

Welcome!

Webinar #4: RECIPROCATING ENGINES & HEAT RECOVERY in TFX 05 JULY 2017

Agenda:

- * Introduction
- * Reciprocating Engine component in TFX: Database or User Defined
- * Available Heat from Exhaust Gas and Engine Cooling
- * Heat Recovery for Hot Water, Steam and Chilled Water
- * Multiple Engines
- * Off Design Simulation
- * Q & A Session

Thermodflow Training and Support

- Standard Training
- On-site Training course
- Advanced Workshop
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

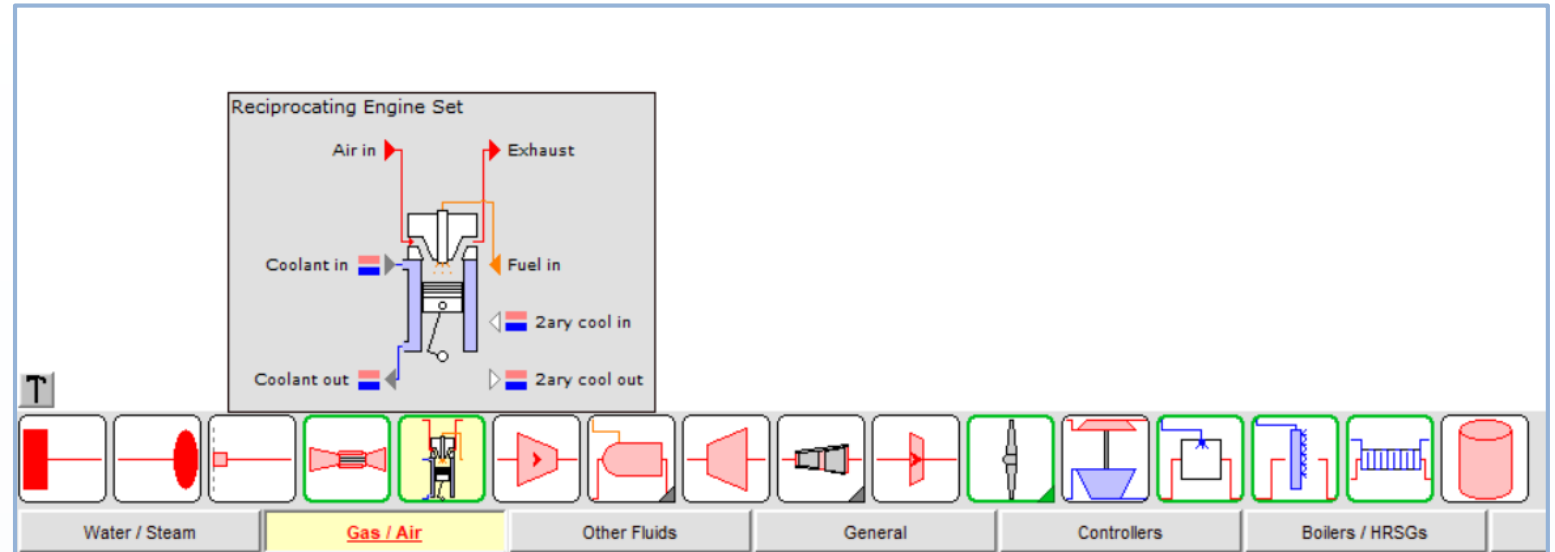
→ Feature Awareness Webinars

Feature Awareness Webinars

- 1- Assemblies in THERMOFLEX
- 2- SCRIPTS in Thermostat Programs
- 3- Multi Point Design
- 4- Reciprocating Engines**

Reciprocating Engine Component in TFX

- Database
- User Defined



Reciprocating Engine Database

Reciprocating Engine Selection

File

☐ Display entire reciprocating engine library

Engine Selection Filter

Smallest power kW Largest power kW

Sort

☐ Manufacturer ☐ Smallest to largest power ☒ Largest to smallest power

☒ Show 50 Hz engines ☐ Show 60 Hz engines
☒ Show gas engines ☐ Show Diesel engines

ID	Model	Fuel	Aspiration	Mode	RPM	Freq. Hz	Power kW	Texh C	Exh. flow t/h	Elec. Eff. %
338	JEN JMS612GS-NLC	G	TA	P	1500	50	1464	410	8,83	41,6
345	CUM QSV81-G	G	TA	C	1500	50	1370	517	7,85	37,9
293	DEU TBG620V16K	G	TA	P	1500	50	1358	523	7,33	40,0
295	DEU TBG620V16K	G	TA	P	1500	50	1290	531	7,51	38,5
326	MTU G16V4000	G	TA	C	1500	50	1285	410	7,40	39,9
325	MTU G16V4000	G	TA	C	1500	50	1285	390	7,97	38,9
162	CAT 3606E	G	TA	C	1000	50	1265	465	9,43	35,9
272	WAU 9500S	G	TA	C	1000	50	1225	579	5,22	30,4
278	WAU 9500L	G	TA	C	1000	50	1225	354	7,94	33,8
163	CAT 3606E	G	TA	C	1000	50	1195	469	8,83	35,4
281	WAU 9500L	G	TA	C	1000	50	1175	357	7,56	34,0
275	WAU 9500S	G	TA	C	1000	50	1175	577	5,05	30,1
292	DEU TBG620V12K	G	TA	P	1500	50	1019	515	5,50	40,0
336	JEN JMS320GS-NLC	G	TA	P	1500	50	972	515	5,55	38,1

Data source: Jenbacher Engineering Information 2001 CD
Date of last revision: 11/9/2001
Nox level: less than 500 mg/mn3
Applicable standards: Based on DIN-ISO 3046; Based on VDE 0530 REM with specified tolerance; Intake air temperature: 25 C; Barometric pressure: 1000

OK Cancel

Reciprocating Engine User Defined

Input Menu - Edit Mode

File GTP/GTM/STM

Site Menu Components Miscellaneous Plant Assembly Non Flowsheet Economics Regional Costs OK Cancel

Reciprocating Engine Set [1]

Main Engine Parameters User-defined Engine

Genset Specification

Engine ID 0

Manufacturer TF

Model number Example for

Engine RPM 1500

Full load electrical power 1500 kW

Full load generator eff. 95,8 %

Full load exhaust temp. 410 C

Full load exhaust flow 2,452 kg/s

Primary heat recovery rate 756,1 kW

2nd heat recovery rate 0 kW

3rd heat recovery rate 0 kW

4th heat recovery rate 0 kW

Estimated other heat loss 4,429 % Q fuel input (LHV)

Min. allowed part load 25 %

Genset Fuel Consumption

Rating LHV 32,35 MJ/scm

☐ Estimate part load data

100 % Load 3523 kW (LHV)

75 % Load 2811,1 kW (LHV)

50 % Load 2098,8 kW (LHV)

25 % Load 1386,5 kW (LHV)

Genset LHV Efficiency

100 % Load 42,58 %

75 % Load 40,02 %

50 % Load 35,73 %

25 % Load 27,05 %

Engine LHV Efficiency

100 % Load 44,45 %

75 % Load 41,95 %

50 % Load 37,93 %

25 % Load 30,01 %

Comments

Data source TF

Last date revised 5/07/2017

Other comment

Example for FAW4

Load User-defined Engine...

Save User-defined Engine...

Overall Size & Weight

Overall length 7,3 m

Overall width 2,5 m

Overall height 2,8 m

Overall weight 15900 kg

Fuel Type

☒ Gas ☐ Diesel

Frequency

☒ 50 Hz ☐ 60 Hz

Rating

NOx Level

☐ Unknown ☐ < 250 mg/Nm3

☒ < 500 mg/Nm3 ☐ > 500 mg/Nm3

Aspiration

☐ Turbocharged

☒ Turbocharged/Aftercooled

Notes

Reciprocating Engine User Defined - 2

Input Menu - Edit Mode

File GTP/GTM/STM

Site Menu Components Miscellaneous

Reciprocating Engine Set [1]

Main Engine Parameters User-defined Engine

Primary Cooling

Coolant Computation Method—

☐ Compute outlet state

☒ Specify outlet state & compute CW flow

☐ Specify CW temperature rise & compute CW flow

Coolant Outlet Phase

☒ Subcooled liquid

☐ Saturated (2-phase)

☐ Superheated vapor

Cooling water temperature rise C

Cooling water outlet temperature C

Cooling water outlet quality

Cooling water path dP/P %

Secondary Cooling

Coolant Computation Method—

☐ Compute outlet state

☐ Specify outlet state & compute CW flow

☐ Specify CW temperature rise & compute CW flow

Coolant Outlet Phase

☐ Subcooled liquid

☐ Saturated (2-phase)

☐ Superheated vapor

Cooling water temperature rise C

Cooling water outlet temperature C

Cooling water outlet quality

Cooling water path dP/P %

Third Cooling Connection

No Heat Adder connected

Fourth Cooling Connection

No Heat Adder connected

Exhaust Temperature

100 % Load	410 C
75 % Load	405 C
50 % Load	396 C
25 % Load	388 C

Generator Efficiency

100 % Load	95,8 %
75 % Load	95,4 %
50 % Load	94,21 %
25 % Load	90,12 %

Genset LHV Efficiency

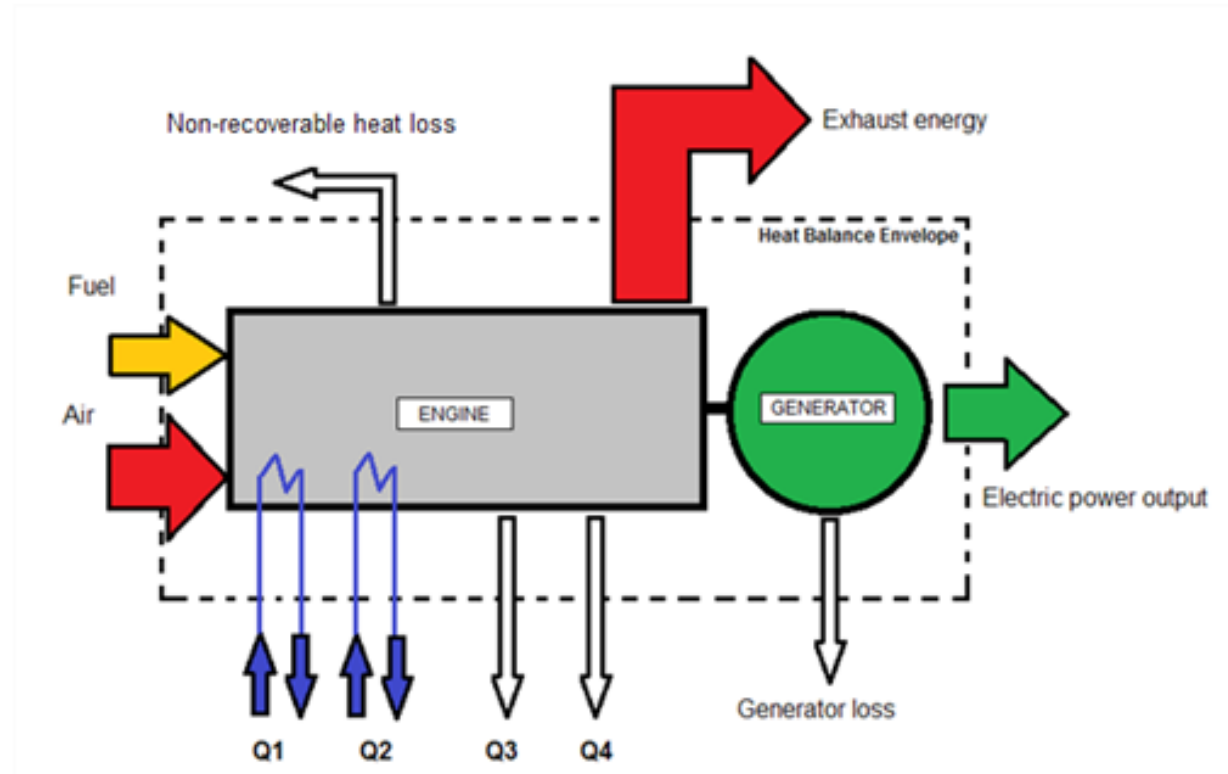
100 % Load	41,56 %
75 % Load	39,06 %
50 % Load	34,88 %
25 % Load	26,4 %

Engine LHV Efficiency

100 % Load	43,38 %
75 % Load	40,94 %
50 % Load	37,02 %
25 % Load	29,29 %

Notes

Reciprocating Engine Heat Balance Envelope



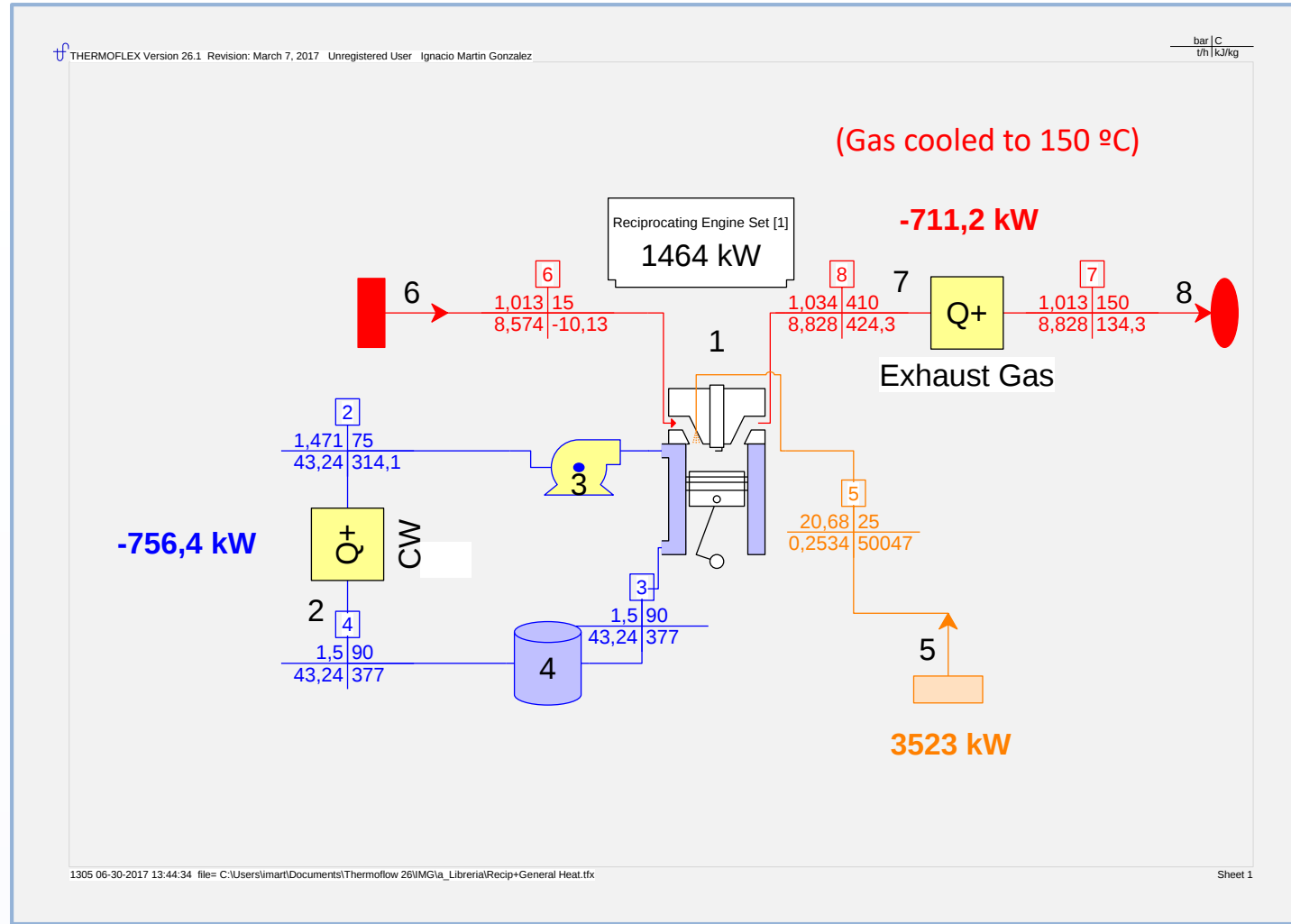
- Q1:** Heat transfer from the cooling water jackets (primary cooling)
- Q2:** Heat transfer from a high temperature charge air cooler (secondary cooling)
- Q3:** Heat transfer from a low temperature charge air cooler
- Q4:** Heat transfer from the lube oil cooler

	NOMINAL		OFF DESIGN	
	<i>Data Base</i>	<i>User Def.</i>	<i>Data Base</i>	<i>User Def.</i>
Power				
Efficiency				Table
Exhaust mf				
Exhaust T			Table	Table
Generator Eff			Table	Table
Heat Recovery-4				
CW T, DT				
Fuel Consumption				
Air mf				

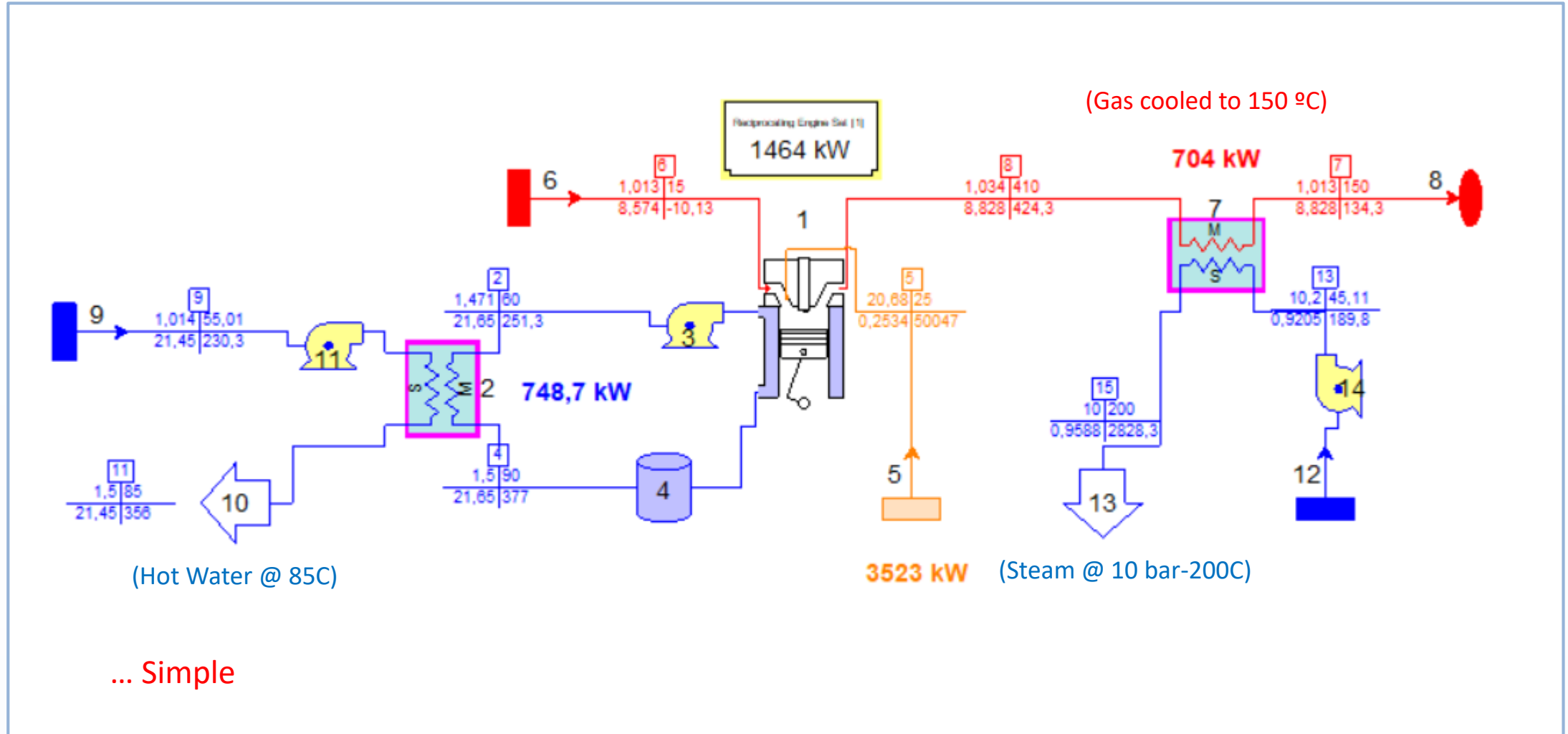
Inputs

Defined / Computed

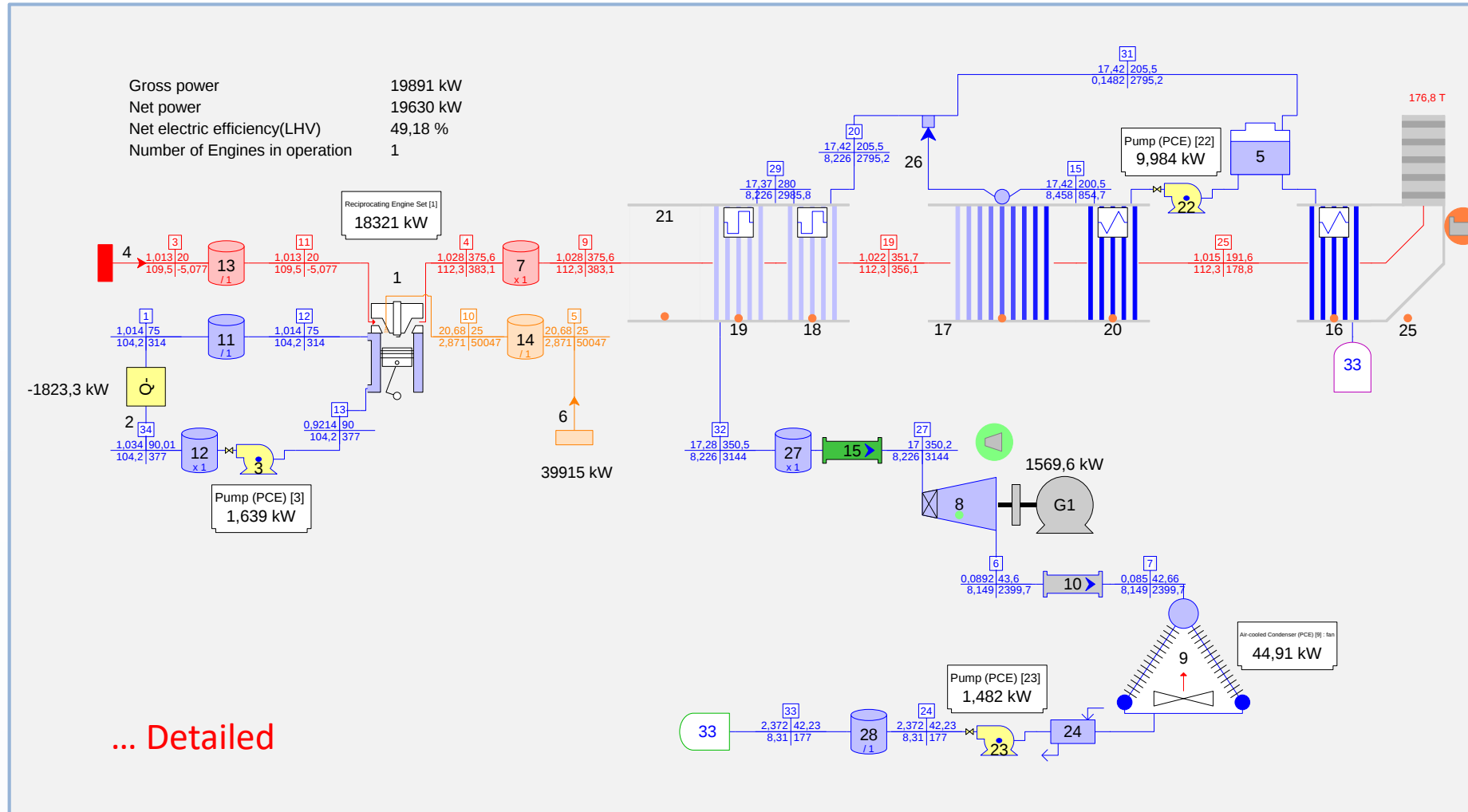
Heat Balance: Available Heat Recovery



Available Heat Recovery, Hot Water & Steam



Exhaust Heat Recovery - Combined Cycle



Cooling Water Circuit: 4 Heating Sources

Input Menu - Edit Mode

File GTP/GTM/STM

Site Menu Components Miscellaneous

Reciprocating Engine Set [1]

Main Engine Parameters User-defined Engine

Genset Specification

Engine ID 0

Manufacturer JEN

Model number JMS612GS-NLC

Engine RPM 1800

Full load electrical power 1413 kW

Full load generator eff. 95.79 %

Full load exhaust temp. 409 C

Full load exhaust flow 7500 kg/h

Primary heat recovery rate 337 kW

2nd heat recovery rate 93 kW

3rd heat recovery rate 342 kW

4th heat recovery rate 177 kW

Estimated other heat loss 1.718 % Q fuel input (LHV)

Min. allowed part load 25 %

Overall Size & Weight

Overall length 8.699 m

Overall width 2.5 m

Overall height 2.8 m

Overall weight 17300 kg

Fuel Type

☒ Gas ☐ Diesel

Frequency

☐ 50 Hz ☒ 60 Hz

Rating

☒ Prime ☐ Continuous

Genset Fuel Consumption

Rating LHV 9.9 kWh/Nm3

☐ Estimate part load data

100 % Load 3374 kW (LHV)

75 % Load 2585 kW (LHV)

50 % Load 1795 kW (LHV)

25 % Load 1200 kW (LHV)

Genset LHV Efficiency

100 % Load 41.88 %

75 % Load 41 %

50 % Load 39.36 %

25 % Load 29.44 %

Engine LHV Efficiency

100 % Load 43.72 %

75 % Load 42.98 %

50 % Load 41.78 %

25 % Load 32.68 %

Comments

Data source Jenbacher Engineering Information 2001 CD

Last date revised 11/9/2001

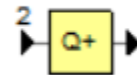
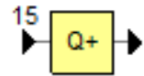
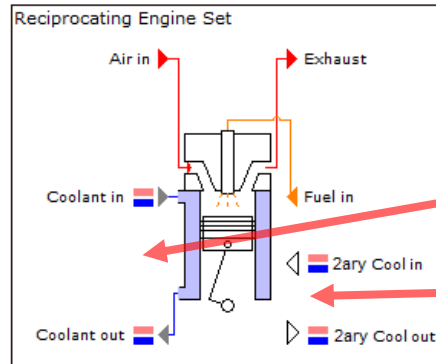
Other comment

Applicable standards: Based on DIN-ISO 3046; Based on VDE 0530 REM with specified tolerance; Intake air temperature: 25 C; Barometric pressure: 1000 mbar; Relative humidity: 30%; Gas flow pressure 80 - 200 mbar

Load User-defined Engine...

Save User-defined Engine...

Cooling Water Circuit: 4 Heating Sources



Input Menu - Edit Mode

File GTP/GTM/STM

Site Menu Components Miscellaneous

Reciprocating Engine Set [1]

Engine Parameters

Primary Cooling

Coolant Computation Method

- ☐ Compute outlet state
- ☒ Specify outlet state & compute CW flow
- ☐ Specify CW temperature rise & compute CW flow

Coolant Outlet Phase

- ☒ Subcooled liquid
- ☐ Saturated (2-phase)
- ☐ Superheated vapor

Cooling water temperature rise: 10 C

Cooling water outlet temperature: 90 C

Cooling water outlet quality: 0

Cooling water path dP/P: 10 %

Secondary Cooling

Coolant Computation Method

- ☐ Compute outlet state
- ☒ Specify outlet state & compute CW flow
- ☐ Specify CW temperature rise & compute CW flow

Coolant Outlet Phase

- ☒ Subcooled liquid
- ☐ Saturated (2-phase)
- ☐ Superheated vapor

Cooling water temperature rise: 10 C

Cooling water outlet temperature: 44,5 C

Cooling water outlet quality: 0

Cooling water path dP/P: 10 %

Third Cooling Connection

Choose Heat Adder Heat Adder [2]

Fourth Cooling Connection

Choose Heat Adder Heat Adder [3]

Exhaust Temperature

Load	Temperature (C)
100 % Load	409
75 % Load	410
50 % Load	410
25 % Load	410

Generator Efficiency

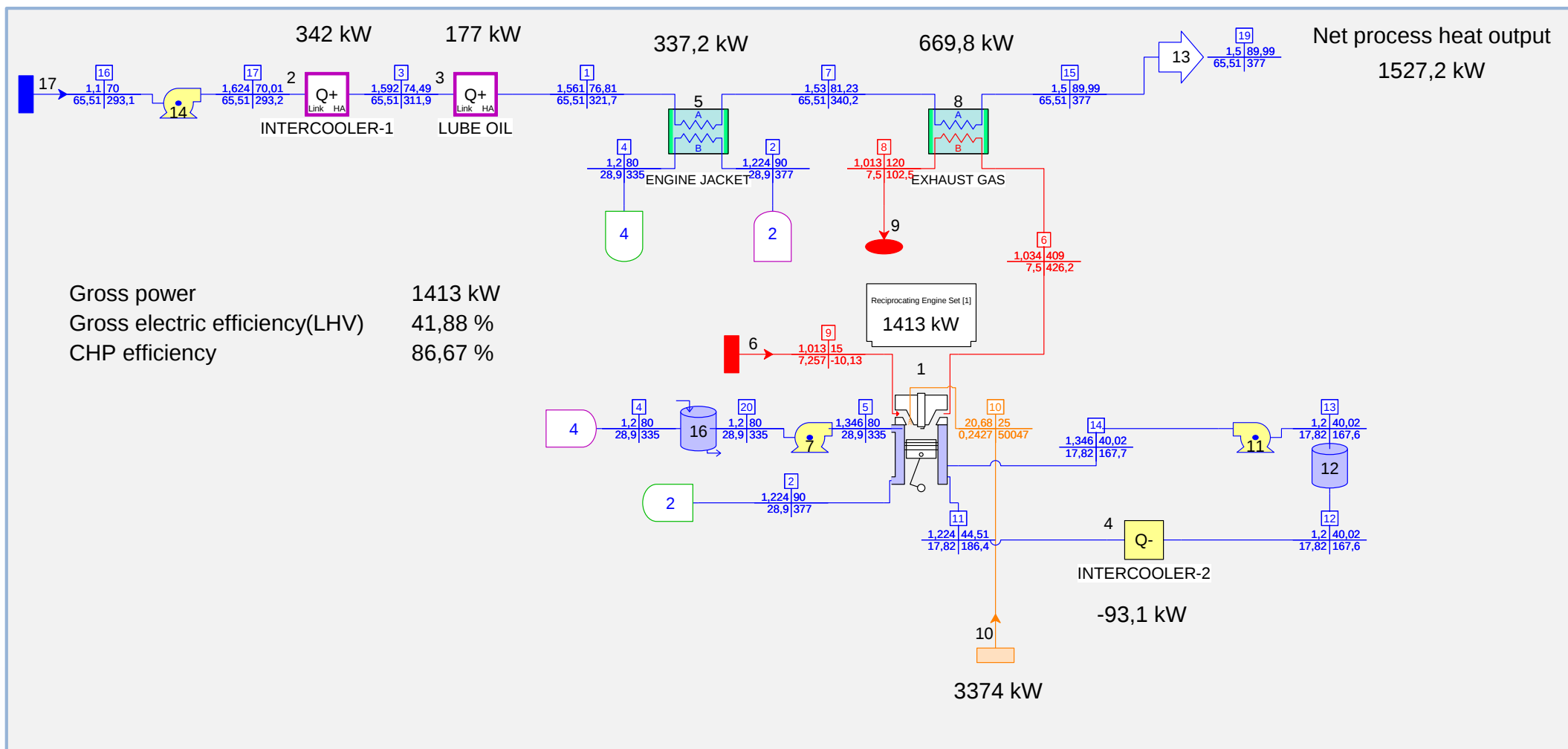
Load	Efficiency (%)
100 % Load	95,79
75 % Load	95,38
50 % Load	94,2
25 % Load	90,09

Genset LHV Efficiency

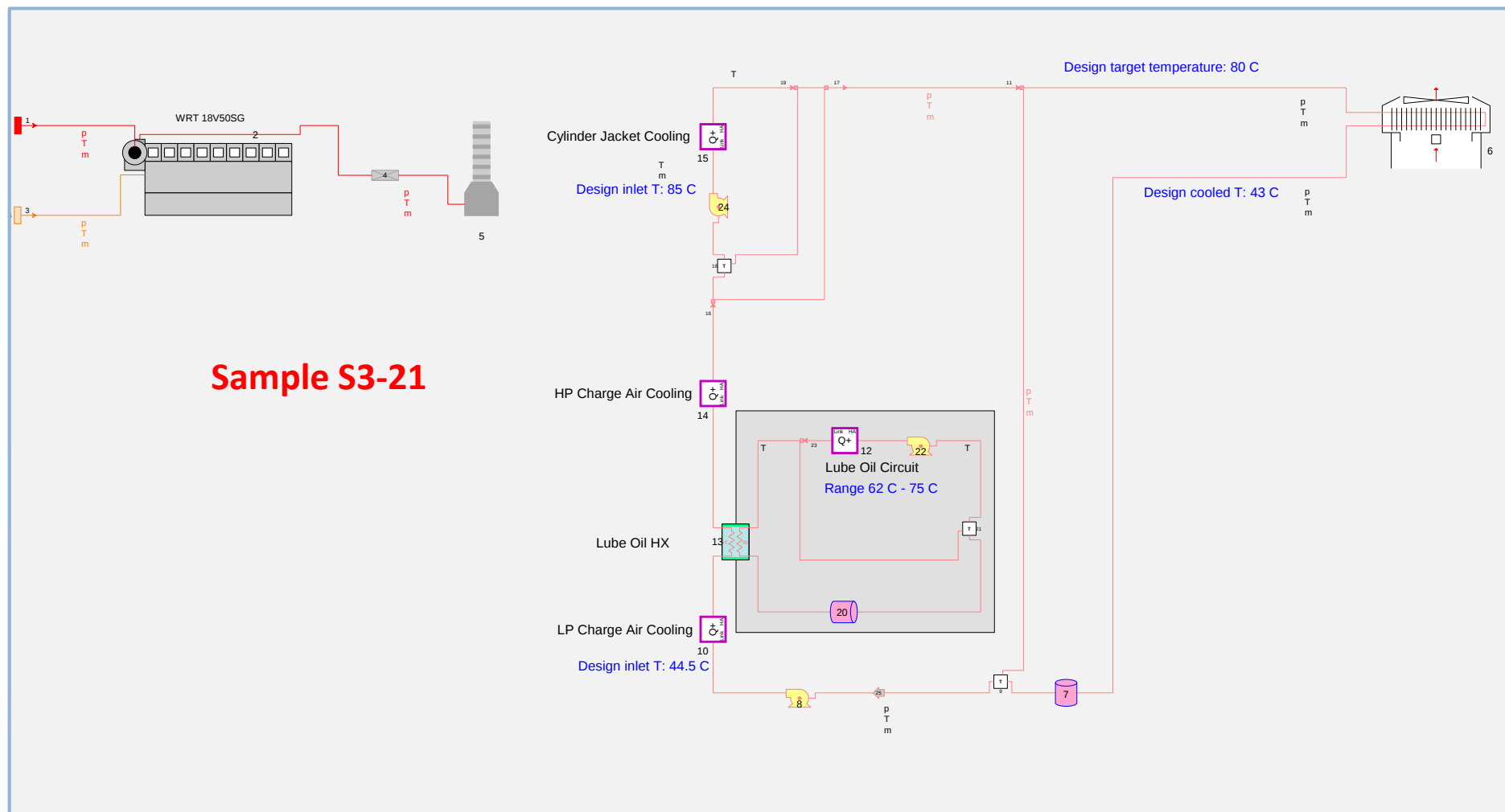
Load	Efficiency (%)
100 % Load	41,88
75 % Load	41
50 % Load	39,36
25 % Load	29,44

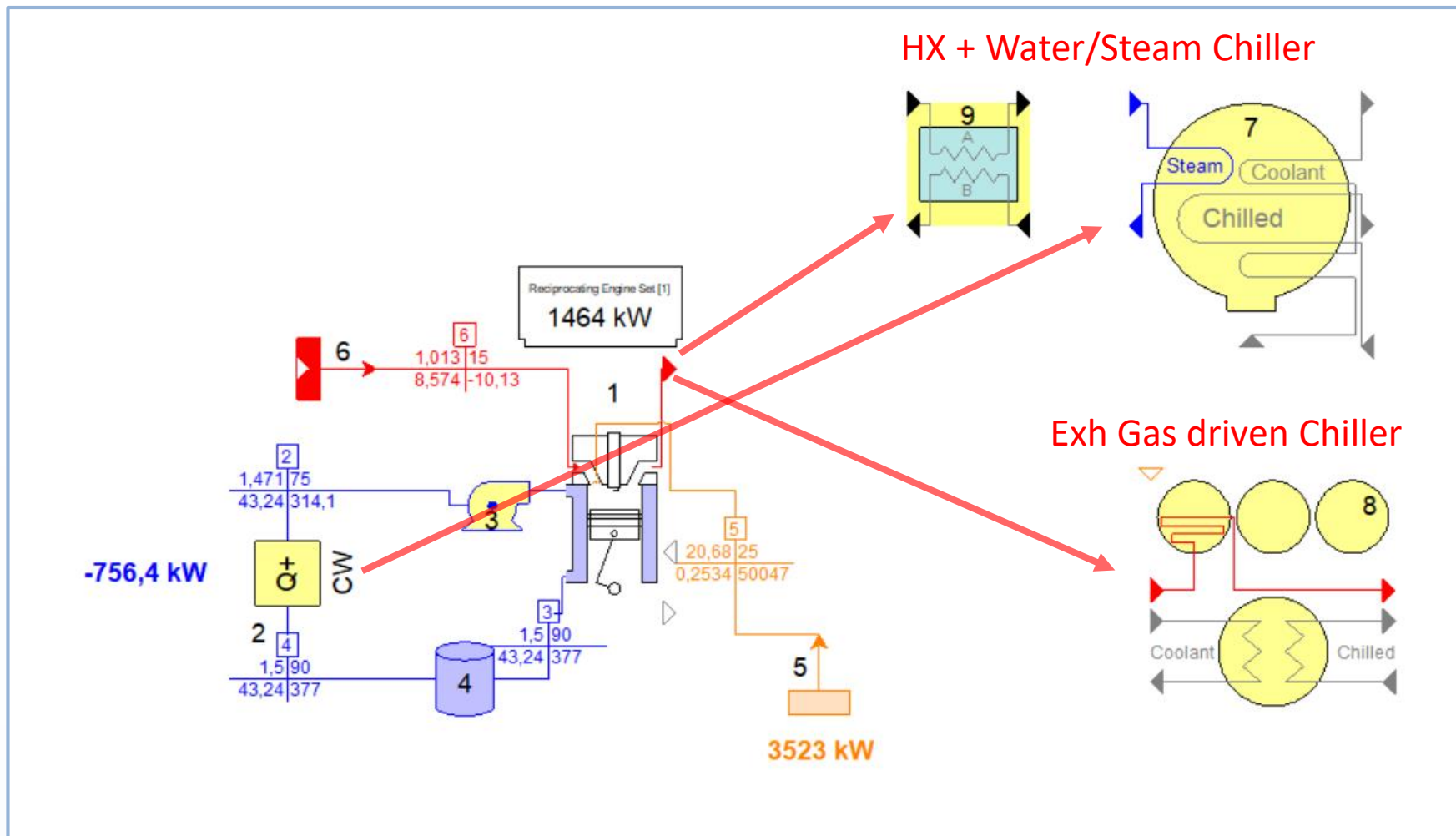
Engine LHV Efficiency

Load	Efficiency (%)
100 % Load	43,72
75 % Load	42,98
50 % Load	41,78
25 % Load	32,68

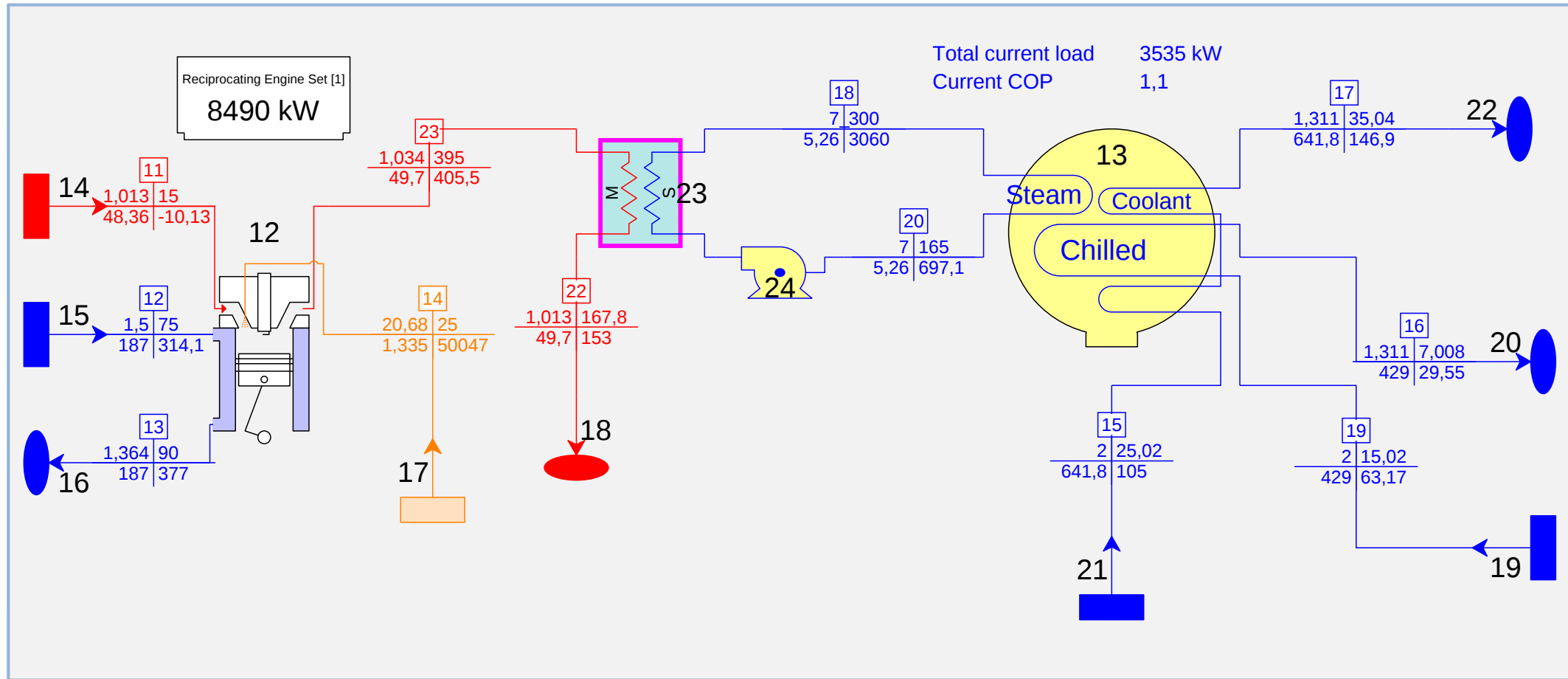


Cooling Water Circuit (detailed)





Heat Recovery with Water / Steam Absorption Chillers



Water / Steam Absorption Chillers

Input Menu - Edit Mode

File GTP/GTM/STM

Site Menu Components Miscellaneous Fix Pressure Plant Assembly Non Flowtest Economics Regional Costs

OK Cancel

Absorption Chiller (PCE) [13] Thermodynamic Design

Chiller Type

- ☐ Single-stage using hot water Nameplate COP 0,67
- ☐ Single-stage using low pressure steam Nameplate COP 0,67
- ☒ Two-stage using medium pressure steam Nameplate COP 1,1

Chiller Load Chiller load set by network-determined heating flow

Chiller load 1000 ton

Auxiliary load / chiller load 0,005

Price of chilled output (as Process) 0 USD/GJ

heating steam or hot water

1st Generator

2nd Generator

Condenser

Evaporator

Absorber

Chilled water

Cooling water

Chilled water exit temperature 7 C

Chilled water pressure drop 0,6895 bar

Chiller Performance Corrections

- ☒ Automatic
- ☐ User-defined

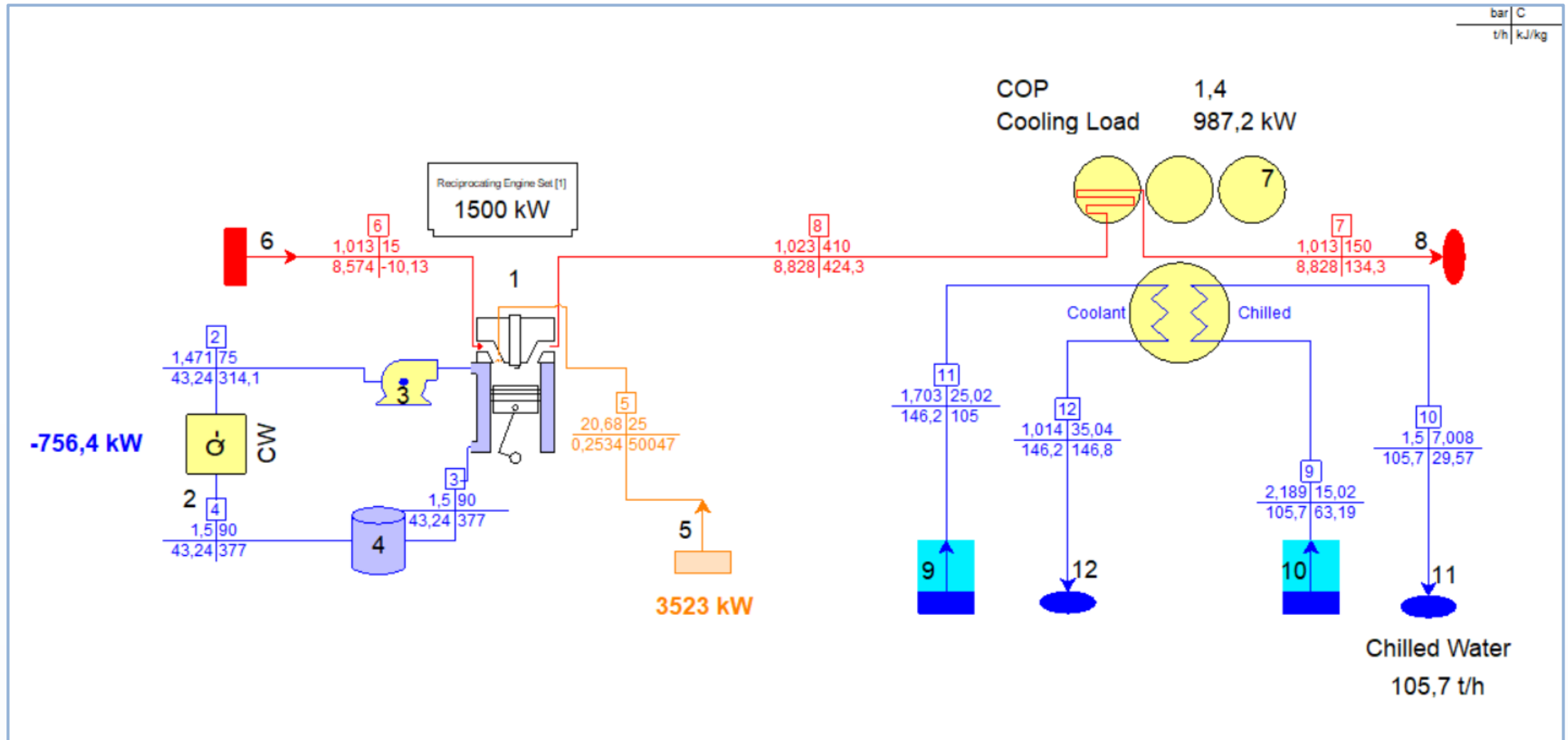
Edit Data

Standard conditions:

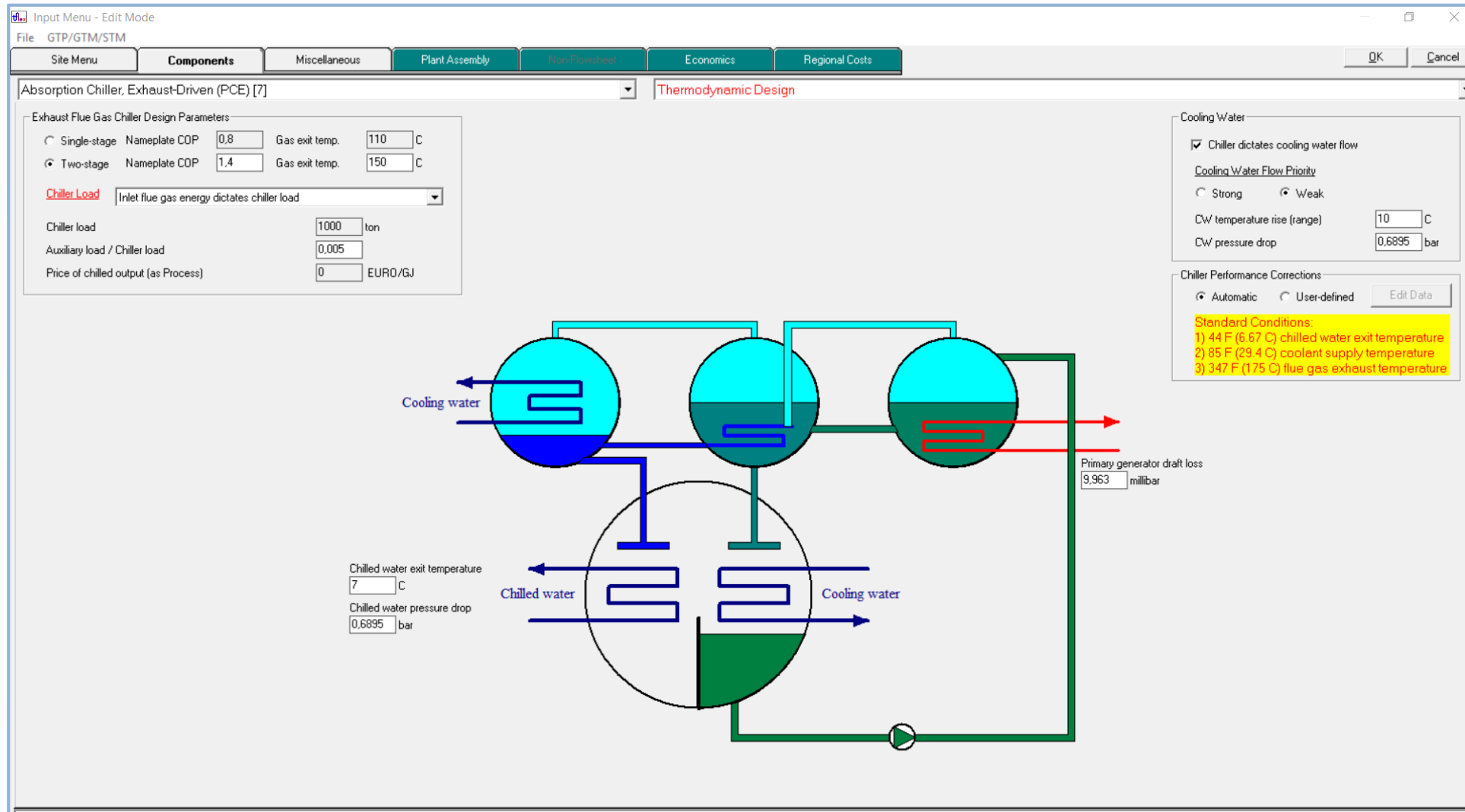
- 1) 44 F (6.67 C) chilled water exit temperature
- 2) 85 F (29.4 C) cooling water supply temperature
- 3) Steam source pressure of 20 psia (1.4 bar) for single-stage units, and 130 psia (9 bar) for two-stage units

Notes

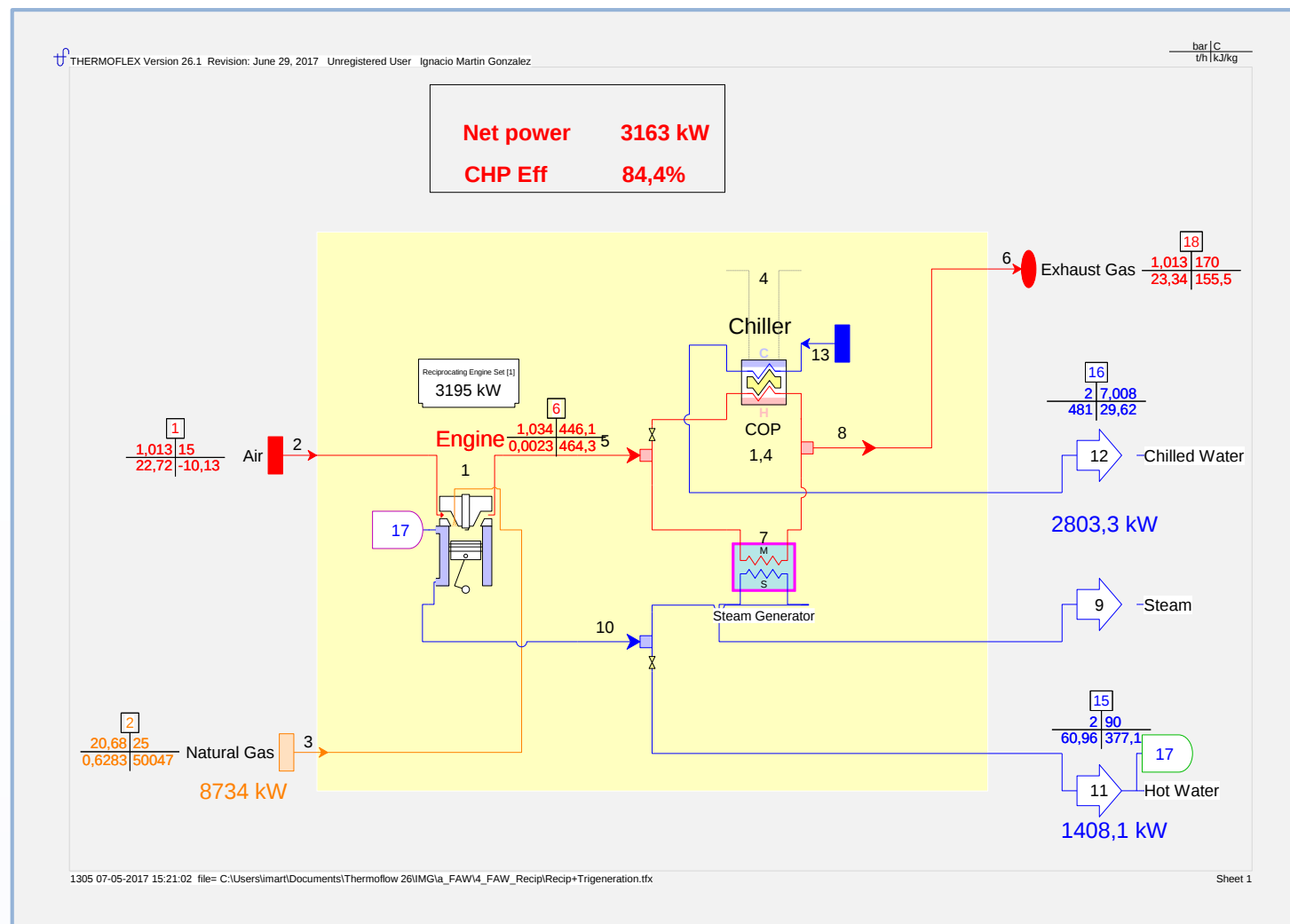
Heat Recovery, Exhaust Gas driven Absorption Chillers



Exhaust Gas-driven Absorption Chillers

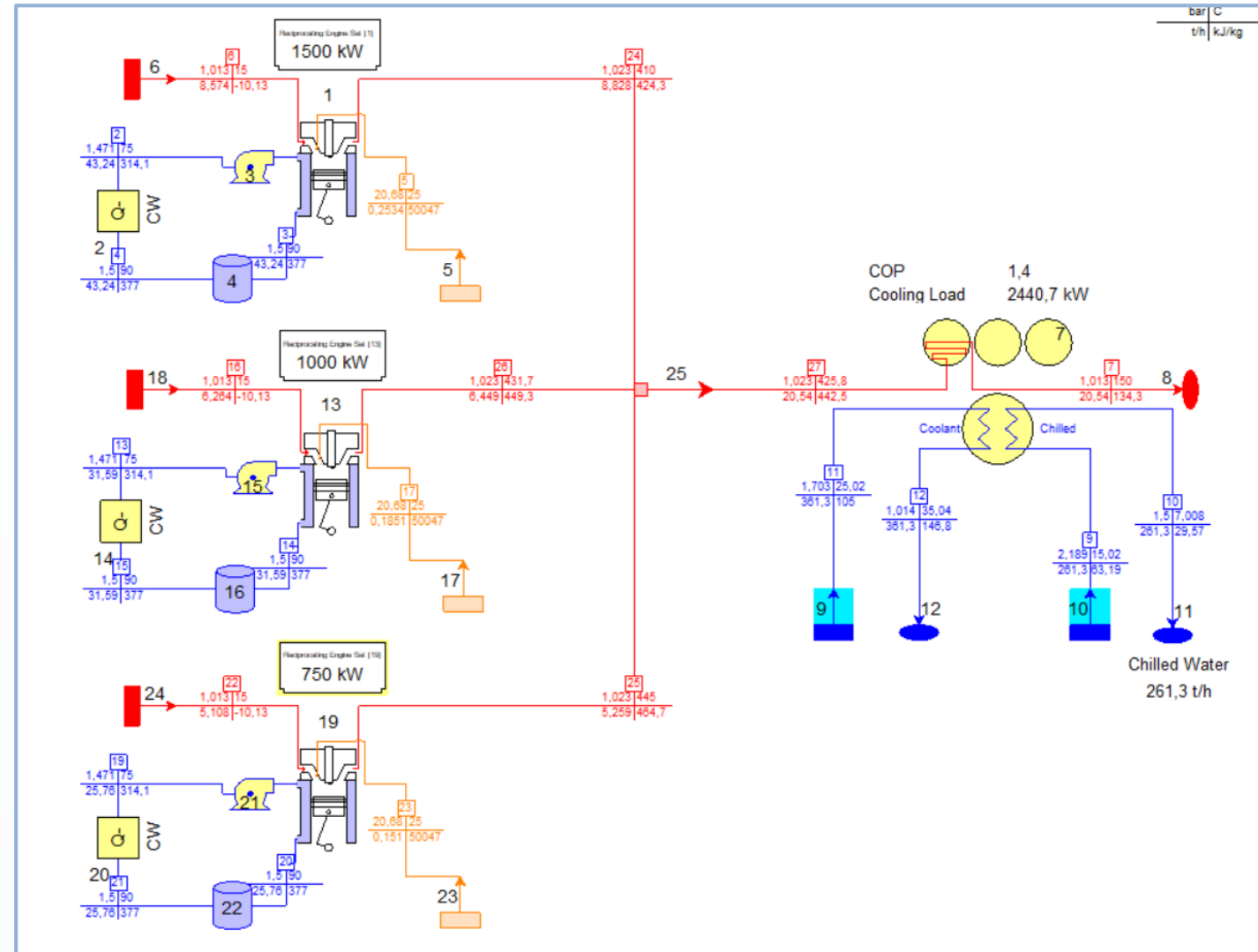


website: www.Thermoflow.ir
Telegram: @Thermoflow_users
Recip Engine Trigeneration



Multiple Engines

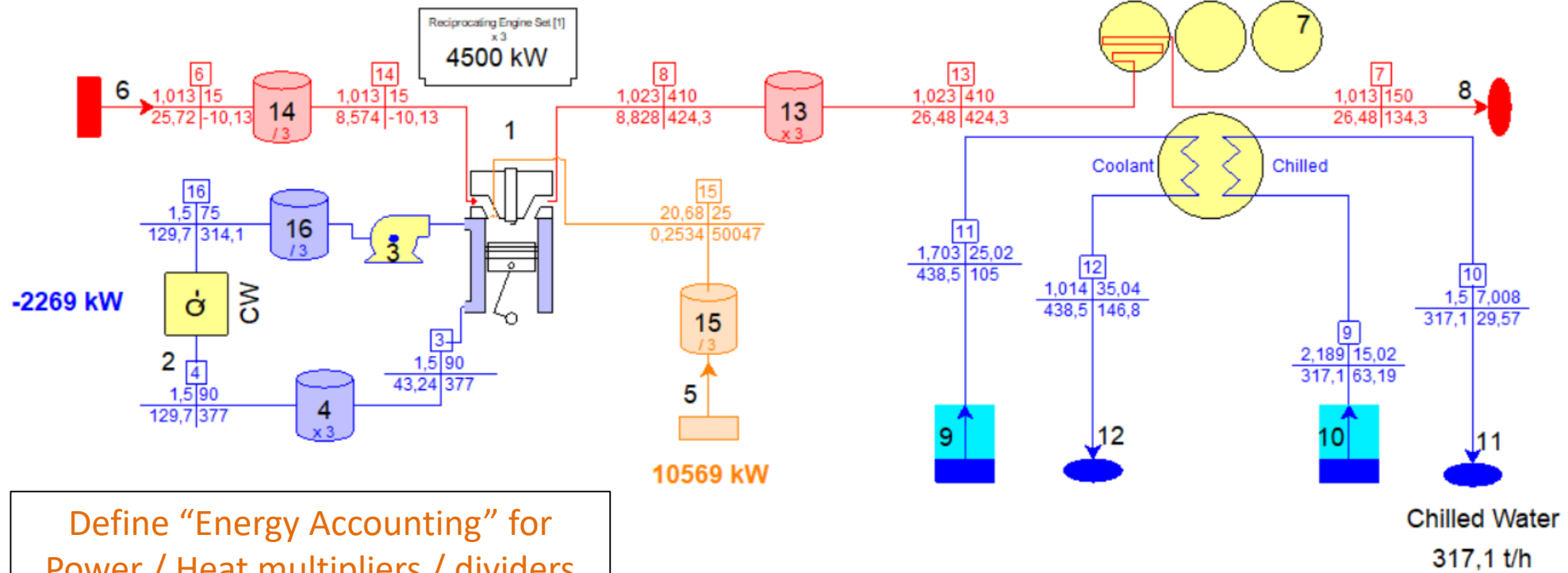
... if different Engine models
or running at different loads



Multiple Engines

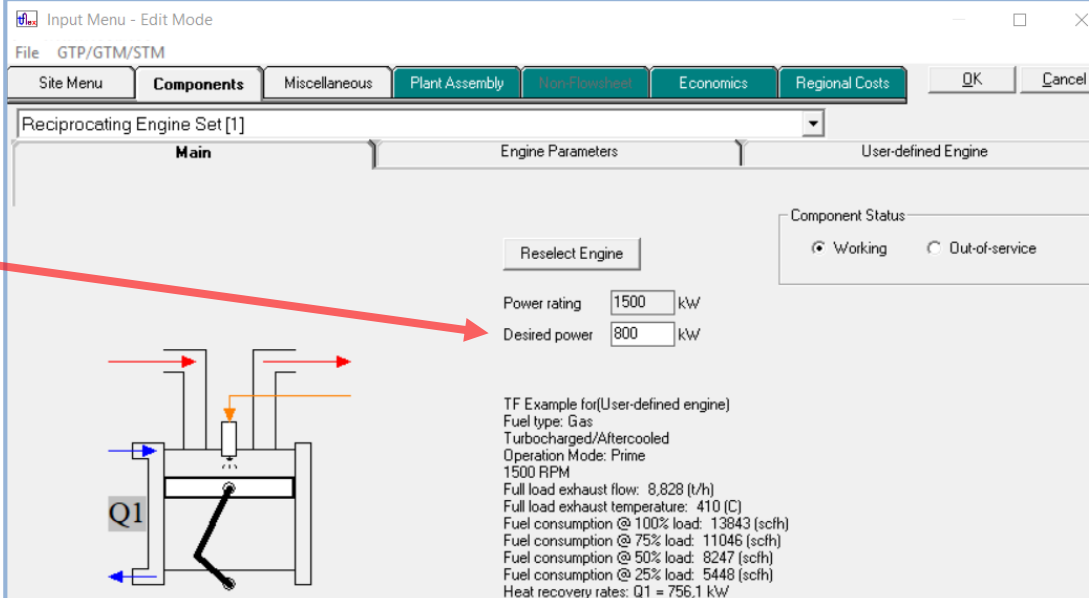
... or

Use "Fluid Specification components"
as Flow multipliers / dividers



Recip Engines Off-Design Simulation

Recip Engines “modeless”
Just enter the “desired power”
to simulate part load



Input Menu - Edit Mode

File GTP/GTM/STM

Site Menu Components Miscellaneous Plant Assembly Non-Flowchart Economics Regional Costs OK Cancel

Reciprocating Engine Set [1]

Main Engine Parameters User-defined Engine

Reselect Engine

Power rating 1500 kW

Desired power 800 kW

TF Example for(User-defined engine)

Fuel type: Gas

Turbocharged/Aftercooled

Operation Mode: Prime

1500 RPM

Full load exhaust flow: 8,828 (t/h)

Full load exhaust temperature: 410 (C)

Fuel consumption @ 100% load: 13843 (scfh)

Fuel consumption @ 75% load: 11046 (scfh)

Fuel consumption @ 50% load: 8247 (scfh)

Fuel consumption @ 25% load: 5448 (scfh)

Heat recovery rates: Q1 = 756,1 kW

Q2 = 0

Component Status

☒ Working ☐ Out-of-service

OD calculations from the Tables

Exhaust Temperature	
100 % Load	410 C
75 % Load	410 C
50 % Load	410 C
25 % Load	410 C

Generator Efficiency	
100 % Load	95,8 %
75 % Load	95,4 %
50 % Load	94,21 %
25 % Load	90,12 %

Genset Fuel Consumption	
Rating LHV	32,35 MJ/scm
☒ Estimate part load data	
100 % Load	42,58 Efficiency(%) (LHV)
75 % Load	40,02 Efficiency(%) (LHV)
50 % Load	35,74 Efficiency(%) (LHV)
25 % Load	27,05 Efficiency(%) (LHV)

Rest of the parameters computed
“User define” your part load case to match the Engine specs