



Welcome!

Webinar #31: Modelling M on N Systems

13 Feb 2019

Agenda:

- * Introduction
- * Modelling M on N systems in GTPM, Design and Simulation
- * Modelling M on N systems in STPM, Design and Simulation
- * Using TFX for modelling M on N systems: standalone, link or import
- * Design a M on N plant in TFX with variable M and N using scripts
- * Q & A Session

Thermoflow Training and Support

- Standard Training
- On site training course
- User's Meetings / Advanced Workshops
- Webinars when new version is released
- Help, Tutorials, PPT, Videos
- Technical Support

→ Feature Awareness Webinars

Feature Awareness Webinars

- 1- Assemblies in TFX, June 2016
- 2- Scripts in Thermoflow programs, GTP-GTM-TFX
- 3- Multi Point Design in GTP-GTM
- 4- Reciprocating Engines in TFX
- 5- TIME in GTM
- 6- Matching ST Performance in STP
- 7- Modeling Solar Systems in TFX
- 8- Combining THERMOFLEX & Application-Specific Programs
- 9- Methods & Methodology in GT PRO & STEAM PRO
- 10- Supplementary Firing & Control Loops in GT PRO & GT MASTER
- 11- The Wind Turbine Feature in Thermoflex
- 12- Modelling GT's in Thermoflow program-1
- 13- Thermoflex for on line and off line performance monitoring
- 14- Tflow 27, what's new
- 15- Modelling GT's in Thermoflow program-2
- 16- Multi Point Design in GTP-GTM
- 17- Total Plant Cost in TFX
- 18- Steam Turbine Tuning
- 19- User Defined Components in TFX
- 20- Cooling System Optimization

.....



31- Modelling M on N Systems

M on N Systems

- **GTPM:** **M** x Gas Turbine + **M** x HRSG + **N** x Steam Turbine-Cooling System
- **STPM:** **M** x Boiler + **N** x Steam Turbine-Cooling System
- **TFX:** Any Combination

Design M on N Systems in **GT Pro**

- In GT Pro the user can select:
 - A number of **M** GT units and equal number of HRSGs → GT-HRSG = 1 block
 - A number of **N** ST units and equal number of Cooling Systems
 - M and N can be different unless you select a “Single Shaft” Configuration
 - All the GT, HRSG, ST and Cooling Systems must be exactly the same: there is only one input for all the inputs related to them

GT PRO 28.0 - C:\Users\imart\Documents\Thermoflow 28\GTPRO.GTP

File View Options Tools Window ExcelLink Scripts Help

Navigator

New Session

Start Design

Plant Criteria

GT Selection

GT Inputs

ST-HRSG

HRSG Inputs

Water Circuits

HRSG Layout

Cooling System

ST Inputs

Environment

Other PEACE

Economics

Gasification

Desalination

Compute

Text Output

Graphics Output

PEACE Output

Carrying on...

Multiple Designs (MACRO)

Run from Excel (ELINK)

Off Design Simulation (GT MASTER)

Fully-Flexible Design

Number of gas turbines: Single shaft GT/ST configuration

Display Entire GT Library | Display Partial GT Library

Did you know that if you cannot find a particular engine:
 -> its nominal power may be outside the power range set below
 -> it may be filtered out by 'Show new specs only' switch
 -> it may be filtered out by 'Show 50/60 Hz' switch
 -> it may be listed under a different name, click 'Show other names' checkbox
 Click the red button to see the whole list, or the white one to use the filter.

Engine Selection Filter

Show engines rated from MW Up to MW

Sort by: Manufacturer Smallest to largest power Largest to smallest power ID #

Show new specs only
 Show 50 Hz engines
 Show 60 Hz engines
 Show other name(s)

*** Reference price for basic genset with included appurtenances, excluding stack. It is not a cost estimate for a Simple Cycle plant.

ID	Manufacturer & Model	Shafts	RPM	PR	TIT C	TET C	Air Flow t/h	Gen Power kWe	LHV HR kJ/kWh	LHV Eff %	Price*** MM\$
Kawasaki											
371	Kawasaki GPB180D	1	9420	18,6	1249	533	211	18045	10576	34,0	8,7
474	Kawasaki GPB300D	2	5600	25,0	1260	469	313	30137	8946	40,2	14,4
MAN Turbo											
269	MAN TURBO THM 1304-11	2	8600	11,0	996	487	172	10760	12090	29,8	5,3
294	MAN TURBO THM 1304-12	2	8600	11,0	1010	494	174	11520	11779	30,6	5,7
Mitsubishi Hitachi Power Systems											
35	MHPS MF111B	1	9660	14,6	1135	526	200	14838	11510	31,3	7,2
279	MHPS H-15	1	9710	14,6	1177	546	188	15086	11257	32,0	7,4
280	MHPS H-25 (28)	1	7280	14,6	1260	547	319	28150	10568	34,1	10,6
372	MHPS H-25 (32)	1	7280	14,7	1193	557	341	31820	10329	34,9	10,7
617	MHPS H-25 (42)	1	7280	19,0	1300	569	405	41035	9949	36,2	12,3
478	MHPS H-100 (110)	2	3000	19,9	1350	538	1088	112440	9368	38,4	22,8
NPD Saturn											
423	Saturn GTE-110	1	3000	14,7	1210	517	1283	110000	10445	34,5	27,6
Pratt & Whitney											
307	P+W FT8 Swift Pac 30	3	3000	19,3	1160	463	296	25048	9543	37,7	11,8
308	P+W FT8 Swift Pac 30	3	3000	20,2	1221	480	307	27555	9437	38,1	12,1
309	P+W FT8 Swift Pac 60	3	3000	19,3	1160	463	593	50300	9506	37,9	17,2

Design M on N Systems in GT Pro, Inputs, Select N

GT PRO 28.0 - C:\Users\imart\Documents\Thermoflow 28\GTPRO.GTP

File View Options Tools Window Excel Link Scripts Help

Navigator

- New Session
- Start Design
- Plant Criteria
- GT Selection
- GT Inputs
- ST-HRSG
- HRSG Inputs
- Water Circuits
- HRSG Layout
- Cooling System
- ST Inputs**
- Environment
- Other PEACE
- Economics
- Gasification
- Desalination
- Compute
- Text Output
- Graphics Output
- PEACE Output
- Carrying on...
- Multiple Designs (MACRO)
- Run from Excel (ELINK)
- Off Design Simulation (GT MASTER)

ST Main Inputs

Number of steam turbines: Automatic User-defined (2)

High Pressure Turbine Ports

- Main HPT bleed
- Secondary HPT bleed
- HPT steam addition

Low Pressure Turbine Ports

- Main LPT bleed
- Secondary LPT bleed
- LPT steam addition

Extra LPT bleeds: None

Casing Configuration

Crossover pressure: 1,9 bar

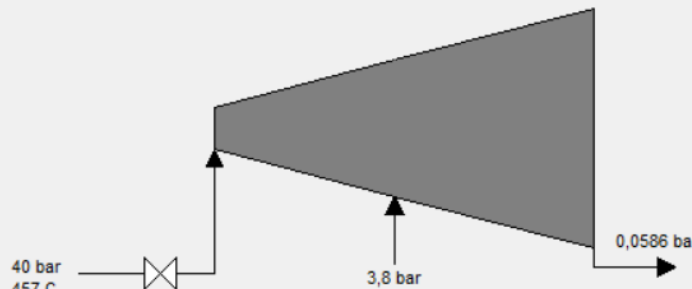
ST Tuning / Output Matching: ST Tuning / Output Matching

Desired ST/Gen output (per ST): 20542 kW

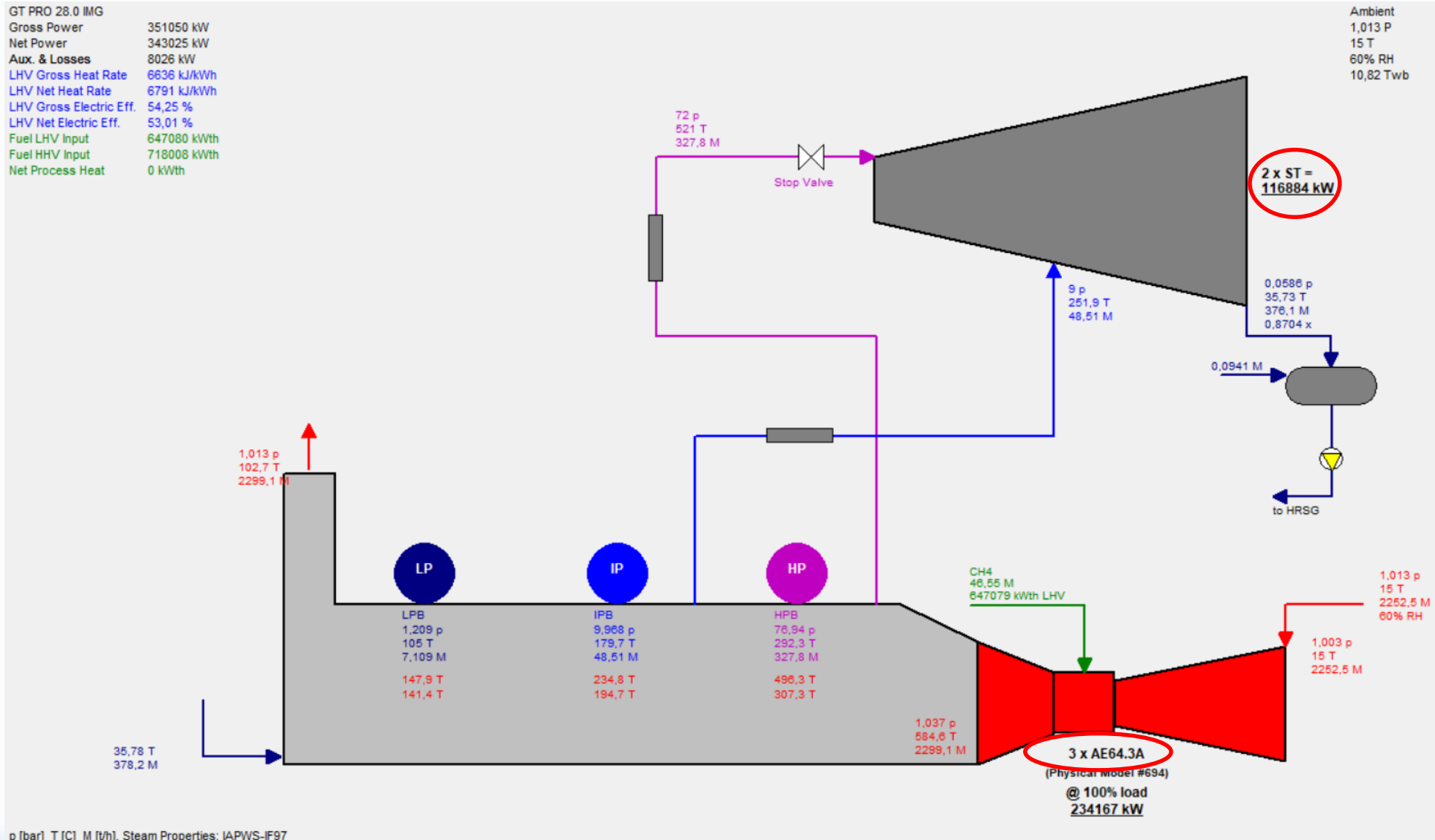
ST equipped with over-flow bypass

40 bar 457 C → 3,8 bar → 0,0586 bar

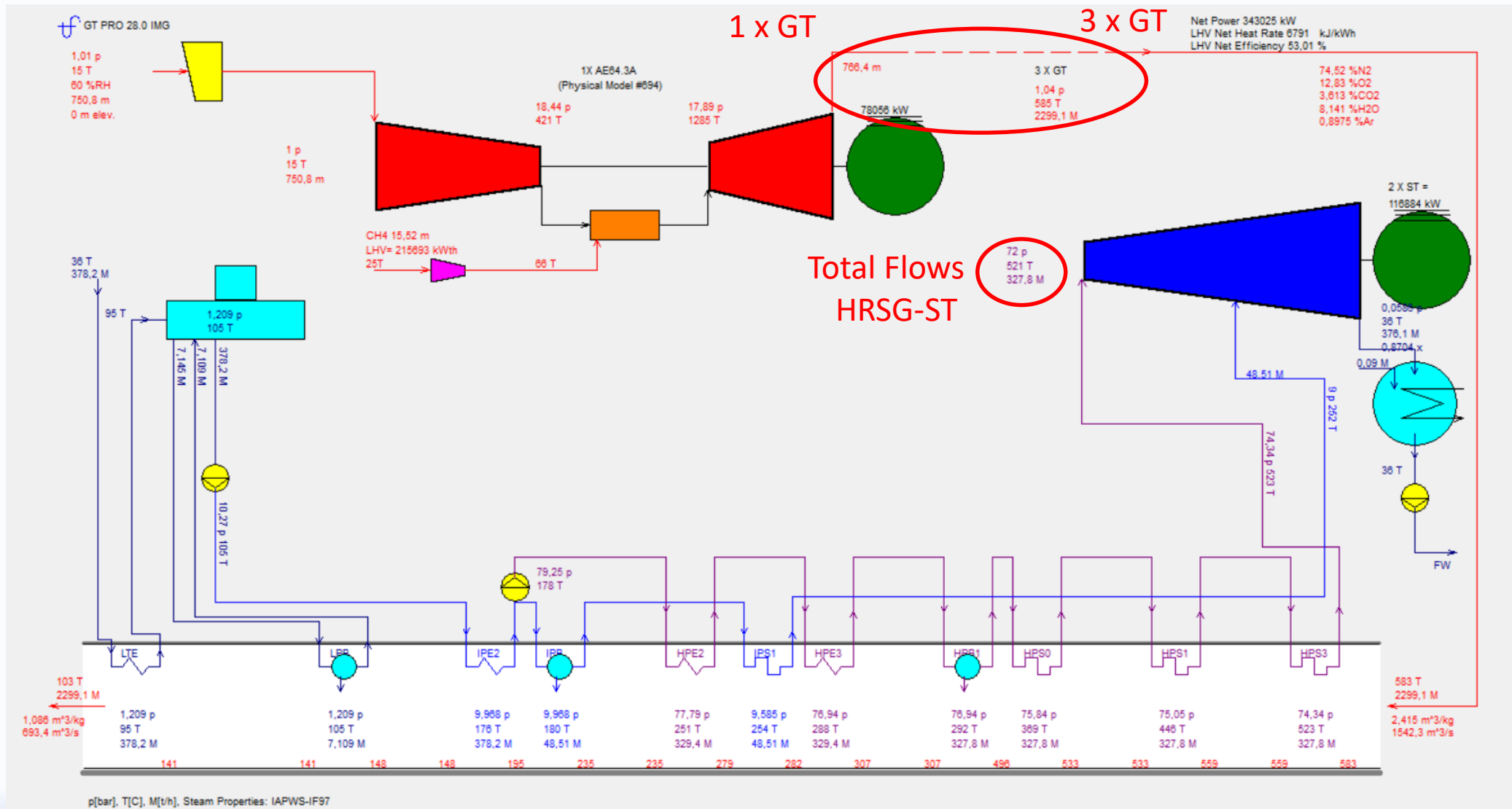
Mass flows are plant total (2 ST's)



Design M on N Systems in GT Pro, Outputs



Design M on N Systems in GT Pro, Outputs

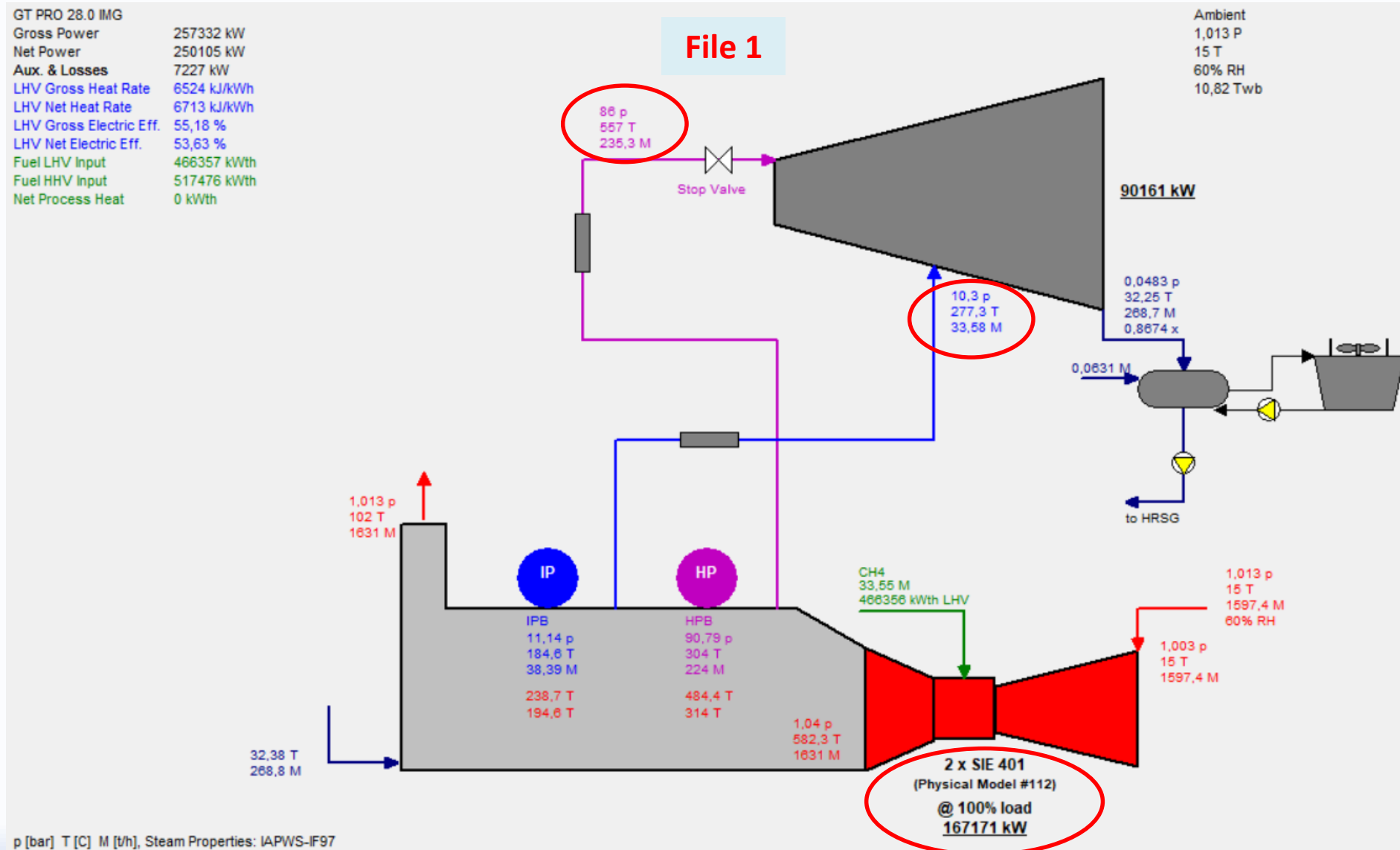


Design M on N Systems in GT Pro

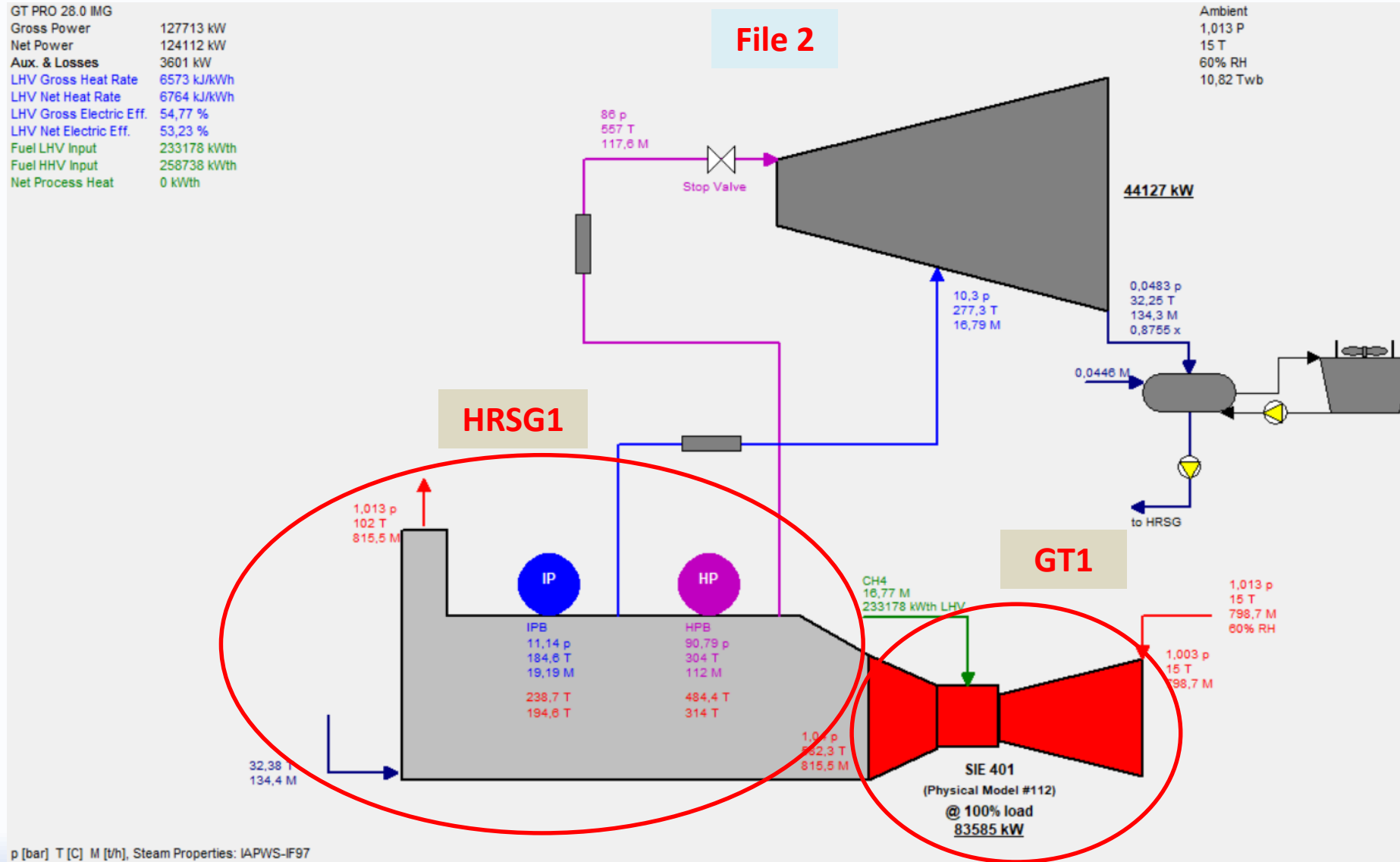
→ **Example:** How to design a system in GT Pro with **different Gas Turbine** models (2x1 2P combined cycle system, similar size GTs):

- Create 3 GT Pro files:
 - File 1: 2xGT (1)-HRSG (1) + 1xST
 - File 2: 1xGT (1)-HRSG (1)- ST(1)
 - File 3: 1xGT (2)-HRSG (2)
- } → Check the Pinch & ST inlet *P* and *T*
- Add the steam from HRSG (2) from File 3 to the ST(1) in File 2

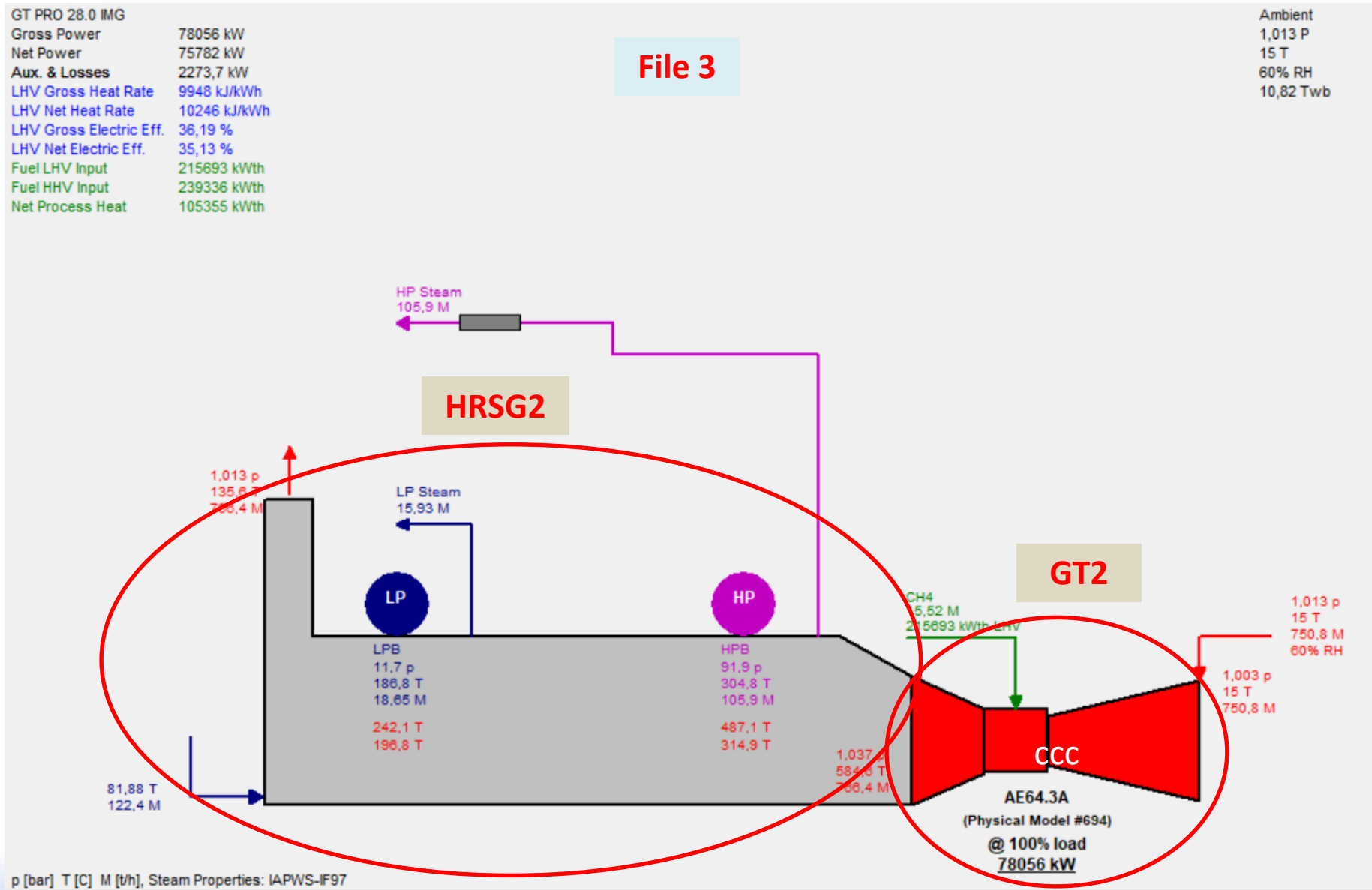
Example 2x1 System in GT Pro w/ different GT models



Example 2x1 System in GT Pro w/ different GT models



Example 2x1 System in GT Pro w/ different GT models



Example 2x1 System in GT Pro w/ different GT models

Navigator: **New Session**

- Start Design
- Plant Criteria
- GT Selection
- GT Inputs
- ST-HRSG
- HRSG Inputs
- Water Circuits
- HRSG Layout**
- Cooling System
- ST Inputs
- Environment
- Other PEACE
- Economics
- Gasification

HX Locations & Duties

HRSG Heat & Mass Flow Additions

Condensate return

Water / Steam Circuit

- High pressure
- Reheat
- Intermediate pressure
- Low pressure

Location	Pressure (bar)	Temperature (C)	Mass Flow (t/h)	Heat Flow (kW)
1	90,79	388,9	0	0
2	90,79	473,8	0	0
3	90,79	473,8	0	0
4	87,72	558,7	105,9	0

HRSG External Heat Transfer

Steam

P 87,72 bar
T 558,7 C
M 105,9 t/h
Q 0 kW

Condensate return

Water / Steam Circuit

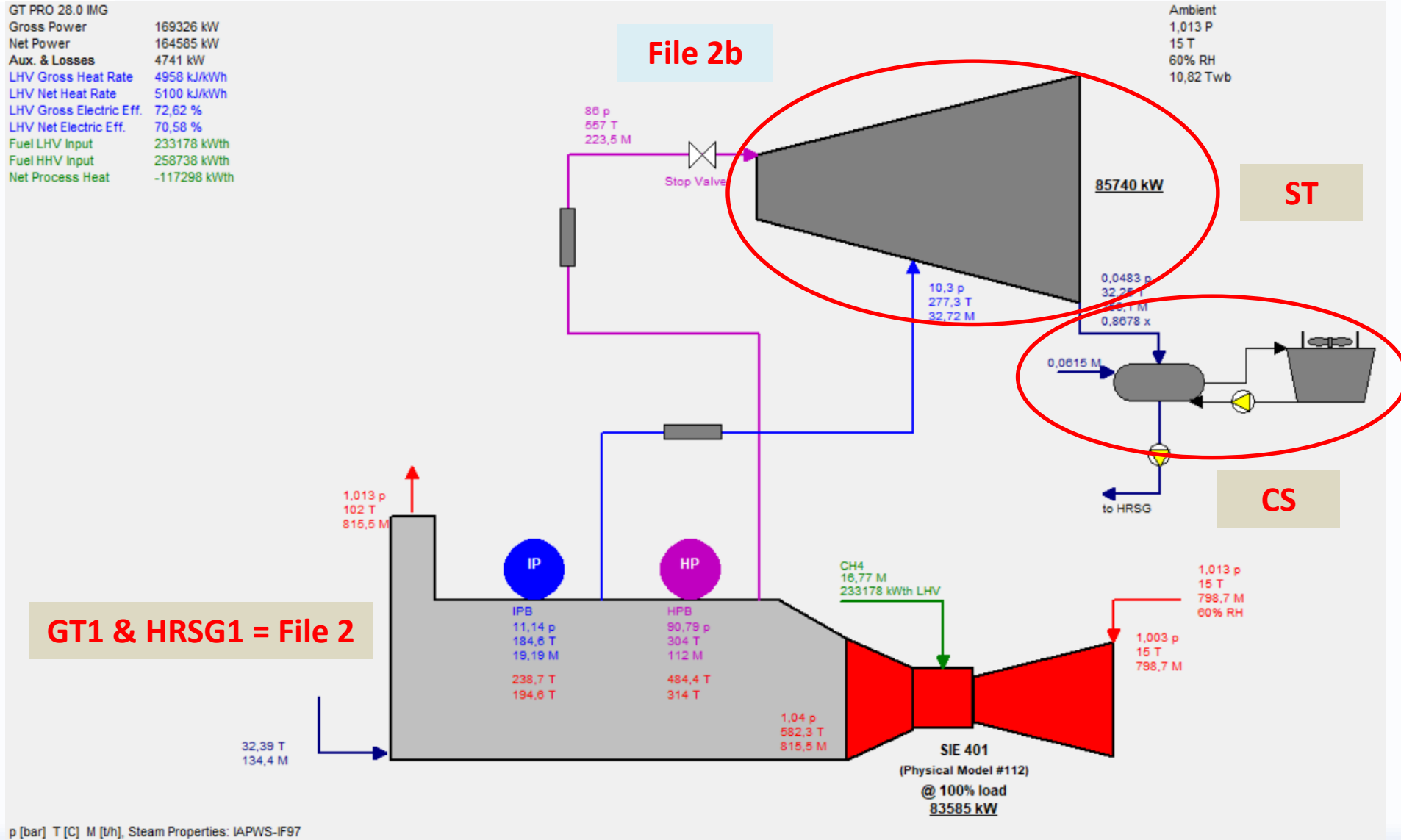
- High pressure
- Intermediate pressure
- Low pressure

Location	Pressure (bar)	Temperature (C)	Mass Flow (t/h)	Heat Flow (kW)
1	11,14	247,5	0	0
2	10,71	279	15,93	0

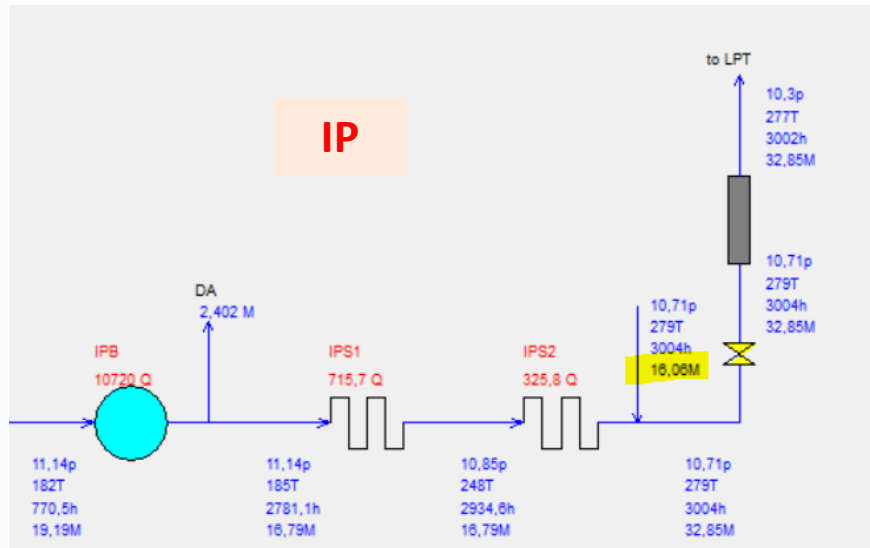
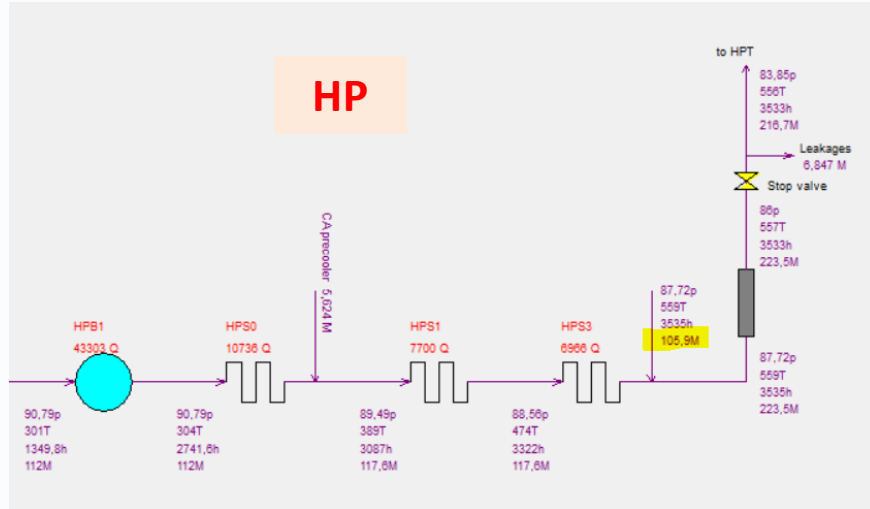
Steam

P 10,71 bar
T 279 C
M 15,93 t/h
Q 0 kW

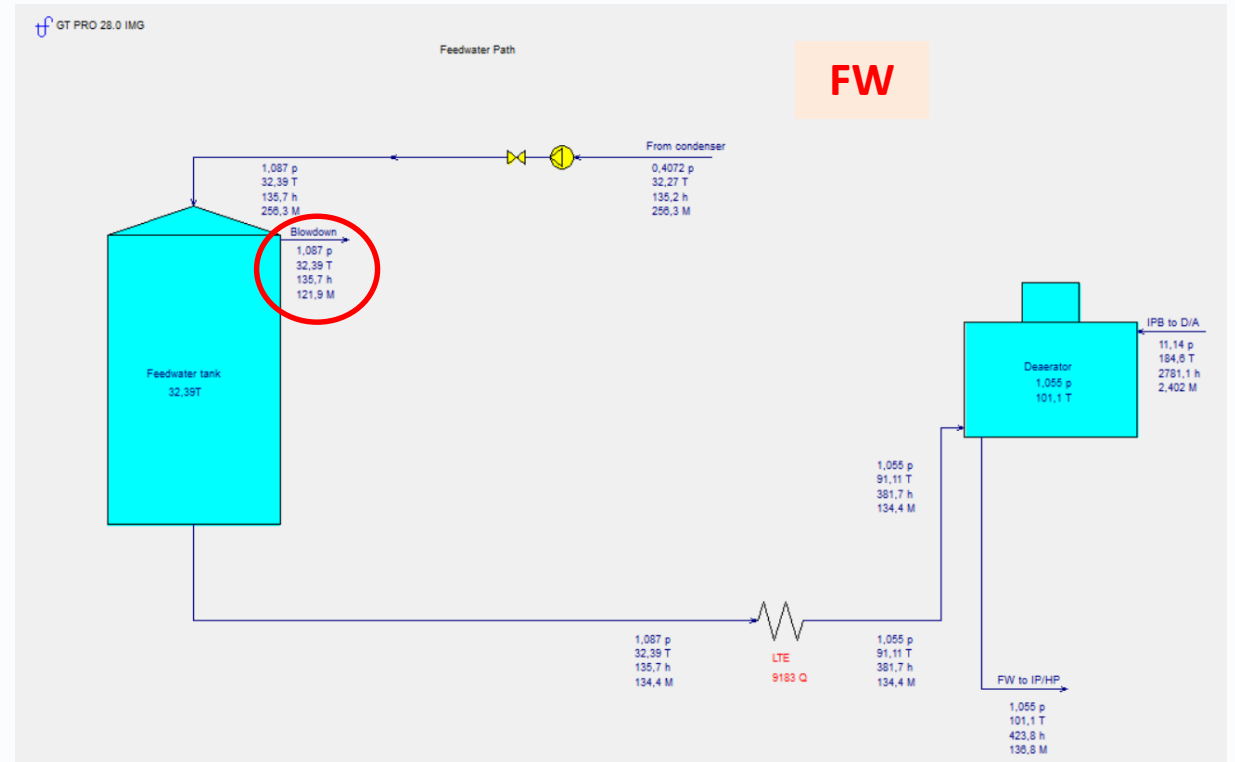
Example 2x1 System in GT Pro w/ different GT models



Example 2x1 System in GT Pro w/ different GT models



File 2b



Design M on N Systems in GT Pro

Components Design from each file

	GT	HRSG	ST	CS
File1	2xGT1	2xHRSG1	ST1	CS1
File2	1xGT1	1xHRSG1	ST2	CS2
File3	1xGT2	1xHRSG2		
File2b	1xGT1	1xHRSG1	ST	CS

Design M on N Systems in GT Pro

Integration of Results

- Gross Power
- Net Power - Auxiliaries
- Fuel consumption – Heat input
- Efficiency

- Plot
- Cost Estimation
- Financial

Design M on N Systems in GT Pro

Integration of Results, Energy

		Sum 2b+3	File 2b	File 3		File 1
Gross Power	kW	247.408				257.332
GT	kW		83.585	78.056		
ST	kW		85.767			
Auxiliaries **	kW	7.026	4.742	2.284		7.227
	% / GP	2,84%				2,81%
Net Power	kW	240.382				
Heat Input-LHV	kW	448.871	233.178	215.693		
Efficiency	%	53,55%				53,63%

Design M on N Systems in GT Pro

Integration of Results, Cost

		Total	Sum 2b+3	File 2b	File 3		File 1
Cost Estimation	M€		246,52	156,4	90,1		238,3
Net Power	MW		240	165	76		250
Specific Cost	USD/kW	?	1026	950	1190		953
Plot	Ha	?		2,066	1,351		2,508

Design M on N Systems in GT Pro

- Other Options
 - ELINK
 - Link in TFX
 - Import to TFX

Design M on N Systems in GT Pro using ELINK

File 2b

File 3

Computation Message ->		OK	OK
INPUT VARIABLE DESCRIPTION	Units	Input	Input
Addition/extraction @ HPS3 exit (plant total)	t/h	105,9	105,9
Addition/extraction @ IPS2 exit (plant total)	t/h	16,06	16,06
OUTPUT VARIABLE DESCRIPTION	Units	Output	Output
Plant gross output	kW	169.352	169.341
Plant net output	kW	164.611	164.600
Plant total fuel LHV chemical energy input (77F/25C)	kW	233.178	233.178
HPT pressure before stop valve	bar	86,0	86,0
HPT temperature before stop valve	C	557,0	557,0
HP/IP/LP Casing: Group LPTL - Group inlet pressure	bar	10,3	10,3
IP steam induction to LPT, after pipe Temperature	C	277,3	277,3

Computation Message ->		OK	OK
INPUT VARIABLE DESCRIPTION	Units	Input	Input
Main HP process pressure / HPT pressure before stop valve	bar	86,0	86,0
Main HP process temperature	C	557,0	557,0
Main IP process pressure / IP steam pressure @ turbine	bar	10,3	10,3
Main IP process temperature	C	277,3	277,3
OUTPUT VARIABLE DESCRIPTION	Units	Output	Output
Plant gross output	kW	78.056	78.056
Plant net output	kW	75.771	75.771
Plant total fuel LHV chemical energy input (77F/25C)	kW	215.693	215.693
HP superheater steam mass flow	t/h	105,9	105,9
IP superheater steam mass flow	t/h	16,06	16,06

		Total	1	2
Gross P	kW	247.397	169.341	78.056
Net P	kW	240.371	164.600	75.771
Aux	kW	7.026	4.741	2.284
Heat Input LHV	kW	448.871	233.178	215.693
Net Eff LHV	%	53,6%	70,6%	35,1%

Design M on N Systems in GT Pro

- Other Examples
 - Case of 3P-RH
 - GTs with different Exhaust T

Design M on N Systems in GT Pro

- Other Examples: RH Option

GT PRO 28.0 - C:\Users\imart\Documents\Thermoflow 28\IMG\FAW\FAW MxN\H1b_GT+HRSG-3PRH_RHT.GTP

File View Options Tools Window Excel Link Scripts Help

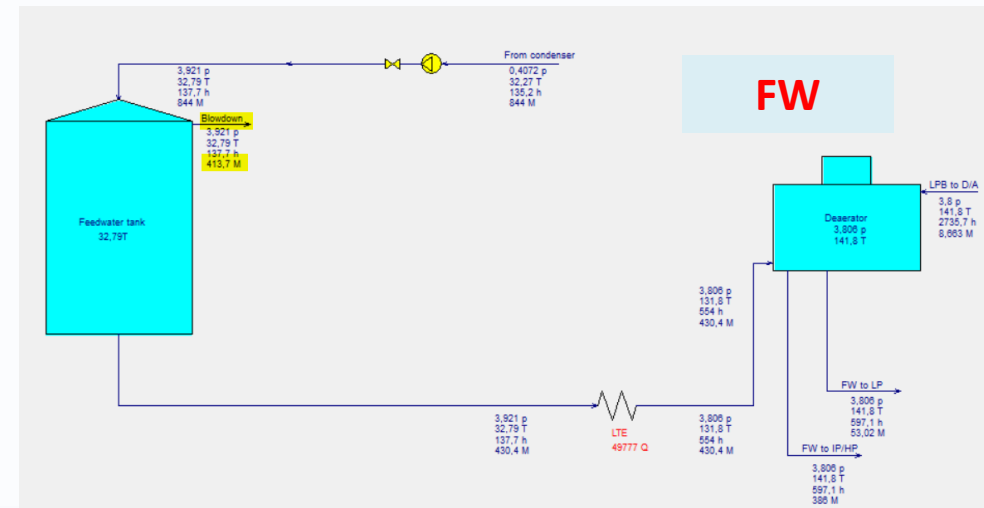
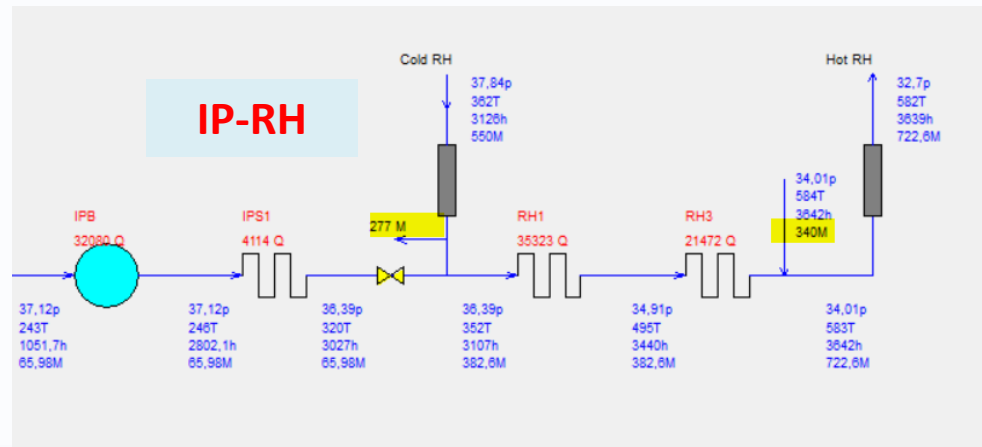
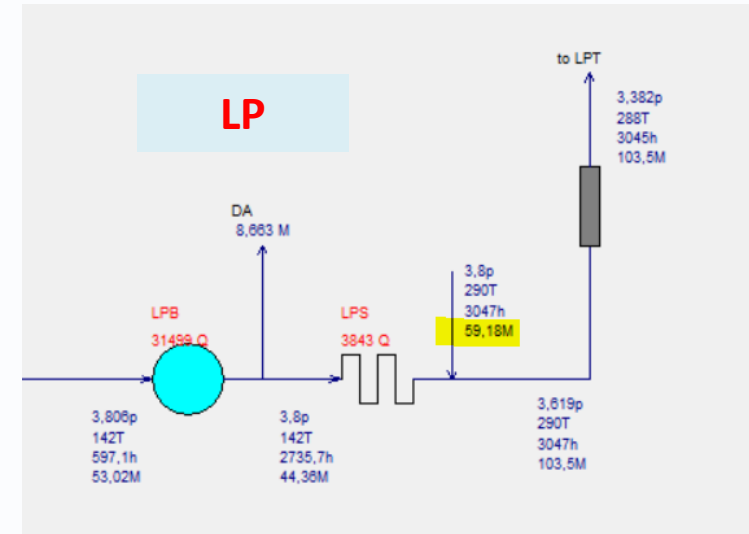
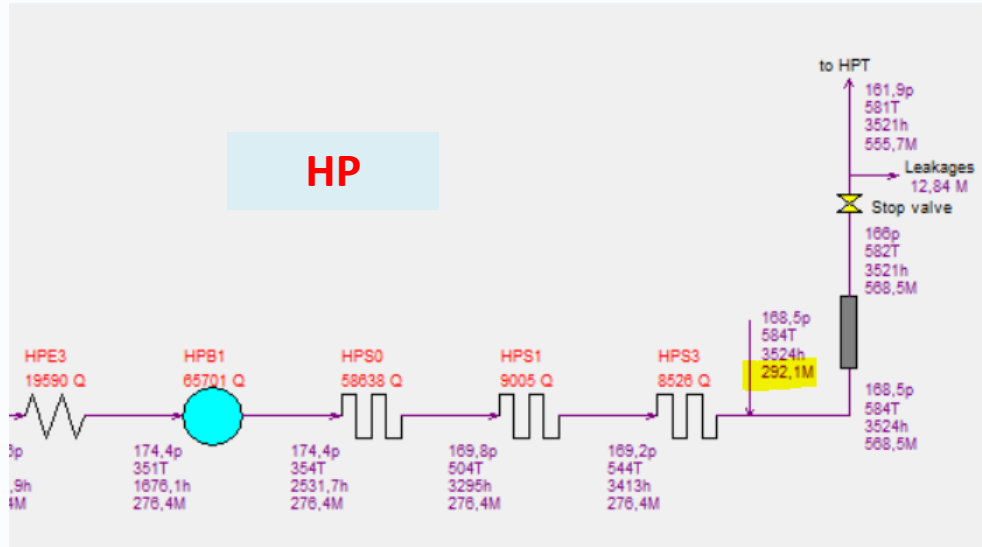
Navigator

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- Carrying on...
- Multiple Designs (MACRO)

HRSG Main Inputs	Thermodynamic Design Assumptions	Hardware Design	Radiant Boiler	Miscellaneous	Equipment Options
1. Percentage of SO2 converted to SO3 in exhaust gas			5	%	
2. Use reheater(s) to heat external steam; 0=no, 1=yes			1		
3. External steam mixing with IP steam before reheater(s); 0=no, 1=yes			1		
4. Debit reheat steam from process condensate return; 0=yes, 1=no			1		
5. External steam massflow at reheater(s) inlet			277	t/h	
6. External steam temperature at reheater(s) inlet			365	C	
7. Hot reheat steam pressure at delivery			32,7	bar	
8. Desired hot reheat steam temperature at delivery			581,2	C	
9. Steam addition from external source to HPB			0	t/h	
10. Steam addition from external source to IPB			0	t/h	
11. Steam addition from external source to LPB			0	t/h	
12. Disable HRSG cross flow corrections; 0=no, 1=yes			0		
13. Compute HRSG radiation Q from DB or GT exhaust; 0=yes 1=no			1		
14. Fin bulk averaged temp. conductivity correction; 0=yes 1=no			0		
15. HRSG heat exchanger gas side pressure drop correction factor			1		
16. Use baffle for HRSG heat exchangers w/ staggered tubing; 0=yes, 1=no			0		
17. Exhaust gas SO3 ppm threshold to trigger warnings and actions			1		
18. Hydrostatic correction for drum elevation (0 to 5)			0		
19. Dilution air fan aerodynamic efficiency			87	%	
20. Dilution air fan electric and mechanical efficiency			90	%	
21. Additional pressure rise for dilution air fan			0	millibar	
22. Dilution air fan sizing; 0=Current heat balance, 1=User-defined			0		
23. Desired exhaust gas temperature after dilution for fan sizing			400	C	
22. Correction factor for HRSG radiation Q from DB or GT exhaust			1		

Design M on N Systems in GT Pro

- Other Examples: RH Option



Design M on N Systems in GT Pro

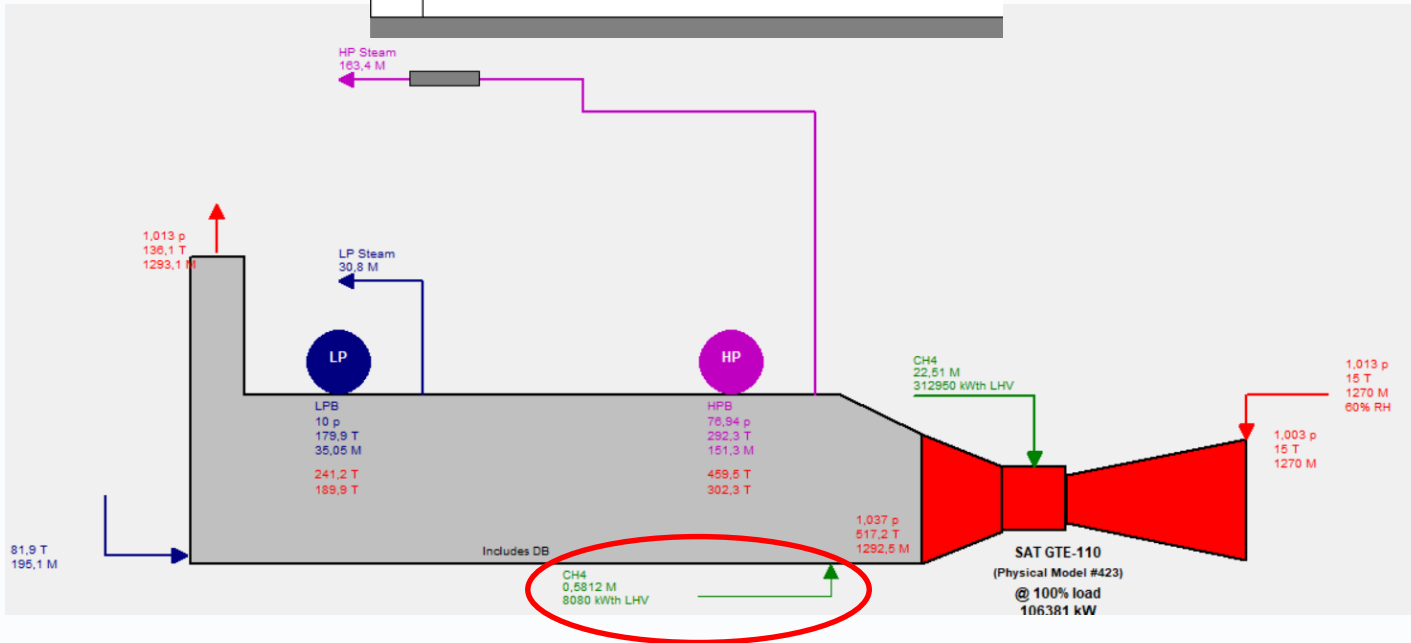
- Other Examples: Different Exhaust T
 - If the 2 GTs have a different exhaust T you can add a Duct Burner to the plant with a lower T_{ex} , to match the final steam Temperatures
 - In GT Pro DB will come automatically to achieve the desired steam T
 - In GT Master you need to define a Control Loop to run the DB at any condition

Design M on N Systems in GT Pro

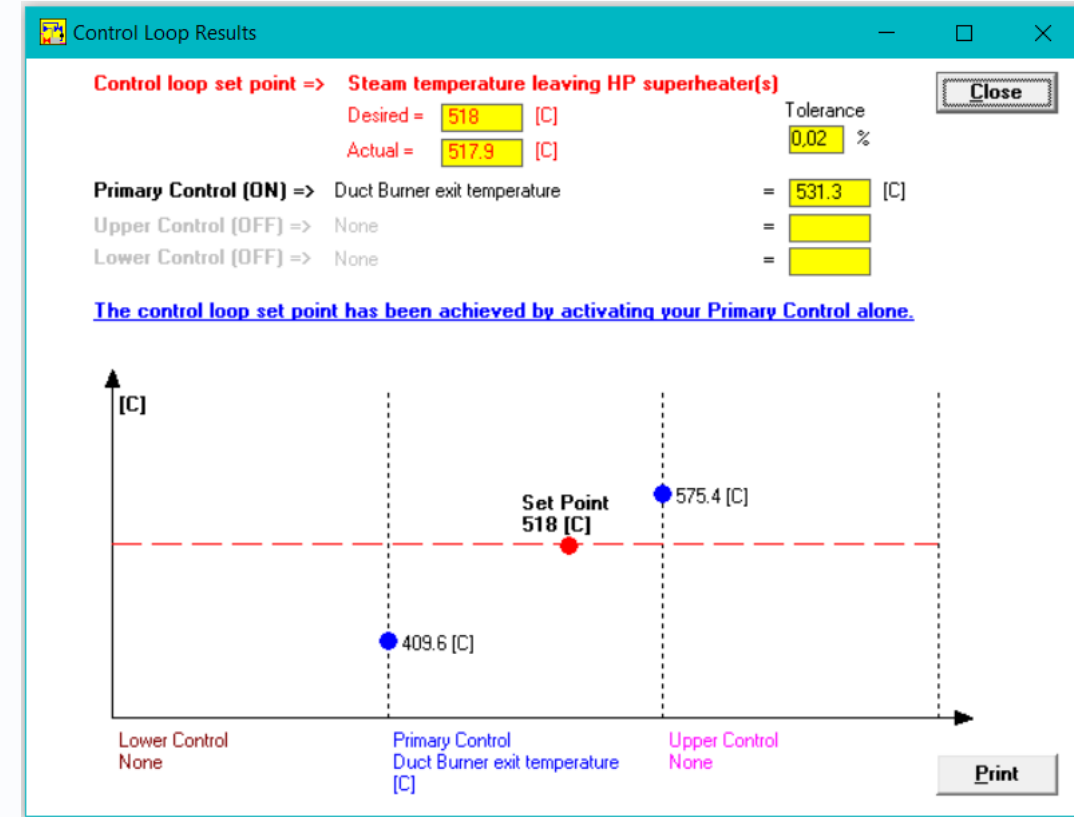
GT Pro

GT PRO Text Output - Messages

Warning Messages	
No warning messages	
Advisory Messages	
No advisory messages	
Remarks	
1.	'You have selected 'No duct burner' on 'HRSG Main Inputs' tab. However, duct firing is needed to achieve current heat balance. GT PRO has included a duct burner for you.



GT Master



Design M on N Systems: Simulation in **GT Master**

- M on N Systems, same GT Models:
 - Only 1 input for GT / HRSG: all of them run on the same condition
 - You can:
 - Operate on simple cycle
 - Switch off some of the GTs
 - Use TFX if you need to run the GTs at different condition
- M on N Systems, different GT Models:
 - Run the 2 Files 2b & 3 separately, iterative process on Pressures-mass flows, then integrate the results
 - Use Thermoflex

Modelling M on N Systems in Steam Pro – Steam Master

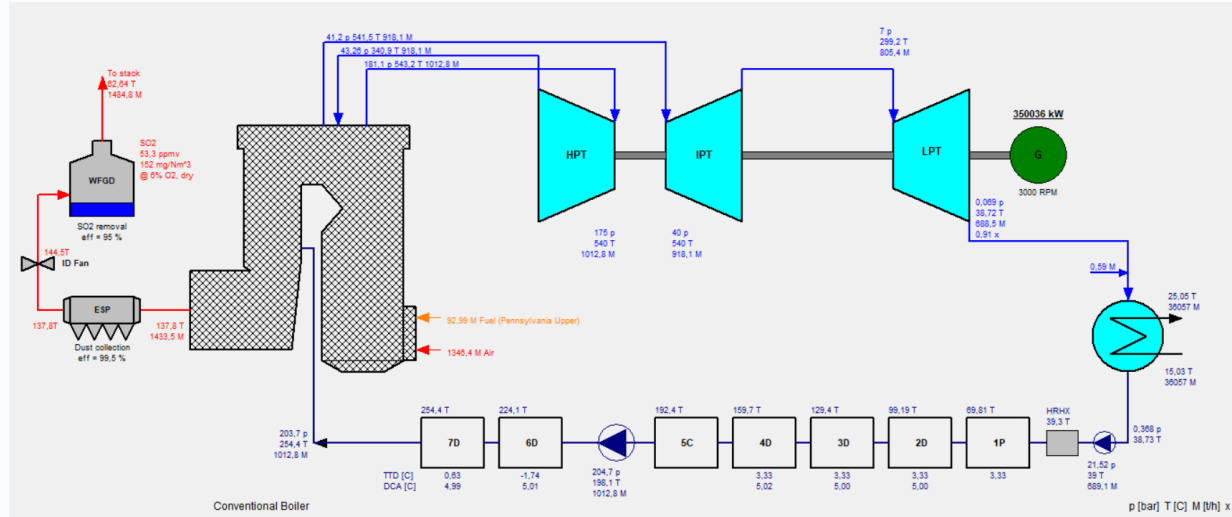
- In **Steam Pro** the user can select:
 - For Conventional Boilers **M** units → Boiler-ST = 1 unit
 - For CFB-BFB and Grate Boilers: **M** units comprised by **N** Boilers + **1** ST
 - You **cannot link** STP files with TFX
 - You can import STP files into TFX
 - Be careful, only 1 Unit can be imported from STP into TFX
- In **Steam Master** you can:
 - For Conventional Boilers run **M** units
 - For CFB-BFB and Grate Boilers you can switch off Boilers of each Unit
 - STM files can be linked to TFX
 - STM files **cannot be imported** into TFX

Modelling M on N Systems in Steam Pro – Steam Master

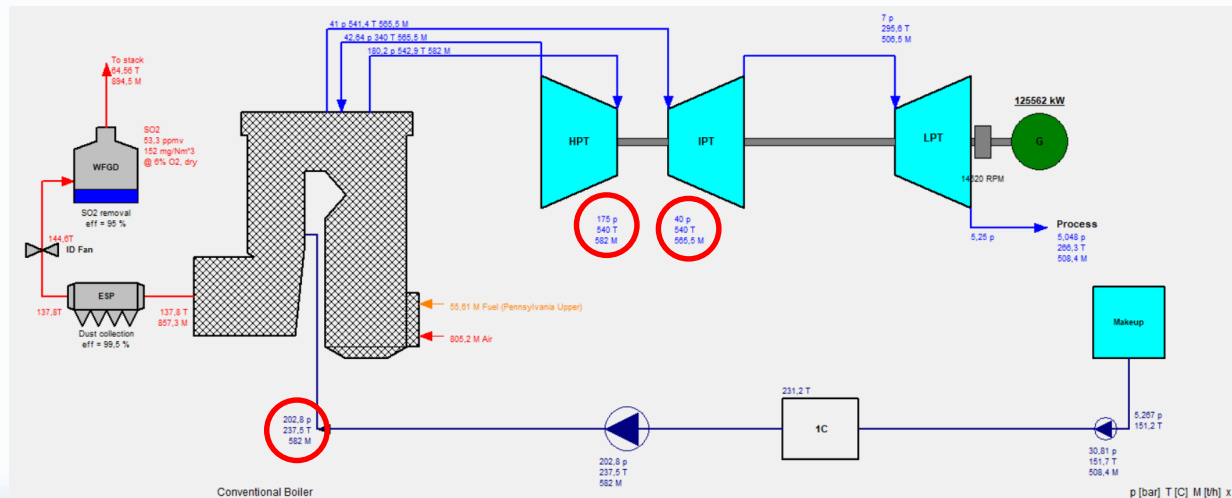
- **Example:** How to create a plant with **2 different Boilers** feeding 1 ST:
- Create 2 STP files:
 - File 1: Boiler (1) + ST (1) + FWHS (1) + CS (1) → HP1 flow
 - File 2: Boiler (2) + ST (2) (no FWH, no CS) → HP2, cRH2, hRH2 and FW2 flows
 - Add / Extract the steam flows from File 2 to File 1 at appropriate locations
 - Steam Cycle specification to Steam Flow (HP1 + HP2)
 - Steam Addition to Port 0 (SPHR), massflow = HP2
 - Steam Extraction (Process) from Port 1 (HPTex), mf = cRH2
 - Steam Addition to Port 2 (IPTin), mf = hRH2
 - Water Extraction “after FWH8”, mf = FW2
 - Run and save as File 1b

- Example: How to create a plant with 2 different Boilers feeding 1 ST:

File 1



File 2



Modelling M on N Systems in Steam Pro – Steam Master

- Example: How to create a plant with 2 different Boilers feeding 1 ST:

Process Streams | **Steam Additions** | Water Addition and Extraction | External Steam Sources | District Heating System | District Heater Hardware

Number of steam additions: 2

Double-click an addition tag to define its steam addition parameters.

Steam Add 2
40 bar 540 C 565 t/h

Steam Add 1
181.1 bar 540 C 582 t/h

Steam Additions, HP2, hRH2

Process Streams | **Process Streams** | Steam Additions | Water Addition and Extraction | External Steam Sources | District Heating System | District Heater Hardware

Number of process streams: 1

Process condensate return location: Condenser hotwell

Desuperheating source for process steam: Boiler feed pump

Double-click a process tag to define its process steam parameters.

Steam Extraction, cRH2

Process 1
42.84 bar 345 C 565 t/h

Process Streams | Steam Additions | **Water Addition and Extraction** | External Steam Sources

Water Addition

Number of water additions: 0

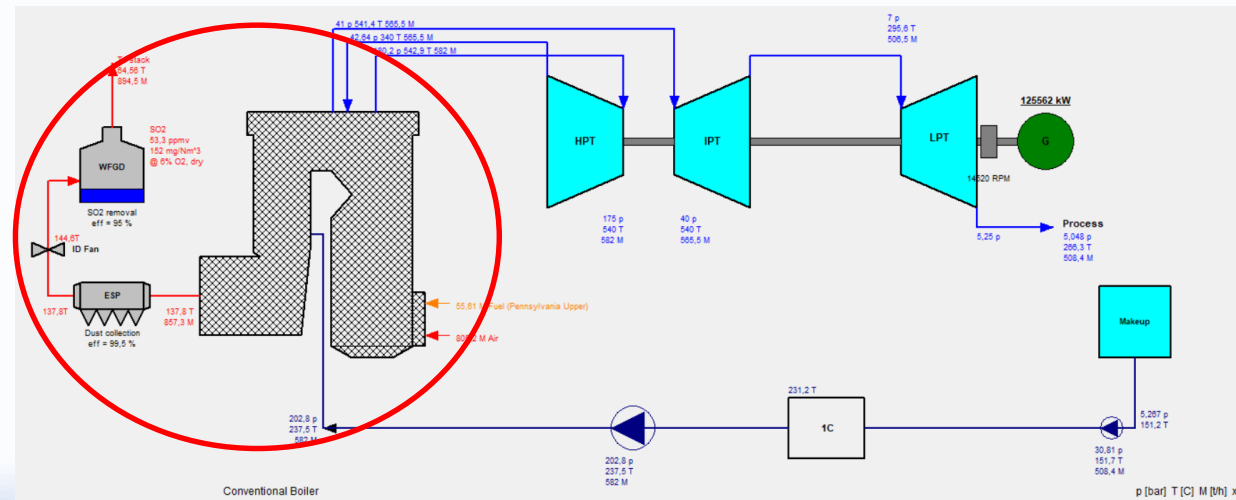
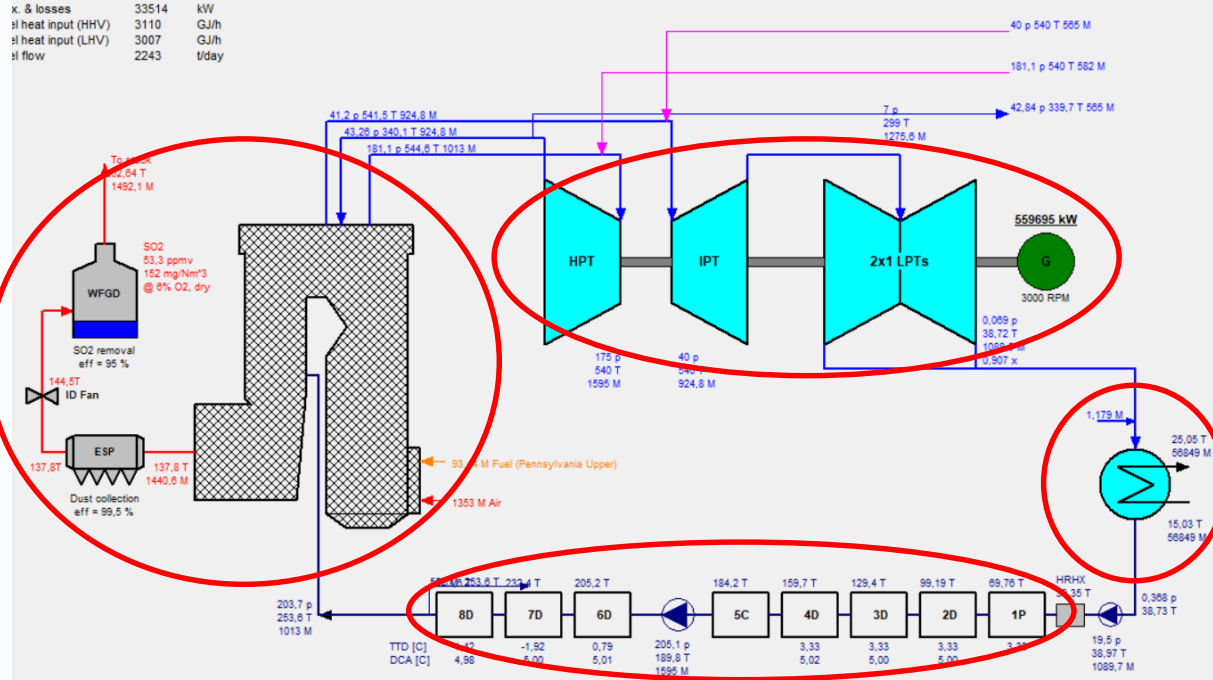
No.	Addition location	Mass flow rate	Pressure	Temperature
No. 1		NA t/h	NA bar	NA C
No. 2		NA t/h	NA bar	NA C
No. 3		NA t/h	NA bar	NA C

Water Extraction

Number of water extractions: 1

No.	Extraction location	Desired mass flow
No. 1	After Pw/H8	562 t/h
No. 2		NA t/h
No. 3		NA t/h

Water Extraction, FW2



Modelling M on N Systems in Steam Pro – Steam Master

- Example: How to create a plant with 2 different Boilers feeding 1 ST:

Components Design from each file

	Boiler	ST	FWHS	CS
File1	Boiler 1	ST 1	FWHS 1	CS 1
File2	Boiler 2	ST 2		
File1b	Boiler 1	ST	FWHS	CS

Integration of Results

		Total	File 1b	File 2
Gross Power	MW	559,7	559,7	125,6
Auxiliaries **	MW	?	24,4	12,8
Net Power	MW	?		
Heat Input-HHV	MW	1.378,0	863,9	514,1
Gross Efficiency	%	40,6%		
Cost Estimation	MUSD	?	940,8	489,0

- Example: How to create a plant with 2 different Boilers feeding 1 ST:

Integration of Results:

- Auxiliaries associated to the Boilers should be OK in File 1b and File 2
- Auxiliaries associated to the Steam Cycle:
 - Remove the CFP and BFP from File 2, depending on the pumps configuration
 - Check the Additional PEACE and Miscellaneous
- Cost Estimation:
 - Remove the cost associated to the steam cycle in File 2
 - Check the cost of the general and auxiliary equipment, Tanks, Buildings, ...

Design M on N Systems in **Thermoflex**

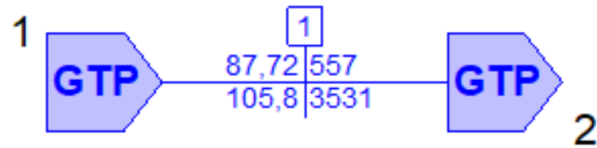
- In THERMOFLEX the user can:
 - *Standalone*: Any combination of GTs-HRSGs-Boilers-STs-Cooling Systems, ...
 - *Link* with Files with GTP-GTM-STM
 - *Import* Files from GTP-GTM-STP

- Example: Design M on N Combined Cycle plant with variable M and N using scripts → Sample (S2-37)

Design M on N Systems using THERMOFLEX

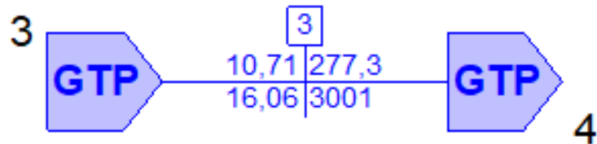
→ **Link** GTP-TFX, only “connections”

HP Steam from File3 SH addition to File 2b SH exit



Check Presures!!

IP Steam from File3 SH addition to File 2b SH exit

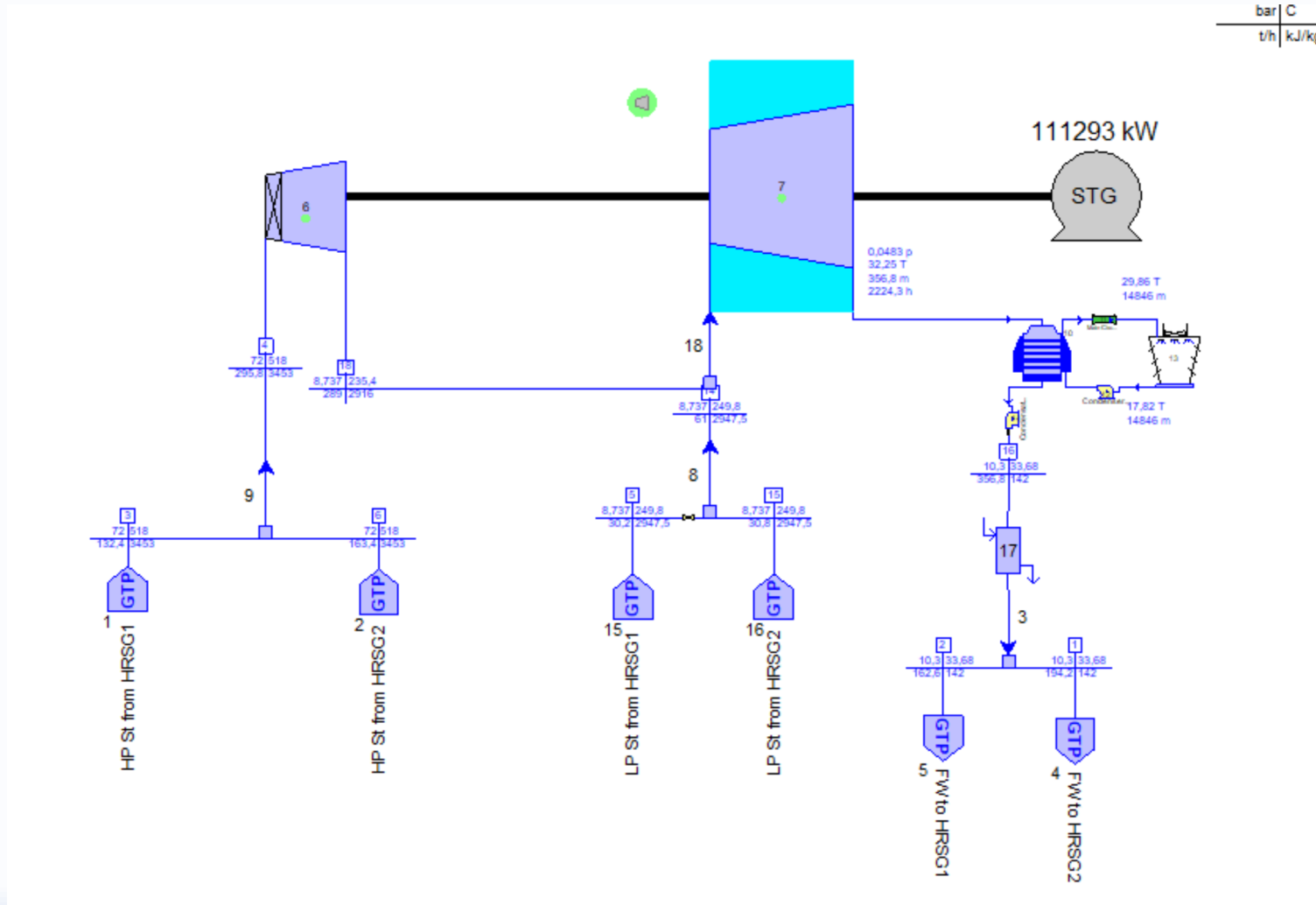


Summary of TFX & Linked Files						
	Gross power	Net power	Net HR	Net Eff	Fuel input	[kW]
File name	[kW]	[kW]	[kJ/kWh]	[%]	LHV	HHV
F2_1XGT1-HRSG1-ST.GTP	169299	164559	5101	70,57	233178	258738
F3_1XGT2-HRSG2.GTP	78056	75758	10250	35,12	215693	239336
THERMOFLEX						
Totals	247355	240317	6724	53,54	448871	498074

Performance of Gas Turbines in GT PRO Files							
			Gross Power	Gross LHV eff	Gross LHV HR	Exh. Flow	Exh. Temp.
File name	GT name	Units	[kW]	[%]	[kJ/kWh]	[t/h]	[C]
F2_1XGT1-HRSG1-ST.GTP	SIE 401	1	83585	35,85	10043	815,5	582,3
F3_1XGT2-HRSG2.GTP	AE64.3A	1	78056	36,19	9948	766,4	584,6

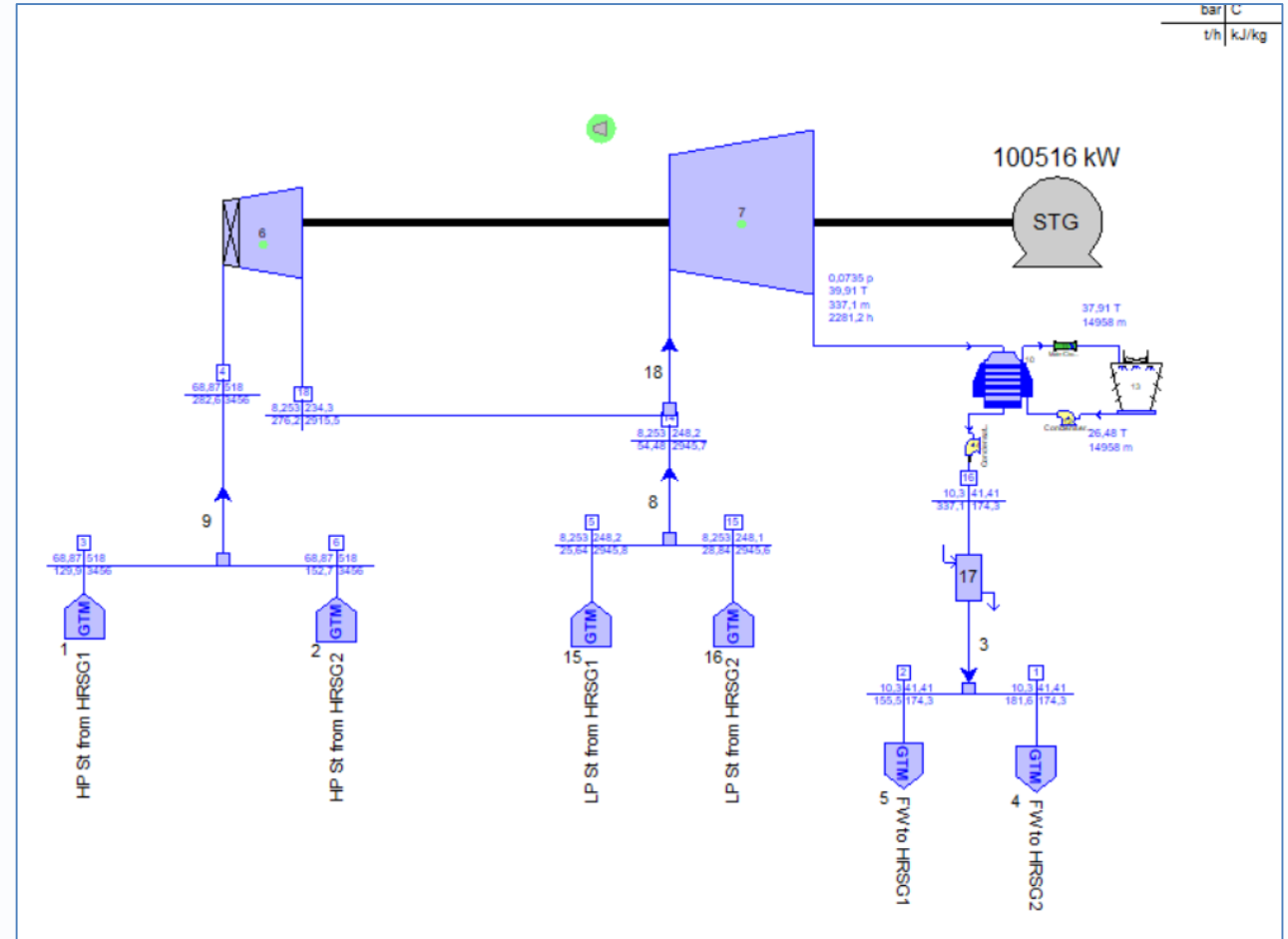
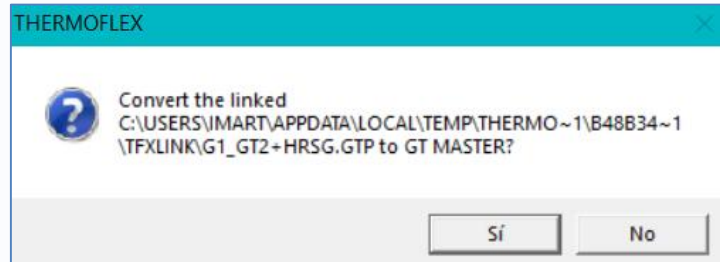
Design M on N Systems using THERMOFLEX

→ **Link** GTP-TFX, GT-HRSG in GTP, ST-CS in TFX



Design M on N Systems using THERMOFLEX

→ Off Design, GTP Links converted to GTM



→ **Import** from GTP (GTM) into TFX

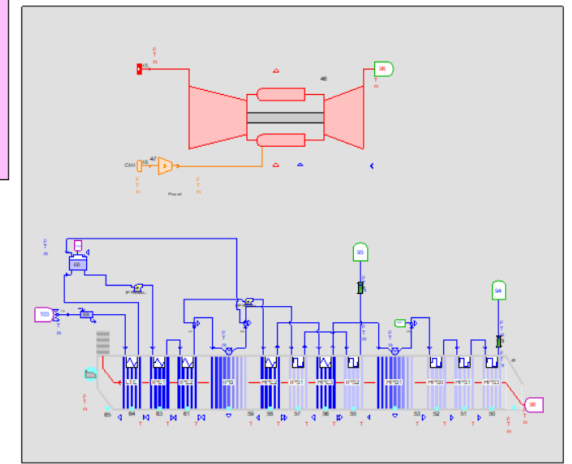
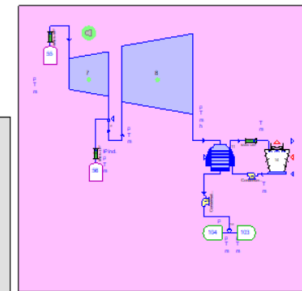
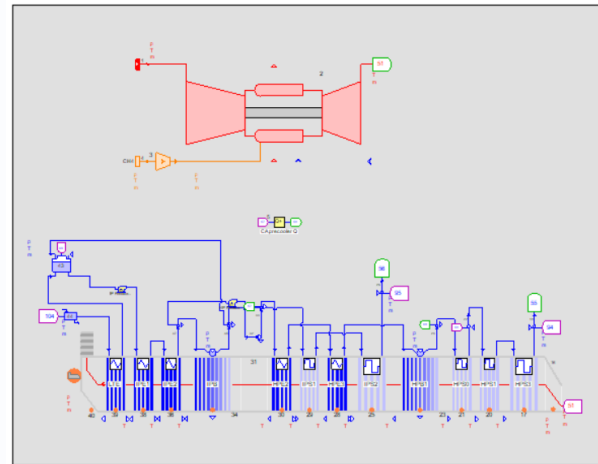
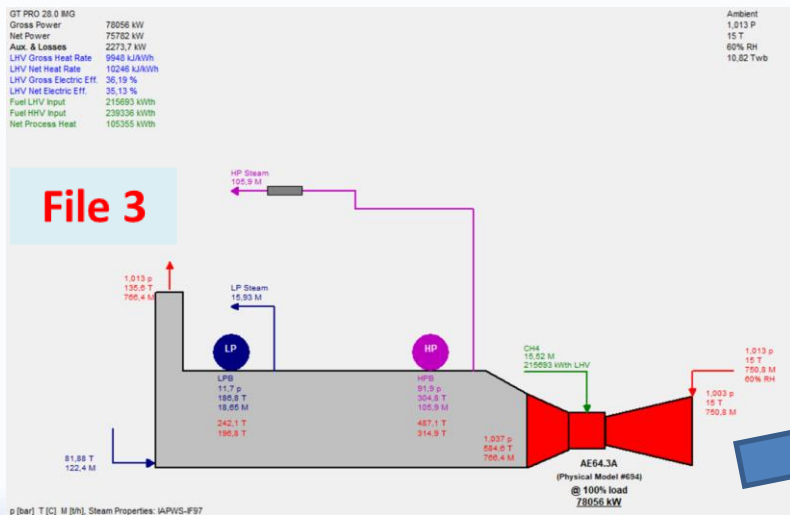
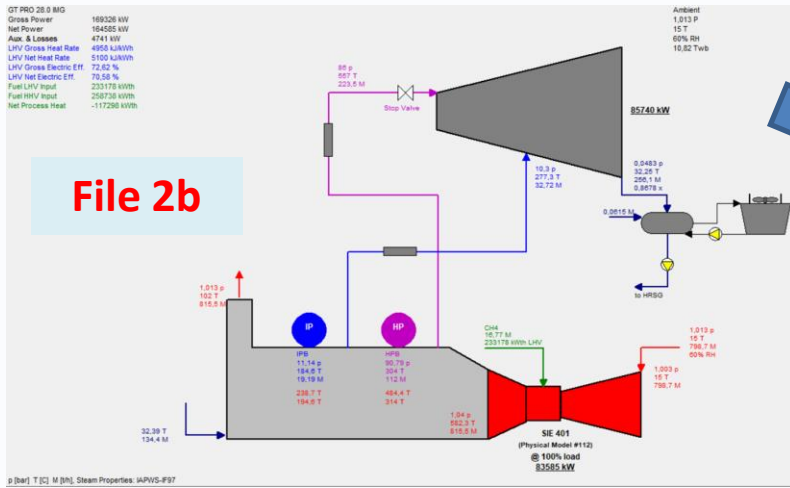
- Import File 2b
- Import File 3
- Copy All in File 3 and Paste it into File 2b
- Change sources / sinks / process by connections & add Mixers /Splitters:
 - HP steam from HRSG2: mix with HP steam from HRSG1, before ST
 - IP steam from HRSG2: mix with IP steam from HRSG1, before ST
 - Feedwater from Condensate Pump: Split to HRSG2
- Run in design mode, TD-ED
- Run in Off Design mode

→ Import from GT Pro: redesign

→ Import from GT Master: hardware fixed, simulation

Design M on N Systems using THERMOFLEX

→ Import from GTP (GTM) into TFX



→ Import from GTP (GTM) into TFX

Final Plant Results

	Unit	LHV	HHV				
Net fuel/energy input	[kW]	448933	498142				
Gross heat rate	[kJ/kWh]	6539					
Net heat rate	[kJ/kWh]	6721	7458				
Gross electric efficiency	[%]	55,05					
Net electric efficiency	[%]	53,56	48,27				
CHP efficiency	[%]	53,56					
PURPA efficiency	[%]	53,56					
Gross power	[kW]	247138					
Net power	[kW]	240459					
Total auxiliaries and transformer losses	[kW]	6679					
Net process heat output	[kW]	0					
POWER DEVICE(S)							
Generator	Component	Shaft	Shaft [kW]	Eff [%]	Multiplier	Gen [kW]	Accounted [kW]
	ST Assembly [1]: ST Group [7]		33657				
	ST Assembly [1]: ST Group [8]		53269,3				
ST Assembly [1] generator			86926,3	98,52	1	85635,6	85635,6
Gas Turbine (GT PRO) [2] generator			86559,7	96,47	1	83505,5	83505,5
Gas Turbine (GT PRO) [46] generator			80491,7	96,9	1	77997,2	77997,2
Total Generator(s)						247138,2	247138,2

Project Cost Summary (USD)	Reference Cost	Estimated Cost	
Power Plant			
I. Specialized Equipment	93.832.000	98.524.000	USD
II. Other Equipment	7.945.000	8.342.000	USD
III. Civil	11.994.000	13.625.000	USD
IV. Mechanical	14.777.000	17.345.000	USD
V. Electrical Assembly & Wiring	4.978.000	5.855.000	USD
VI. Buildings & Structures	6.711.000	7.718.000	USD
VII. Engineering & Startup	13.900.000	13.921.000	USD
VIII. Linked Files & Other Systems	0	0	USD
Subtotal - Contractor's Internal Cost	154.136.000	165.329.000	USD
IX. Contractor's Soft & Miscellaneous Costs	41.001.000	46.877.000	USD
Contractor's Price	195.137.000	212.205.000	USD
X. Owner's Soft & Miscellaneous Costs	17.562.000	19.098.000	USD
Other Standalone Plants (Owner's Cost)	0	0	USD
Total - Owner's Cost	212.700.000	231.304.000	USD
Nameplate Net Plant Output	240	240	MW
Price per kW - Contractor's	811,5	882,5	USD/kW
Cost per kW - Owner's	884,6	961,9	USD/kW
* Cost estimates as of September 2018.			

Financial Summary	Cash Flow	
These results are based on simplified annual model defined by the user.		
Annual Electricity Exported	1.580	10 ⁶ kWh
Annual Heat Exported	0	TJ
Annual Fuel Imported	10.618	TJ LHV
Annual Water Imported	1.430	10 ⁶ l
Annual CO2 Emission	582	ktonne
Annual Desal Water Exported	0	MM imperial gal.
Annual Hydrogen Exported	0	TJ LHV
Annual Syngas Exported	0	TJ LHV
Annual CO2 Captured	0	ktonne
Annual Limestone Consumed	0	ktonne
Annual Lime Consumed	0	ktonne
Annual CO2 Capture Solvent Consumed	0	ktonne
Annual Combustion Waste Production	0	ktonne
Annual FGD Waste/Byproducts Production	0	ktonne
Annual Activated Carbon Consumed	0	ktonne
Total Investment	231.304.000	USD
Specific Investment	961,9	USD per kW
Initial Equity	69.391.180	USD
Cumulative Net Cash Flow	535.235.600	USD
Internal Rate of Return on Investment (ROI)	13,339	%
Internal Rate of Return on Equity (ROE)	24,429	%
Years for Payback of Equity	4,707	years
Net Present Value	111.567.400	USD
Break-even Electricity Price @ Input Fuel Price (i.e. Levelised Cost of Electricity)	0,0557	USD/kWh
Break-even Fuel LHV Price @ Input Electricity Price	7,073	USD/GJ

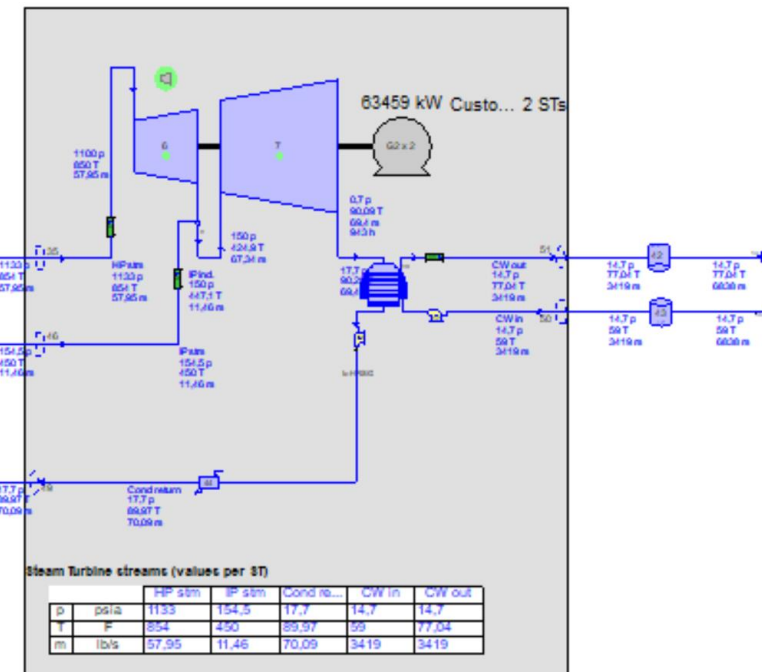
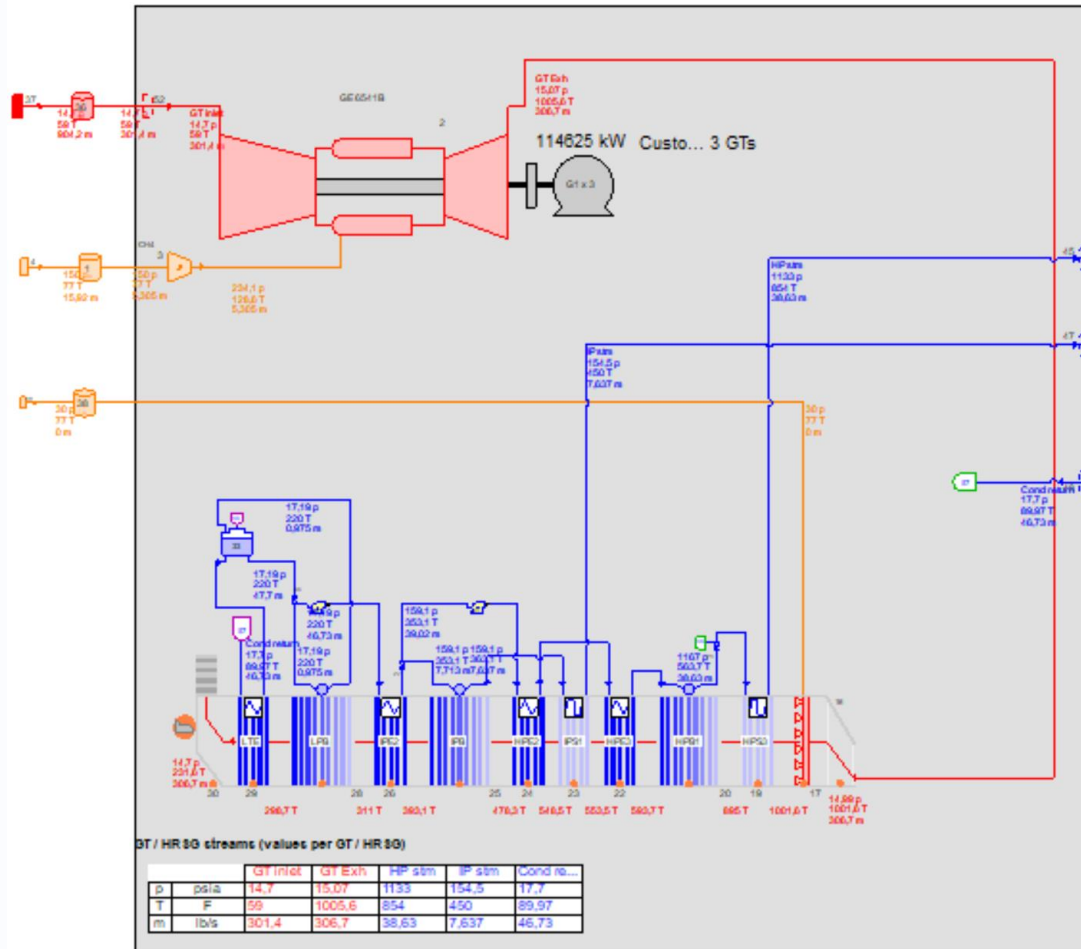
Design M on N Systems in Thermoflex

Sample (S2-37)

Custo... 3 GTs

Custo... 2 STs

psia | F
lb/s | BTU/lb



Gross power 178085 kW
 Net power 173097 kW
 Net electric efficiency(LHV) 47.91 %

→ Conclusions: Which Option to choose?

- Programs you have licenced
- Your ability with the programs GTPM-TFX, ...
- Stage of Project: feasibility, conceptual, matching a HB, vendor data, ...
- Level of details you need
- Plant complexity
- Flexibility you require
- ...

Q & A Session

- Please forward your questions on the WebEx Chat
- Further questions by email to: info@thermoflow.com

- PP Presentation will be available on the Website / Tutorials
- Video will be available on the Service Center

Thank you!

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