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LAMPIRAN

LAMPIRAN 1

Lampiran 1 Profil Perusahaan

PT Semen Tonasa adalah produsen semen terbesar di Kawasan Timur Indonesia yang menempati lahan seluas 1.571 hektar di Desa Biring Ere, Kecamatan Bungoro, Kabupaten Pangkep, sekitar 68 kilometer dari kota Makassar. Perseroan yang memiliki kapasitas terpasang 5.980.000 ton semen per tahun ini, mempunyai empat unit pabrik, yaitu Pabrik Tonasa II, III, IV dan V. Keempat unit pabrik tersebut menggunakan proses kering dengan kapasitas masing-masing 590.000 ton semen pertahun untuk Unit II dan III, 2.300.000 ton semen per tahun untuk unit IV serta 2.500.000 ton semen untuk unit V yang diproyeksikan mampu mendukung kebutuhan Semen Nasional. Didukung dengan bahan baku yang berlimpah, Pabrik ini diperkirakan akan terus beroperasi untuk turut memberikan sumbangsih kepada Negara dan berkontribusi pada perekonomian nasional hingga beberapa puluh tahun ke depan.

Pendapatan utama perseroan adalah hasil penjualan Semen Portland (OPC), Semen non OPC yaitu Tipe Komposit (PCC), tersebar di wilayah Sulawesi, Kalimantan, Bali, Nusa Tenggara, Maluku, dan Papua. Didukung dengan merek yang sudah terkenal di Kawasan Timur Indonesia, perseroan berusaha secara terus menerus mempertahankan *brand image* produk dengan menjaga kestabilan pasokan produk di pasar. Selain itu, dukungan sistem distribusi yang optimal juga merupakan unsur kesuksesan penjualan semen. Disamping itu, penjualan ekspor juga dilakukan jika terjadi kelebihan produksi setelah pemenuhan pasar dalam negeri.

Visi dan Misi Perusahaan

a. Visi Perusahaan:

- 1) Menjadi perusahaan persemenan terkemuka di Indonesia yang efisien dan berwawasan lingkungan

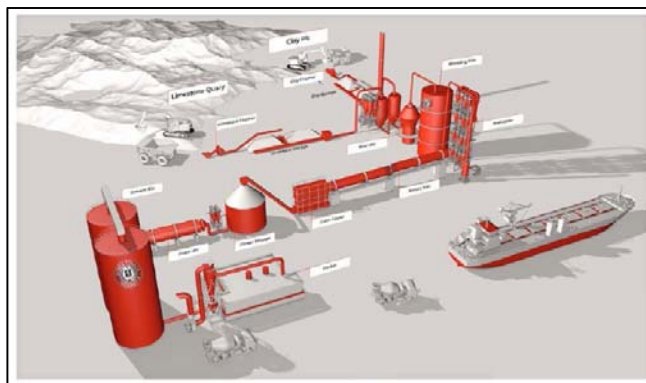
b. Misi Perusahaan :

- 1) Meningkatkan nilai perusahaan sesuai keinginan *stakeholders*.
- 2) Memproduksi semen untuk memenuhi kebutuhan konsumen dengan kualitas dan harga bersaing serta penyerahan tepat waktu.
- 3) Senantiasa berupaya melakukan *improvement* di segala bidang, guna meningkatkan daya saing di pasar dan produktifitas perusahaan.
- 4) Membangun lingkungan kerja yang mampu membangkitkan motivasi karyawan untuk bekerja secara profesional.

Sistem dan Manajemen Produksi

Proses bisnis dari Perusahaan adalah memproduksi dan memasarkan semen. Proses ini dimulai dari penambangan bahan baku (tanah liat, batu silika dan batu kapur) lalu dilakukan proses produksi di empat unit pabrik utama yakni Tonasa 2, Tonasa 3, Tonasa 4 dan Tonasa 5. Produk kemudian dikemas di bagian *packer*

Tiap-tiap tahapan dari pembuatan semen dilakukan kendali mutu. Pengendalian mutu di lapangan selalu terhubung dan diawasi oleh karyawan melalui *Central Control Room (CCR)* dan pengujian kimia secara langsung di Laboratorium Proses. Dengan begitu perusahaan dapat menghasilkan produk yang bermutu tinggi. Proses pembuatan semen dapat dilihat pada gambar berikut:



Alur proses produksi semen terbagi atas beberapa tahapan yaitu:

- a. Penambangan bahan mentah (*Quarry*). Pada proses ini dilakukan peledakan untuk mengambil batu kapur dan pengerukan untuk

tanah liat. Setelah itu batu kapur dan tanah liat diangkut menggunakan *dump truck* ke pemecah (*Crusher*).

- b. Batu kapur dan tanah liat dipecah dengan *Hammer crusher* kemudian ditampung pada tempat penyimpanan (*Storage*).
- c. Penggilingan Bahan baku (*Raw Mill*). Pada proses ini batu kapur dan tanah liat yang disimpan dalam *storage* dicampur dengan pasir silika dan pasir besi dengan proporsi yang tepat lalu digiling dan dikeringkan menjadi *Raw Meal*. *Raw Meal* merupakan bahan baku untuk pembuatan terak (*Clinker*).
- d. Proses menghomogenkan komposisi kimia (Prehomogenisasi). Pada proses ini *Raw meal* dihomogenkan dengan alat yang bernama *Blending silo*. Proses ini dilakukan agar komposisi kimia dari produk tetap sehingga kualitasnya terjamin.
- e. Bahan kemudian dipanaskan di *Preheater*.
- f. Setelah itu dilakukan proses pembakaran pada *Rotary Kiln*. Proses pembakaran ini menggunakan batubara. *Output* dari proses ini adalah *clinker*.
- g. *Clinker* kemudian didinginkan dengan *Grate Cooler* dengan cara meniupkan udara dengan kipas angin pendingin. Panas dari proses ini dialirkan ke *Preheater* agar menghemat energi. Setelah *clinker* didinginkan, *clinker* kemudian disimpan pada *clinker storage*.
- h. *Clinker* yang dipindahkan dari *clinker storage* digiling di *Finish Mill* dengan menambahkan Gypsum. Hasil akhir dari proses ini adalah semen. Setelah itu semen disimpan dalam *Cement Silo*.
- i. Semen yang disimpan dalam *Cement Silo* kemudian dibawa ke tempat pengepakan semen (*Packer*).

LAMPIRAN 2

Lampiran 2 berisi data awal berdasarkan data historis yang diberikan oleh perusahaan dan hasil wawancara dengan beberapa karyawan PT Semen Tonasa.

Periode	Jenis Batubara (Ton)	
	Batubara 4100 GAR	Batubara 4200 GAR
Jan-19	32.635,91	26.922,52
Feb-19	71.934,86	20.751,45
Mar-19	147.410,66	31.781,82
Apr-19	98.220,55	26.982,34
Mei-19	105.147,61	42.484,55
Jun-19	90.120,53	24.763,16
Jul-19	82.135,70	37.388,96
Agu-19	98.571,18	27.078,40
Sep-19	118.212,36	19.399,40
Okt-19	101.517	35.071,38
Nov-19	134.469,71	54.315,40
Des-19	204.230,24	24.517,49
Jan-20	76.395,52	69.459,57
Feb-20	106.005,51	29.115,21
Mar-20	72.623,40	33.065,18
Apr-20	85.026,86	34.366,23
Mei-20	91.278,40	53.734,35
Jun-20	78.443,70	31.710,07
Jul-20	95.720,58	33.072,62
Agu-20	95.457,71	50.288,27
Sep-20	131.186,37	36.014,08
Okt-20	12.635,78	25.171,55
Nov-20	70.977,93	24.540,66
Des-20	105.827,51	42.758,87

No	Jenis Bahan Bakar	Lead Time (Hari)
1	Batubara 4200 GAR	8
2	Batubara 4100 GAR	8

No	Jenis Bahan Bakar	Biaya Pemesanan per Ton (Rupiah)
1	Batubara 4200 GAR	Rp. 95.000
2	Batubara 4100 GAR	Rp. 95.000

No	Jenis Bahan Bakar	Biaya Pemesanan per Ton (Rupiah)
1	Batubara 4200 GAR	Rp. 95.000
2	Batubara 4100 GAR	Rp. 95.000

LAMPIRAN 3

Lampiran 3 berisi perhitungan biaya pemesanan.

$$\text{Rata-rata biaya pemesanan} = \frac{((\text{kuantitas pemesanan bulan 1} \times \text{biaya pemesanan per ton}) + (\text{kuantitas pemesanan bulan 2} \times \text{biaya pemesanan per ton}) + \dots + (\text{kuantitas pemesanan bulan (n)} \times \text{biaya pemesanan per ton}))}{\text{Jumlah periode (n)}}$$

Biaya Pemesanan Batubara 4100 GAR

$$\begin{aligned} \text{Rata-rata biaya pemesanan} = & 3.100.411.450 + 6.833.811.700 + 14.004.012.700 + \\ & 9.330.952.250 + 9.989.022.950 + 8.561.450.350 + \\ & 7.802.891.500 + 9.364.262.100 + 11.230.174.200 + \\ & 9.644.115.000 + 12.774.622.450 + 19.401.872.800 + \\ & 7.257.574.400 + 10.070.523.450 + 6.899.223.000 + \\ & 8.077.551.700 + 8.671.448.000 + 7.452.151.500 + \\ & 9.093.455.100 + 9.068.482.450 + 12.462.705.150 + \\ & 1.200.399.100 + 6.742.903.350 + 10.053.613.450 \\ & \hline & 24 \\ = & \text{Rp. 9.128.651.254} \end{aligned}$$

Biaya Pemesanan Batubara 4200 GAR

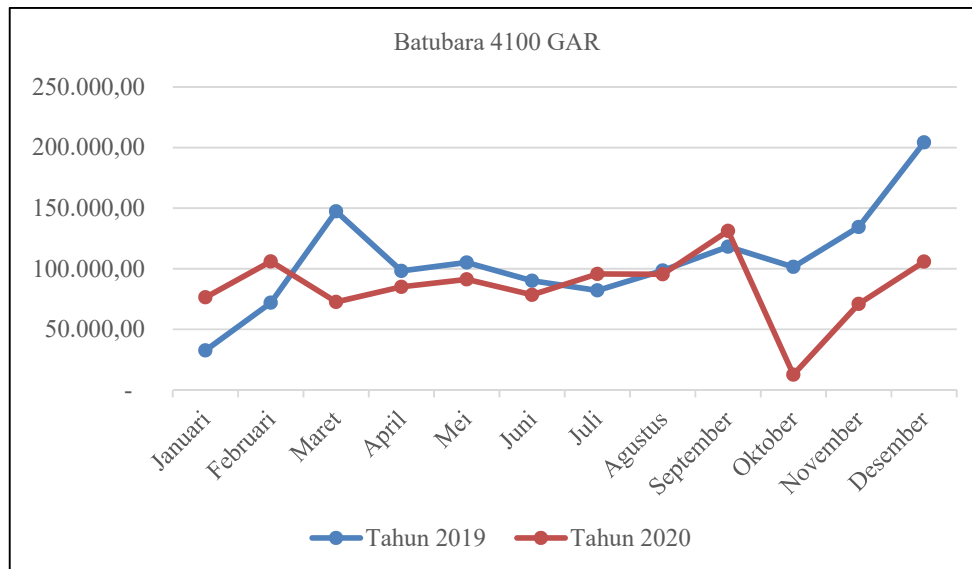
$$\begin{aligned} \text{Rata-rata biaya pemesanan} = & 2.557.639.400 + 1.971.387.750 + 3.019.272.900 + \\ & 2.563.322.300 + 4.036.032.250 + 2.352.500.200 + \\ & 3.551.951.200 + 2.572.448.000 + 1.842.943.000 + \\ & 3.331.781.100 + 5.159.963.000 + 2.329.161.550 + \\ & 6.598.659.150 + 2.765.944.950 + 3.141.192.100 + \\ & 3.264.791.850 + 5.104.763.250 + 3.012.456.650 + \\ & 3.141.898.900 + 4.777.385.650 + 3.421.337.600 + \\ & 2.391.297.250 + 2.331.362.700 + 4.062.092.650 \end{aligned}$$

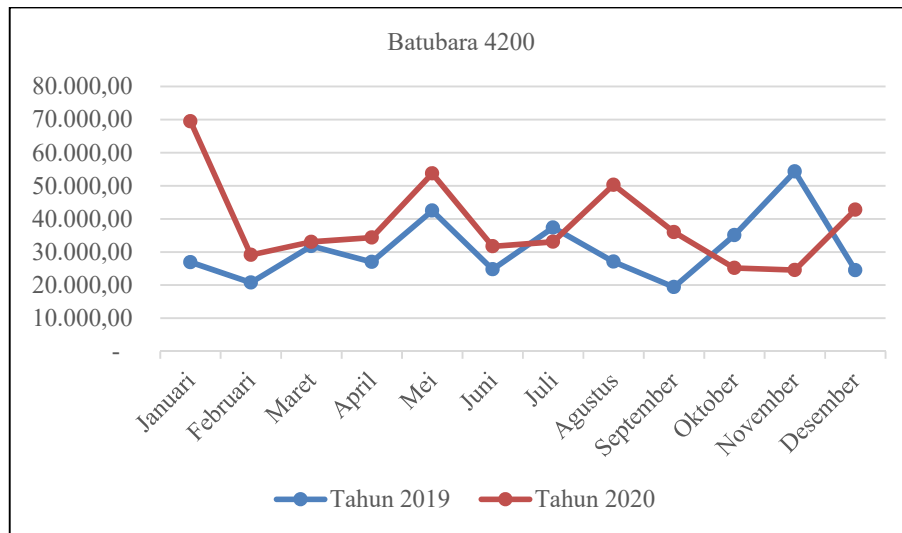
24

$$= \text{Rp. } 3.304.232.723$$

LAMPIRAN 4

Lampiran 4 berisi pola data permintaan batubara pada tahun 2019 dan tahun 2020.





Lampiran 5

Perhitungan batubara 4100 GAR dengan menggunakan *Silver-Meal*.

Diketahui:

Total Demand = 1.031.422 ton

Biaya Pesan = Rp. 9.128.651.254

Biaya Simpan = Rp. 228,07/ton

Safety Stock = 24.933,10 ton

Perhitungan:

Pemesanan 1:

Biaya pemesanan = Rp. 9.128.651.254

Biaya penyimpanan = Rp. 228,07/ton

$m=1$ A (biaya pesan) = Rp. 9.128.651.254

h (biaya simpan) = $0 \times 89.179,00 = 0$

Jadi biaya *mean* per bulan = $\frac{1}{1} \times (9.128.651.254 + 0)$

= Rp. 9.128.651.254

$m=2$ A (biaya pesan) = Rp. 9.128.651.254

D_2 (Demand ke-2) = 103.045,00

h (biaya simpan) = $1 \times 103.045 \times 228,07$

$$= \text{Rp.}140.254.549,50$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{2}x(9.128.651.254 + (1 \times 103.045 \times \\ &228,07)) \\ &= \text{Rp.} 4.576.076.363,66 \end{aligned}$$

$$m=3 \quad A \text{ (biaya pesan)} = \text{Rp.} 9.128.651.254$$

$$D_3 \text{ (Demand ke-3)} = 75.962$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 2 \times 75.962 \times 228,07 \\ &= \text{Rp.}34.649.306,7 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{3}x(9.128.651.254 + (2 \times 103.045 \times \\ &228,07) + (1 \times 75.962 \times 228,07))) \\ &= \text{Rp.} 3.054.433.520 \end{aligned}$$

Meskipun Biaya untuk $m = 2 >$ biaya untuk $m = 3$; atau Rp. 4.576.076.363,66 > Rp. 3.054.433.520. Namun karena kuantitas permintaan telah melebihi kapasitas gudang maka di ambil $m = 2$. Jumlah batubara 4100 GAR yang dipesan pertama adalah $89.179 + 103.045 = 192.224$ ton.

Pemesanan 2:

$$m=3 \quad A \text{ (biaya pesan)} = \text{Rp.} 9.128.651.254$$

$$D_3 \text{ (Demand ke-3)} = 75.962,00$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 0 \times 75.962 \times 228,07 \\ &= \text{Rp.} 0 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{1}x(9.128.651.254 + (0 \times 75.962,00 \\ &x 228,07) \\ &= \text{Rp.} 9.128.651.254,17 \end{aligned}$$

$$m=4 \quad A \text{ (biaya pesan)} = \text{Rp.} 9.128.651.254$$

$$D_4 \text{ (Demand ke-4)} = 83.787$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 1 \times 83.787 \times 228,07 \\ &= \text{Rp.} 19.109.301,1 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{2}x(9.128.651.254 + (0 \times 75.962 \times \\ &228,07) + (1 \times 83.787 \times 228,07)) \\ &= \text{Rp. } 4.573.880.277,63 \end{aligned}$$

$$m=5 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_5 \text{ (Demand ke-5)} = 90.653$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 2 \times 90.653 \times 228,07 \\ &= \text{Rp. } 41.350.459,4 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{3}x(9.128.651.254 + (0 \times 75.962 \times \\ &228,07) + (1 \times 83.787 \times 228,07) + (2 \\ &\times 90.653 \times 228,07)) \\ &= \text{Rp. } 3.063.037.004,89 \end{aligned}$$

$$m=6 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_6 \text{ (Demand ke-6)} = 79.727$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 3 \times 79.727 \times 228,07 \\ &= \text{Rp. } 54.550.010,7 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{4}x(9.128.651.254 + (0 \times 75.962 \times \\ &228,07) + (1 \times 83.787 \times 228,07) + (2 \\ &\times 90.653 \times 228,07) + (3 \times 79.727 \times \\ &228,07)) \\ &= \text{Rp. } 2.310.915.256 \end{aligned}$$

Meskipun Biaya untuk $m = 5 >$ biaya untuk $m = 6$; atau Rp. 3.063.037.004,89 > Rp. 2.310.915.256. Namun karena kuantitas permintaan telah melebihi kapasitas gudang maka di ambil $m = 5$. Jumlah batubara 4100 GAR yang dipesan kedua adalah $75.962,00 + 83.787 + 90.653 = 250.402$ ton.

Pemesanan 3:

$$m=6 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_6 \text{ (Demand ke-6)} = 79.727$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 0 \times 79.727 \times 228,07 \\ &= \text{Rp. } 0 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{1} \times (9.128.651.254 + (0 \times 79.727 \times \\ &228,07)) \\ &= \text{Rp. } 9.128.651.254 \end{aligned}$$

$$m=7 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_7 \text{ (Demand ke-7)} = 93.993$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 1 \times 93.993 \times 228,07 \\ &= \text{Rp. } 21.436.983,51 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{2} \times (9.128.651.254 + (0 \times 79.727 \times \\ &228,07) + (1 \times 93.993 \times 228,07)) \\ &= \text{Rp. } 4.575.044.118,84 \end{aligned}$$

$$m=8 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_8 \text{ (Demand ke-8)} = 95.484$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 2 \times 95.484 \times 228,07 \\ &= \text{Rp. } 43.554.071,76 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{3} \times (9.128.651.254 + (0 \times 79.727 \times \\ &228,07) + (1 \times 93.993 \times 228,07) + (2 \times \\ &95.484 \times 228,07)) \\ &= \text{Rp. } 3.064.547.436 \end{aligned}$$

Meskipun Biaya untuk $m = 7 >$ biaya untuk $m = 8$; atau Rp. 4.575.044.118,84 $>$ Rp. 3.064.547.436. Namun karena kuantitas permintaan telah melebihi kapasitas gudang maka di ambil $m = 7$. Jumlah batubara 4100 GAR yang dipesan ketiga adalah $79.727 + 93.993 = 173.720$ ton.

Pemesanan 4:

$$m=8 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_8 \text{ (Demand ke-8)} = 95.484$$

$$h \text{ (biaya simpan)} = 0 \times 95.484 \times 228,07$$

$$= \text{Rp. } 0$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{1}x(9.128.651.254 + (0 \times 95.484 \times \\ &228,07)) \\ &= \text{Rp. } 9.128.651.254 \end{aligned}$$

$$m=9 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_9 \text{ (Demand ke-9)} = 127.614$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 1 \times 127.614 \times 228,07 \\ &= \text{Rp. } 29.104.924,98 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{2}x(9.128.651.254 + (0 \times 95.484 \times \\ &228,07) + (1 \times 127.614 \times 228,07)) \\ &= \text{Rp. } 4.578.878.089 \end{aligned}$$

$$m=10 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_{10} \text{ (Demand ke10)} = 24.491$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 2 \times 24.491 \times 228,07 \\ &= \text{Rp. } 11.171.324,74 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{3}x(9.128.651.254 + (0 \times 95.484 \times \\ &228,07) + (1 \times 127.614 \times 228,07) + (2 \times 24.491 \times 228,07)) \\ &= \text{Rp. } 3.056.309.167,96 \end{aligned}$$

$$m=11 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_{11} \text{ (Demand ke11)} = 65.144$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 3 \times 65.144 \times 228,07 \\ &= \text{Rp. } 44.572.176,24 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{4}x(9.128.651.254 + (0 \times 95.484 \times \\ &228,07) + (1 \times 127.614 \times 228,07) + (2 \\ &\times 24.491 \times 228,07) + (3 \times 65.144 \times \\ &228,07)) \\ &= \text{Rp. } 2.303.374.920,03 \end{aligned}$$

Meskipun Biaya untuk $m = 10 >$ biaya untuk $m = 11$; atau $\text{Rp.}3.056.309.167,96 > \text{Rp.}2.303.374.920,03$. Namun karena

kuantitas permintaan telah melebihi kapasitas gudang maka di ambil $m = 10$. Jumlah batubara 4100 GAR yang dipesan ketiga adalah $79.727 + 93.993 = 247.589$ ton.

Pemesanan 5:

$$m=11 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_{11} \text{ (Demand ke11)} = 65.144$$

$$h \text{ (biaya simpan)} = 0 \times 65.144 \times 228,07 \\ = \text{Rp. } 0$$

$$\text{Jadi biaya mean per bulan} = \frac{1}{1} \times (9.128.651.254 + (0 \times 65.144 \times 228,07)) \\ = \text{Rp. } 9.128.651.254$$

$$m=12 \quad A \text{ (biaya pesan)} = \text{Rp. } 9.128.651.254$$

$$D_{12} \text{ (Demand ke12)} = 102.343$$

$$h \text{ (biaya simpan)} = 1 \times 102.343 \times 228,07 \\ = \text{Rp. } 23.341.368,01$$

$$\text{Jadi biaya mean per bulan} = \frac{1}{2} \times (9.128.651.254 + (0 \times 65.144 \times 228,07) + (1 \times 102.343 \times 228,07)) \\ = \text{Rp. } 4.575.996.311,09$$

Pemesanan kelima sebesar 167.487 ton.

Lampiran 6

Berikut contoh perhitungan metode Algoritma *Silver-Meal* untuk batubara 4200 GAR

Diketahui:

$$\text{Total Demand} = 461.472 \text{ ton}$$

$$\text{Biaya Pesan} = \text{Rp. } 3.304.232.723$$

$$\text{Biaya Simpan} = \text{Rp. } 228,07/\text{ton}$$

$$\text{Safety Stock} = 9.822,42 \text{ ton}$$

Perhitungan:

Pemesanan 1:

$$\begin{aligned}
&\text{Biaya pemesanan} &&= \text{Rp. } 3.304.232.723 \\
&\text{Biaya penyimpanan} &&= \text{Rp. } 228,07/\text{ton} \\
m=1 & \text{ A (biaya pesan)} &&= \text{Rp. } 3.304.232.723 \\
& \text{ h (biaya simpan)} &&= 0 \times 64.965,00 = 0 \\
&\text{Jadi biaya } mean \text{ per bulan} &&= \frac{1}{1} \times (3.304.232.723 + 0) \\
&&&= \text{Rp. } 3.304.232.723 \\
m=2 & \text{ A (biaya pesan)} &&= \text{Rp. } 3.304.232.723 \\
& \text{ D}_2 \text{ (Demand ke-2)} &&= 33.150 \\
& \text{ h (biaya simpan)} &&= 1 \times 33.150 \times 228,07 \\
&&&= \text{Rp. } 7.560.520,5 \\
&\text{Jadi biaya } mean \text{ per bulan} &&= \frac{1}{2} \times (3.304.232.723 + (1 \times 33.150 \times \\
&&&228,07)) \\
&&&= \text{Rp. } 1.655.896.621,71 \\
m=3 & \text{ A (biaya pesan)} &&= \text{Rp. } 3.304.232.723 \\
& \text{ D}_3 \text{ (Demand ke-3)} &&= 32.670,00 \\
& \text{ h (biaya simpan)} &&= 2 \times 32.670 \times 228,07 \\
&&&= \text{Rp. } 14.902.093,80 \\
&\text{Jadi biaya } mean \text{ per bulan} &&= \frac{1}{3} \times (3.304.232.723 + (1 \times 33.150 \times \\
&&&228,07) + (2 \times 32.670 \times 228,07)) \\
&&&= \text{Rp. } 1.108.898.445,74 \\
m=4 & \text{ A (biaya pesan)} &&= \text{Rp. } 3.304.232.723 \\
& \text{ D}_4 \text{ (Demand ke-4)} &&= 34.236 \\
& \text{ h (biaya simpan)} &&= 3 \times 34.236 \times 228,07 \\
&&&= \text{Rp. } 23.424.613,56 \\
&\text{Jadi biaya } mean \text{ per bulan} &&= \frac{1}{4} \times (3.304.232.723 + (1 \times 33.150 \times \\
&&&228,07) + (2 \times 32.670 \times 228,07) + (3 \\
&&&\times 34.236 \times 228,07)) \\
&&&= \text{Rp. } 837.529.987,69 \\
m=5 & \text{ A (biaya pesan)} &&= \text{Rp. } 3.304.232.723 \\
& \text{ D}_5 \text{ (Demand ke-5)} &&= 51.798
\end{aligned}$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 4 \times 51.798 \times 228,07 \\ &= \text{Rp. } 47.254.279,44 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{5} \times (3.304.232.723 + (1 \times 33.150 \times \\ &228,07) + (2 \times 32.670 \times 228,07) + (3 \\ &\times 34.236 \times 228,07) + (4 \times 51.798 \times \\ &228,07)) \\ &= \text{Rp. } 679.474.846,04 \end{aligned}$$

$$m=6 \quad A \text{ (biaya pesan)} = \text{Rp. } 3.304.232.723$$

$$D_6 \text{ (Demand ke-6)} = 33.912$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 5 \times 33.912 \times 228,07 \\ &= \text{Rp. } 38.671.549,20 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{6} \times (3.304.232.723 + (1 \times 33.150 \times \\ &228,07) + (2 \times 32.670 \times 228,07) + (3 \\ &\times 34.236 \times 228,07) + (4 \times 51.798 \times \\ &228,07) + (5 \times 33.912 \times 228,07)) \\ &= \text{Rp. } 681.813.411,32 \end{aligned}$$

$$m=7 \quad A \text{ (biaya pesan)} = \text{Rp. } 572.674.296,57$$

$$D_7 \text{ (Demand ke-7)} = 32.936$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 6 \times 32.936 \times 228,07 \\ &= \text{Rp. } 45.070.281,12 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya } mean \text{ per bulan} &= \frac{1}{7} \times (3.304.232.723 + (1 \times 33.150 \times \\ &228,07) + (2 \times 32.670 \times 228,07) + (3 \\ &\times 34.236 \times 228,07) + (4 \times 51.798 \times \\ &228,07) + (5 \times 33.912 \times 228,07) + (6 \\ &\times 32.936 \times 1.371,10)) \\ &= \text{Rp. } 497.302.294,36 \end{aligned}$$

Meskipun Biaya untuk $m = 6 >$ biaya untuk $m = 7$; atau Rp.681.813.411,32 $>$ Rp.497.302.294,36. Namun karena kuantitas permintaan telah melebihi kapasitas gudang maka di

ambil $m = 6$. Jumlah batubara 4100 GAR yang dipesan pertama adalah $64.965,00 + 33.150,00 + 32.670,00 + 34.236,00 + 51.798,00 + 33.912,00 = 250.731$ ton.

Pemesanan 2:

$$m=7 \quad A \text{ (biaya pesan)} = \text{Rp. } 572.674.296,57$$

$$D_7 \text{ (Demand ke-7)} = 32.936$$

$$h \text{ (biaya simpan)} = 0 \times 32.936 \times 228,07 \\ = \text{Rp. } 0$$

$$\text{Jadi biaya mean per bulan} = \frac{1}{1} \times (3.304.232.723 + (0 \times 32.936 \times 228,07)) \\ = \text{Rp. } 3.304.232.722,92$$

$$m=8 \quad A \text{ (biaya pesan)} = \text{Rp. } 3.304.232.723$$

$$D_8 \text{ (Demand ke-8)} = 48.567$$

$$h \text{ (biaya simpan)} = 1 \times 48.567 \times 228,07 \\ = \text{Rp. } 11.076.675,69$$

$$\text{Jadi biaya mean per bulan} = \frac{1}{2} \times (3.304.232.723 + (0 \times 32.936 \times 228,07) + (1 \times 48.567 \times 228,07)) \\ = \text{Rp. } 1.657.654.699,30$$

$$m=9 \quad A \text{ (biaya pesan)} = \text{Rp. } 3.304.232.723$$

$$D_9 \text{ (Demand ke-9)} = 37.441$$

$$h \text{ (biaya simpan)} = 2 \times 37.441 \times 228,07 \\ = \text{Rp. } 17.078.337,74$$

$$\text{Jadi biaya mean per bulan} = \frac{1}{3} \times (3.304.232.723 + (0 \times 32.936 \times 228,07) + (1 \times 48.567 \times 228,07) + (2 \times 37.441 \times 228,07)) \\ = \text{Rp. } 1.110.795.912,12$$

$$m=10 \quad A \text{ (biaya pesan)} = \text{Rp. } 3.304.232.723$$

$$D_{10} \text{ (Demand ke10)} = 26.256$$

$$h \text{ (biaya simpan)} = 3 \times 26.256 \times 228,07$$

$$= \text{Rp. } 17.964.617,76$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{4} \times (3.304.232.723 + (0 \times 32.936 \times \\ &228,07) + (1 \times 48.567 \times 228,07) + (2 \\ &\times 37.441 \times 228,07) + (3 \times 26.256 \times \\ &228,07)) \\ &= \text{Rp. } 837.588.088,53 \end{aligned}$$

$$m=11 \quad A \text{ (biaya pesan)} = \text{Rp. } 3.304.232.723$$

$$D_{11} \text{ (Demand ke11)} = 24.604$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 4 \times 24.604 \times 228,07 \\ &= \text{Rp. } 22.445.737,12 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{5} \times (3.304.232.723 + (0 \times 32.936 \times \\ &228,07) + (1 \times 48.567 \times 228,07) + (2 \\ &\times 37.441 \times 228,07) + (3 \times 26.256 \times \\ &228,07) + (4 \times 24.604 \times 228,07)) \\ &= \text{Rp. } 674.559.618,25 \end{aligned}$$

$$m=12 \quad A \text{ (biaya pesan)} = \text{Rp. } 3.304.232.723$$

$$D_{12} \text{ (Demand ke12)} = 40.937$$

$$\begin{aligned} h \text{ (biaya simpan)} &= 5 \times 40.937 \times 228,07 \\ &= \text{Rp. } 46.682.507,95 \end{aligned}$$

$$\begin{aligned} \text{Jadi biaya mean per bulan} &= \frac{1}{6} \times (3.304.232.723 + (0 \times 32.936 \times \\ &228,07) + (1 \times 48.567 \times 228,07) + (2 \\ &\times 37.441 \times 228,07) + (3 \times 26.256 \times \\ &228,07) + (4 \times 24.604 \times 228,07) + (5 \times \\ &40.937 \times 228,07)) \\ &= \text{Rp. } 569.913.433,20 \end{aligned}$$

Pemesanan kedua sebesar 210.741 ton.

Lampiran 7

Rumus 1 Algoritma *Wagner-Within*

Perhitungan:

Periode 1

$$Q_{11} = c_{1e1} = 89.179 \text{ ton}$$

$$Q_{12} = c_{1e1} + c_{2e2} = 89.179 + 103.045 = 192.224 \text{ ton}$$

$$Q_{13} = c_{1e1} + c_{2e2} + c_{3e3} = 89.179 + 103.045 + 75.962 = 268.186 \text{ ton}$$

$$Q_{14} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} = 89.179 + 103.045 + 75.962 + 83.787 = 351.973 \text{ ton}$$

$$Q_{15} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} = 89.179 + 103.045 + 75.962 + 83.787 + 90.653 = 442.626 \text{ ton}$$

$$Q_{16} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} = 89.179 + 103.045 + 75.962 + 83.787 + 90.653 + 91.623 = 522.353 \text{ ton}$$

$$Q_{17} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} = 89.179 + 103.045 + 75.962 + 83.787 + 90.653 + 91.623 + 93.993 = 616.346 \text{ ton}$$

$$Q_{18} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} = 89.179 + 103.045 + 75.962 + 83.787 + 90.653 + 91.623 + 93.993 + 95.484 = 711.830 \text{ ton}$$

$$Q_{19} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} = 89.179 + 103.045 + 75.962 + 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 = 839.444 \text{ ton}$$

$$Q_{110} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} = 89.179 + 103.045 + 75.962 + 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + 24.491 = 863.935 \text{ ton}$$

$$Q_{111} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} = 89.179 + 103.045 + 75.962 + 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + 24.491 + 65.144 = 929.079 \text{ ton}$$

$$Q_{112} = c_{1e1} + c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} +$$

$$\begin{aligned}
& c_{9e9} + c_{10e10} + c_{11e11} + c_{12e12} = 89.179 + 103.045 + \\
& 75.962 + 83.787 + 90.653 + 91.623 + 93.993 + \\
& 95.484 + 127.614 + 24.491 + 65.144 + 102.343 = \\
& 1.031.422 \text{ ton}
\end{aligned}$$

Periode 2

$$Q_{22} = c_{2e2} = 103.045 \text{ ton}$$

$$Q_{23} = c_{2e2} + c_{3e3} = 103.045 + 75.962 = 179.007 \text{ ton}$$

$$\begin{aligned}
Q_{24} &= c_{2e2} + c_{3e3} + c_{4e4} = 103.045 + 75.962 + 83.787 = \\
& 262.794 \text{ ton}
\end{aligned}$$

$$\begin{aligned}
Q_{25} &= c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} = 103.045 + 75.962 + \\
& 83.787 + 90.653 = 415.463 \text{ ton}
\end{aligned}$$

$$\begin{aligned}
Q_{26} &= c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} = 103.045 + 75.962 + \\
& 83.787 + 90.653 + 91.623 = 433.174 \text{ ton}
\end{aligned}$$

$$\begin{aligned}
Q_{27} &= c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} = 103.045 + \\
& 75.962 + 83.787 + 90.653 + 91.623 + 93.993 = \\
& 527.167 \text{ ton}
\end{aligned}$$

$$\begin{aligned}
Q_{28} &= c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} = \\
& 103.045 + 75.962 + 83.787 + 90.653 + 91.623 + \\
& 93.993 + 95.484 = 622.651 \text{ ton}
\end{aligned}$$

$$\begin{aligned}
Q_{29} &= c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} = \\
& 103.045 + 75.962 + 83.787 + 90.653 + 91.623 + \\
& 93.993 + 95.484 + 127.614 = 750.265 \text{ ton}
\end{aligned}$$

$$\begin{aligned}
Q_{210} &= c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + \\
& c_{10e10} = 103.045 + 75.962 + 83.787 + 90.653 + \\
& 91.623 + 93.993 + 95.484 + 127.614 + 24.491 = \\
& 774.756 \text{ ton}
\end{aligned}$$

$$\begin{aligned}
Q_{211} &= c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + \\
& c_{10e10} + c_{11e11} = 103.045 + 75.962 + 83.787 + \\
& 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + \\
& 24.491 + 65.144 = 839.900 \text{ ton}
\end{aligned}$$

$$Q_{212} = c_{2e2} + c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} +$$

$$c_{10e10} + c_{11e11} + c_{12e12} = 103.045 + 75.962 + 83.787 \\ + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + \\ 24.491 + 65.144 + 102.343 = 942.243 \text{ ton}$$

Periode 3

$$Q_{33} = c_{3e3} = 75.962 \text{ ton}$$

$$Q_{34} = c_{3e3} + c_{4e4} = 75.962 + 83.787 = 159.749 \text{ ton}$$

$$Q_{35} = c_{3e3} + c_{4e4} + c_{5e5} = 75.962 + 83.787 + 90.653 = \\ 347.458 \text{ ton}$$

$$Q_{36} = c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} = 75.962 + 83.787 + \\ 90.653 + 91.623 = 330.129 \text{ ton}$$

$$Q_{37} = c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} = 75.962 + 83.787 \\ + 90.653 + 91.623 + 93.993 = 424.122 \text{ ton}$$

$$Q_{38} = c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} = 75.962 + \\ 83.787 + 90.653 + 91.623 + 93.993 + 95.484 = \\ 519.606 \text{ ton}$$

$$Q_{39} = c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} = 75.962 \\ + 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + \\ 127.614 = 647.220 \text{ ton}$$

$$Q_{310} = c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} \\ = 75.962 + 83.787 + 90.653 + 91.623 + 93.993 \\ + 95.484 + 127.614 + 24.491 = 671.711 \text{ ton}$$

$$Q_{311} = c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + \\ c_{11e11} = 75.962 + 83.787 + 90.653 + 91.623 + \\ 93.993 + 95.484 + 127.614 + 24.491 + 65.144 = \\ 736.855 \text{ ton}$$

$$Q_{312} = c_{3e3} + c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} \\ + c_{11e11} + c_{12e12} = 75.962 + 83.787 + 90.653 + \\ 91.623 + 93.993 + 95.484 + 127.614 + 24.491 + \\ 65.144 + 102.343 = 839.198 \text{ ton}$$

Periode 4

$$Q_{44} = c_{4e4} = 83.787 \text{ ton}$$

$$Q_{45} = c_{4e4} + c_{5e5} = 83.787 + 90.653 = 207.595 \text{ ton}$$

$$Q_{46} = c_{4e4} + c_{5e5} + c_{6e6} = 83.787 + 90.653 + 91.623 = 254.167 \text{ ton}$$

$$Q_{47} = c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} = 83.787 + 90.653 + 91.623 + 93.993 = 348.160 \text{ ton}$$

$$Q_{48} = c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} = 83.787 + 90.653 + 91.623 + 93.993 + 95.484 = 443.644 \text{ ton}$$

$$Q_{49} = c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} = 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 = 571.258 \text{ ton}$$

$$Q_{410} = c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} = 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + 24.491 = 595.749 \text{ ton}$$

$$Q_{411} = c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} = 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + 24.491 + 65.144 = 660.893 \text{ ton}$$

$$Q_{412} = c_{4e4} + c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} + c_{12e12} = 83.787 + 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + 24.491 + 65.144 + 102.343 = 763.236 \text{ ton}$$

Periode 5

$$Q_{55} = c_{5e5} = 90.653 \text{ ton}$$

$$Q_{56} = c_{5e5} + c_{6e6} = 90.653 + 91.623 = 170.380 \text{ ton}$$

$$Q_{57} = c_{5e5} + c_{6e6} + c_{7e7} = 90.653 + 91.623 + 93.993 = 264.373 \text{ ton}$$

$$Q_{58} = c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} = 90.653 + 91.623 + 93.993 + 95.484 = 359.857 \text{ ton}$$

$$Q_{59} = c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} = 90.653 + 91.623 + 93.993 + 95.484 + 127.614 = 487.471 \text{ ton}$$

$$Q_{510} = c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} = 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + 24.491 =$$

511.962 ton

$$\begin{aligned} Q_{511} &= c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} = \\ &90.653 + 91.623 + 93.993 + 95.484 + 127.614 + \\ &24.491 + 65.144 = 577.106 \text{ ton} \end{aligned}$$

$$\begin{aligned} Q_{512} &= c_{5e5} + c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} + c_{12e12} \\ &= 90.653 + 91.623 + 93.993 + 95.484 + 127.614 + \\ &24.491 + 65.144 + 102.343 = 679.449 \text{ ton} \end{aligned}$$

Periode 6

$$Q_{66} = c_{6e6} = 91.623 \text{ ton}$$

$$Q_{67} = c_{6e6} + c_{7e7} = 91.623 + 93.993 = 173.720 \text{ ton}$$

$$\begin{aligned} Q_{68} &= c_{6e6} + c_{7e7} + c_{8e8} = 91.623 + 93.993 + 95.484 = \\ &269.204 \text{ ton} \end{aligned}$$

$$\begin{aligned} Q_{69} &= c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} = 91.623 + 93.993 + 95.484 \\ &+ 127.614 = 396.818 \text{ ton} \end{aligned}$$

$$\begin{aligned} Q_{610} &= c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} = 91.623 + 93.993 \\ &+ 95.484 + 127.614 + 24.491 = 421.309 \text{ ton} \end{aligned}$$

$$\begin{aligned} Q_{611} &= c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} = 91.623 + \\ &93.993 + 95.484 + 127.614 + 24.491 + 65.144 = \\ &486.453 \text{ ton} \end{aligned}$$

$$\begin{aligned} Q_{612} &= c_{6e6} + c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} + c_{12e12} = \\ &91.623 + 93.993 + 95.484 + 127.614 + 24.491 + \\ &65.144 + 102.343 = 588.796 \text{ ton} \end{aligned}$$

Periode 7

$$Q_{77} = c_{7e7} = 93.993 \text{ ton}$$

$$Q_{78} = c_{7e7} + c_{8e8} = 93.993 + 95.484 = 189.477 \text{ ton}$$

$$\begin{aligned} Q_{79} &= c_{7e7} + c_{8e8} + c_{9e9} = 93.993 + 95.484 + 127.614 = \\ &317.091 \text{ ton} \end{aligned}$$

$$\begin{aligned} Q_{710} &= c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} = 93.993 + 95.484 + \\ &127.614 + 24.491 = 341.582 \text{ ton} \end{aligned}$$

$$\begin{aligned} Q_{711} &= c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} = 93.993 + 95.484 \\ &+ 127.614 + 24.491 + 65.144 = 406.726 \text{ ton} \end{aligned}$$

$$Q_{712} = c_{7e7} + c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} + c_{12e12} = 93.993 + 95.484 + 127.614 + 24.491 + 65.144 + 102.343 = 509.069 \text{ ton}$$

Periode 8

$$Q_{88} = c_{8e8} = 95.484 \text{ ton}$$

$$Q_{89} = c_{8e8} + c_{9e9} = 95.484 + 127.614 = 223.098 \text{ ton}$$

$$Q_{810} = c_{8e8} + c_{9e9} + c_{10e10} = 95.484 + 127.614 + 24.491 = 247.589 \text{ ton}$$

$$Q_{811} = c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} = 95.484 + 127.614 + 24.491 + 65.144 = 312.733 \text{ ton}$$

$$Q_{812} = c_{8e8} + c_{9e9} + c_{10e10} + c_{11e11} + c_{12e12} = 95.484 + 127.614 + 24.491 + 65.144 + 102.343 = 415.076 \text{ ton}$$

Periode 9

$$Q_{99} = c_{9e9} = 127.614 \text{ ton}$$

$$Q_{910} = c_{9e9} + c_{10e10} = 127.614 + 24.491 = 152.105 \text{ ton}$$

$$Q_{911} = c_{9e9} + c_{10e10} + c_{11e11} = 127.614 + 24.491 + 65.144 = 18.257.302.508,33 ; 217.249 \text{ ton}$$

$$Q_{912} = c_{9e9} + c_{10e10} + c_{11e11} + c_{12e12} = 127.614 + 24.491 + 65.144 + 102.343 = 18.257.302.508,33 ; 319.592$$

ton

Periode 10

$$Q_{1010} = c_{10e10} = 24.491 \text{ ton}$$

$$Q_{1011} = c_{10e10} + c_{11e11} = 24.491 + 65.144 = 89.635 \text{ ton}$$

$$Q_{1012} = c_{10e10} + c_{11e11} + c_{12e12} = 24.491 + 65.144 + 102.343 = 191.978 \text{ ton}$$

Periode 11

$$Q_{1111} = c_{11e11} = 65.144 \text{ ton}$$

$$Q_{1112} = c_{11e11} + c_{12e12} = 65.144 + 102.343 = 167.487 \text{ ton}$$

Periode 12

$$Q_{1212} = c_{12e12} = 102.343 \text{ ton}$$

Lampiran 8

Total Biaya Variabel (Z_{cc}) Algoritma *Wagner-Within*

Periode 1

$$Z_{11} = 9.128.651.254,17 + 228,07 (89.179 - 89.179) = 9.128.651.254,17$$

$$Z_{12} = 9.128.651.254,17 + 228,07 [(192.224 - 89.179) + (192.224 - 192.224)] = 9.152.152.727,32$$

Periode 2

$$Z_{22} = 9.128.651.254,17 + 228,07 (103.045 - 103.045) = 9.128.651.254,17$$

$$Z_{23} = 9.128.651.254,17 + 228,07 [(179.007 - 103.045) + (179.007 - 179.007)] = 9.145.975.907,51$$

Periode 3

$$Z_{33} = 9.128.651.254,17 + 228,07 (75.962 - 75.962) = 9.128.651.254,17$$

$$Z_{34} = 9.128.651.254,17 + 228,07 [(159.749 - 75.962) + (159.749 - 159.749)] = 9.147.760.555,26$$

$$Z_{35} = 9.128.651.254,17 + 228,07 [(347.458 - 75.962) + (347.458 - 159.749) + (347.458 - 347.458)] = 9.189.111.014,68$$

Periode 4

$$Z_{44} = 9.128.651.254,17 + 228,07 (83.787 - 83.787) = 9.128.651.254,17$$

$$Z_{45} = 9.128.651.254,17 + 228,07 [(207.595 - 83.787) + (207.595 - 207.595)] = 9.149.326.483,88$$

$$Z_{46} = 9.128.651.254,17 + 228,07 [(254.167 - 83.787) + (254.167 - 207.595) + (254.167 - 254.167)] =$$

Periode 5

$$Z_{55} = 9.128.651.254,17 + 228,07 (90.653 - 90.653) = 9.128.651.254,17$$

$$Z_{56} = 9.128.651.254,17 + 228,07 [(170.380 - 90.653) + (170.380 - 170.380)] = 9.146.834.591,06$$

Periode 6

$$Z_{66} = 9.128.651.254,17 + 228,07 (79.727 - 79.727) = 9.128.651.254,17$$

$$Z_{67} = 9.128.651.254,17 + 228,07 [(264.373 - 79.727) + (264.373 - 264.373)] = 9.150.088.237,68$$

Periode 7

$$Z_{77} = 9.128.651.254,17 + 228,07 (93.993 - 93.993) = 9.128.651.254,17$$

$$Z_{78} = 9.128.651.254,17 + 228,07 [(189.477 - 93.993) + (189.477 - 189.477)] = 9.150.428.290,05$$

Periode 8

$$Z_{88} = 9.128.651.254,17 + 228,07 (95.484 - 95.484) = 9.128.651.254,17$$

$$Z_{89} = 9.128.651.254,17 + 228,07 [(223.098 - 95.484) + (223.098 + 223.098)] = 9.157.756.179,15$$

$$Z_{810} = 9.128.651.254,17 + 228,07 [(22.910.952 - 95.484) + (22.910.952 + 223.098) + (22.910.952 - 22.910.952)] = 9.168.927.503,89$$

Periode 9

$$Z_{99} = 9.128.651.254,17 + 228,07 (127.614 - 127.614) = 9.128.651.254,17$$

$$Z_{910} = 9.128.651.254,17 + 228,07 [(16.084.884 - 127.614) + (16.084.884 - 16.084.884)] = 9.134.236.916,54$$

$$Z_{911} = 9.128.651.254,17 + 228,07 [(217.249 - 127.614) + (217.249 - 16.084.884) + (217.249 - 217.249)] = 9.163.951.700,70$$

Periode 10

$$Z_{1010} = 9.128.651.254,17 + 228,07 (24.491 - 24.491) = 9.128.651.254,17$$

$$Z_{1011} = 9.128.651.254,17 + 228,07 [(89.635 - 24.491) + (89.635 - 89.635)] = 9.143.508.646,25$$

$$Z_{1012} = 9.128.651.254,17 + 228,07 [(191.978 - 24.491) + (191.978 - 89.635) + (191.978 - 191.978)] = 9.190.191.382,27$$

Periode 11

$$Z_{1111} = 9.128.651.254,17 + 228,07 (65.144 - 65.144) = 9.128.651.254,17$$

$$Z_{1112} = 9.128.651.254,17 + 228,07 (167.487 - 65.144) + (167.487 - 167.487)] = 9.151.992.622,18$$

Periode 12

$$Z_{1111} = 9.128.651.254,17 + 228,07 (102.343 - 65.144 - 102.343) = 9.128.651.254,17$$

Lampiran 9

Perhitungan Biaya Minimum

$$F_1 = \text{Min}\{Z_{11} + f_0 ; Z_{12} + f_0\}$$

$$\text{Min} \{ 9.128.651.254,17 + 0 ; 9.152.152.727,32 + 0\}$$

$$= 9.128.651.254,17 \text{ untuk } Z_{11} + F_0$$

$$F_2 = \text{Min}\{Z_{22} + f_1 ; Z_{23} + f_1\}$$

$$\text{Min} \{9.128.651.254,17 + 9.128.651.254,17 ;$$

$$9.145.975.907,51 + 9.128.651.254,17\} =$$

$$18.257.302.508,33 \text{ untuk } Z_{22} + F_1$$

$$F_3 = \text{Min}\{Z_{33} + f_2 ; Z_{34} + f_2 ; Z_{35} + f_2 ; \}$$

$$\text{Min} \{9.128.651.254,17 + 18.257.302.508,33 ;$$

$$9.147.760.555,26 + 18.257.302.508,33 ;$$

$$9.189.111.014,68 + 18.257.302.508,33\} =$$

$$27.385.953.762,50 \text{ untuk } Z_{33} + F_2$$

$$F_4 = \text{Min}\{Z_{44} + f_3 ; Z_{45} + f_3 ; Z_{46} + f_3\}$$

$$\text{Min} \{9.128.651.254,17 + 27.385.953.762,50 ;$$

$$9.147.760.555,26 + 27.385.953.762,50 ;$$

$$9.189.111.014,68 + 27.385.953.762,50 = 36.514.605.016,67 \text{ untuk } Z_{44} + F_3$$

$$F_5 = \text{Min}\{Z_{55} + f_4 ; Z_{56} + f_4\}$$

$$\text{Min} \{9.128.651.254,17 + 45.643.256.270,83 ; 9.146.834.591,06 + 45.643.256.270,83\} = 45.643.256.270,83 \text{ untuk } Z_{55} + F_4$$

$$F_6 = \text{Min}\{Z_{66} + f_5 ; Z_{67} + f_5\}$$

$$\text{Min} \{ 9.128.651.254,17 + 54.771.907.525; 9.150.088.237,68 + 18.257.302.508,33\} = 54.771.907.525 \text{ untuk } Z_{66} + F_5$$

$$F_7 = \text{Min}\{Z_{77} + f_6 ; Z_{78} + f_6\}$$

$$\text{Min} \{ 9.128.651.254,17 + 54.771.907.525; 9.150.428.290,05 + 54.771.907.525\} = 63.900.558.779,17 \text{ untuk } Z_{77} + F_6$$

$$F_8 = \text{Min}\{Z_{88} + f_7 ; Z_{89} + f_7 ; Z_{810} + f_7\}$$

$$\text{Min} \{ 9.128.651.254,17 + 63.900.558.779,17; 9.157.756.179,15 + 63.900.558.779,17; 9.168.927.503,89 + 63.900.558.779,17\} = 73.029.210.033,33 \text{ untuk } Z_{88} + F_7$$

$$F_9 = \text{Min}\{Z_{99} + f_8 ; Z_{910} + f_8 ; Z_{911} + f_8\}$$

$$\text{Min} \{9.128.651.254,17 + 73.029.210.033,33; 9.134.236.916,54 + 73.029.210.033,33; 9.163.951.700,70 + 73.029.210.033,33\} = 82.157.861.287,50 \text{ untuk } Z_{99} + F_8$$

$$F_{10} = \text{Min}\{Z_{1010} + f_9 ; Z_{1011} + f_9 ; Z_{1012} + f_9\}$$

$$\text{Min} \{ 9.128.651.254,17 + 82.157.861.287,50; 9.143.508.646,25 + 82.157.861.287,50; 9.190.191.382,27 + 82.157.861.287,50\} = 91.286.512.541,67 \text{ untuk } Z_{1010} + F_9$$

$$F_{11} = \text{Min}\{Z_{1111} + f_{10} ; Z_{1112} + f_{10}\}$$

$$\begin{aligned} & \text{Min} \{9.128.651.254,17 + 91.286.512.541,67; \\ & 9.151.992.622,18 + 91.286.512.541,67\} = \\ & 100.415.163.795,83 \text{ untuk } Z_{1111} + F_{10} \end{aligned}$$

$$F_{12} = \text{Min}\{Z_{1212} + f_{11}\}$$

$$\begin{aligned} & \text{Min} \{9.128.651.254,17 + 100.415.163.795,83\} = \\ & 109.543.815.050 \text{ untuk } Z_{1212} + F_{11} \end{aligned}$$

Lampiran 10

Grafik perbandingan *Safety Stock & Reorder Point* batubara

