



# Welcome!

## Webinar #9: METHODS & METHODOLOGIES 16 August 2017

### Agenda:

- \* Introduction – Method & Methodology Fundamental Differences
- \* Examples illustrating the differences in Method used.
- \* Examples illustrating other fundamental differences arising from Method used
- \* Methodology – type 1, type 2, type 3 – meaning, examples etc.
- \* Methodology in STPro
- \* Q & A Session (pls. send Q's anytime during the presentation to both the presenter & host)

# ThermoFlow 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 Thermostat
- 2- Scripts in Thermostat programs
- 3- Multi Point Design
- 4- Reciprocating Engines
- 5- Simplified Annual & TIME
- 6- Matching ST Performance
- 7- Modelling Solar Systems
- 8- Combining Thermostat & Application Specific
- 9- Methods and Methodology explained**

# Introduction – Method & Methodology in GTPRO

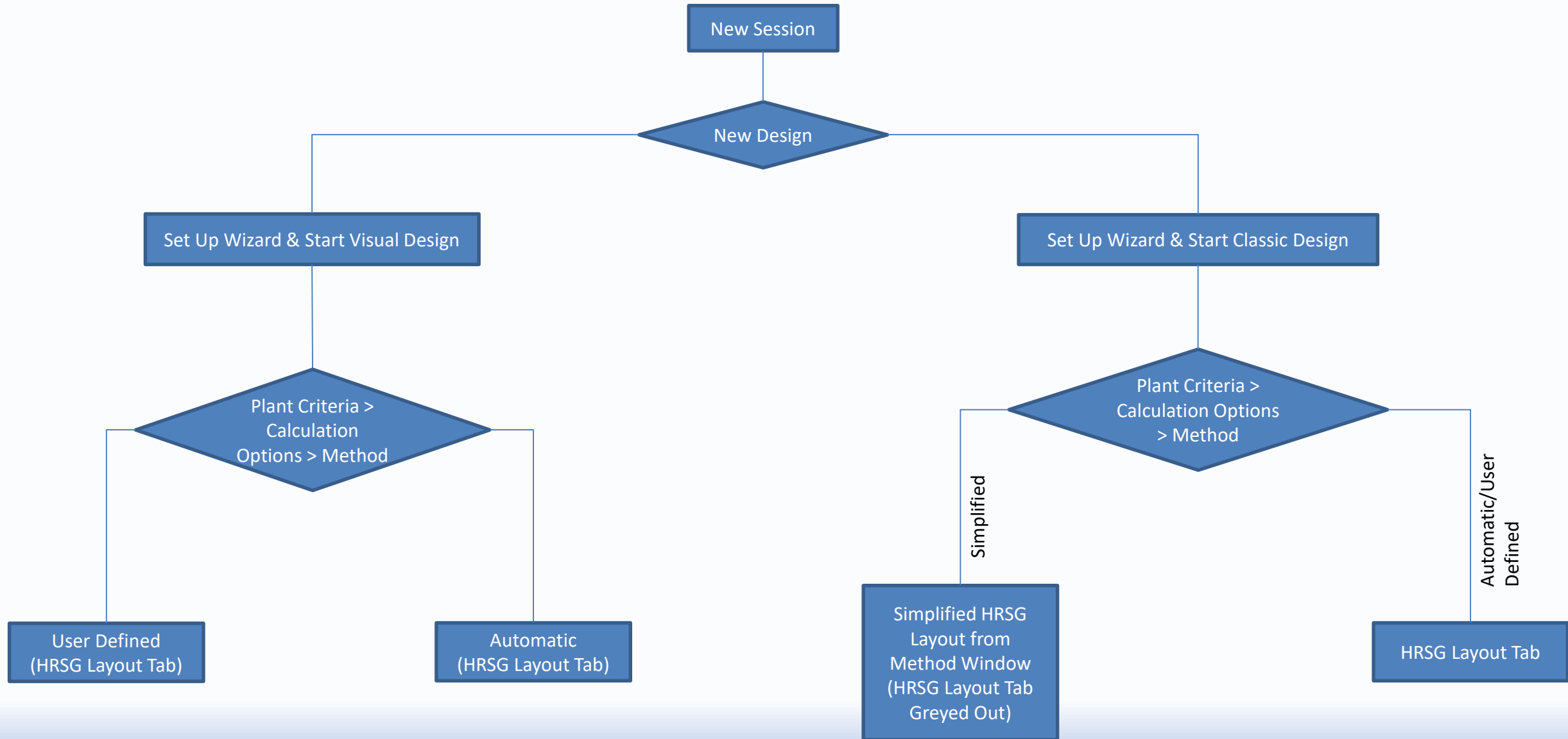
- Both Methods & Methodology feature at the early stage of model definition.
- Each serve a completely different purpose.

Method : influences the method used for the HRSG design (either by the Simplified, the Automatic or the User Defined Method)

*Note that since there is no HRSG in a Rankine plant, Method does not feature in Steam Pro.*

Methodology : allows the user to choose how the program applies effects of hardware determined from the initial calculation into subsequent calculation runs (either in GTPro or GTM)

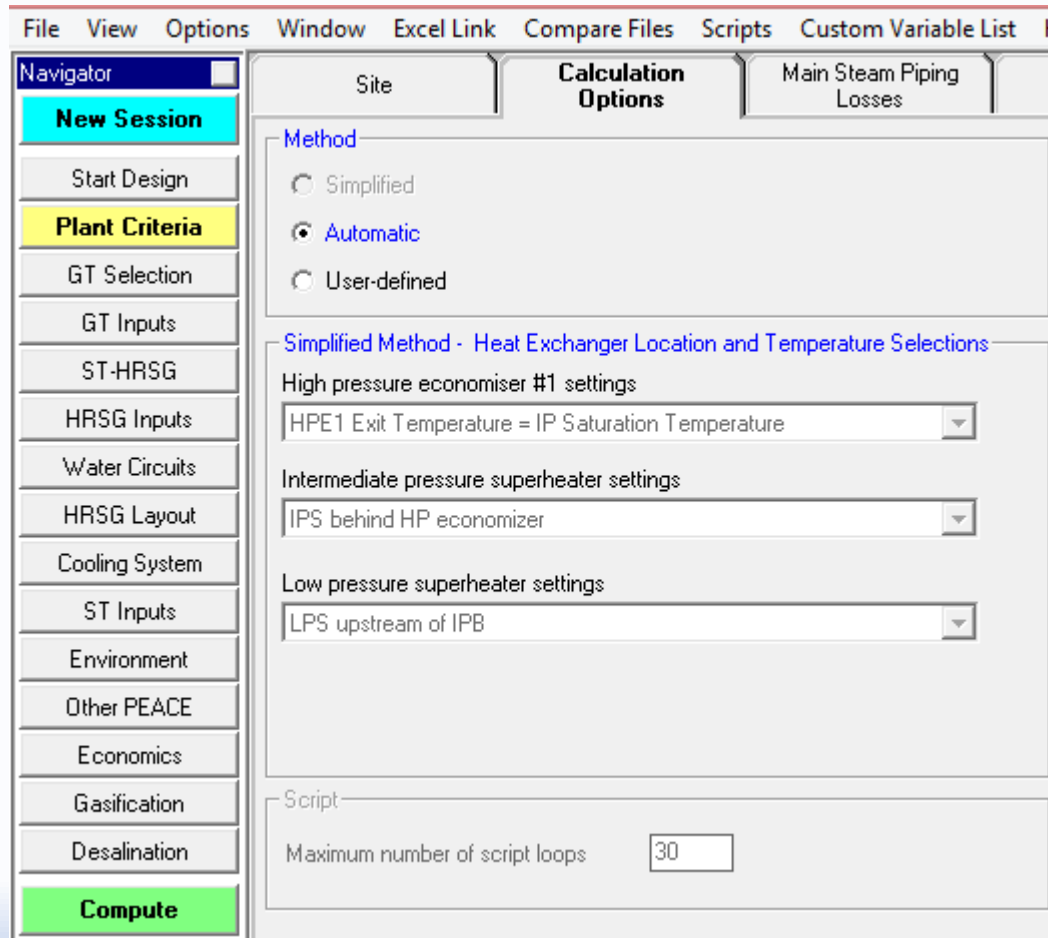
# Method (In Terms of a Flowchart)



# Differences in Representation – 2P HRSG, Condensing ST

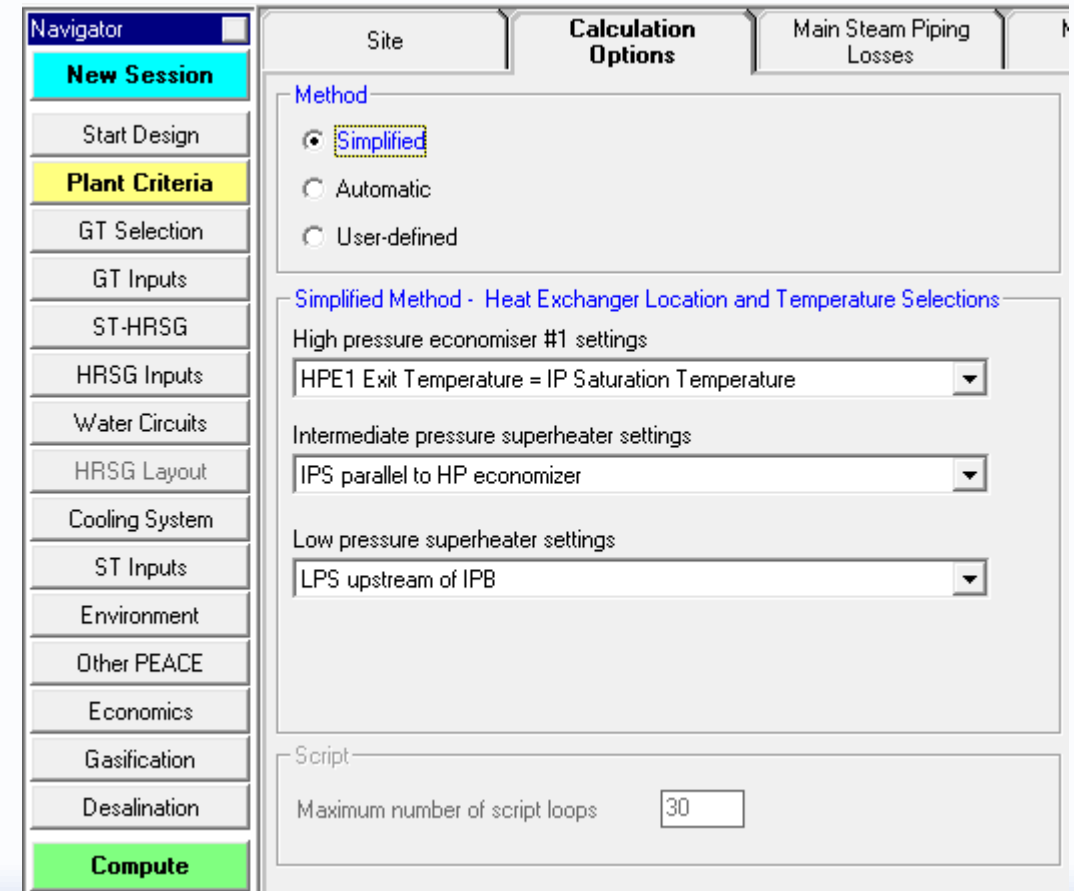
Visual Method

Calculation Options > Automatic or User Defined only



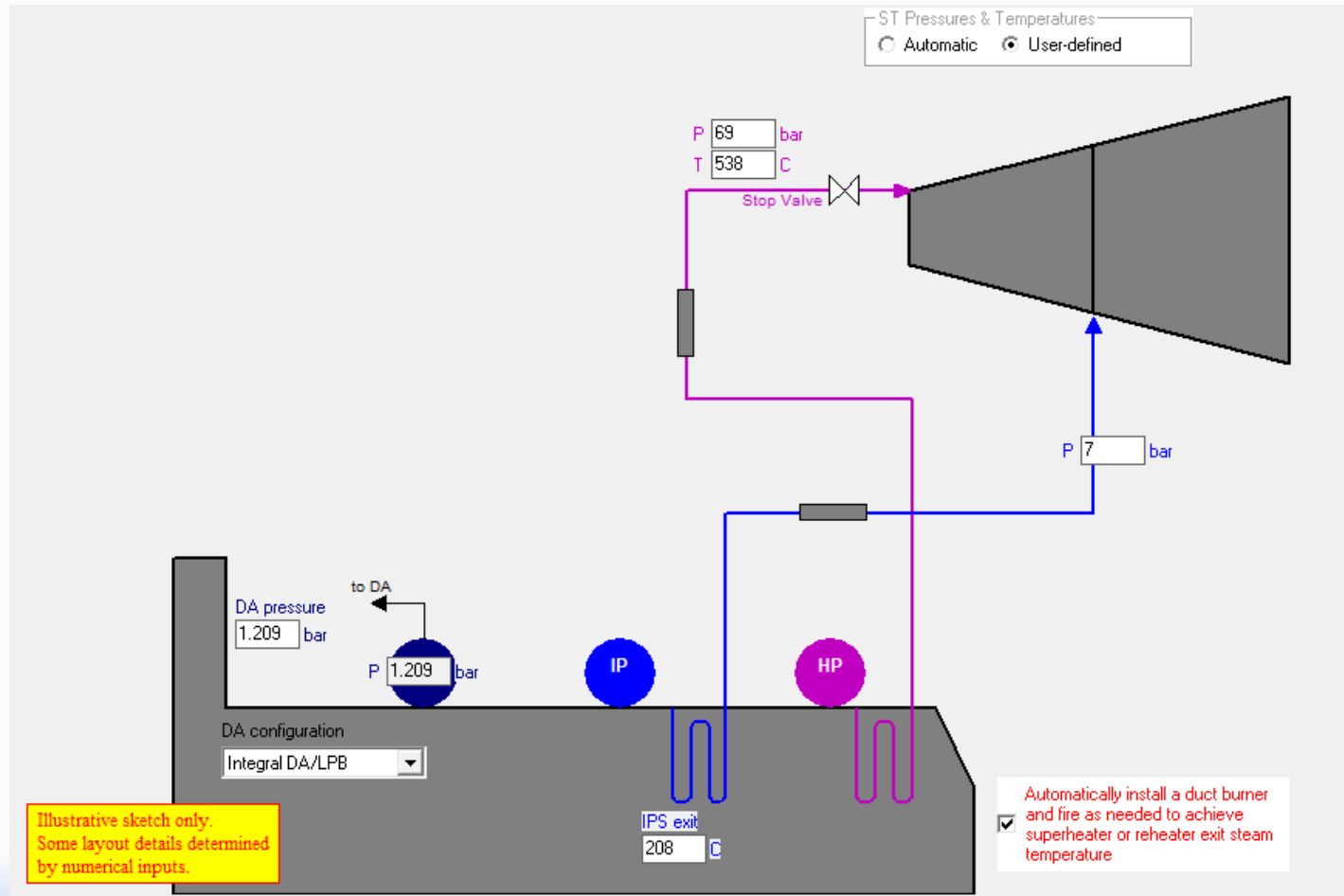
Classic Method

Calculation Options > Simplified Method Available



# Example 1

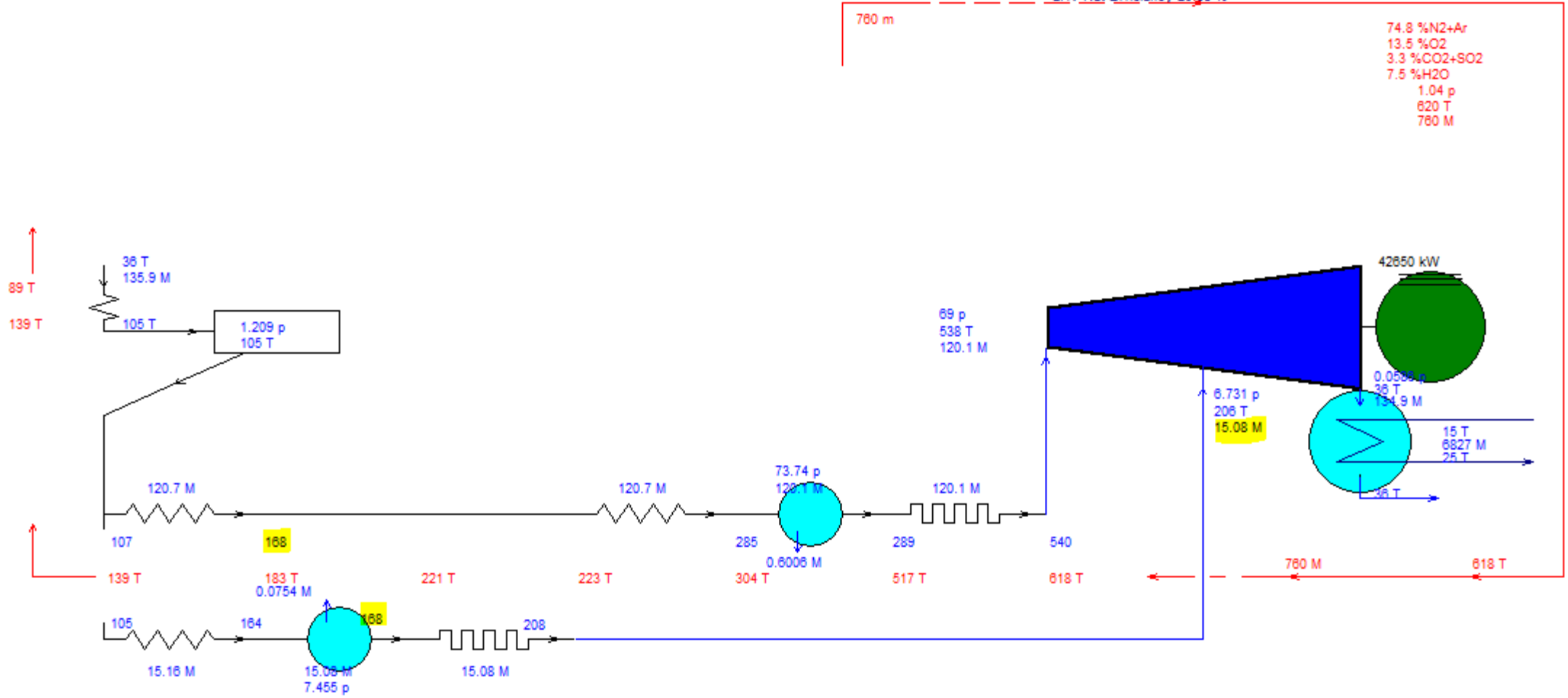
- Consider a 2 PL HRSG being supplied with exhaust gas source, 760 t/hr @ 620 deg C
- HRSG Design Method = Simplified
- ST-HRSG conditions as shown, HP & IP Pinch @ 15degC, approach temp @ 4 degC



# Example 1– GTPro Result/ HPE1 exit temperature = IP Saturation temperature

GT PRO 26.1 skavale@email.cz

Net Power 41429 kW  
 LHV Net Heat Rate 12253 kJ/kWh  
 LHV Net Efficiency 29.38 %



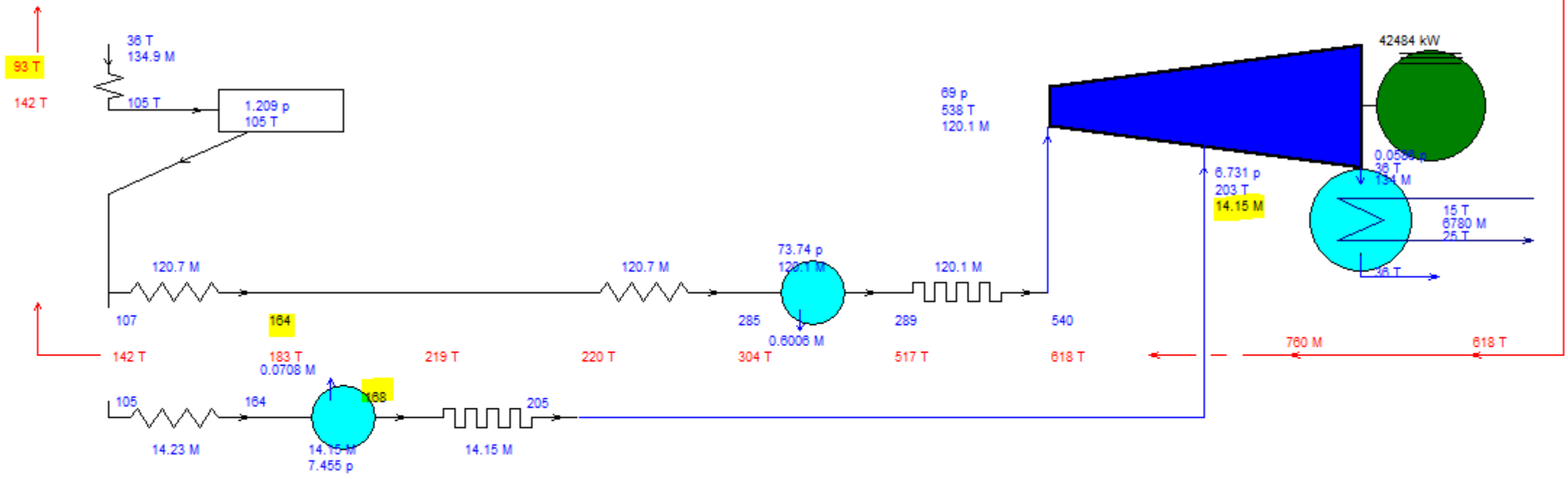
2436 08-08-2017 13:05:41 file=C:\TFLOW26\MYFILES\Method\_2PL\_Var1.gtp  
 p[bar], T[C], m[t/h], Steam Properties: IAPWS-IF97



GT PRO 26.1 skavale@email.cz

**Worth Noting:**  
 1<sup>st</sup> Design yields more IP steam generation with a lower stack temp and larger STG output. Potentially also allows the HPE1 and LPE1 to be combined into one unit since output temperatures for both the IP and HP streams are the same.

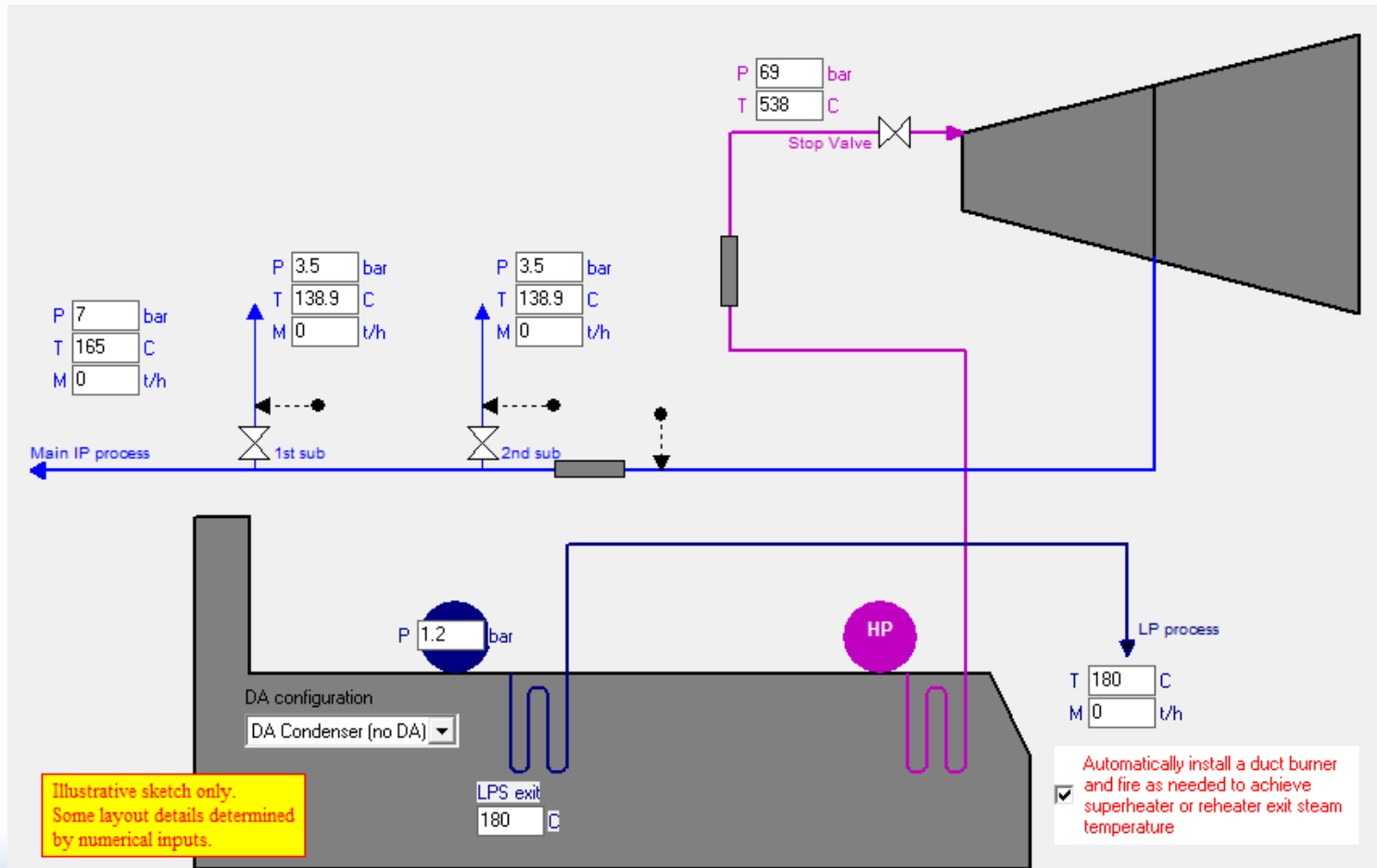
Net Power 41268 kW  
 LHV Net Heat Rate 12301 kJ/kWh  
 LHV Net Efficiency 29.27 %



2436 08-08-2017 13:10:05 file=C:\TFLOW26\MYFILES\Method\_2PL\_Var2.gtp  
 p[bar], T[C], m[t/h], Steam Properties: IAPWS-IF97

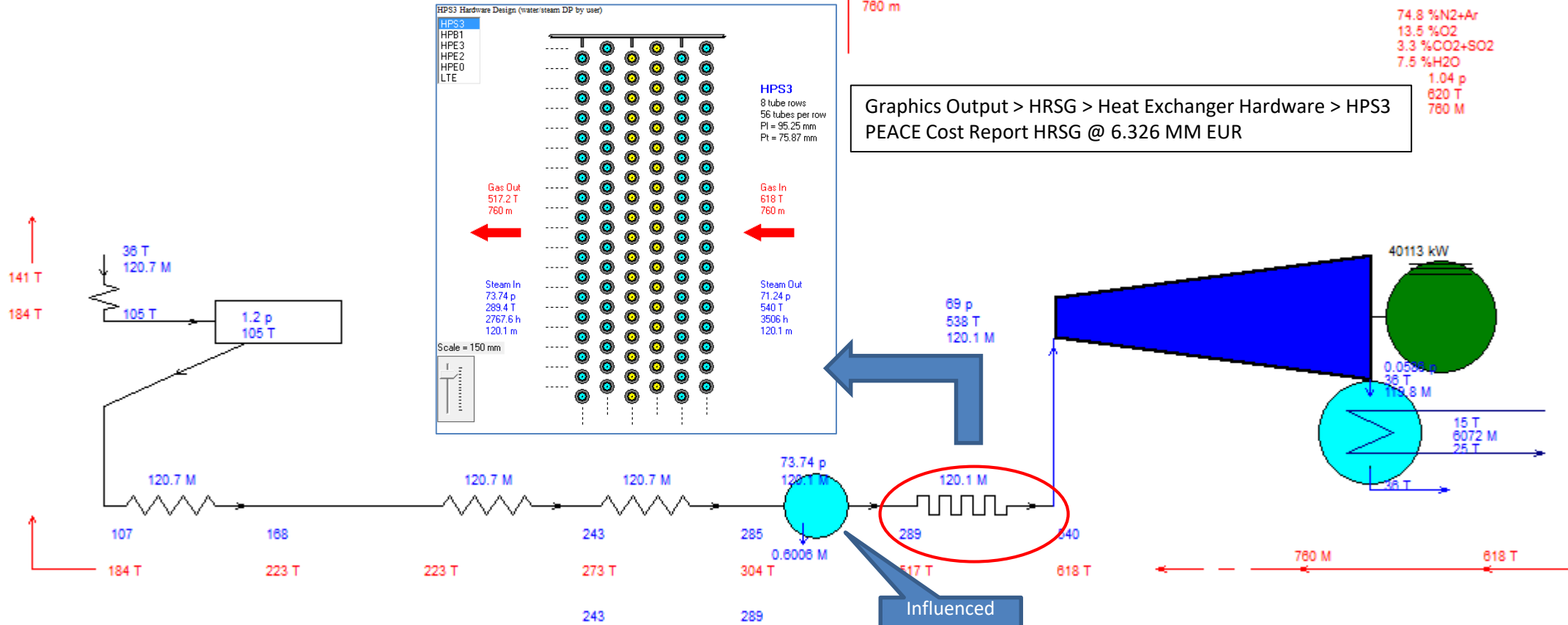
# Example 2

- Consider a 1 PL HRSG being supplied with exhaust gas source, 760 t/hr @ 620 deg C
- HRSG Design Method = Simplified/Automatic – what are the differences in terms of GTPro Output, PEACE results etc.
- ST-HRSG conditions as shown, HP & IP Pinch @ 15degC, approach temp @ 4 degC



# Cycle Flow Schematic – Simplified Method HRSG Spec

Net Power 38969 kW  
 LHV Net Heat Rate 13026 kJ/kWh  
 LHV Net Efficiency 27.64 %



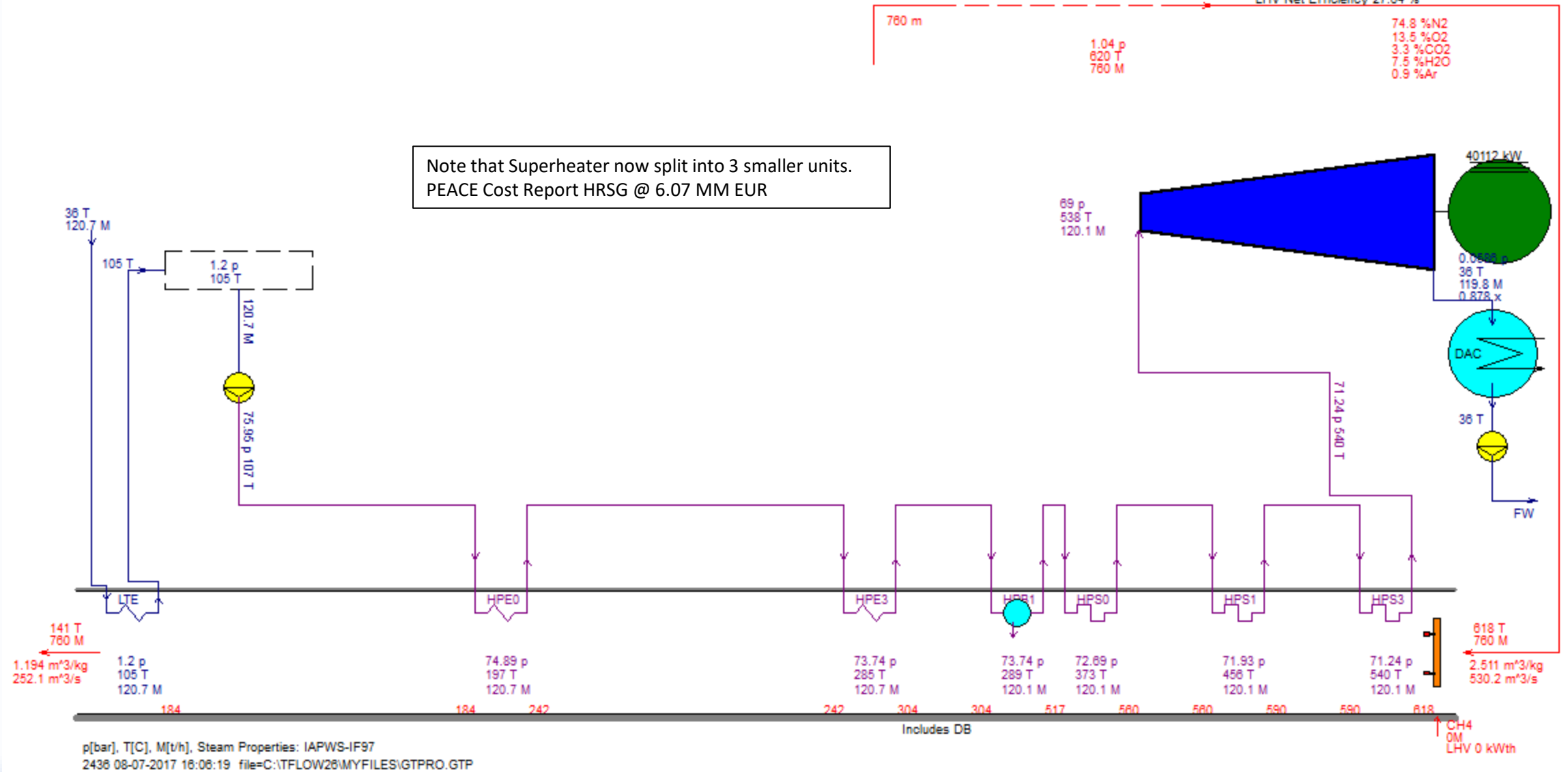
Design : 1P non reheat condensing ST, no GT, gas flow into HRSG @ 760 t/hr & 620 degC, ST inlet conditions = 69 bar & 538 deg C (@ stop valve)

Influenced by Pinch – HRSG Inputs still Active

GT PRO 26.1 skavale@email.cz

Net Power 38968 kW  
LHV Net Heat Rate 13026 kJ/kWh  
LHV Net Efficiency 27.64 %

Note that Superheater now split into 3 smaller units.  
PEACE Cost Report HRSG @ 6.07 MM EUR



# What Happens in GTM?

(Note: Method not available in GTM – since design is now fixed)

Transfer the Simplified Method Plant to GTM, Inspect the HRSG Inputs Screen  
 (Previously had 3 economisers – program has further simplified the design to just 1 equivalent Economiser)

File View Options Tools Window New Session Control Loops Excel Link Compare Files Scripts Custom Variable List Help

Main Inputs Plant Criteria HRSG Inlet ST Inputs ST Process HRSG Inputs HRSG Process Water Circuits Cooling System Environment Gasification Desalination Site Major Equipment Pipes, Pumps, Economics Re-design in GT PRO COMPUTE

HRSG Main Inputs Hardware Temperature Set Points Assumptions Radiant Boiler Miscellaneous

Edit Heat Exchangers View HRSG tube plan

	Zone 17				Zone 15				Zone 13				Zone 11				Zone 10				Zone 9				Zone 8				Zone 7				Zone 6				Zone 5				Zone 4				Zone 3				Zone 2				Zone 1				Zone 0																																			
Path																	HPE0				HPE2				HPE1								HPE3								HPB1				HPS0				HPS1				HPS2				HPS3				Path																															
2																	0 rows				0 rows				0 rows								21 rows 56 tube/row								16 rows 56 tube/row				0 rows				7 rows 56 tube/row				0 rows				0 rows				2																															
1																																																													1																															
0	LTE				LPE				LPB								LPS																																																				0																							
	3 rows 56 tube/row				0 rows				0 rows								0 rows																																																																											

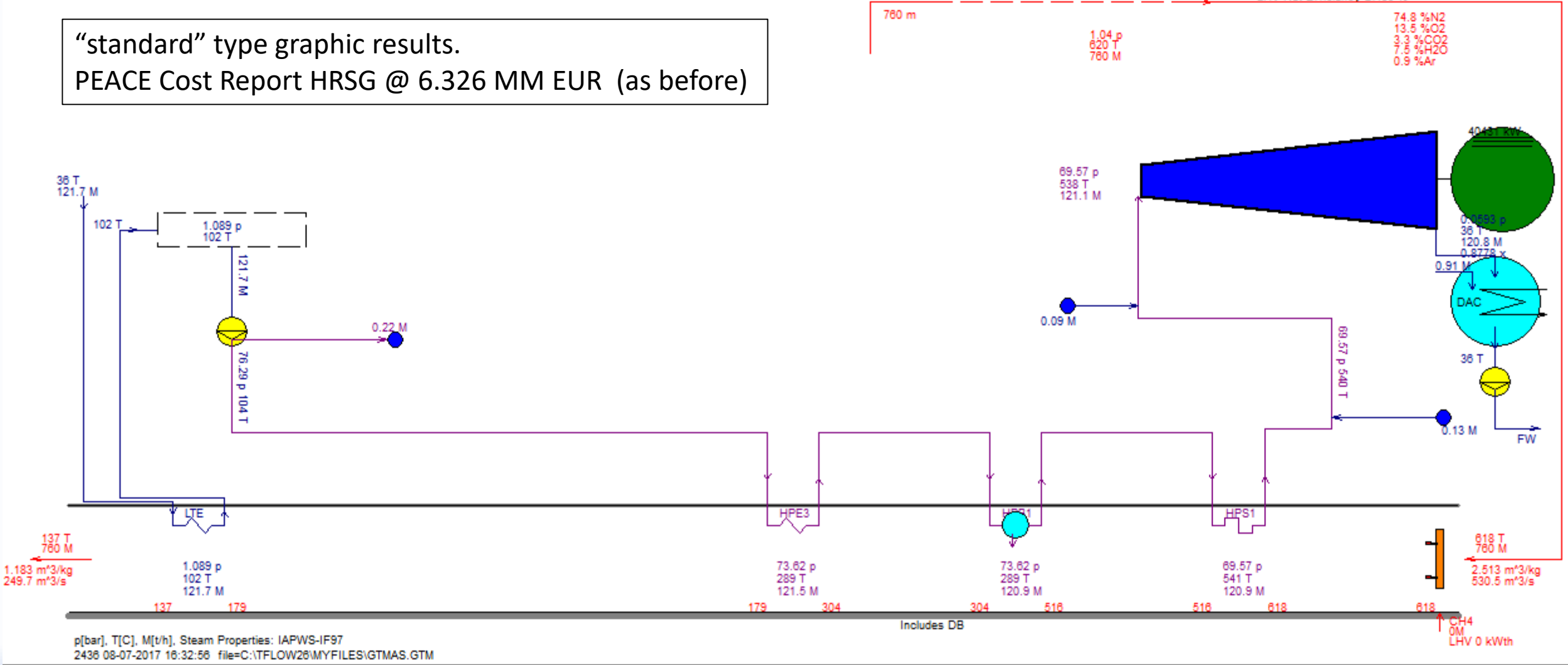
**Duct Burner**

← Gas Flow ←

Heat exchangers and the primary duct burner may be relocated with the mouse.

“standard” type graphic results.  
PEACE Cost Report HRSG @ 6.326 MM EUR (as before)

Net Power 39284 kW  
LHV Net Heat Rate 12922 kJ/kWh  
LHV Net Efficiency 27.86 %

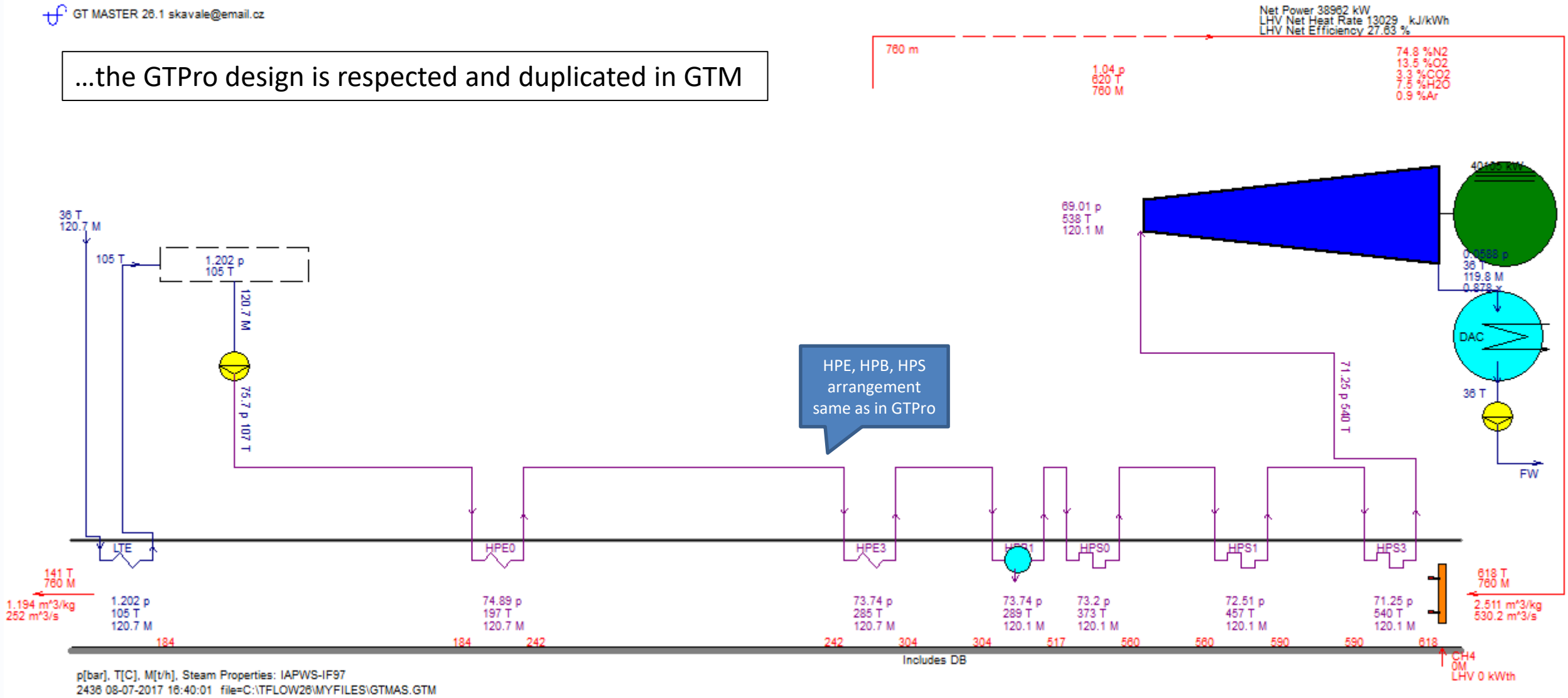


# GTM Output

(Method= Automatic in GTPro)

GT MASTER 26.1 skavale@email.cz

...the GTPro design is respected and duplicated in GTM



# Conclusion

The Simplified Method of HRSG Specification is significantly different in its approach to the other two methods of HRSG specification

The Calculation code is a preserved version of the earlier calculation method for HRSG specification/design. Being a simpler & distinctly separate code, it may be a useful alternative to the other two HRSG specification methods in the event that these return error messages during calculation.

The difference in design Method yields differences in HRSG heat transfer surface arrangements which may also yield subsequent differences in HRSG cost.

Further information is provided in the Help Menu, GTPro ch. 4.2.1 and GTPro ch.20

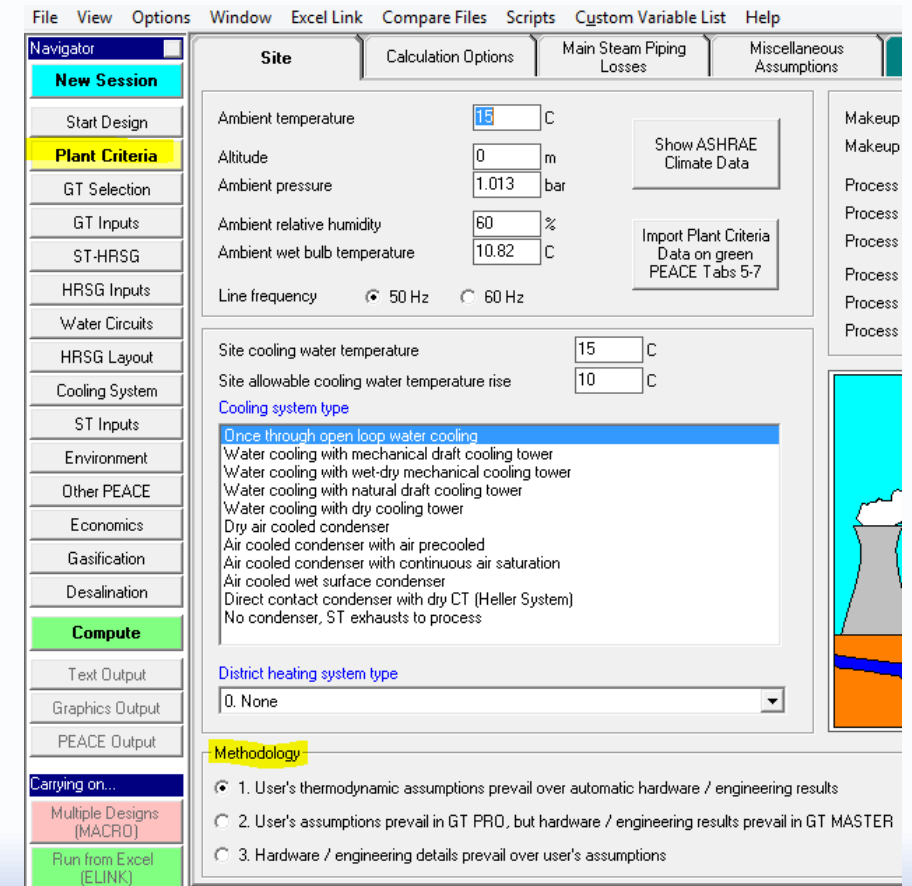
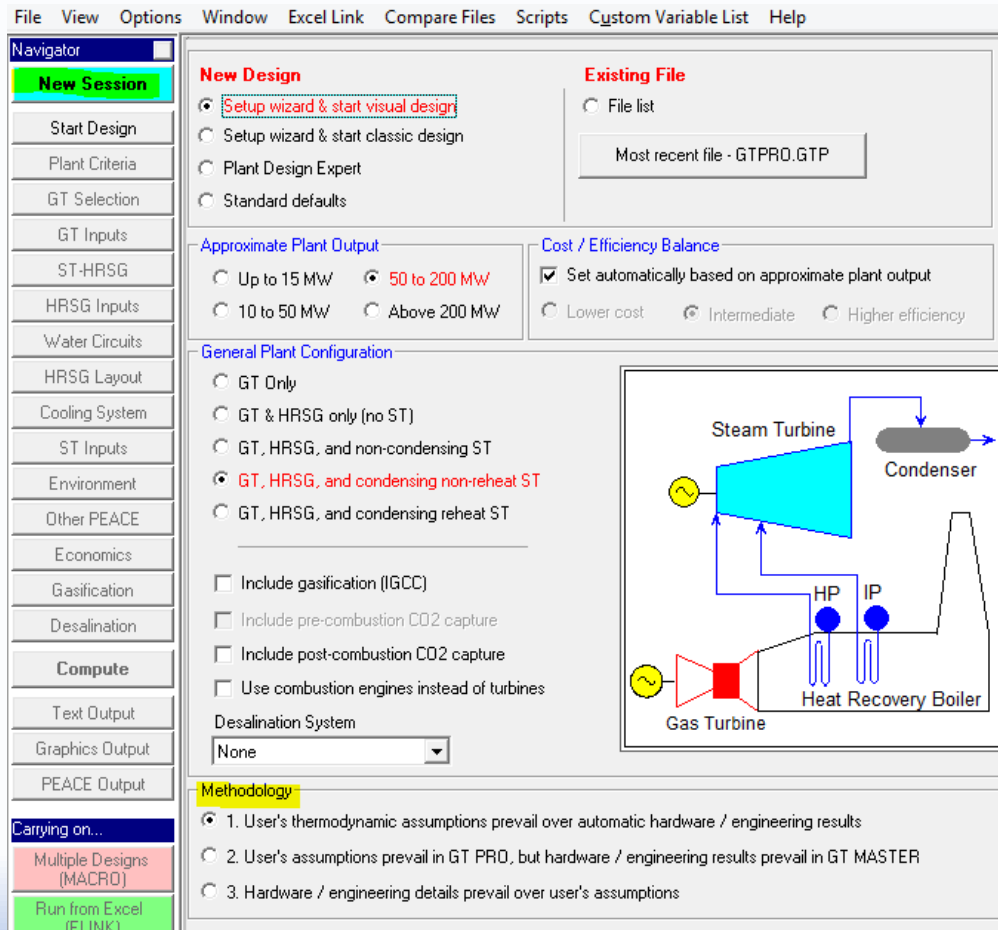
Method	HPE1 Setting	Intermediate Pressure Superheater Settings	HP Steam t/hr	IP Steam t/hr	MWe	Stack Temp degC
Simplified	HPE1 exit temperature = IP saturation temperature	IPS behind HP economiser	120.1	14.15	42.484	93
Automatic	HPE1 common with IPE	IPS1 behind HPE3, IPS2 behind HPB	120.1	12.16	41.956	100
Auto. Mimic of Simplified	HPE1 common with IPE	IPS behind HP economiser	120.1	12.16	41.955	100



# Methodology

(As Applicable to GTPRO)

Can be specified at the New Session or Plant Criteria tab  
 Is available for both the “Setup Wizard and Start Visual Design” as well as the “Setup Wizard and Start Classic Design” method of plant specification  
 Unavailable for the PDE and Standard Defaults Method of Plant Design.



# Methodology 1

(As Applicable to GTPro)

Ref GTPro Help 2.4.5

“Users thermodynamic assumptions prevail over automatic hardware/engineering results.”

This means that: **Method 1** is the default and results in the shortest computation times. The heat balance results in GT PRO and GT MASTER rely on the assumptions used to create the hardware. The hardware characteristics do not feed back into the heat balance automatically. For example, the pressure drops in the heat balance pipes are computed directly from assumptions made at the **Plant Criteria** topic, §4.3. Those assumptions are also used by PEACE to size the pipes. In GT MASTER, a resistance coefficient derived from the GT PRO heat balance is used to scale the pressure drops at off design. Thus, under identical flow conditions the pressure drops in GT PRO and GT MASTER will be identical, but are not computed using the hardware definition of the piping system shown in the PEACE outputs.

	Methodology		
	1	2	3
<b>GT PRO Defaults</b>			
1. Pipe dp	Udf	Udf	PHW
2. HRSG water-side dp	Udf	Udf	PHW
3. Stack loss	No	No	Yes
4. Rad q from GT/DB	No	No	Yes
5. Hydrostatic corr.	No	No	Yes
6. PEACE aux HX q to CT	No	No	Yes
<b>GT MASTER Defaults</b>			
1. Pipe dp	RC	PHW	PHW
2. HRSG water-side dp CF	GTP	1	1
3. Stack loss	GTP	Yes	Yes
4. Rad q from GT/DB	GTP	Yes	Yes
5. Hydrostatic corr.	GTP	GTP	GTP
6. PEACE aux HX q to CT	GTP	GTP	GTP
7. Cooling water flow	Udf	PHW	PHW

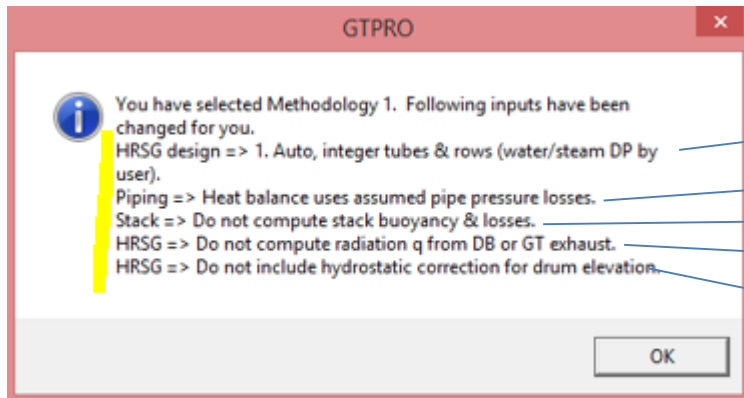
Udf: User-defined, PHW: PEACE Hardware (if licensed)  
RC: Resistance coefficient

Site	Calculation Options	Main Steam Piping Losses	Miscellaneous Assumptions
		<input checked="" type="radio"/> Heat balance uses assumed pipe pressure losses below <input type="radio"/> Heat balance uses hardware-based pressure drops from PEACE pipe results	
		1. Pressure loss in HP piping (DP/P)	3.25 %
		2. Pressure loss in HPT piping (DP/P)	3.75 %
		3. Pressure loss in hot RH piping (DP/P)	6.5 %
		4. Pressure loss in cold RH piping (DP/P)	6.5 %
		5. Pressure loss in IP piping (DP/P)	6.5 %
		6. Pressure loss in LP piping (DP/P)	9 %
		7. Pressure loss in LPT piping (DP/P)	9 %
		8. Enthalpy drop in HP piping	2.5 kJ/k
		9. Enthalpy drop in HPT piping	2.5 kJ/k
		10. Enthalpy drop in hot RH piping	2.5 kJ/k
		11. Enthalpy drop in cold RH piping	2.5 kJ/k
		12. Enthalpy drop in IP piping	2.5 kJ/k
		13. Enthalpy drop in LP piping	2.5 kJ/k
		14. Enthalpy drop in LPT piping	2.5 kJ/k

# Methodology 1

(As Applicable to GTPRO Ref GTPRO Help 2.4.5)

On leaving Plant Criteria Screen, note the below message advising of changes to selections made by the program to various aspects of the plant hardware



From HRSG Inputs > Hardware Design Tab

From Plant Criteria > Main Steam Piping Losses Tab

From HRSG Inputs > Equipment Options (PEACE) Tab

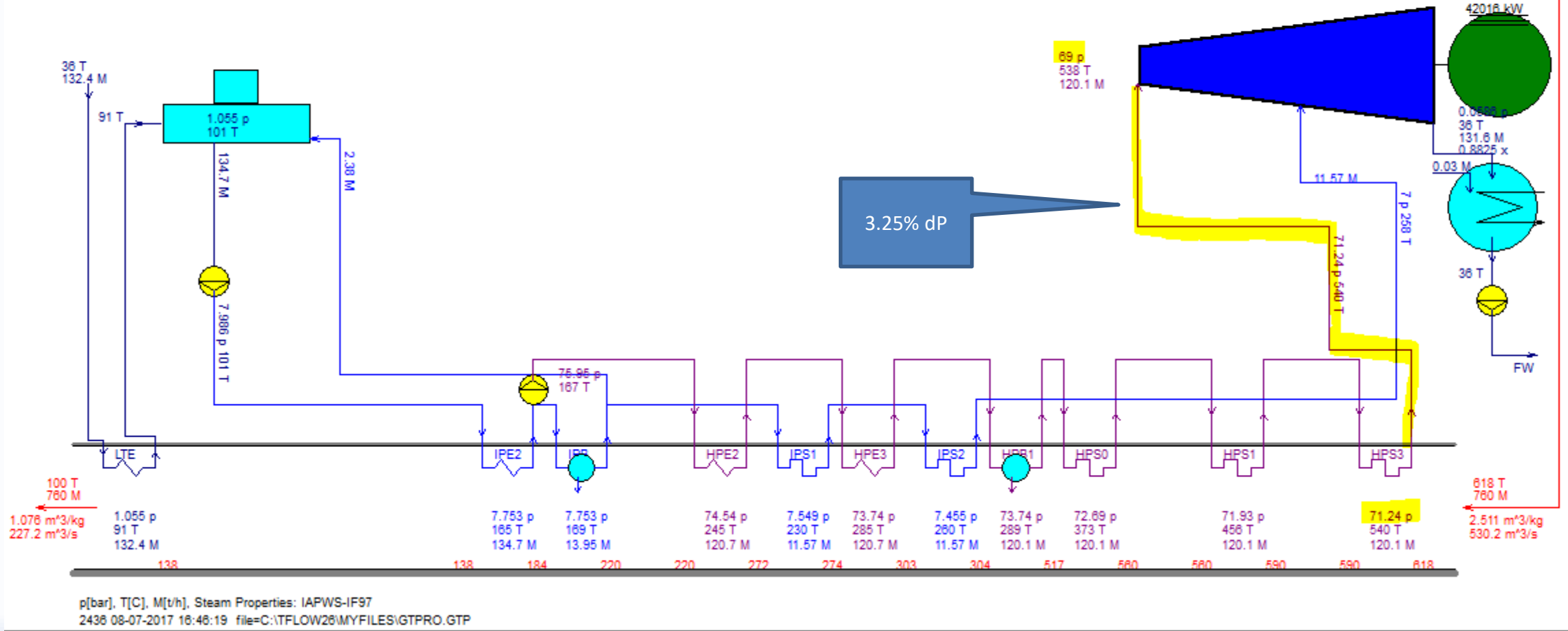
From HRSG Inputs > Miscellaneous Tab (item 13)

From HRSG Inputs > Miscellaneous Tab (item 18)

# Example: Methodology 1

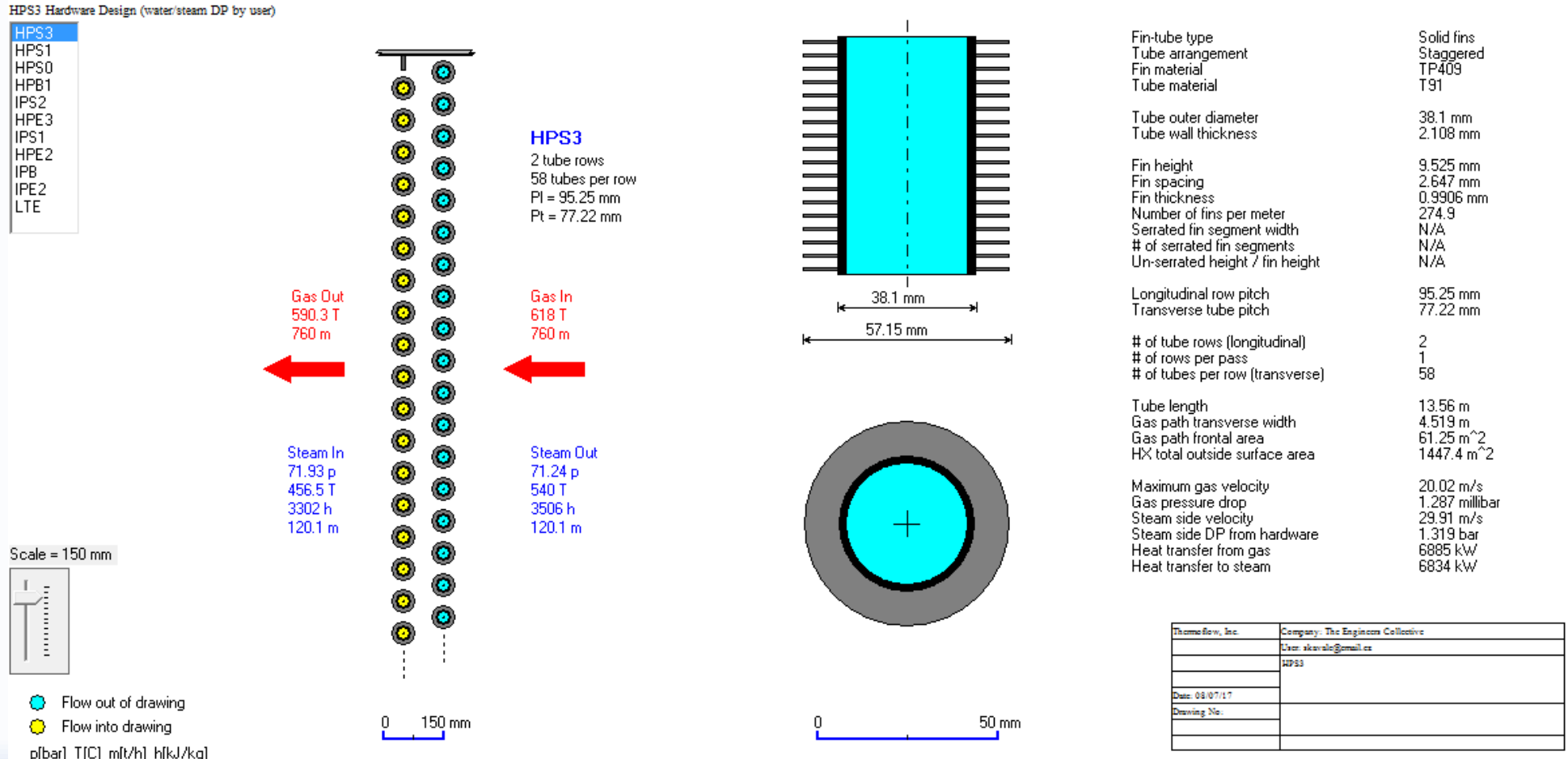
GT PRO 26.1 skavale@email.cz

Design : 2PL non reheat condensing ST, no GT, gas flow into HRSG @ 760 t/hr & 620 degC, ST inlet conditions @ stop valve = 69 bar & 538 deg C & 7bar @ LP admin  
 Plant Criteria > Main Steam Piping Losses > Pressure Loss in HP Piping > 3.25%



# Example: Methodology 1 (cntd)

Note that Hardware has been calculated and can be determined from the GTPro calculated outputs- but these details have not been fed back into the model .



# Methodology 1 – GTM Input Screen

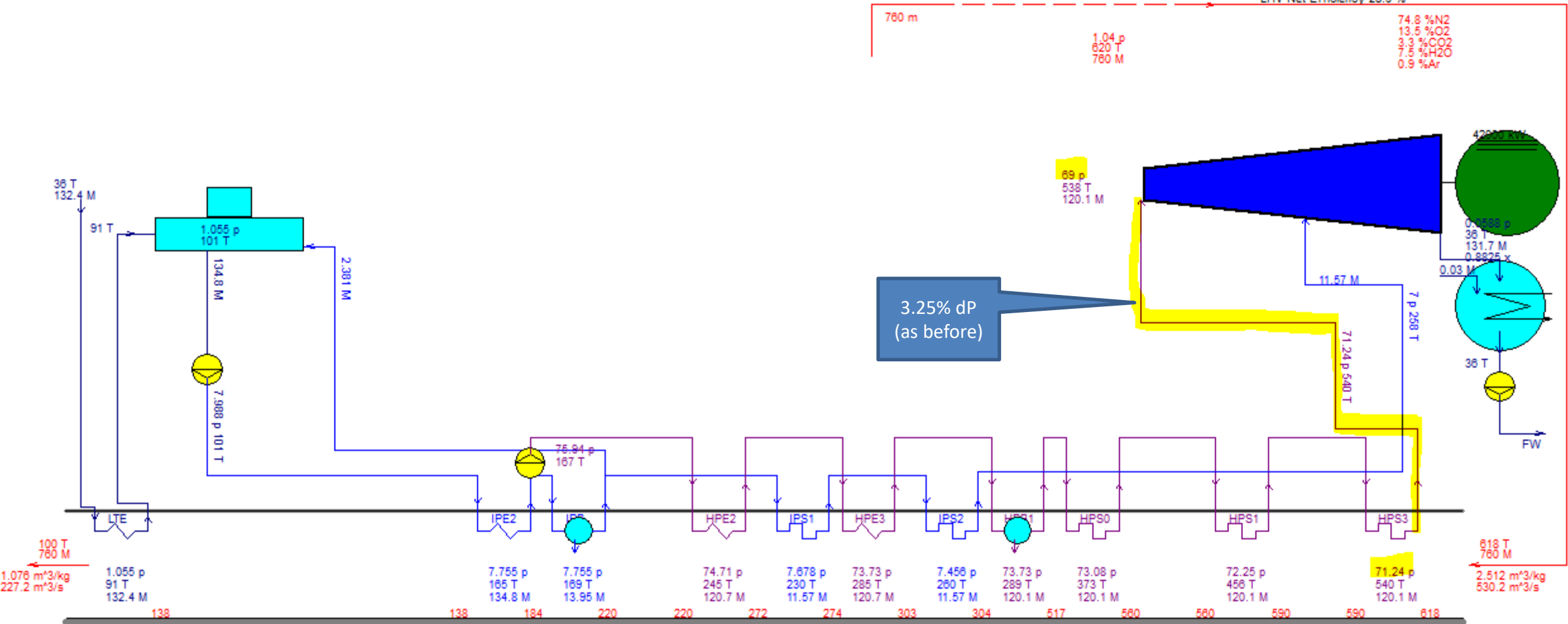
Main Inputs	Plant Criteria	HRSG Inlet	ST Inputs	ST Process	HRSG Inputs	HRSG Process	Water Circuits	Cooling System	Environment	Gasification	Desalination
Site		Calculation Options				<b>Main Steam Piping Losses</b>				Misce	
	<b>Resistance coefficient</b>	Enthalpy loss	<b>Pressure drop model</b>								
1. HPB to HPT	<input type="text" value="0.8518"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	<b>Use resistance coefficient</b>	<input type="button" value="Click to edit pipe details..."/>							
2. IPB to LPT	<input type="text" value="2.863"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							
3. Hot reheat to HPT	<input type="text" value="0"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							
4. Cold reheat pipe	<input type="text" value="0"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							
5. LPB to LPT addition	<input type="text" value="0"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							
6. HP process	<input type="text" value="0"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							
7. IP process	<input type="text" value="0"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							
8. HPT extraction for process	<input type="text" value="0"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							
9. LPT extraction for process	<input type="text" value="0"/> m <sup>-4</sup>	<input type="text" value="2.5"/> kJ/kg	Use resistance coefficient	<input type="button" value="Click to edit pipe details..."/>							

GTM- Methodology 1- Pressure Drop Model = Resistance Co-Efficient

# Methodology 1 – GTM Output

GT MASTER 26.1 skavale@email.cz

Net Power 40754 kW  
LHV Net Heat Rate 12456 kJ/kWh  
LHV Net Efficiency 28.9 %



p[bar], T[C], M[t/h], Steam Properties: IAPWS-IF97  
2436 08-07-2017 17:07:48 file=C:\TFLOW26\MYFILES\GTMAS.GTM

# Methodology 2

(As Applicable to GTPro)

Ref GTPro Help 2.4.5

“Users assumptions prevail in GTPro, but hardware/engineering results prevail in GTMaster.”

This means that: Essentially there is no difference to Methodology 1 when in GTPro, however once the user enters GTMaster for off design calculations, the physical hardware parameters calculated/defined in GTPro now dominate in subsequent GTMaster calculations.

...same defaults in GTPro M2 as in M1

	Methodology		
	1	2	3
GT PRO Defaults			
1. Pipe dp	Udf	Udf	PHW
2. HRSG water-side dp	Udf	Udf	PHW
3. Stack loss	No	No	Yes
4. Rad q from GT/DB	No	No	Yes
5. Hydrostatic corr.	No	No	Yes
6. PEACE aux HX q to CT	No	No	Yes
GT MASTER Defaults			
1. Pipe dp	RC	PHW	PHW
2. HRSG water-side dp CF	GTP	1	1
3. Stack loss	GTP	Yes	Yes
4. Rad q from GT/DB	GTP	Yes	Yes
5. Hydrostatic corr.	GTP	GTP	GTP
6. PEACE aux HX q to CT	GTP	GTP	GTP
7. Cooling water flow	Udf	PHW	PHW

Udf: User-defined, PHW: PEACE Hardware (if licensed)  
RC: Resistance coefficient

Site
Calculation Options
**Main Steam Piping Losses**
Miscellaneous Assumptions

Heat balance uses assumed pipe pressure losses below  
 Heat balance uses hardware-based pressure drops from PEACE pipe results

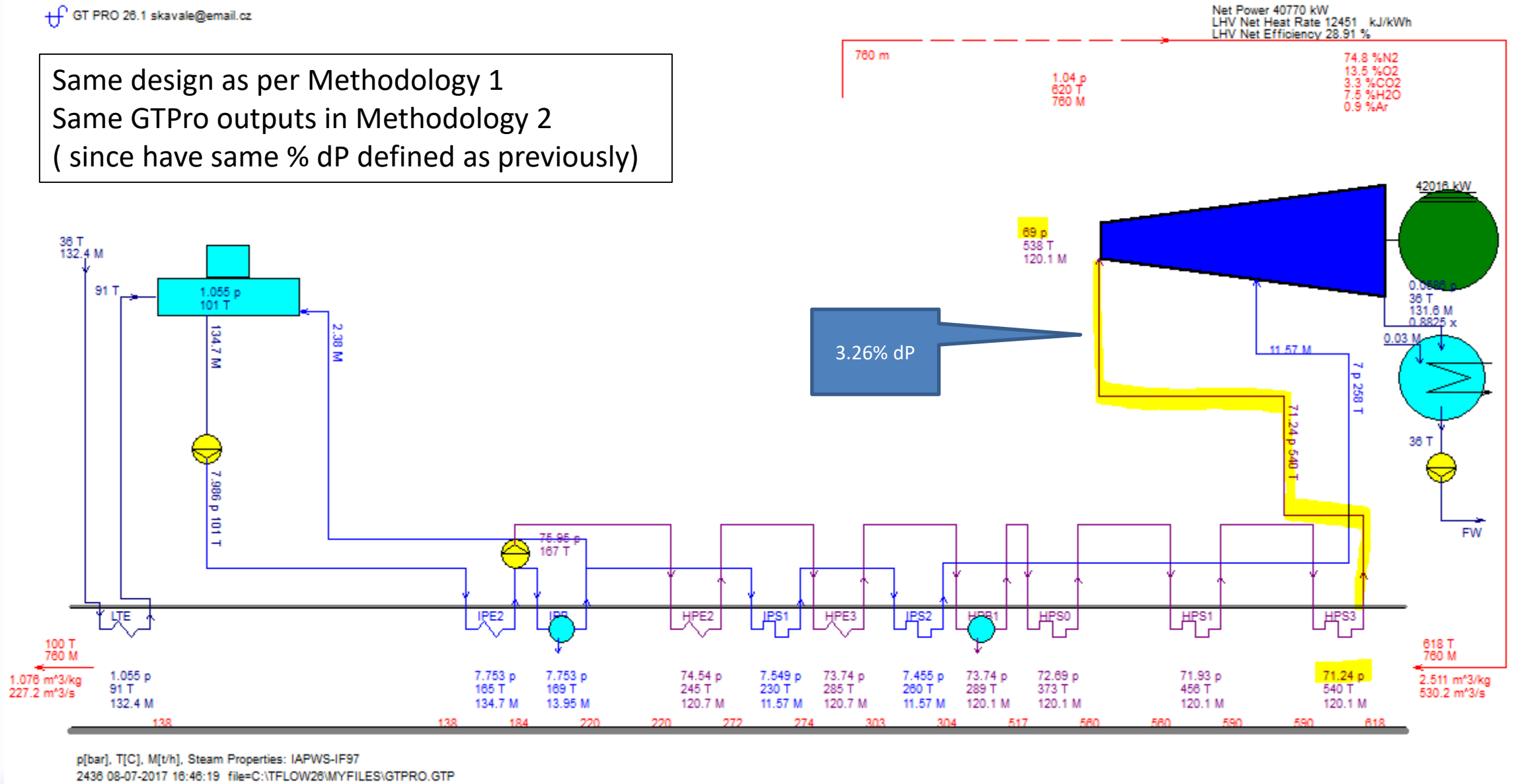
1. Pressure loss in HP piping (DP/P)	3.25 %
2. Pressure loss in HPT piping (DP/P)	3.75 %
3. Pressure loss in hot RH piping (DP/P)	6.5 %
4. Pressure loss in cold RH piping (DP/P)	6.5 %
5. Pressure loss in IP piping (DP/P)	6.5 %
6. Pressure loss in LP piping (DP/P)	9 %
7. Pressure loss in LPT piping (DP/P)	9 %
8. Enthalpy drop in HP piping	2.5 kJ/k
9. Enthalpy drop in HPT piping	2.5 kJ/k
10. Enthalpy drop in hot RH piping	2.5 kJ/k
11. Enthalpy drop in cold RH piping	2.5 kJ/k
12. Enthalpy drop in IP piping	2.5 kJ/k
13. Enthalpy drop in LP piping	2.5 kJ/k
14. Enthalpy drop in LPT piping	2.5 kJ/k



# Example: Methodology 2

GT PRO 26.1 skavale@email.cz

Same design as per Methodology 1  
 Same GTPRO outputs in Methodology 2  
 ( since have same % dP defined as previously)



# Methodology 2 – GTM Input Screen

Note the difference: in prior example with Methodology 1, the GTM input screen had Main Steam Piping Losses/Pressure Drop Model as “Use Resistance Co Efficient”, with Methodology 2, this is now “Use PEACE hardware description. Model calculation is therefore based on the hardware characteristics calculated previously in GTPro.

Also- could have “manually” switched on Methodology 2 in prior example by manually changing the pressure drop model in this screen.

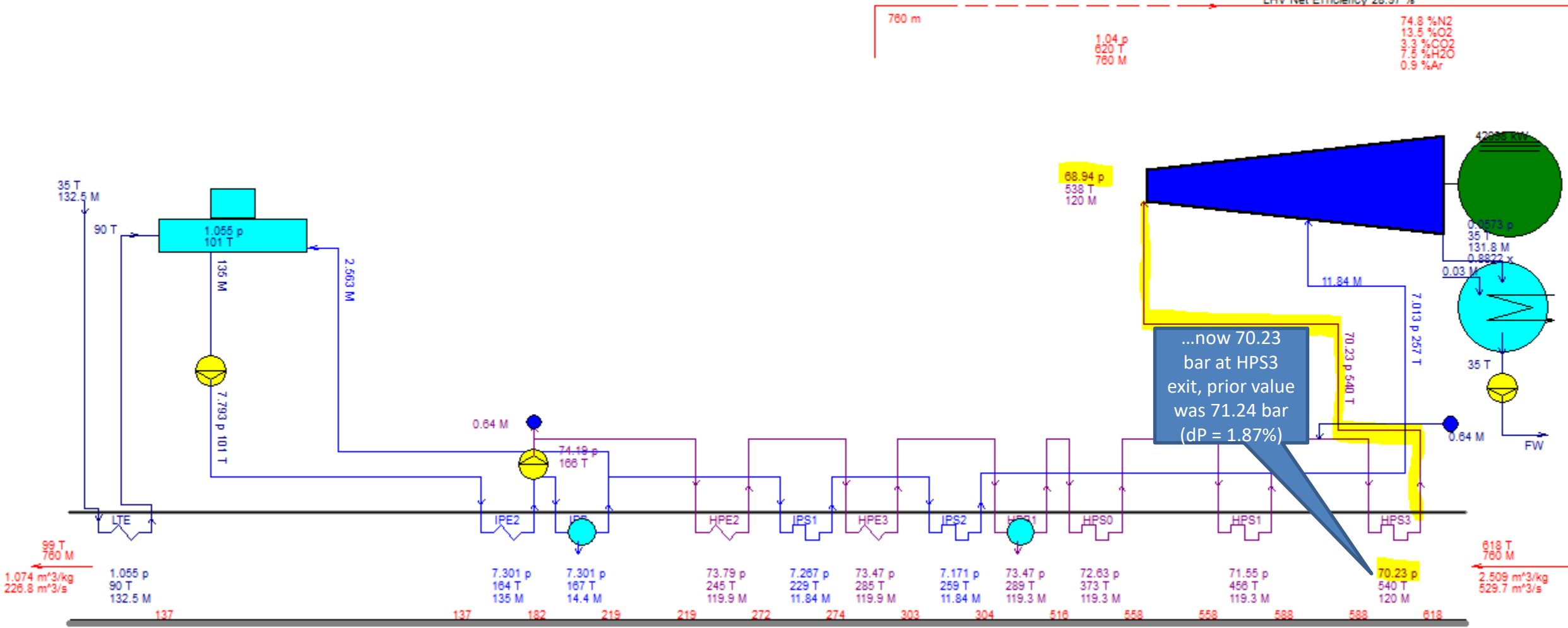
Main Inputs	Plant Criteria	HRSG Inlet	ST Inputs	ST Process	HRSG Inputs	HRSG Process	Water Circuits	Cooling System	Environment	Gasification	Desalination
Site		Calculation Options					<b>Main Steam Piping Losses</b>			Miscellaneous	
	Resistance coefficient	Enthalpy loss	<b>Pressure drop model</b>								
1. HPB to HPT	0.8518 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>							
2. IPB to LPT	2.863 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>							
3. Hot reheat to HPT	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>							
4. Cold reheat pipe	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>							
5. LPB to LPT addition	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>							
6. HP process	0 m <sup>-4</sup>	2.5 kJ/kg	Use resistance coefficient	<a href="#">Click to edit pipe details...</a>							
7. IP process	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>							
8. HPT extraction for process	0 m <sup>-4</sup>	2.5 kJ/kg	Use resistance coefficient	<a href="#">Click to edit pipe details...</a>							
9. LPT extraction for process	0 m <sup>-4</sup>	2.5 kJ/kg	Use resistance coefficient	<a href="#">Click to edit pipe details...</a>							

Pumps	<b>Pipes</b>	Tanks	Cooling
Pipe pressure drop model		Pipe schedule	
Use PEACE hardware description		140	
Pipe material		Fitting pressure class (for those denoted by (*) below)	
P-22		900 psig / 60 barg	
<b>Pipe Group</b>			
HPB to HPT (HP0)		1. Sizing pressure	
IPB to LPT (IP0)		2. Sizing temperature	
Main Circulating Water (CW0)		3. Sizing flow	
Main Auxiliary CW (CW1)		4. Sizing pressure drop (DP/Psizing)	
CW for ST+Generator Lube Oil Cooler (CW7)		5. Physical length of pipe run	
Condensate (FW1)		6. Number of pipes in plant	
Makeup from Water Treatment System (FW2)		7. Nominal diameter	
Feedwater to Boiler (FW3)		8. Wall thickness	
Condenser Air Removal (CAR0)		9. Inside diameter	
Raw Water (RW0)		10. Outside diameter	
Service Water (SW0)		11. Equivalent length of pipe run	
ST+Generator Lube Oil (OIL3)		12. Number short 90 degrees elbows	
Service Air (SERVA)		13. Number long 90 degrees elbows	
Boiler & Equipment Drain Piping (BEDR)		14. Number sweeping 90 degrees elbows	
Boiler Blowdown Piping (BLDN)		15. Number short 45/60 degrees elbows	
Steam Blow Piping from HRSG & ST (STBL)		16. Number long 45/60 degrees elbows	
Main Fire Protection (FP0)		17. Number full-size tees with flow through run	
Miscellaneous Fire Protection (FP1)		18. Number full-size tees with flow through branch	

# Methodology 2 – GTM Output

GT MASTER 26.1 skavale@email.cz

Net Power 40848 kW  
 LHV Net Heat Rate 12427 kJ/kWh  
 LHV Net Efficiency 28.97 %



...now 70.23 bar at HPS3 exit, prior value was 71.24 bar (dP = 1.87%)

p[bar], T[C], M[t/h]. Steam Properties: IAPWS-IF97  
 2436 08-07-2017 17:20:54 file=C:\TFLOW26\MYFILES\GTMAS.GTM

# Methodology 3

(As Applicable to GTPro Ref GTPro Help 2.4.5)

“Hardware/engineering details prevail over users assumptions.”

**Method 3** results in a heat balance most tightly coupled to the hardware characteristics of the designed plant. In this mode, the GT PRO and GT MASTER heat balances are very similar, and most consistent with the PEACE description of the plant. Outputs from both GT PRO and GT MASTER are consistent with hardware definitions of the components, rather than on the assumptions used to create those hardware definitions. Consider the procedure used with this method as it applies to the pipes described above. The assumed pressure drops in the main piping (§4.3) are applied in the initial GT PRO heat balance. Those initial heat balance results are used by PEACE to design the piping systems. The resulting piping system pressure drop characteristics are used in a second GT PRO heat balance calculation. The second (final) GT PRO result is based on pressure drops computed using the hardware characteristics of the piping system shown in the PEACE outputs. In GT MASTER, changing the piping system design will affect the computed pressure drops (and plant cost) automatically.

	Methodology		
	1	2	3
<b>GT PRO Defaults</b>			
1. Pipe dp	Udf	Udf	PHW
2. HRSG water-side dp	Udf	Udf	PHW
3. Stack loss	No	No	Yes
4. Rad q from GT/DB	No	No	Yes
5. Hydrostatic corr.	No	No	Yes
6. PEACE aux HX q to CT	No	No	Yes
<b>GT MASTER Defaults</b>			
1. Pipe dp	RC	PHW	PHW
2. HRSG water-side dp CF	GTP	1	1
3. Stack loss	GTP	Yes	Yes
4. Rad q from GT/DB	GTP	Yes	Yes
5. Hydrostatic corr.	GTP	GTP	GTP
6. PEACE aux HX q to CT	GTP	GTP	GTP
7. Cooling water flow	Udf	PHW	PHW

Udf: User-defined, PHW: PEACE Hardware (if licensed)  
RC: Resistance coefficient

...same defaults in GTPro M3 as in M1

Site
Calculation Options
**Main Steam Piping Losses**
Miscellaneous Assumptions

Heat balance uses assumed pipe pressure losses below

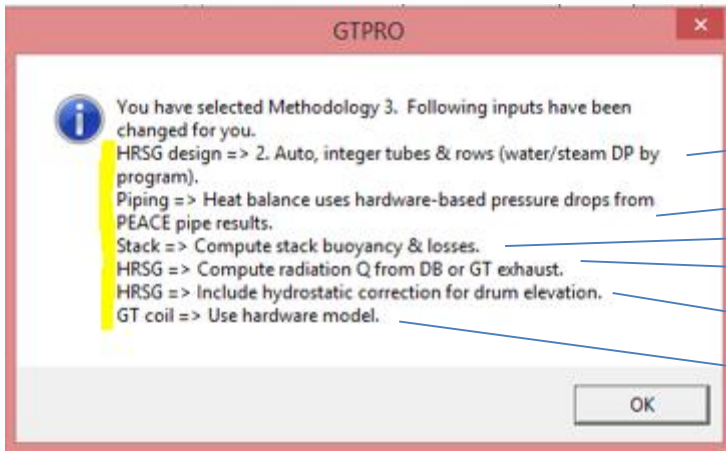
Heat balance uses hardware-based pressure drops from PEACE pipe results

1. Pressure loss in HP piping (DP/P)	3.25 %
2. Pressure loss in HPT piping (DP/P)	3.75 %
3. Pressure loss in hot RH piping (DP/P)	6.5 %
4. Pressure loss in cold RH piping (DP/P)	6.5 %
5. Pressure loss in IP piping (DP/P)	6.5 %
6. Pressure loss in LP piping (DP/P)	9 %
7. Pressure loss in LPT piping (DP/P)	9 %
8. Enthalpy drop in HP piping	2.5 kJ/k
9. Enthalpy drop in HPT piping	2.5 kJ/k
10. Enthalpy drop in hot RH piping	2.5 kJ/k
11. Enthalpy drop in cold RH piping	2.5 kJ/k
12. Enthalpy drop in IP piping	2.5 kJ/k
13. Enthalpy drop in LP piping	2.5 kJ/k
14. Enthalpy drop in LPT piping	2.5 kJ/k

# Methodology 3

(As Applicable to GTPro Ref GTPro Help 2.4.5)

On leaving Plant Criteria Screen, note the below message advising of changes to selections made by the program to various aspects of the plant hardware

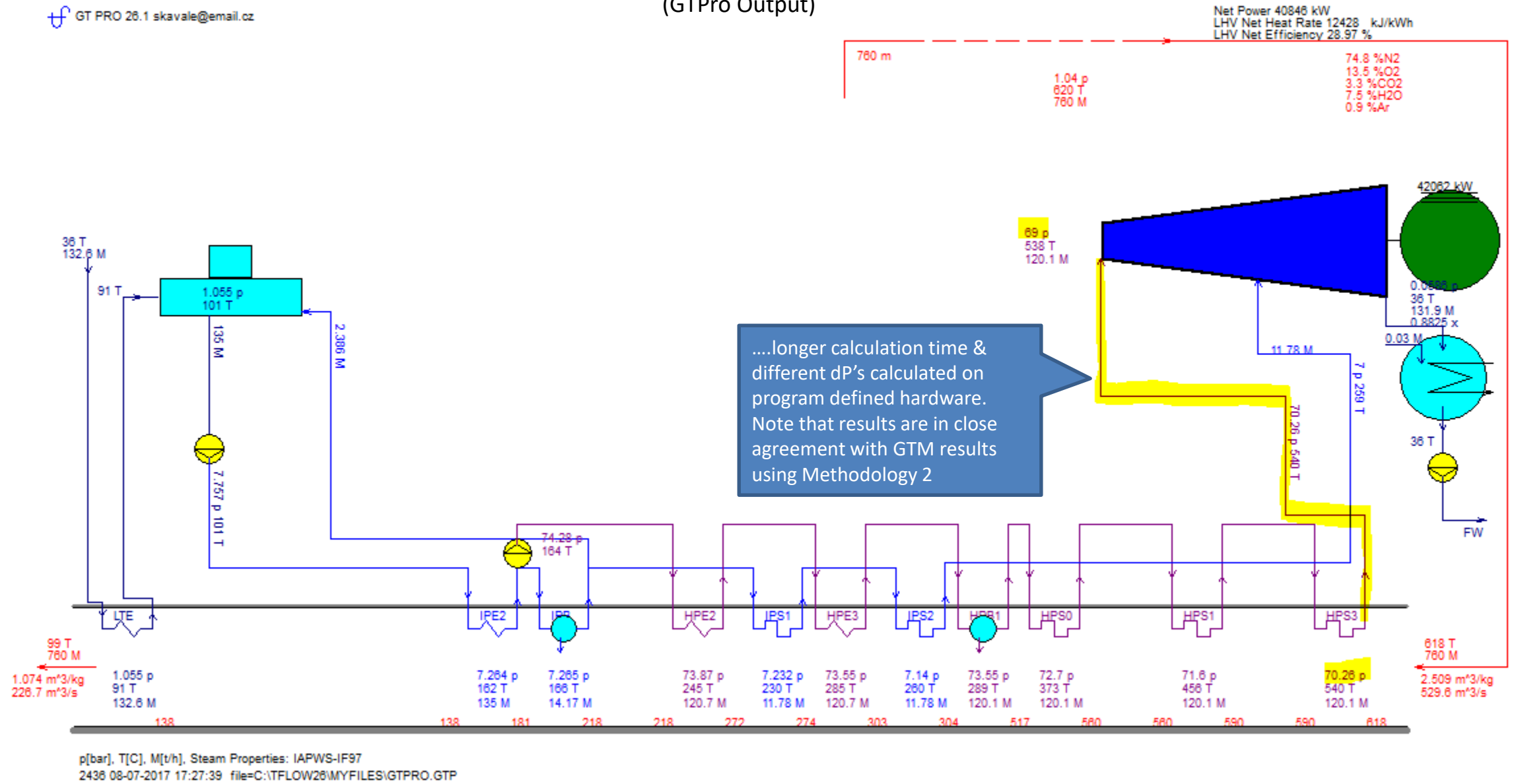


- From HRSG Inputs > Hardware Design Tab
- From Plant Criteria > Main Steam Piping Losses Tab
- From HRSG Inputs > Equipment Options (PEACE) Tab
- From HRSG Inputs > Miscellaneous Tab (item 13)
- From HRSG Inputs > Miscellaneous Tab (item 18)
- From GT Inputs > Inlet Heating & Cooling > Coil Tab

# Example: Methodology 3

(GTPro Output)

GT PRO 26.1 skavale@email.cz



....longer calculation time & different dp's calculated on program defined hardware. Note that results are in close agreement with GTM results using Methodology 2

# Methodology 3 – GTM Input Screen

Note the difference in Resistance Co- Efficients between the Methodology 2 & Methodology 3 GTM Input screens... reason = ???

Site	Calculation Options		Main Steam Piping Losses	Misce
	Resistance coefficient	Enthalpy loss	Pressure drop model	
1. HPB to HPT	0.4766 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>
2. IPB to LPT	0.8335 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>
3. Hot reheat to HPT	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>
4. Cold reheat pipe	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>
5. LPB to LPT addition	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>
6. HP process	0 m <sup>-4</sup>	2.5 kJ/kg	Use resistance coefficient	<a href="#">Click to edit pipe details...</a>
7. IP process	0 m <sup>-4</sup>	2.5 kJ/kg	Use PEACE hardware description	<a href="#">Click to edit pipe details...</a>
8. HPT extraction for process	0 m <sup>-4</sup>	2.5 kJ/kg	Use resistance coefficient	<a href="#">Click to edit pipe details...</a>
9. LPT extraction for process	0 m <sup>-4</sup>	2.5 kJ/kg	Use resistance coefficient	<a href="#">Click to edit pipe details...</a>



Pumps
**Pipes**
Tanks
Cooler

**Pipe pressure drop model**

Use PEACE hardware description

Pipe material: P-22

Pipe schedule: 140

Fitting pressure class (for those denoted by (\*) below): 900 psig / 60 barg

**Pipe Re-sizing Method**

Specify hardware

Specify thermodynamic inputs

**Cross**

Sta

Cus

**Pipe Group**

**HPB to HPT (HP0)**

- IPB to LPT (IP0)
- Main Circulating Water (CW0)
- Main Auxiliary CW (CW1)
- CW for ST+Generator Lube Oil Cooler (CW7)
- Condensate (FW1)
- Makeup from Water Treatment System (FW2)
- Feedwater to Boiler (FW3)
- Condenser Air Removal (CAR0)
- Raw Water (RW0)
- Service Water (SW0)
- ST+Generator Lube Oil (OIL3)
- Service Air (SERVA)
- Boiler & Equipment Drain Piping (BEDR)
- Boiler Blowdown Piping (BLDN)
- Steam Blow Piping from HRSG & ST (STBL)
- Main Fire Protection (FP0)
- Miscellaneous Fire Protection (FP1)

1. Sizing pressure: 71.24 bar

2. Sizing temperature: 540 C

3. Sizing flow: 120.1 t/h

4. Sizing pressure drop (DP/Psizing): 3.148 %

**5. Physical length of pipe run: 72.24 m**

**6. Number of pipes in plant: 1**

7. Nominal diameter: 254 mm

8. Wall thickness: 25.4 mm

9. Inside diameter: 222.3 mm

10. Outside diameter: 273.1 mm

11. Equivalent length of pipe run: 107.8 m

12. Number short 90 degrees elbows: 0

13. Number long 90 degrees elbows: 8

14. Number sweeping 90 degrees elbows: 0

15. Number short 45/60 degrees elbows: 0

16. Number long 45/60 degrees elbows: 0

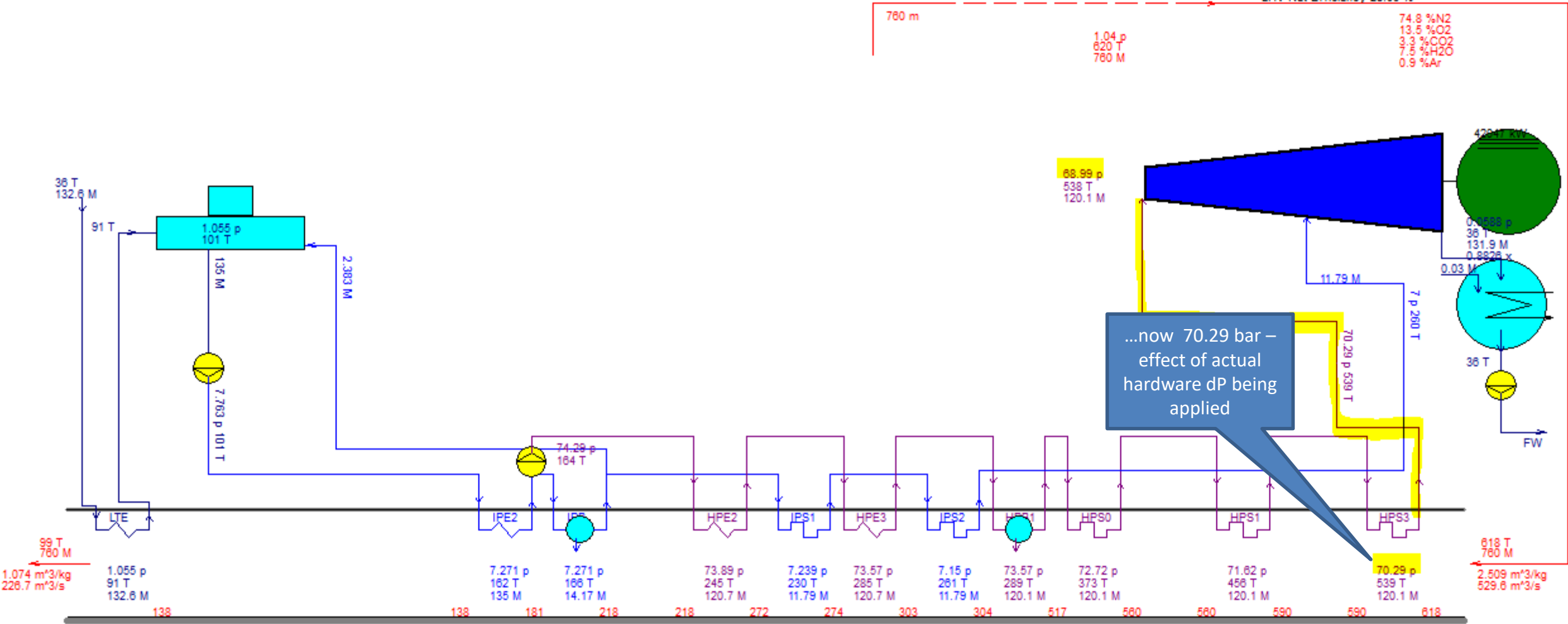
17. Number full-size tees with flow through run: 0

18. Number full-size tees with flow through branch: 0

# Methodology 3 – GTM Output

GT MASTER 26.1 skavale@email.cz

Net Power 40831 kW  
 LHV Net Heat Rate 12432 kJ/kWh  
 LHV Net Efficiency 28.96 %



p[bar], T[C], M[t/h], Steam Properties: IAPWS-IF97  
 2436 08-07-2017 17:40:46 file=C:\TFLOW26\MYFILES\GTMAS.GTM



# Methodology – Conclusions

Methodology 1- Most likely use when the design of a new plant is required.

Methodology 3- Appropriate when are replicating an existing plant design and many of the physical parameters for pipe runs and heat transfer areas can be replicated in GTPro

	Method 1	Method 2	Method 3
<b>GT PRO Defaults</b>			
Water-side pressure drop in HRSG heat exchangers	User-defined	User-defined	Hardware
Water-side pressure drop correction factor in HRSG heat exchangers	Computed	Computed	1
Switch to include radiation heat transfer from GT or DB exhaust to downstream heat exchanger	Off	Off	On
Pressure drop in heat balance pipes	User-defined	User-defined	Hardware
Switch to estimate buoyancy and pressure losses in HRSG stack	Off	Off	On
Switch to include hydrostatic correction for HRSG drum elevation	Off	Off	On
Switch to add heat rejected from auxiliary heat exchangers to the main plant cooling tower thereby increasing its size	Off	Off	On
<b>GT MASTER Defaults</b>			
HRSG heat exchanger water-side pressure drop correction factor	From GT PRO	1	1
HRSG heat exchanger gas-side pressure drop correction factor	From GT PRO	From GT PRO	From GT PRO
HRSG heat exchanger gas-side convective h.t.c. correction factors	From GT PRO	From GT PRO	From GT PRO
Switch to include radiation heat transfer from GT or DB exhaust to downstream heat exchanger	From GT PRO	On	On
Switch to include hydrostatic correction for drum elevation	From GT PRO	From GT PRO	From GT PRO
Calculation of pressure drop in heat balance pipes	Resistance Coefficient	PCE Hardware	PCE Hardware
Method to determine cooling water flow rate	User-defined	PCE Hardware	PCE Hardware
Switch to estimate buoyancy and pressure losses in HRSG stack	From GT PRO	On	On
Switch to add heat rejected from auxiliary heat exchangers to the main plant cooling tower thereby increasing its size	From GT PRO	From GT PRO	From GT PRO

# Methodology in STP/M

- Define at the New Session window
- In contrast to GTP, have fewer parameters impacted

	Methodology		
STEAM PRO Defaults	1	2	3
1. Pipe dp	Udf	Udf	PHW
2. Conv. HX water dp	Udf	Udf	PHW
STEAM MASTER Defaults	1	2	3
1. Pipe dp	RC	PHW	PHW
2. Conv. HX water dp	CFSTP	1	1
3. Cooling water flow	Udf	PHW	PHW

Udf: User-defined  
 PHW: PEACE Hardware (if licensed)  
 RC: Resistance coefficient

## 3.3.1 Pipe Pressure Drop Calculation - Resistance Coefficient Method

This finds the off-design pressure drop from the equation:

$$\Delta P = R v m^2$$

where

$\Delta P$  = pipe pressure loss

$R$  = pipe resistance coefficient

$v$  = average steam specific volume

$m$  = steam mass flow rate

## 3.3.2 Pipe Pressure Drop Calculation - PEACE Hardware Method

This method is only available in combined GTM/PCE mode. It uses the actual pipe hardware description, such as diameter, length, number of fittings of each type, and a wall roughness commensurate with the pipe's material. It computes friction factor as a function of Reynolds Number and wall roughness, to find pressure drop from the equation:

$$\Delta P = f \{ (L + \Sigma L_e) / D \} \frac{1}{2} \rho V^2 \tag{3-2}$$

where

$\Delta P$  = pipe pressure loss

$f$  = pipe friction factor, a function of Reynolds Number and pipe wall roughness

$L$  = pipe length

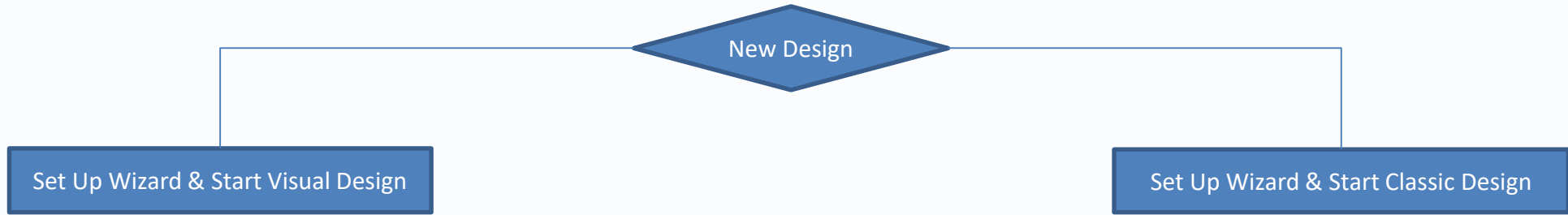
$\Sigma L_e$  = sum of equivalent lengths for all fittings (elbows, valves, etc.) in the pipe

$D$  = pipe diameter

$\rho$  = steam or water density, averaged between pipe inlet and exit states

$V$  = steam or water velocity, averaged between pipe inlet and exit states

# ....further to the NEW DESIGN topic....



**Visual Method**

**Number of HRSG Evaporator Pressures**

1-P  2-P  3-P  4-P  None

**Lowest Pressure Evaporator**

is connected to steam turbine

feeds the deaerator

feeds both process and deaerator

**Cycle Type Options**

HRSG and condensing, non-reheat ST

**Internal Calculation Procedure**

This selection is for advanced users only.

Alternative 1 / 3: [Cycle Type 6, Subtype 5]  
Recommended

Click for alternatives

Classic Method

Visual Method

**Steam System Type**

- 0. Simple cycle gas turbine(s)
- 1. Single pressure HRSG for process/STIG only
- 2. Dual pressure HRSG for process/STIG only
- 3. Single pressure CC, non-condensing turbine
- 4. Single pressure CC, extraction condensing turbine
- 5. Dual pressure CC, non-condensing turbine
- 6. Dual pressure CC, extraction/induction condensing turbine
- 7. Dual pressure reheat CC, extraction/induction condensing turbine
- 8. Triple pressure CC, extraction/induction condensing turbine
- 9. Triple pressure reheat CC, extraction/induction condensing turbine
- 10. Dual pressure reheat CC, reheat before IP
- 11. Triple pressure reheat CC, reheat before IP

**Classic Method**

ST connected to intermediate pressure boiler (IPB)

Above sketch is for illustration only. Steam turbine may have bleeds and additions. HRSG heat exchanger sequence may be modified. Various process streams may be established later.

# ....further to the NEW DESIGN topic (continued)....

Setup Wizard & Start Visual Design – this is the recommended method of starting a new design. Ref Help > GTPro > Ch.2 & Ch.3. This start method is intended for less experienced users and provides more internal mechanisms to ensure that a sound thermodynamic model results.

Setup Wizard & Start Classic Design – this is the alternative method of starting a new design. Ref Help > GTPro > Ch.2 & Ch.3. This start method has more flexibility in the design and so requires more experience on the part of the user to ensure that a sound design results

# Changing the Cycle Type

File View Options Window Excel Link Compare Files Scripts Custom Variable List 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)

Site Calculation Options Main Steam Piping Losses Miscellaneous Assumptions Regional Costs Site Characteristics Buildings Notes **Change Cycle Type**

Ambient temperature: 15 C  
 Altitude: 0 m  
 Ambient pressure: 1.013 bar  
 Ambient relative humidity: 60 %  
 Ambient wet bulb temperature: 10.82 C  
 Line frequency: 50 Hz

Site cooling water temperature: 15 C  
 Site allowable cooling water temperature rise: 10 C

Makeup water source pressure: 3.447 bar  
 Makeup water source temperature: 15 C  
 Process condensate return pressure: 3.447 bar  
 Process condensate return temperature: 82.22 C  
 Process condensate return percentage: 100 %  
 Process water return pressure: 3.447 bar  
 Process water return temperature: 15 C  
 Process water return percentage: 100 %

Exhaust steam

Cooling system type

- Once through open loop water cooling
- Water cooling with mechanical draft cooling tower
- Water cooling with wet-dry mechanical cooling tower
- Water cooling with natural draft cooling tower
- Water cooling with dry cooling tower
- Dry air cooled condenser
- Air cooled condenser with air precooled
- Air cooled condenser with continuous air saturation
- Air cooled wet surface condenser
- Direct contact condenser with dry CT (Heller System)
- No condenser, ST exhausts to process

District heating system type

Methodology

- 1. User's thermodynamic assumptions prevail over automatic hardware / engineering results
- 2. User's assumptions prevail in GT PRO, but hardware / engineering results prevail in GT MASTER
- 3. Hardware / engineering details prevail over user's assumptions

If required, the design (once defined in Visual Method say) can be changed at the Plant Criteria Screen/Change Cycle Type Tab. This then opens the Classic Method type options as shown below.

Site Calculation Options Main Steam Piping Losses Miscellaneous Assumptions Regional Costs Site Characteristics Buildings

Caution: This tab allows experienced GT PRO users to change steam cycle type and ST/HRSG connections using classic method. It is NOT intended for casual users. To preserve user's inputs, GT PRO will NOT automatically initialize inputs when a new steam system type is selected. It is user's responsibility to carefully examine and/or edit inputs to make sure they are commensurate with the new steam system type.

**Current Steam System Type**

Type 6. Dual pressure CC, extraction/induction condensing turbine

ST connected to intermediate pressure boiler (IPB)

Change current steam system type with data below

**Steam System Type**

- 0. Simple cycle gas turbine(s)
- 1. Single pressure HRSG for process/STIG only
- 2. Dual pressure HRSG for process/STIG only
- 3. Single pressure CC, non-condensing turbine
- 4. Single pressure CC, extraction condensing turbine
- 5. Dual pressure CC, non-condensing turbine
- 6. Dual pressure CC, extraction/induction condensing turbine
- 7. Dual pressure reheat CC, extraction/induction condensing turbine
- 8. Triple pressure CC, extraction/induction condensing turbine
- 9. Triple pressure reheat CC, extraction/induction condensing turbine
- 10. Dual pressure reheat CC, reheat before IP
- 11. Triple pressure reheat CC, reheat before IP

Include Reverse Osmosis (RO)

ST connected to intermediate pressure boiler (IPB)

ST connected to low pressure boiler (LPB)

Above sketch is for illustration only. Steam turbine may have bleeds and additions. HRSG heat exchanger sequence may be modified. Various process streams may be established later.

In this case the design was initially defined by the Visual Method (2 PL, non reheat). The design was then changed to a Type 9 (3 PL, non reheat). Note the cautionary highlighted test. Once the new design is chosen, confirm the new design by clicking on the "Change Current Steam System Type With Data Below" in order for the changes to take effect.

# Q & A Time....