DATA UNTUK VERIFIKASI DAN VALIDASI MODEL

Types of HSR	Haramain	LIMIT
	AVE Class 102	
Manufactured/Derived from	Talgo & Bombardier	
Design Speed (km/h)	330	475
Trainsets (cars)	14	-
Seat Capacity (pax)	314	-
1st class	121	-
2nd class	193	-
Max. axle load (tons)	17	17.68
Train Length (m)	200	400
Width (mm)	2,960	3587
Height (mm)	3,360	4898
Floor height (mm)	1,250	1250
Weight per train (tons)	324	-
Weight per car (tons)	27	68
Price (in million)	Rp 634,067	-
Buying costs (in million)	Rp 592,586	-
Leasing cost (in million)	Rp 41,481	-
Operating Costs	Rp 118,517	-
Maintenance costs	Rp 21,533	-
Total costs	Rp 914,166	-
Buy	Rp 732,636	-
Lease	Rp 181,531	-

Sumber: KHI, Talgo

Verif_step_2

Global optimal solution found.

Objective value:	2178.372
Objective bound:	2178.372
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.25
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	4
Nonlinear constraints:	0
Total nonzeros:	8
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	0.000000	732.6360
X2	12.00000	181.5310

Row	Slack or Surplus	Dual Price
1	2178.372	-1.000000
2	3423.378	0.000000
3	0.7718400	0.000000
4	62640.00	0.000000

VALIDASI MODEL – LP RELAKSASI

Tahap 1 - Iterasi 0

Basis	X1	X2	S3	S4	S5	S6	RHS
Z	-0.90432	-0.90432	0	1	0	0	10.08
S3	732.636	181.531	1	0	0	0	5601.75
S5	2880	2880	0	0	1	0	97200
S6	0.90432	0.90432	0	-1	0	1	10.08

Variabel Masuk -> X1
Variabel Keluar -> S3

Tahap 1 - Iterasi 1

Basis	X1	X2	S3	S4	S5	S6	RHS
Z	0	-0.68025	0.001234	1	0	0	3.16555
X1	1	0.247778	0.001365	0	0	0	7.64602
S5	0	2166.4	-3.93101	0	1	0	75179.5
S6	0	0.68025	-0.00123	-1	0	1	3.16555

Variabel Masuk -> X2
Variabel Keluar -> S6

Tahap 1 - Iterasi 2

Basis	X1	X2	S3	S4	S5	S6	RHS
Z	0	0	0	0	0	1	0
X1	1	0	0.001815	0.364246	0	-0.36425	6.49298
S5	0	0	0	3184.71	1	-3184.71	65098.1
X2	0	1	-0.00181	-1.47005	0	1.47005	4.65351

Tahap 2 - Iterasi 2

Basis	X1	X2	S3	S4	S5	RHS
Z	0	0	-1	0	0	5601.75
X1	1	0	0.001815	0.364246	0	6.49298
S5	0	0	0	3184.71	1	65098.1
X2	0	1	-0.00181	-1.47005	0	4.65351

Variabel Masuk -> S3
Variabel Keluar -> X1

Tahap 2 - Iterasi 3

Basis	X1	X2	S3	S4	S5	RHS
Z	551.105	0	0	200.738	0	2023.43
S3	551.105	0	1	200.738	0	3578.32
S5	0	0	0	3184.71	1	65098.1

X2	1	1	0	-1.1058	0	11.1465

Solusi optimum:

Variabel	Nilai	Biaya
X1	0	732.64
X2	11.15	181.53
Z		2023.43

VALIDASI MODEL – *BRANCH-AND-BOUND*

Tahap 1 - Iterasi 0

Basis	X1	X2	S3	S4	S5	S6	S7	RHS
Z	-0.90432	-0.90432	0	1	0	0	0	10.08
S3	732.636	181.531	1	0	0	0	0	5601.75
S5	2880	2880	0	0	1	0	0	97200
S6	0	1	0	0	0	1	0	11
S7	0.90432	0.90432	0	-1	0	0	1	10.08

Variabel Masuk -> X1
Variabel Keluar -> S3

Tahap 1 - Iterasi 1

Basis	X1	X2	S3	S4	S5	S6	S7	RHS
Z	0	-0.68025	0.001234	1	0	0	0	3.16555
X1	1	0.247778	0.001365	0	0	0	0	7.64602
S5	0	2166.4	-3.93101	0	1	0	0	75179.5
S6	0	1	0	0	0	1	0	11
S7	0	0.68025	-0.00123	-1	0	0	1	3.16555

Variabel Masuk -> X2
Variabel Keluar -> S7

Tahap 1 - Iterasi 2

Basis	X1	X2	S3	S4	S5	S6	S7	RHS
Z	0	0	0	0	0	0	1	0
X1	1	0	0.001815	0.364246	0	0	-0.36425	6.49298
S5	0	0	0	3184.71	1	0	-3184.71	65098.1
S6	0	0	0.001815	1.47005	0	1	-1.47005	6.34649
X2	0	1	-0.00181	-1.47005	0	0	1.47005	4.65351

Tahap 2 - Iterasi 2

Basis	X1	X2	S3	S4	S5	S6	RHS
Z	0	0	-1	0	0	0	5601.75
X1	1	0	0.001815	0.364246	0	0	6.49298
S5	0	0	0	3184.71	1	0	65098.1
S6	0	0	0.001815	1.47005	0	1	6.34649
X2	0	1	-0.00181	-1.47005	0	0	4.65351

Variabel Masuk -> S3 Variabel Keluar -> S6

Tahap 2 - Iterasi 3

Basis	X1	X2	S3	S4	S5	S6	RHS
Z	0	0	0	810.151	0	551.105	2104.17
X1	1	0	0	-1.1058	0	-1	0.146497
S5	0	0	0	3184.71	1	0	65098.1
S3	0	0	1	810.151	0	551.105	3497.58
X2	0	1	0	0	0	1	11

Solusi optimum:

Variabel	Nilai	Biaya
X1	0.15	732.64
X2	11.00	181.53
Z		2104.17

Tahap 1 - Iterasi 0

Basis	X1	X2	S3	S4	S5	S6	S7	S8	RHS
Obj.	-0.90432	-1.90432	0	1	0	1	0	0	22.08
S3	732.636	181.531	1	0	0	0	0	0	5601.75
S5	2880	2880	0	0	1	0	0	0	97200
S7	0.90432	0.90432	0	-1	0	0	1	0	10.08
S8	0	1	0	0	0	-1	0	1	12

Variabel Masuk -> X2
Variabel Keluar -> S7

Tahap 1 - Iterasi 1

Basis	X1	X2	S3	S4	S5	S6	S7	S8	RHS
Obj.	1	0	0	-1.1058	0	1	2.1058	0	0.853503
S3	551.105	0	1	200.738	0	0	-200.738	0	3578.32
S5	0	0	0	3184.71	1	0	-3184.71	0	65098.1
X2	1	1	0	-1.1058	0	0	1.1058	0	11.1465
S8	-1	0	0	1.1058	0	-1	-1.1058	1	0.853503

Variabel Masuk -> S4 Variabel Keluar -> S8

Tahap 1 - Iterasi 2

Basis	X1	X2	S3	S4	S5	S6	S7	S8	RHS
Obj.	0	0	0	0	0	0	1	1	0
S3	732.636	0	1	0	0	181.531	0	-181.531	3423.38
S5	2880	0	0	0	1	2880	0	-2880	62640
X2	0	1	0	0	0	-1	0	1	12
S4	-0.90432	0	0	1	0	-0.90432	-1	0.90432	0.77184

Tahap 2 - Iterasi 2

Basis	X1	X2	S3	S4	S5	S6	RHS
Obj.	732.636	0	0	0	0	181.531	2178.37
S3	732.636	0	1	0	0	181.531	3423.38
S5	2880	0	0	0	1	2880	62640
X2	0	1	0	0	0	-1	12
S4	-0.90432	0	0	1	0	-0.90432	0.77184

Solusi optimum:

Variabel	Nilai	Biaya
X1	0	732.64
X2	12	181.53
Z		2178.37

SPESIFIKASI CR400AF

Types of HSR	CR400AF
Manufactured/Derived from	CRRC Qingdao Sifang
Design Speed (km/h)	350/420
Trainsets (cars)	8
Seat Capacity (pax)	581
1st class	134
2nd class	447
Max. axle load (tons)	15.0
Train Length (m)	205.0
Width (mm)	3,360
Height (mm)	4,050
Floor height (mm)	1,250
Weight per train (tons)	408
Weight per car (tons)	51
Track gauge (mm)	1,435
Price (in million)	
Buying costs (in million)	Rp 426,310
Leasing cost (in million)	Rp 29,842
Maintenance costs	Rp 65,109
Operating Costs	Rp 42,531
Total costs	Rp 671,432
Owned	Rp 533,950
Leased	Rp 137,482

Kkt_Jkt_Bdg_step_2

Global optimal solution found.

Objective value:	2944.714
Objective bound:	2944.714
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.12
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	5.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2944.714	-1.000000
2	2657.036	0.000000
3	1.632960	0.000000
4	77040.00	0.000000
5	0.000000	0.000000

LAMPIRAN 9. HASIL *RUNNING* LINGO UNTUK SKENARIO VERSI 1

```
Scenario_RN1
Global optimal solution found.
Objective value:                              2944.714
Objective bound:                              2944.714
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
Elapsed runtime seconds:                          0.12

Model Class:                                      PILP

Total variables:                     2
Nonlinear variables:                 0
Integer variables:                   2

Total constraints:                   5
Nonlinear constraints:               0

Total nonzeros:                      9
Nonlinear nonzeros:                  0



Variable           Value        Reduced Cost
X1                 5.000000            533.9500
X2                 2.000000            137.4820

Row    Slack or Surplus      Dual Price
1            2944.714          -1.000000
2            2657.036           0.000000
3           0.6249600           0.000000
4            77040.00           0.000000
5            0.000000           0.000000
```

Scenario_RT1
Global optimal solution found.

Objective value:	2410.764
Objective bound:	2410.764
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.11
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2410.764	-1.000000
2	3190.986	0.000000
3	0.9676800	0.000000
4	79920.00	0.000000
5	0.000000	0.000000

Scenario_SN1

Global optimal solution found.	
Objective value:	3478.664
Objective bound:	3478.664
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.12
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	6.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	3478.664	-1.000000
2	2123.086	0.000000
3	0.2822400	0.000000
4	74160.00	0.000000
5	0.000000	0.000000

Scenario_ST1
Global optimal solution found.

Objective value:	2273.282
Objective bound:	2273.282
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.12
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	1.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2273.282	-1.000000
2	3328.468	0.000000
3	1.310400	0.000000
4	82800.00	0.000000
5	0.000000	0.000000

Scenario_TN1
Global optimal solution found.

Objective value:	4150.096
Objective bound:	4150.096
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.23
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	7.000000	533.9500
X2	3.000000	137.4820

Row	Slack or Surplus	Dual Price
1	4150.096	-1.000000
2	1451.654	0.000000
3	1.612800	0.000000
4	68400.00	0.000000
5	0.000000	0.000000

Scenario_TT1

Global optimal solution found.	
Objective value:	1739.332
Objective bound:	1739.332
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.14
Model Class:	PILP
Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	3.000000	533.9500
X2	1.000000	137.4820

Row	Slack or Surplus	Dual Price
1	1739.332	-1.000000
2	3862.418	0.000000
3	1.653120	0.000000
4	85680.00	0.000000
5	0.000000	0.000000

Scenario_STN1
Global optimal solution found.

Objective value:	4684.046
Objective bound:	4684.046
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.85
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	8.000000	533.9500
X2	3.000000	137.4820

Row	Slack or Surplus	Dual Price
1	4684.046	-1.000000
2	917.7040	0.000000
3	0.2620800	0.000000
4	65520.00	0.000000
5	0.000000	0.000000

Scenario_STT1
Global optimal solution found.

Objective value:	1067.900
Objective bound:	1067.900
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.19
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	2.000000	533.9500
X2	0.000000	137.4820

Row	Slack or Surplus	Dual Price
1	1067.900	-1.000000
2	4533.850	0.000000
3	1.330560	0.000000
4	91440.00	0.000000
5	0.000000	0.000000

LAMPIRAN 9. HASIL *RUNNING* LINGO UNTUK SKENARIO VERSI 2

```
Scenario_rn2
Global optimal solution found.
Objective value:                              2410.764
Objective bound:                              2410.764
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
Elapsed runtime seconds:                          0.20

Model Class:                                      PILP

Total variables:                     2
Nonlinear variables:                 0
Integer variables:                   2

Total constraints:                   5
Nonlinear constraints:               0

Total nonzeros:                      9
Nonlinear nonzeros:                  0


Variable           Value        Reduced Cost
X1                 4.000000           533.9500
X2                 2.000000           137.4820

Row    Slack or Surplus      Dual Price
1           2410.764          -1.000000
2           3190.986           0.000000
3           1.336104           0.000000
4           75816.00           0.000000
5           0.000000           0.000000
```

Scenario_rt2
Global optimal solution found.

Objective value:	2410.764
Objective bound:	2410.764
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.11
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2410.764	-1.000000
2	3190.986	0.000000
3	0.5911920	0.000000
4	80568.00	0.000000
5	0.000000	0.000000

Scenario_sn2
Global optimal solution found.

Objective value:	2410.764
Objective bound:	2410.764
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.12
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2410.764	-1.000000
2	3190.986	0.000000
3	0.7005600	0.000000
4	73440.00	0.000000
5	0.000000	0.000000

Scenario_st2
Global optimal solution found.

Objective value:	2410.764
Objective bound:	2410.764
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.11
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2410.764	-1.000000
2	3190.986	0.000000
3	1.226736	0.000000
4	82944.00	0.000000
5	0.000000	0.000000

Scenario_tn2
Global optimal solution found.

Objective value:	2410.764
Objective bound:	2410.764
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.12
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2410.764	-1.000000
2	3190.986	0.000000
3	1.445472	0.000000
4	68688.00	0.000000
5	0.000000	0.000000

Scenario_tt2
Global optimal solution found.

Objective value:	2410.764
Objective bound:	2410.764
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.13
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2410.764	-1.000000
2	3190.986	0.000000
3	0.4818240	0.000000
4	87696.00	0.000000
5	0.000000	0.000000

Scenario_en2
Global optimal solution found.

Objective value:	2410.764
Objective bound:	2410.764
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.12
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	2.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2410.764	-1.000000
2	3190.986	0.000000
3	1.182384	0.000000
4	63936.00	0.000000
5	0.000000	0.000000

Scenario_et2
Global optimal solution found.

Objective value:	2273.282
Objective bound:	2273.282
Infeasibilities:	0.000000
Extended solver steps:	0
Total solver iterations:	0
Elapsed runtime seconds:	0.11
Model Class:	PILP

Total variables:	2
Nonlinear variables:	0
Integer variables:	2
Total constraints:	5
Nonlinear constraints:	0
Total nonzeros:	9
Nonlinear nonzeros:	0

Variable	Value	Reduced Cost
X1	4.000000	533.9500
X2	1.000000	137.4820

Row	Slack or Surplus	Dual Price
1	2273.282	-1.000000
2	3328.468	0.000000
3	0.2847600	0.000000
4	93240.00	0.000000
5	0.000000	0.000000

BIAYA SEWA (DALAM MILYAR RP.)

Tipe	Tahun									
	0	1	2	3	4	5	6	7	8	9
CR400AF	29,842	28,153	26,559	25,056	23,637	22,299	21,037	19,846	18,723	17,663

(Lanjutan)

Tipe	Tahun									
	10	11	12	13	14	15	16	17	18	19
CR400AF	16,663	15,720	14,830	13,991	13,199	12,452	11,747	11,082	10,455	9,863

(Lanjutan)

Tipe	Tahun						Total (dalam Milyar)
	20	21	22	23	24	25	
CR400AF	9,305	8,778	8,281	7,812	7,370	6,953	411,319

Sumber: China Railways, CRRC, UIC

BIAYA OPERASIONAL (DALAM MILYAR RP.)

Tipe	Tahun								
	0	1	2	3	4	5	6	7	8
CRH380A	Rp 9,203	Rp 8,986	Rp 8,774	Rp 8,567	Rp 8,365	Rp 8,168	Rp 7,975	Rp 7,787	Rp 7,603

(Lanjutan)

Tipe	Tahun						
	9	10	11	12	13	14	15
CRH380A	Rp 7,424	Rp 7,249	Rp 7,078	Rp 6,911	Rp 6,748	Rp 6,588.92	Rp 6,433.52

(Lanjutan)

Tipe	Tahun						
	16	17	18	19	20	21	22
CRH380A	Rp 6,281.78	Rp 6,133.63	Rp 5,988.97	Rp 5,847.72	Rp 5,709.80	Rp 5,575.14	Rp 5,443.647

(Lanjutan)

Tipe	Tahun			Total (dalam Milyar)
	23	24	25	
CRH380A	Rp 5,315.259	Rp 5,189.8994	Rp 5,067.4961	Rp 171,212

Sumber: China Railways, CRRC, UIC