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LAMPIRAN

Analisa Kualitas Bahan Bakar Tanggal 06 Oktober 2025 Sampai Dengan 10

November 2025

Tanggal	Fiber			Cangkang		
	M (%) (O/WM)	O (%) (O/WM)	N (%) (O/WM)	M (%) (O/WM)	O (%) (O/WM)	N (%) (O/WM)
06 - 10	29,42%	3,94%	66,64%	14,68%	1,24%	84,08%
07 - 10	26,44%	3,93%	69,63%	13,62%	1,29%	85,09%
08 - 10	39,91%	3,92%	56,17%	14,47%	1,18%	84,35%
09 - 10	35,34%	3,94%	60,72%	13,54%	1,21%	85,25%
10 - 10	34,63%	3,91%	61,46%	14,23%	1,04%	84,73%
11 - 10	34,99%	3,92%	61,09%	13,27%	1,11%	85,62%
13 - 10	31,10%	3,92%	64,98%	11,86%	1,16%	86,98%
14 - 10	33,76%	3,92%	62,32%	13,52%	1,09%	85,39%
15 - 10	33,33%	3,94%	62,73%	13,28%	1,14%	85,58%
16 - 10	35,95%	3,95%	60,10%	13,55%	1,14%	85,31%
17 - 10	33,95%	3,91%	62,14%	13,48%	1,08%	85,44%
18 - 10	31,24%	3,91%	64,85%	13,48%	1,08%	85,44%
20 - 10	33,21%	3,93%	62,86%	13,67%	1,07%	85,26%
21 - 10	34,36%	3,91%	61,73%	13,96%	1,08%	84,96%
22 - 10	32,47%	3,92%	63,61%	15,61%	1,14%	83,25%
23 - 10	38,08%	3,90%	58,02%	14,41%	1,13%	84,46%
24 - 10	35,34%	3,92%	60,74%	13,22%	1,11%	85,69%
25 - 10	32,51%	3,92%	63,57%	13,33%	1,08%	85,59%
27 - 10	36,14%	3,92%	59,94%	13,52%	1,12%	85,36%
28 - 10	37,36%	3,92%	58,72%	12,91%	1,14%	85,95%
29 - 10	43,18%	3,93%	52,89%	13,72%	1,08%	85,20%
30 - 10	34,37%	3,91%	61,72%	14,24%	1,06%	84,70%
31 - 10	33,54%	3,91%	62,55%	11,99%	1,11%	86,90%
01 - 11	31,96%	3,92%	64,12%	10,75%	1,11%	88,14%
03 - 11	31,90%	3,93%	64,17%	12,15%	1,04%	86,81%
04 - 11	32,84%	3,92%	63,24%	15,05%	1,05%	83,90%
05 - 11	34,21%	3,93%	61,86%	14,55%	1,18%	84,37%
06 - 11	36,70%	3,91%	59,39%	14,33%	1,10%	84,57%
07 - 11	34,12%	3,92%	61,96%	16,42%	1,15%	82,43%
08 - 11	33,22%	3,91%	62,87%	12,44%	1,18%	86,38%
10 - 11	36,07%	3,92%	60,01%	13,39%	1,15%	85,46%
Rata-rata	34,25%	3,92%	61,83%	13,63%	1,12%	85,25%

(Sumber : Data Primer, 2025)

Perhitungan nilai kalor bahan bakar per sampel

$$\text{Fiber} = (66,64\% \times 3850 \text{ kkal/kg}) + (3,94\% \times 8800 \text{ kkal/kg}) - (29,42\% \times 600 \text{ kkal/kg})$$

$$= 2.565,64 \text{ kkal/kg} + 346,70 \text{ kkal/kg} - 176,52 \text{ kkal/kg}$$

$$= 2.735,82 \text{ kkal/kg}$$

$$\text{Cangkang} = (84,08\% \times 4700 \text{ kkal/kg}) + (1,24\% \times 8800 \text{ kkal/kg}) - (14,68\% \times 600 \text{ kkal/kg})$$

$$= 3.951,76 \text{ kkal/kg} + 109,12 \text{ kkal/kg} - 88,08 \text{ kkal/kg}$$

$$= 3.972,8 \text{ kkal/kg}$$

Perhitungan Nilai kalor dari jumlah bahan bakar yang tersedia pada tanggal 06

Oktober 2025 adalah 56.333 kg TBS/jam:

$$\text{Fiber} = 12,5\% \times 56.333 \text{ kg} = 7.041,62 \text{ kg}$$

$$\text{Cangkang} = 1,11\% \times 56.333 \text{ kg} = 625,29 \text{ kg}$$

$$\begin{aligned} \text{Total nilai kalor fiber} &= 7.041,62 \text{ kg} \times 2.735,82 \text{ kkal/kg} \\ &= 19.264.604,8 \text{ kkal/kg} \end{aligned}$$

$$\begin{aligned} \text{Total nilai kalor cangkang} &= 625,29 \text{ kg} \times 3.972,8 \text{ kkal/kg} \\ &= 2.484.152,11 \text{ kkal/kg} \end{aligned}$$

$$\text{Total nilai kalor fiber + cangkang} = 21.748.756,9 \text{ kkal/kg}$$

Potensi Nilai Kalor Bahan Bakar Fiber dan Cangkang Terhadap Sampel

Tanggal	Nilai kalor bahan bakar		
	Fiber (kkal/kg)	Cangkang (kkal/kg)	Total gabungan fiber + cangkang (kkal/kg)
06 – 10	2.735,84	3.972,80	6.708,64
07 – 10	2.867,96	4.031,03	6.898,99
08 – 10	2.268,04	3.981,47	6.249,51
09 – 10	2.472,40	4.031,99	6.504,39
10 – 10	2.502,51	3.988,45	6.490,96
11 – 10	2.486,99	4.042,20	6.529,19
13 – 10	2.660,09	4.118,98	6.779,07
14 – 10	2.541,72	4.028,13	6.569,85
15 – 10	2.561,85	4.042,90	6.604,75
16 – 10	2.445,75	4.028,59	6.474,34
17 – 10	2.532,77	4.029,84	6.562,61
18 – 10	2.653,37	4.029,84	6.683,21
20 – 10	2.566,69	4.019,36	6.586,05
21 – 10	2.514,53	4.004,40	6.518,93
22 – 10	2.599,13	3.919,41	6.518,54
23 – 10	2.348,49	3.982,60	6.331,09
24 – 10	2.471,41	4.045,79	6.517,2
25 – 10	2.597,35	4.037,79	6.635,14
27 – 10	2.435,81	4.029,36	6.465,17
28 – 10	2.381,52	4.062,51	6.444,03
29 – 10	2.123,03	4.017,12	6.140,15
30 – 10	2.514,08	3.988,74	6.502,82
31 – 10	2.551,02	4.110,04	6.661,06
01 – 11	2.621,82	4.175,76	6.797,58
03 – 11	2.624,99	4.098,69	6.723,68
04 – 11	2.582,66	3.945,40	6.528,06
05 – 11	2.522,19	3.981,93	6.504,12
06 – 11	2.410,40	3.985,61	6.396,01
07 – 11	2.525,70	3.876,89	6.402,59
08 – 11	2.565,26	4.089,06	6.654,32
10 – 11	2.438,93	4.037,48	6.476,41
Jumlah	78.124,3	124.734,16	202.858,5
Rata-rata	2.520,13	4.023,68	6.543,82

Potensi Nilai Kalor Bahan Bakar Fiber dan Cangkang terhadap massa fiber +
cangkang

Tanggal	Nilai kalor bahan bakar		
	Fiber (kkal/jam)	Cangkang (kkal/jam)	Total gabungan fiber + cangkang (kkal/jam)
06 – 10	19.264.745,66	2.484.152,11	21.748.756,9
07 – 10	20.374.332,00	2.542.934,97	22.917.266,96
08 – 10	15.733.393,5	2.452.585,52	18.185.979
09 – 10	15.791.466,04	2.286.823,77	18.078.289,81
10 – 10	17.349.901,83	2.212.153,91	19.562.055,74
11 – 10	17.336.185,54	2.254.173,25	19.590.358,79
13 – 10	16.772.186,66	2.306.175,71	19.078.362,37
14 – 10	17.968.359,12	2.528.698,89	20.497.058,01
15 – 10	17.709.428,59	2.481.734,17	20.191.162,75
16 – 10	15.831.339,75	2.315.633,53	18.146.973,28
17 – 10	17.459.650	2.466.826,26	19.926.476,25
18 – 10	18.371.933,88	2.477.747,12	20.849.681
20 – 10	16.719.726,66	2.324.998,79	19.044.725,45
21 – 10	17.352.444,64	2.453.856,28	19.806.300,92
22 – 10	18.019.430,40	2.412.906,38	20.432.336,78
23 – 10	15.306.870,70	2.305.009,40	17.611.880,10
24 – 10	15.457.730,41	2.247.072,22	17.704.802,64
25 – 10	17.983.064,41	2.482.473,67	20.465.538,08
27 – 10	16.855.805,20	2.476.001,43	19.331.806,63
28 – 10	16.780.189,92	2.541.831,26	19.322.021,18
29 – 10	14.670.392,06	2.464.945,00	17.135.337,07
30 – 10	15.791.439,30	2.224.520,30	18.015.959,59
31 – 10	17.660.073,71	2.526.605,99	20.186.679,69
01 – 11	18.392.722,76	2.601.289,69	20.994.012,45
03 – 11	16.648.999,08	2.308.423,19	18.957.422,27
04 – 11	16.581.968,53	2.265.882,67	18.847.851,20
05 – 11	15.987.203,98	2.241.269,12	18.228.473,10
06 – 11	15.067.699,65	2.212.372,25	17.280.071,90
07 – 11	16.081.434,98	2.191.993,61	18.273.428,59
08 – 11	16.051.139,65	2.272.004,41	18.323.144,06
10 – 11	17.120.361,81	2.516.722,78	19.637.084,59

Jumlah	524.491.620,4	73.879.817,65	598.371.438
Rata-rata	16.919.084,53	2.383.219,92	19.302.304,5

kondisi uap yang dibangkitkan *boiler* per tanggal

- *Entalphy steam* = 668,58 kkal/kg

- *Entalphy feed water* = 79,17 kkal/kg

- Efisiensi *boiler* = 73 % (vendor)

$$\frac{\Delta Entalphy}{\eta}$$

$$\frac{589,41}{73\%} = 807,41 \text{ kkal/kg uap}$$

steam yang dapat dihasilkan dari bahan bakar yang tersedia per tanggal 06 Oktober

$$2025 \text{ adalah } \frac{21.748.756,9 \text{ kkal/kg}}{807,41 \text{ kkal/kg}} = 26.936,44 \text{ kg uap/jam}$$

Penggunaan Bahan Bakar dan *Steam* yang Dihasilkan

Tanggal	Bahan bakar fiber + cangkang (kg/jam)	<i>Steam</i> yang dihasilkan (kg/jam)
06 – 10	7.666,91	26.936,45
07 – 10	7.734,96	28.423,81
08 – 10	7.553	22.621,63
09 - 10	6.954,27	22.338,18
10 – 10	7.487,64	24.191,9
11 – 10	7.528,41	24.297,82
13 – 10	6.865,01	23.785,52
14 – 10	7.697,13	25.469,14
15 – 10	7.526,6	25.031,5
16 – 10	7.047,8	22.533,31
17 – 10	7.505,64	24.741,71
18 – 10	7.538,85	25.956,33
20 – 10	7.092,57	23.735,29
21 – 10	7.513,66	24.593,1
22 – 10	7.548,5	25.342,12
23 – 10	7.096,52	21.928,51
24 – 10	6.810,03	22.064,81

Tanggal	Bahan bakar fiber + cangkang (kg/jam)	Steam yang dihasilkan (kg/jam)
25 – 10	7.538,43	25.333,03
27 – 10	7.534,49	24.014,37
28 – 10	7.671,68	23.986,12
29 – 10	7.523,8	21.268,7
30 – 10	6.838,9	22.416,27
31 – 10	7.537,49	25.056,08
01 – 11	7.638,2	26.011,02
03 – 11	6.905,71	23.544,04
04 – 11	6.994,81	23.394,88
05 – 11	6.901,48	22.569,49
06 – 11	6.806,21	21.503,86
07 – 11	6.932,52	22.683,57
08 – 11	6.812,75	22.726,1
10 – 11	7.642,96	24.377,24
Jumlah	226.446,9	742.875,9
Rata-rata	7.304,73	23.963,74

Perhitungan Konsumsi Bahan Bakar dalam per ton *Steam* yang dihasilkan

- Metode energi :

$$LHV_{mix} = \frac{(m_{fiber} \times LHV_{fiber}) + (m_{cangkang} \times LHV_{cangkang})}{m_{fiber} + m_{cangkang}}$$

$$= \frac{(7.041,61 \frac{kg}{jam} \times 2.735,82 \frac{kcal}{kg}) + (625,29 \frac{kg}{jam} \times 3.972,8 \frac{kcal}{kg})}{7.666,91 \frac{kg}{jam}}$$

$$= \frac{21.748.756,9 \text{ kkal/jam}}{7.666,91 \text{ kg/jam}}$$

$$= 2.836,7 \text{ kkal/kg}$$

$$K \text{ per ton steam} = \frac{h_{steam} - h_{feed water}}{\eta \times LHV_{mix}}$$

$$= \frac{668,58 \text{ kkal/kg} - 79,17 \text{ kkal/kg}}{73\% \times 2.836,7 \text{ kkal/kg}}$$

$$= 284,63 \text{ kg/ton steam}$$

Perhitungan *Steam* yang dihasilkan oleh *boiler* dari tiap-tiap bahan bakar

- Fiber

$$Q = \frac{(Gbb \times N.O) \times \eta}{\Delta entalphy}$$

$$Q = \frac{(7.041,62 \text{ kg/jam} \times 2.735,82 \text{ kkal/kg}) \times 73\%}{589,41 \text{ kkal/kg}} = 23.875,93 \text{ kg/jam}$$

- Cangkang

$$Q = \frac{(625,29 \text{ kg/jam} \times 3.972,8 \text{ kkal/kg}) \times 73\%}{589,41 \text{ kkal/kg}} = 3.078,77 \text{ kg/jam}$$

Steam yang Dihasilkan dari Masing-masing Bahan bakar dan Persentase Terhadap

Total *Steam*

Tanggal	<i>Steam</i> total (kg/jam)	<i>Steam</i> fiber (kg/jam)	<i>Steam</i> cangkang (kg/jam)	% Fiber	% Cangkang
06 – 10	26.936,45	23.859,9	3.076,69	88,58	11,42
07 – 10	28.423,81	25.269,74	3.153,93	88,90	11,10
08 – 10	22.621,63	19.570,9	3.050,79	86,51	13,49
09 - 10	22.338,18	19.512,47	2.825,68	87,35	12,65
10 – 10	24.191,9	21.456,28	2.735,73	88,69	11,31
11 – 10	24.297,82	21.501,97	2.795,84	88,49	11,51
13 – 10	23.785,52	20.910,45	2.875,19	87,91	12,09
14 – 10	25.469,14	22.327,02	3.142,10	87,66	12,34
15 – 10	25.031,5	21.954,83	3.076,67	87,71	12,29
16 – 10	22.533,31	19.657,9	2.875,34	87,24	12,76
17 – 10	24.741,71	21.678,68	3.062,92	87,62	12,38
18 – 10	25.956,33	22.871,71	3.084,61	88,12	11,88
20 – 10	23.735,29	20.837,57	2.897,62	87,79	12,21
21 – 10	24.593,1	21.546,3	3.046,92	87,61	12,39
22 – 10	25.342,12	22.349,4	2.992,71	88,19	11,81
23 – 10	21.928,51	19.058,53	2.869,96	86,91	13,09
24 – 10	22.064,81	19.264,44	2.800,45	87,31	12,69
25 – 10	25.333,03	22.260,04	3.072,89	87,87	12,13
27 – 10	24.014,37	20.938,53	3.075,73	87,19	12,81

Tanggal	Steam total (kg/jam)	Steam fiber (kg/jam)	Steam cangkang (kg/jam)	% Fiber	% Cangkang
28 – 10	23.986,12	20.830,78	3.155,41	86,85	13,16
29 – 10	21.268,7	18.209,22	3.059,54	85,62	14,39
30 – 10	22.416,27	19.648,46	2.767,85	87,65	12,35
31 – 10	25.056,08	21.920,08	3.136,08	87,48	12,52
01 – 11	26.011,02	22.788	3.222,91	87,61	12,39
03 – 11	23.544,04	20.677,06	2.866,92	87,82	12,18
04 – 11	23.394,88	20.582,26	2.812,51	87,98	12,02
05 – 11	22.569,49	19.794,53	2.775,02	87,70	12,30
06 – 11	21.503,86	18.750,82	2.753,16	87,20	12,80
07 – 11	22.683,57	19.962,67	2.721,03	88,00	12,00
08 – 11	22.726,1	19.908,14	2.817,95	87,60	12,40
10 – 11	24.377,24	21.253,06	3.124,24	87,18	12,82
Jumlah	742.875,9	632.307	91.274,39	2.716,34	383,68
Rata-rata	23.963,74	20.397	2.958,85	87,62	12,38

Persentase Komposisi Bahan Bakar Fiber dan Cangkang

Tanggal	Fiber (%)	Cangkang (%)
06 – 10	91,84	8,16
07 – 10	91,84	8,16
08 – 10	91,84	8,16
09 – 10	91,84	8,16
10 – 10	92,59	7,41
11 – 10	92,59	7,41
13 – 10	91,84	8,16
14 – 10	91,84	8,16
15 – 10	91,84	8,16
16 – 10	91,84	8,16
17 – 10	91,84	8,16
18 – 10	91,84	8,16
20 – 10	91,84	8,16
21 – 10	91,84	8,16
22 – 10	91,84	8,16
23 – 10	91,84	8,16
24 – 10	91,84	8,16

Tanggal	Fiber (%)	Cangkang (%)
25 – 10	91,84	8,16
27 – 10	91,84	8,16
28 – 10	91,84	8,16
29 – 10	91,84	8,16
30 – 10	91,84	8,16
31 – 10	91,84	8,16
01 – 11	91,84	8,16
03 – 11	91,84	8,16
04 – 11	91,84	8,16
05 – 11	91,84	8,16
06 – 11	91,84	8,16
07 – 11	91,84	8,16
08 – 11	91,84	8,16
10 – 11	91,84	8,16
Rata-rata	91,89	8,11

Data Tekanan *Steam*, Suhu *Feed water*, dan Efisiensi Penyerapan Panas

Tanggal	Tekanan <i>steam</i> (bar)	Suhu <i>feed</i> <i>water</i> (°C)	<i>Entalphy</i> <i>steam</i> (kkal/kg)	<i>Entalphy</i> <i>feed water</i> (kkal/kg)	Perubahan <i>entalphy</i> (kkal/kg)
06 – 10	21	79,16	668,58	79,17	589,41
07 – 10	21,21	80	668,62	80,04	588,58
08 – 10	21,16	81,66	668,61	81,75	586,86
09 - 10	21,14	77,85	668,61	77,82	590,79
10 – 10	21,10	78,33	668,6	78,31	590,29
11 – 10	21,15	80	668,61	80,04	588,57
13 – 10	21,23	83,08	668,63	83,1	585,53
14 – 10	21,39	81,1	668,66	81,17	587,49
15 – 10	21,18	79,75	668,62	79,78	588,84
16 – 10	21,22	80,66	668,62	80,72	587,9
17 – 10	21,20	80,63	668,62	80,69	587,93
18 – 10	21,22	82,14	668,62	82,24	586,38
20 – 10	21,15	82,85	668,61	82,87	585,74
21 – 10	21,10	80,63	668,6	80,69	587,91
22 – 10	21,17	80	668,61	80,04	588,57
23 – 10	21,22	82,22	668,62	82,32	586,3

Tanggal	Tekanan steam (bar)	Suhu <i>feed water</i> (°C)	<i>Entalphy steam</i> (kkal/kg)	<i>Entalphy feed water</i> (kkal/kg)	Perubahan <i>entalphy</i> (kkal/kg)
24 – 10	20,82	82,77	668,54	82,79	585,75
25 – 10	20,6	78,75	668,49	78,75	589,74
27 – 10	21,20	80,90	668,62	80,96	587,66
28 – 10	21,15	80,50	668,61	80,56	588,05
29 – 10	21,11	80,41	668,6	80,47	588,13
30 – 10	21,10	81,81	668,6	81,9	586,7
31 – 10	21,09	80,41	668,6	80,47	588,13
01 – 11	21,07	79,37	668,59	79,39	589,2
03 – 11	20,94	80,71	668,56	80,77	587,79
04 – 11	21,11	80,42	668,6	80,48	588,12
05 – 11	21,06	79	668,59	79	589,59
06 – 11	20,97	81,87	668,57	81,96	586,61
07 – 11	21,04	80,45	668,59	80,52	588,07
08 – 11	21,17	80	668,61	80,04	588,57
10 – 11	21,15	80,50	668,61	80,56	588,05
Jumlah	654,42	2.493,33	20.726,62	2.499,37	18.227,25
Rata-rata	21,11	80,42	668,60	80,62	587,97



