW, MEDIUM and HIGH. The degree of membership of methane is presented in Table 7. the membership set of Methane Gas which consists of 3 classifications:

***Table 7**. Membership function of methane*

PARAMETER	CH4
LOW	$\mu_{low}[x] = \begin{cases} 1 & , \quad x \leq 10 \\ \frac{30-x}{20} & , 10 \leq x \leq 30 \\ 0 & , \quad x \geq 30 \end{cases}$
MEDIUM	$\mu_{medium}[x] = \begin{cases} 0 & , x \leq 20 \\ \frac{x-20}{15} & , 20 \leq x \leq 35 \\ \frac{50-x}{15} & , 35 \leq x \leq 50 \end{cases}$
HIGH	$\mu_{high}[x] = \begin{cases} 0 & , x \leq 40 \\ \frac{x-60}{20} & , 40 \leq x \leq 60 \\ 1 & , x \geq 60 \end{cases}$

4.2.2. Membership Function Of Carbon Dioxide

The variable CO_2 which consists of 3 fuzzy sets, namely LOW, MEDIUM and HIGH. The degree of membership of carbon dioxide is presented in Table 8. the membership set of Methane Gas which consists of 3 classifications:

***Table 8**. Membership function of carbon dioxide*

PARAMETER	CO_2
LOW	$\mu_{low}[x] = \begin{cases} 1 & , \quad x \leq 5 \\ \frac{10-x}{5} & , 5 \leq x \leq 10 \\ 0 & , \quad x \geq 10 \end{cases}$
MEDIUM	$\mu_{medium}[x] = \begin{cases} 0 & , x \leq 10 \; atau \; x \geq 30 \\ \frac{x-20}{10} & , 20 \leq x \leq 30 \\ \frac{40-x}{10} & , 30 \leq x \leq 40 \end{cases}$
HIGH	$\mu_{high}[x] = \begin{cases} 0 & , x \leq 30 \\ \frac{x-30}{10} & , 30 \leq x \leq 40 \\ 1 & , x \geq 30 \end{cases}$

4.2.3. Membership Function Of Oxygen

The variable O_2 which consists of 2 fuzzy sets, namely LOW,and HIGH. The degree of membership of oxygen is presented in Table 9. the membership set of oxygen Gas which consists of 2 classifications:

***Table 9**. Membership function of oxygen*

PARAMETER	O2
LOW	$\mu_{low}[x] = \begin{cases} 1 & , 0{,}2 \leq x \leq 0{,}5 \\ \frac{0{,}5-x}{0{,}3} & , 0{,}3 \leq x \leq 0{,}5 \\ 0 & , \quad x \geq 0{,}5 \end{cases}$
HIGH	$\mu_{high}[x] = \begin{cases} 1 & , 0{,}7 \leq x \leq 1 \\ \frac{x-0{,}5}{0{,}2} & , 0{,}5 \leq x \leq 0{,}7 \\ 0 & , \quad x \leq 0{,}5 \end{cases}$

4.2.4. Membership Function Of H2S

The variable O_2 which consists of 2 fuzzy sets, namely LOW,and HIGH. The degree of membership of H2S is presented in Table 10. the membership set of H2S Gas which consists of 2 classifications:

***Table 10**. Membership function of H2S*

PARAMETER	H2S
LOW	$\mu_{low}[x] = \begin{cases} 1 & , 0{,}2 \leq x \leq 0{,}5 \\ \frac{0{,}5-x}{0{,}3} & , 0{,}3 \leq x \leq 0{,}5 \\ 0 & , \quad x \geq 0{,}5 \end{cases}$
HIGH	$\mu_{high}[x] = \begin{cases} 1 & , 0{,}7 \leq x \leq 1 \\ \frac{x-0{,}5}{0{,}2} & , 0{,}5 \leq x \leq 0{,}7 \\ 0 & , \quad x \leq 0{,}5 \end{cases}$

4.2.5. Membership Function Of Weather

The variable O_2 which consists of 3 fuzzy sets, namely BRIGHT, CLOUDY and RAIN.. The degree of membership of Weather is presented in Table 11. the membership set of Weather Gas which consists of 3 classifications:

***Table 11**. Membership function of H2S*

PARAMETER	CO_2
BRIGHT	$\mu_{BRIGHT}[x] = \begin{cases} \frac{29-x}{9} & , 20 \leq x \leq 29 \\ 0 & , \quad x \geq 29 \end{cases}$

CLOUDY $$\mu_{CLOUDY}[x] = \begin{cases} 0 & ,x \le 27 \text{ atau } x \ge 33 \\ \frac{x-27}{3} & ,27 \le x \le 30 \\ \frac{33-x}{3} & ,30 \le x \le 33 \end{cases}$$

RAIN $$\mu_{RAIN}[x] = \begin{cases} 0 & ,x \le 31 \\ \frac{x-31}{9} & ,31 \le x \le 40 \\ 1 & ,x \ge 40 \end{cases}$$

4.3. Rules base

In order to obtain accuracy, several basic rules were obtained to be used in assessing and evaluating the quality of LFG. The rules obtained were based on 5 parameters, so 108 rules combinations were obtained shown in Table 12. Rules Base

Table 12. *Rules Base LFG*

NO	PARAMETER						OUTPUT
	CH4	CO2	O2	H2S	WEATHER	LFG	CONNECTION
1	LOW	LOW	LOW	LOW	RAIN	DN	LOSS
2	LOW	LOW	LOW	LOW	CLOUDY	DN	LOSS
3	LOW	LOW	LOW	LOW	SUNNY	DN	LOSS
4	LOW	LOW	LOW	HIGH	RAIN	DN	LOSS
5	LOW	LOW	LOW	HIGH	CLOUDY	DN	LOSS
…	…	…	…	…	…	…	…
108	HIGH	HIGH	HIGH	HIGH	RAIN	N	SINC

4.4. Implication Function

After rules were formed, the implication function application was carried out. The sample cases taken in the measurement had the following parameters: CH_4: 53,5 %mmol; CO_2: 39.3 %mmol; O_2: 0.4 %mmol; H_2S: 0.4 %mmol; Weather: 37^0C. Based on Table 5. From the case data, the predicate rules for parameter assessment include: Table 13. Parameter Assessment of Predicate Rules.

Table 13. *Parameter Assessment of Predicate Rules*

SAMPLING	Parameter	Measurement Results	Membership		
			Low	Medium	High
	CH4	53,5		0,15	0,675
	CO2	39,3		0,14	0,4
CASE 1	O2	0,4	0,33		
	H2S	0,4	0,33		
	CUACA	37			0,66

The calculation of fuzzy values in LFG, based on data Table 13, then the predicate rules for parameter assessment include Table 14.

Table 14. *Parameter of Assessment*

NO	No. Rules	RULES	MIN VALUE a-predicaten
1	R99	IF CH4 (HIGH) AND CO2 (HIGH) AND O2 (LOW) and H2S (LOW) and Weather (HIGH) Then NORMAL	0,33
2	R87	IF CH4 (HIGH) AND CO2 (MEDIUM) AND O2 (LOW) and H2S (LOW) And Weather (HIGH) Then NORMAL	0,14
3	R63	IF CH4 (MEDIUM) AND CO2 (HIGH) AND O2 (LOW) and H2S (LOW) And Weather (HIGH) Then Below Normal	0,15
4	R51	IF CH4 (MEDIUM) AND CO2 (MEDIUM) AND O2 (LOW) and H2S (LOW) And Weather (HIGH) Then NORMAL	0,14

4.5. Rules Composition

The rules composition is the overall conclusion by taking the maximum membership level from each consequent application of the implication function and combining all the conclusions of each rule. This way, the Fuzzy solution area was obtained as the following:

$$\mu_{sf}(x) = maks\,\{0{,}33\}$$

The intersection point of rules was when μ LFG Quality = 0.33, then the x value can be determined as: X = 40 + 20 * (0.33) = 46.6; Therefore, membership function of the solution area was obtained, as shown in the following:

$$\mu \text{ Quality LFG} = \{\, 0{,}33;\ 46{,}6 \le X \le 60 \}$$

4.6. Defuzzifikasi

Defuzzification or affirmation is conversion of fuzzy sets into real numbers. The input of the affirmation process is fuzzy set, whereas the resulting output is a number in the domain of fuzzy set. In this research, the method used in the defuzzification process was the Centroid method (Composite Moment). In this method, the researcher assumed that the existing variables were discrete numbers. For example, for the LFG value obtained in the rule composition process, then Z* was optimal, generally formulated as the following:

$$Z = \frac{\int_{46,6}^{60} (0,33) x dx}{\int_{46,6}^{60} (0,33) dx}$$

$$= \frac{0,165\, x2\,]_{46,6}^{60}}{0,33\, x\ \ ]_{46,6}^{60}}$$

$$= \frac{(0,165\, x\, 60^{\ \ 2}) - (0,165\, x\, 40^{\ \ 2})}{(0,33\, x\, 60) - (0,33 x\, 40)}$$

$$= \frac{330}{6,5}$$

$$= 50,7$$

The LFG quality vulnerability value of 50.7 was categorized as **Normal and Synchronous** to PLN

4.7. Mean Absolute Percentage Error

From the results of the application of the Mamdani fuzzy in the MATLAB program, the comparison between the Mamdani fuzzy and the gas production of PLTSa Jatibarang was obtained. Then by using the Mean Absolute Precentage Error (MAPE), the average error can be calculated by comparing the measurement results from the PT data. Bps Jati Barang with the results of calculations using the matlab application. Table 15 is the result of the Mean Absolute Precentage Error Presentation.

Table 15. *MAPE(Mean Absolute Precentage Error)*

No	Date	LFG PT. BPS (y) % mmol	LFG FUZZY (ŷ) %mmol	Y-ŷ	(y – ŷ)/y
1	27/01/2020	47,1	45	2,1	0,044586
2	10/05/2020	41	37,8	3,2	0,078049
3	03/03/2020	30	18,1	11,9	0,396667
4	30 /1/ 2020	42,6	34,9	7,7	0,180751
5	26 /1/ 2020	30	18,6	11,4	0,38
		MAPE			21,60%

Table 15 presents the percentage error is 21%, which means that it is in accordance with the MAPE percentage value classification including accurate values, with an accuracy rate of 79%.

4.8. Fuzzy AHP (F-AHP) Analysis

The steps in determining LFG quality using the AHP fuzzy method are as the following:

4.8.1 Hierarchical Structure

The hierarchical structure of LFG quality selection problem is presented in the following Figure 6.

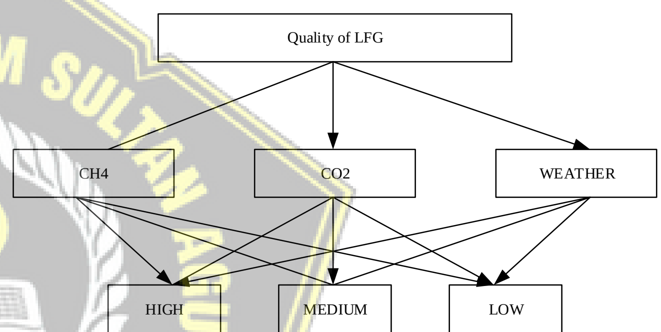

Fig. 6 *Hierarchical Structure of Quality LFG*

Where:
Goal: Determining the best month of quality landfill
Criteria: CH4; CO2 and Weather
Sub-kriteria : H = High; M = Medium; L = Low.

4.8.2. Determination of Synthesis Value

The decision support system will provide a variable and a range of values for each criterion. then represented using a fuzzy triangle, which is then compared in pairs with the input parameters can be seen in Table 16.

Tabel 16. *Paired Matrix Comparison*

	CH4			CO2			CUACA			JUMLAH BARIS		
	H	M	L	H	M	L	H	M	L	H	M	L
CH4	1	3	1	1	2	1	1	3	2	3	8	4
CO2	0,33	1	3	0,5	1	2	0,33	1	3	1,16	3	8
CUACA	0,17	0,33	1	1	0,5	1	0,5	0,33	1	1,67	1,16	3
Amount										**5,83**	**12,16**	**15**

The value of Table 16 is obtained from the comparison between 1 element of the CH4 parameter criteria; CO2 and Weather. After the calculation, the value of the number of rows and columns is obtained, then we will look for the fuzzy synthesis value of each criterion (Ski) where I = 1,2,..., according to Eq. (7).

S_{CH4}=(3,5.4,5.5,5)x(1/11. 1/13. 1/17)

=(0,318. 0,346. 0,196)

S_{CO2}=(4.5.7)x(1/11.1/13.1/17)

=(0,364. 0,385. 0,250)

S_{CUACA}=(3,5. 3,5. 4,5)x(1/11. 1/13. 1/17)

=(0,318. 0,269. 0,161)

Then, the results were input into the calculation of fuzzy synthesis (Si) criteria presented in Table 17.

Table 17. *Conclusion of Calculation Fuzzy Synthesis Value (Si) Criteria*

	*Synthesis (S*i)		
kriteria	**High**	**Medium**	**Low**
CH4	0,201	0,656	0,684
CO2	0,077	0,246	1,318
CUACA	0,111	0,095	0,513

4.8.3. Determination of Vector Value (V) and Defuzzification Ordinate Value (d')

To get the vector value and the ordinary value, Eq. (8). is used

Criteria 1 (CH_4), vector value: 0,639
Criteria 2 (CO_2), vector value: 3,634
Criteria 3 (CUACA), vector value: 0,773

Based on the ordinate values of CH4, CO2, WEATHER, the value of vector weight could be determined as

W' = (0.339, 0.472, 0.189)

4.8.4. Normalization Vector Weight Value (W)

Normalization of the vector weight value is obtained by Eq.(9). where each weight vector element is divided by the number of weight vector itself.

$$W_{local} = \frac{0.339,\ 0.472,\ 0.189}{\text{amount } W_{local} = 1}$$

So that the criteria (local) weights obtained are 0.127, 0.720, 0.153. Sub-criteria and alternative F-AHP calculation completion is the same as the criteria.

4.8.5. Alternative ranking and Decision result

The assessments were classified as High, Medium, and Low for each criterion. Table 18 shows the monthly value data along with the assessment based on the given criteria which are then determined for the weighted value of each month with the assessment that has been given.

Table 18. *Global ranking conclusions*

Global Weight Alternatif	CH_4 0,339	CO_2 0,472	CUACA 0,189		
	CH4	CO2	CUACA	Weight Global	Ranking
January	0,23188	0,116112	0,096957	0,444945	8
February	0,22238	0,622096	0,096957	0,941437	1
March	0,06814	0,622096	0,020979	0,711214	3
April	0,06814	0,622096	0,020979	0,711214	3
May	0,22238	0,116112	0,096957	0,435453	11
June	0,23188	0,116112	0,096957	0,444945	8
July	0,06814	0,622096	0,020979	0,711214	3
August	0,23188	0,622096	0,020979	0,874951	2
September	0,06814	0,622096	0,020979	0,711214	3
October	0,22238	0,116112	0,096957	0,435453	11
November	0,23188	0,116112	0,096957	0,444945	8
December	0,06814	0,622096	0,020979	0,711214	3

Table 18 it can be concluded that using the criteria of CH4, CO2, and weather as inputs and the input classifications consisted of 3 parameters, namely high, medium, and low. Then, the paired matrix comparison with the F-AHP criterion was determined so that the synthesis value of each criterion was obtained. From the value of fuzzy synthesis, the values of vector and ordinate defuzzification were obtained to determine the value of vector weight used for global ranking and decision making, in which it showed that in 2021, February and Agust had the most optimum weight value, namely 0.3457750 compared to other months. The lowest months were February and August, namely 0.2535460

5. CONCLUSION

Based on the results of the research conducted, the following conclusions can be drawn:

1. Utilization of landfill gas potential based on the amount of waste using the Moving Averange forecasting method, results in 2021 reaching 12,462,329 m3/year with gas that can be utilized reaching 5,733,294 m3/year and methane gas of 2,866,647 m3/year. Then obtained energy potential of 23,203,158 kWh or 2.6 MW with engine efficiency of 82.5% and continues to increase by 1.19% per year.Utilizing LFG potential Landfill based on the amount of waste available in 2020, reaching 8,606,375.79 m3/year, with available gas reaching 3,959,363 m3/year, and methane gas of 1,979,682 m3/year, it can be calculated that the potential energy produced with an engine efficiency of 82.5% would reach 16,024,124.53 kWh or 1.8 MW.
2. Based on Fuzzi AHP analysis of waste in TPST Jatibarang which continues to experience significant increases, it is very possible to maximize the potential of

PLTSa landfill gas in TPST Jatibarang with methane gas concentrations reaching 30-60% mmol.

3. The condition of methane gas, carbon dioxide and weather conditions greatly affect the quality of landfill gas. In the calculation of the Fuzzi AHP analysis, it was found that February has the most optimum weight value compared to other months due to sunny weather conditions and balanced levels of methane and carbon dioxide produced by landill gas. So that in February, landfill gas production rarely experienced a drop of CH4. Meanwhile, May and October have the minimum month value so that in that month there is often a drop of CH4 in landfill wells which is influenced by cloudy weather conditions that tend to rain.

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4	12/12/2020	Pengajuan Bab 1 Revisi latar belakang dan tujuan thesis	
5	9/1/2021	Pengajuan bab 2 Revisi penulisan referensi, penulisan penelitian terdahulu mengenai produksi landfill gas Revisi keterangan gambar dan tabel	
6	30/1/2021	Pengajuan bab 3 Revisi model penelitian dan flowchat penelitian Penulisan laporan hasil data lapangan Fuzzifikasi matlab	
7	13/2/2021	Pengajuan bab 4 Revisi hasil peramalan menggunakan moving average Komparasi data lapangan dengan data hasil matlab Fuzzyfikasi dan akurasi hasil perhitungan matlab Perumusan Fuzzi AHP serta pengambilan bobot global	
8	6/3/2021	Pengajuan bab 5 Revisi kesimpulan diselaraskan dengan tujuan latar belakang	