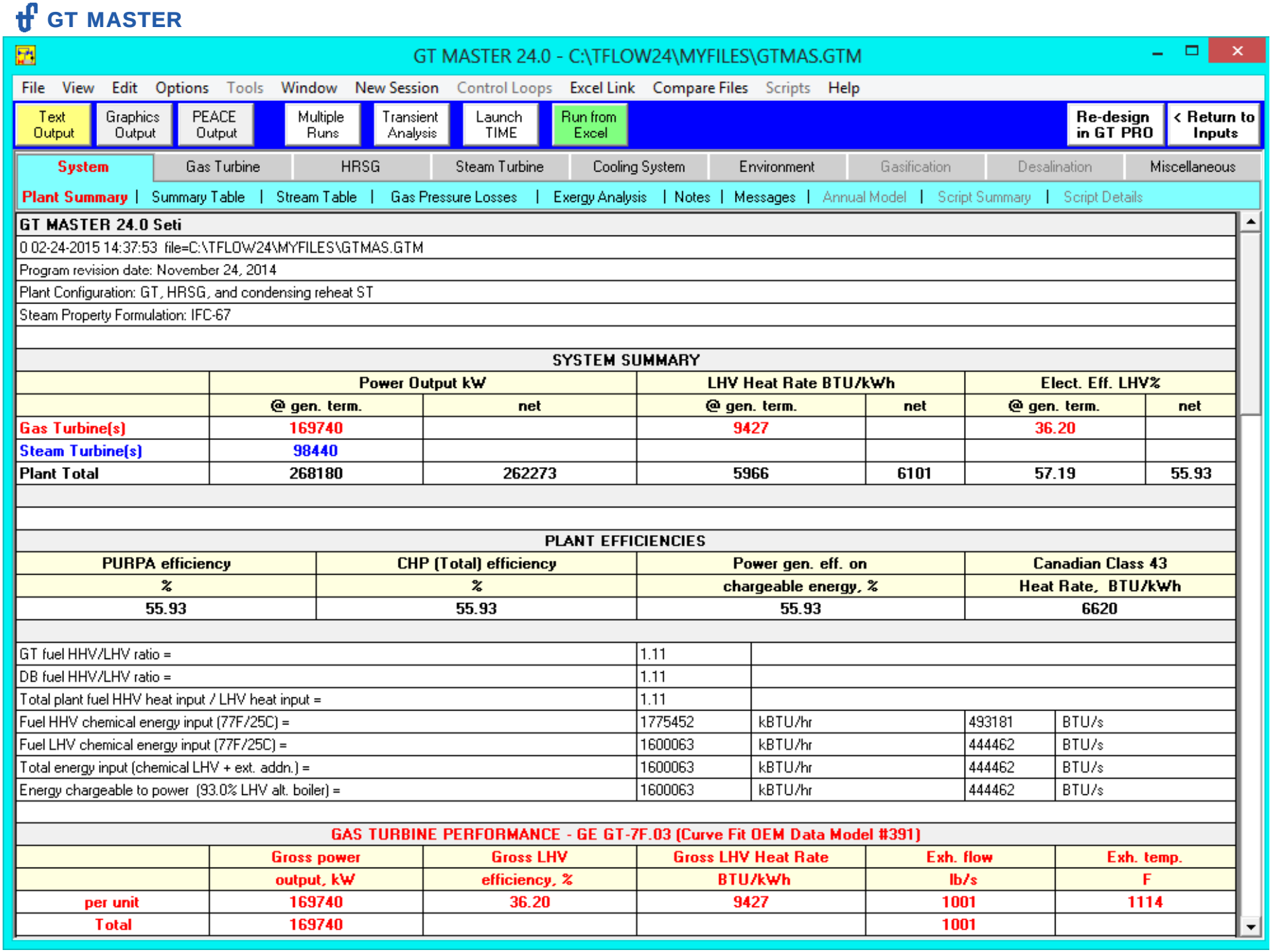
Thermoflow Inc.

WHAT IS GT MASTER?

While **GT PRO** is the design program for combined cycles, **GT MASTER** is the corresponding simulation program for off-design calculations.

- Use **GT MASTER** to evaluate designs at various ambient conditions and loads.
- All **GT MASTER** hardware inputs has automatically been initialized based on the design, which makes it possible to perform calculations by just changing a few parameters.
- Since **GT MASTER** hardware inputs are editable, the model may be fine tuned to match an existing plant or vendor data.
- In combination with **PEACE** (Plant Engineering and Construction Estimator), **GT MASTER** provides engineering details and cost estimation.



GT MASTER 24.0 Seti

0 02-24-2015 14:37:53 file=C:\TFLOW24\MYFILES\GTMAS.GTM

Program revision date: November 24, 2014

Plant Configuration: GT, HRSG, and condensing reheat ST

Steam Property Formulation: IFC-67

SYSTEM SUMMARY

	Power Output kW		LHV Heat Rate BTU/kWh		Elect. Eff. LHV%	
	@ gen. term.	net	@ gen. term.	net	@ gen. term.	net
Gas Turbine(s)	169740		9427		36.20	
Steam Turbine(s)	98440					
Plant Total	268180	262273	5966	6101	57.19	55.93

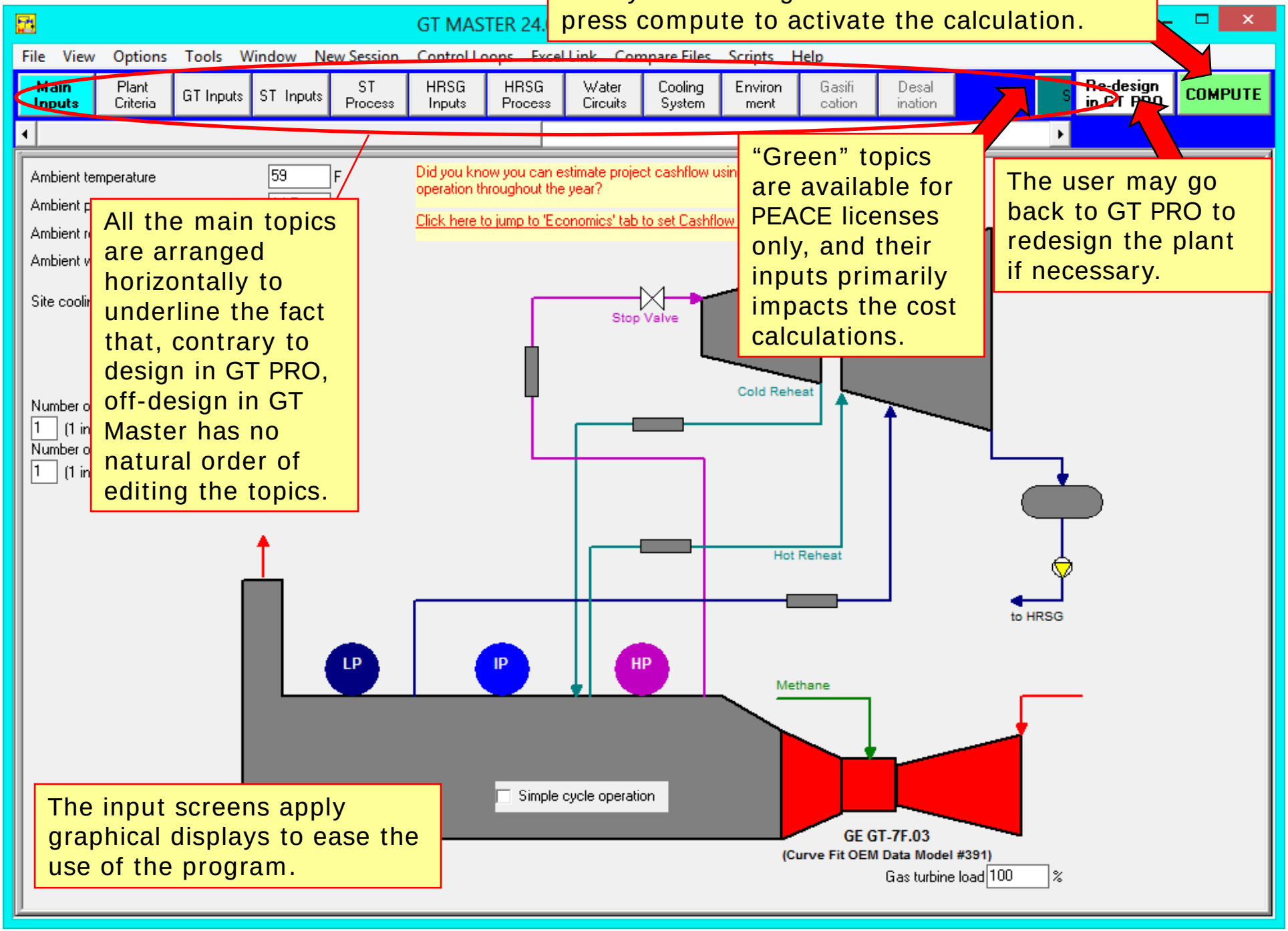
PLANT EFFICIENCIES

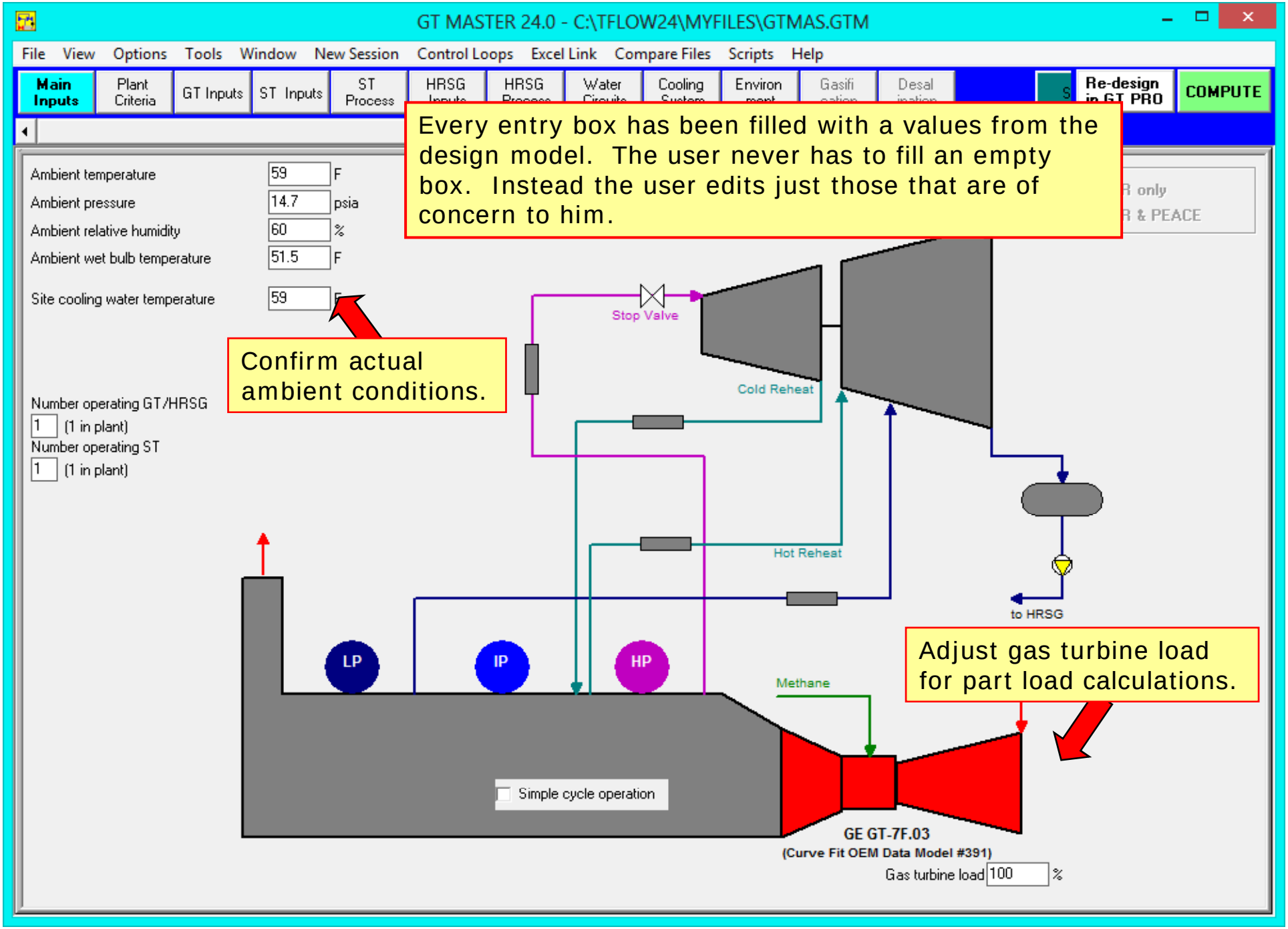
PURPA efficiency	CHP (Total) efficiency	Power gen. eff. on	Canadian Class 43
%	%	chargeable energy, %	Heat Rate, BTU/kWh
55.93	55.93	55.93	6620

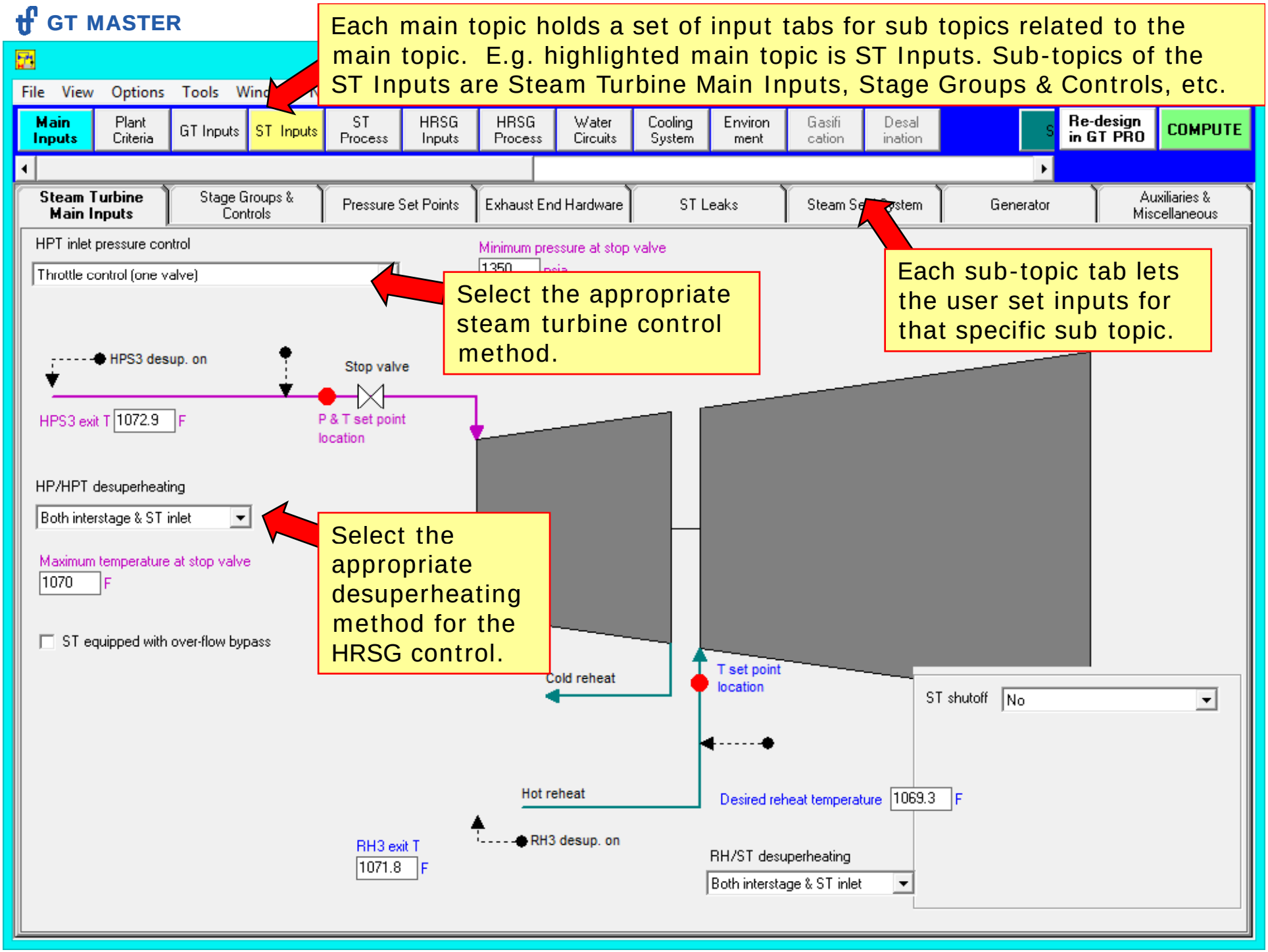
GT fuel HHV/LHV ratio =	1.11			
DB fuel HHV/LHV ratio =	1.11			
Total plant fuel HHV heat input / LHV heat input =	1.11			
Fuel HHV chemical energy input (77F/25C) =	1775452	kBTU/hr	493181	BTU/s
Fuel LHV chemical energy input (77F/25C) =	1600063	kBTU/hr	444462	BTU/s
Total energy input (chemical LHV + ext. addn.) =	1600063	kBTU/hr	444462	BTU/s
Energy chargeable to power (93.0% LHV alt. boiler) =	1600063	kBTU/hr	444462	BTU/s

GAS TURBINE PERFORMANCE - GE GT-7F.03 (Curve Fit OEM Data Model #391)

	Gross power output, kW	Gross LHV efficiency, %	Gross LHV Heat Rate BTU/kWh	Exh. flow lb/s	Exh. temp. F
per unit	169740	36.20	9427	1001	1114
Total	169740			1001	

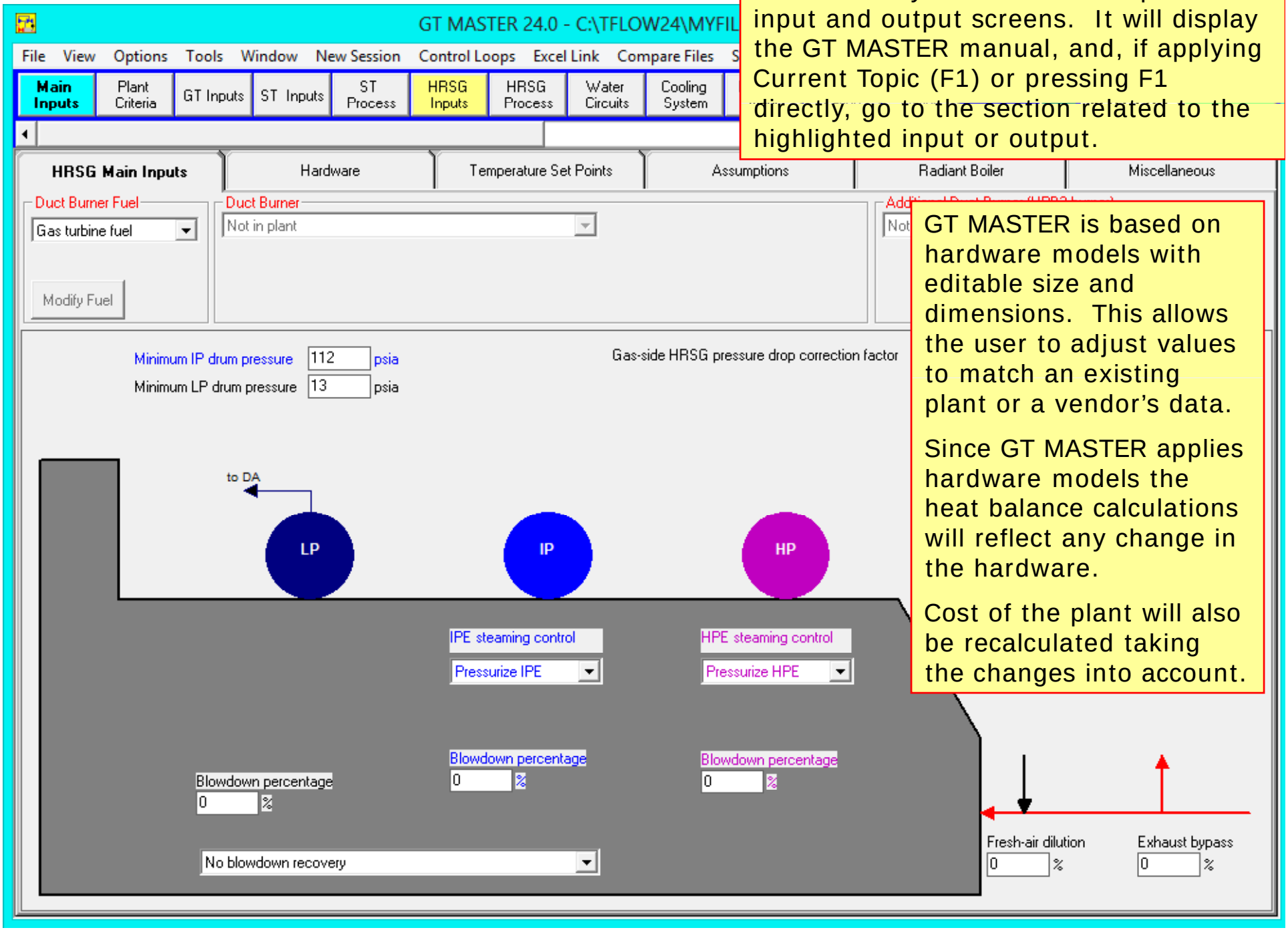

At any time during the session the user can press compute to activate the calculation.
GT MASTER 24.
File View Options Tools Window New Session Control Loops Excel Link Compare Files Scripts Help
Main Inputs
Plant Criteria
GT Inputs
ST Inputs
ST Process
HRSG Inputs
HRSG Process
Water Circuits
Cooling System
Environ ment
Gasifi cation
Desal ination
Re-design in GT PRO
COMPUTE
All the main topics are arranged horizontally to underline the fact that, contrary to design in GT PRO, off-design in GT Master has no natural order of editing the topics.
"Green" topics are available for PEACE licenses only, and their inputs primarily impacts the cost calculations.
The user may go back to GT PRO to redesign the plant if necessary.
Ambient temperature
59
F
Did you know you can estimate project cashflow usin
operation throughout the year?
Click here to jump to 'Economics' tab to set Cashflow
Stop Valve
Cold Reheat
Hot Reheat
to HRSG
LP
IP
HP
Methane
Simple cycle operation
GE GT-7F.03
(Curve Fit OEM Data Model #391)
Gas turbine load
100
%
The input screens apply graphical displays to ease the use of the program.


GT MASTER 24.0 - C:\TFLOW24\MYFILES\GTMAS.GTM
File View Options Tools Window New Session Control Loops Excel Link Compare Files Scripts Help
Main Inputs
Plant Criteria
GT Inputs
ST Inputs
ST Process
HRSG Inputs
HRSG Process
Water Circuits
Cooling System
Environment
Gasification
Desalination
Re-design in GT PRO
COMPUTE
Every entry box has been filled with a values from the design model. The user never has to fill an empty box. Instead the user edits just those that are of concern to him.
Ambient temperature 59 F
Ambient pressure 14.7 psia
Ambient relative humidity 60 %
Ambient wet bulb temperature 51.5 F
Site cooling water temperature 59
Confirm actual ambient conditions.
Number operating GT/HRSG
1 (1 in plant)
Number operating ST
1 (1 in plant)
Stop Valve
Cold Reheat
Hot Reheat
to HRSG
LP
IP
HP
Methane
Adjust gas turbine load for part load calculations.
Simple cycle operation
GE GT-7F.03
(Curve Fit OEM Data Model #391)
Gas turbine load 100 %


GT MASTER
Each main topic holds a set of input tabs for sub topics related to the main topic. E.g. highlighted main topic is ST Inputs. Sub-topics of the ST Inputs are Steam Turbine Main Inputs, Stage Groups & Controls, etc.
File View Options Tools
Main Inputs
Plant Criteria
GT Inputs
ST Inputs
ST Process
HRSG Inputs
HRSG Process
Water Circuits
Cooling System
Environ ment
Gasifi cation
Desal ination
Re-design in GT PRO
COMPUTE
Steam Turbine Main Inputs
Stage Groups & Controls
Pressure Set Points
Exhaust End Hardware
ST Leaks
Generator
Auxiliaries & Miscellaneous
HPT inlet pressure control
Throttle control (one valve)
Minimum pressure at stop valve
1350
Select the appropriate steam turbine control method.
Each sub-topic tab lets the user set inputs for that specific sub topic.
HPS3 desup. on
Stop valve
HPS3 exit T 1072.9 F
P & T set point location
HP/HPT desuperheating
Both interstage & ST inlet
Select the appropriate desuperheating method for the HRSG control.
Maximum temperature at stop valve
1070 F
ST equipped with over-flow bypass
Cold reheat
T set point location
ST shutoff
No
Hot reheat
Desired reheat temperature
1069.3 F
RH3 exit T
1071.8 F
RH3 desup. on
RH/ST desuperheating
Both interstage & ST inlet

GT MASTER

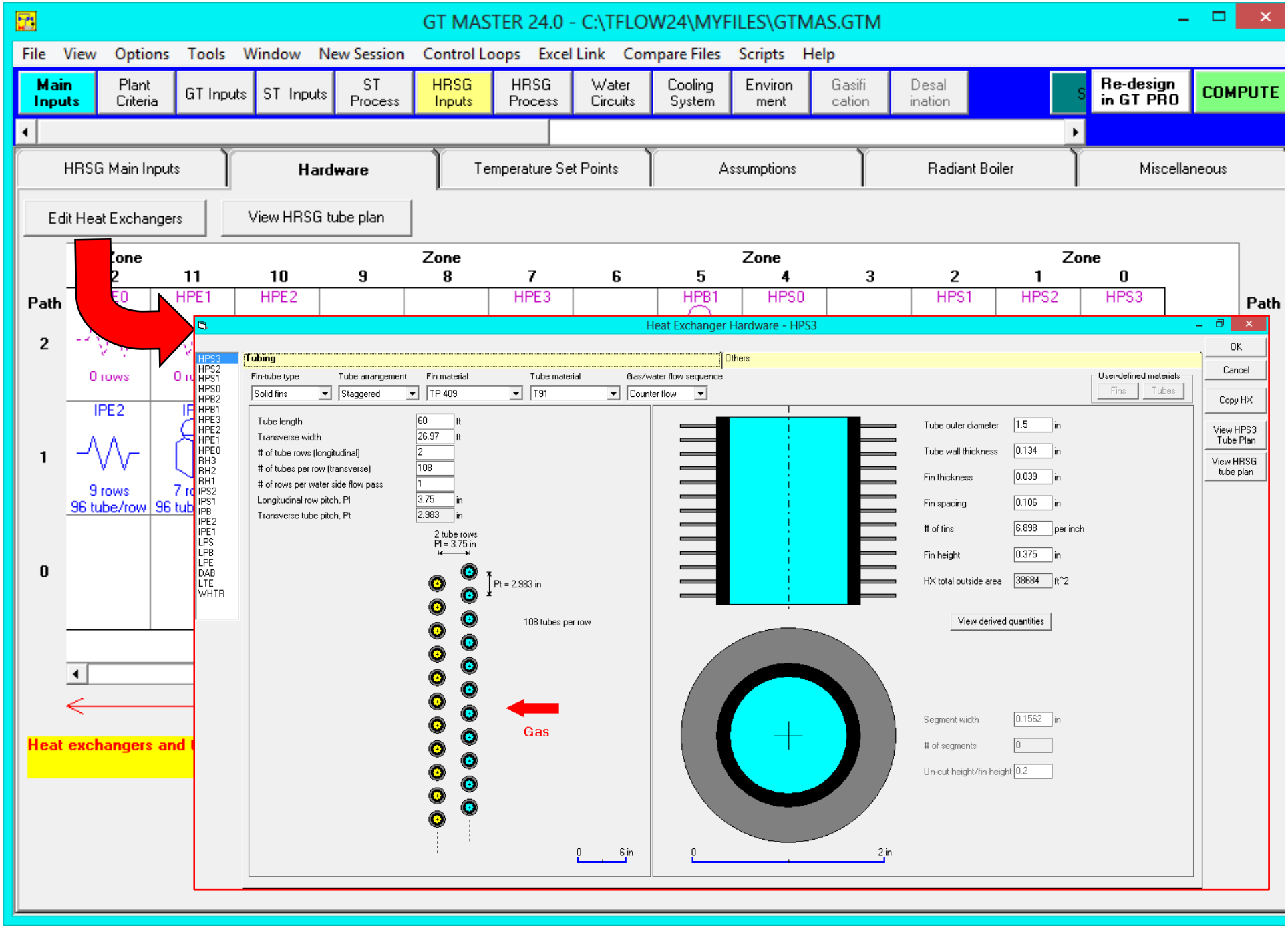
The user may summon the Help on both input and output screens. It will display the GT MASTER manual, and, if applying Current Topic (F1) or pressing F1 directly, go to the section related to the highlighted input or output.

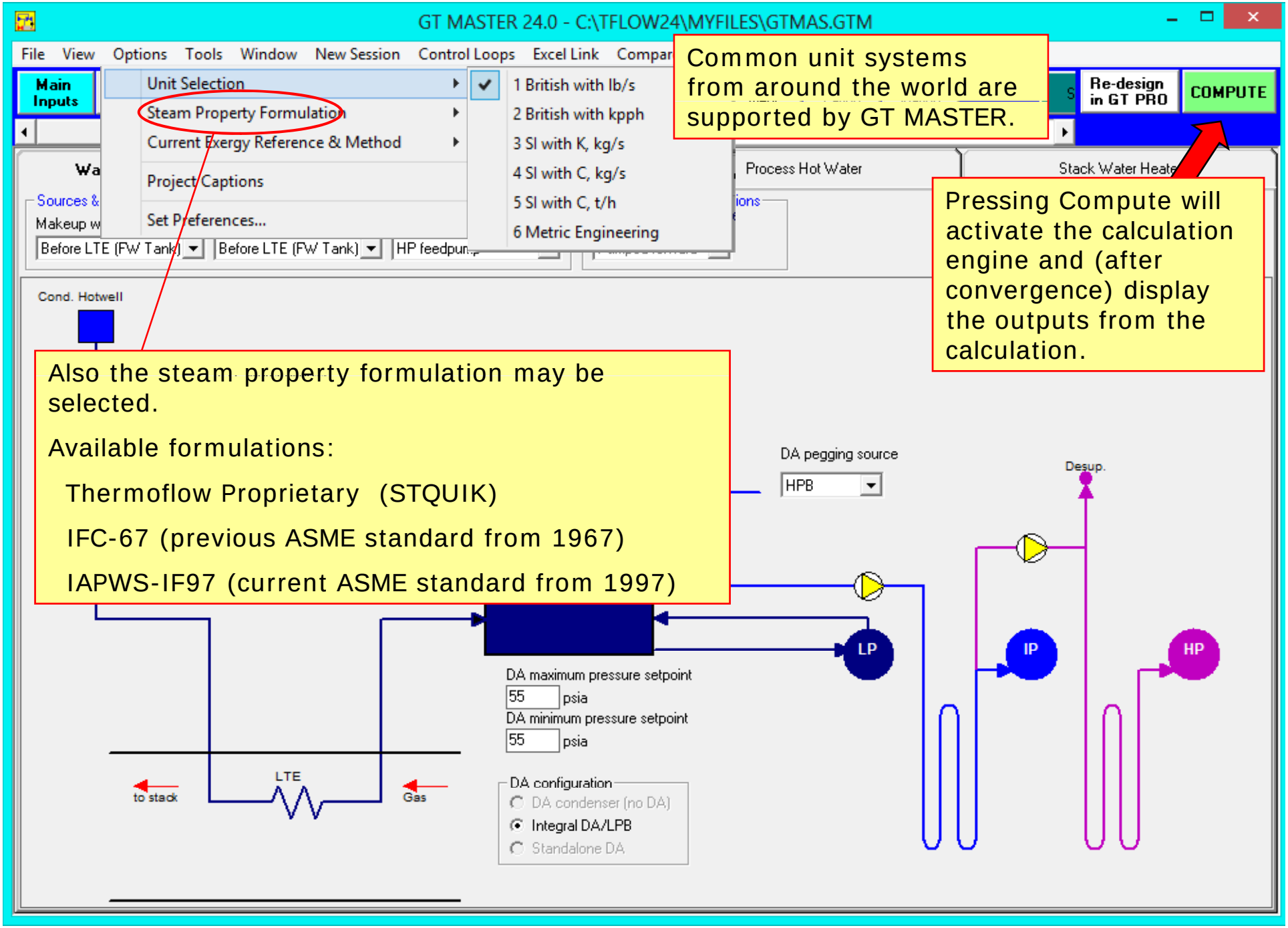


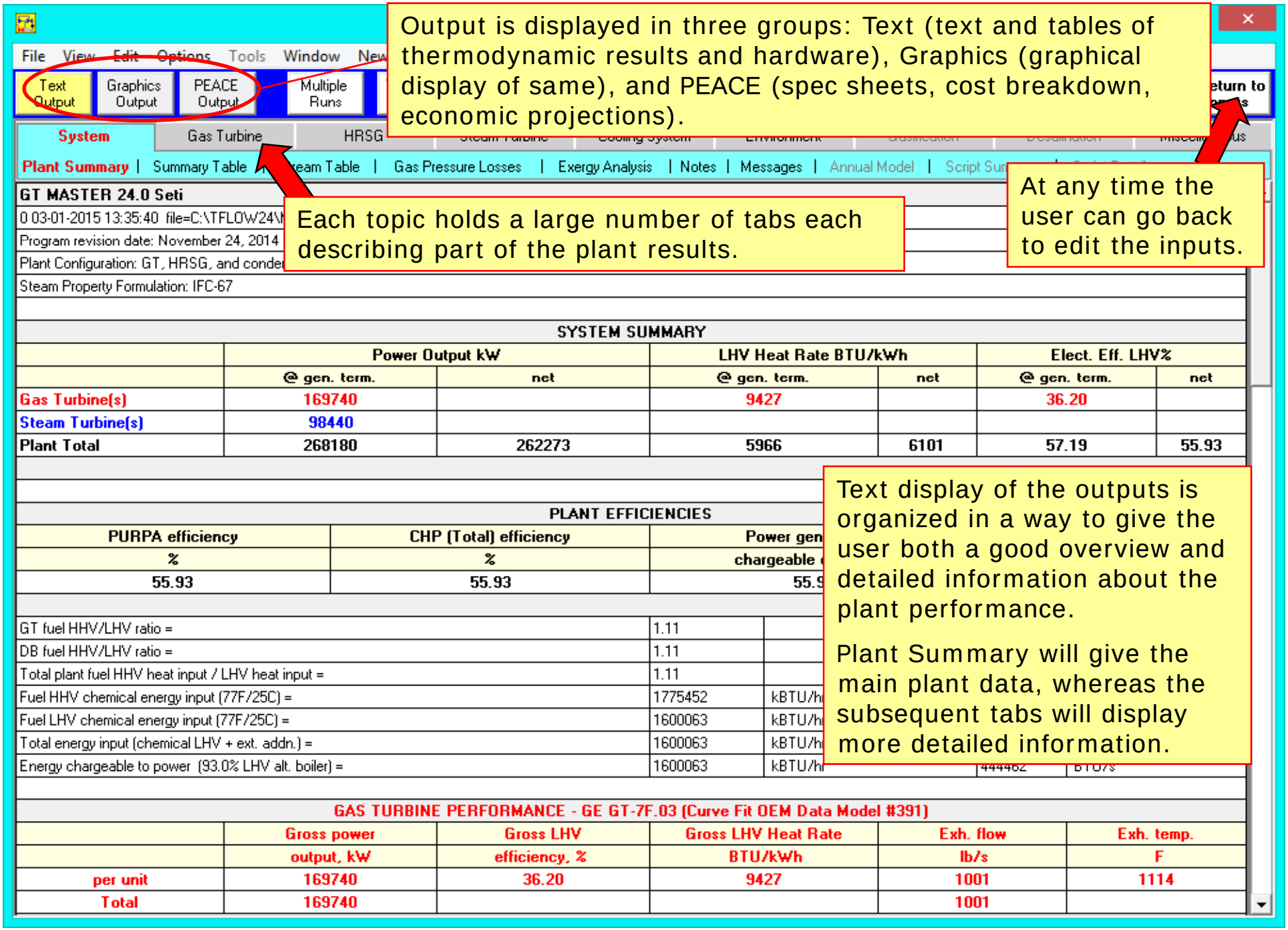
GT MASTER is based on hardware models with editable size and dimensions. This allows the user to adjust values to match an existing plant or a vendor's data.

Since GT MASTER applies hardware models the heat balance calculations will reflect any change in the hardware.

Cost of the plant will also be recalculated taking the changes into account.


GT MASTER 24.0 - C:\TFLOW24\MYFILES\GTMAS.GTM
File View Options Tools Window New Session Control Loops Excel Link Compare Files Scripts Help
Main Inputs
Plant Criteria
GT Inputs
ST Inputs
ST Process
HRSG Inputs
HRSG Process
Water Circuits
Cooling System
Environ ment
Gasifi cation
Desal ination
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
Path
HPE1
HPE2
HPE3
HPB1
HPS0
HPS1
HPS2
HPS3
IPE2
9 rows
96 tube/row
Heat exchangers and
Heat Exchanger Hardware - HPS3
Tubing
Others
Fin-tube type
Solid fins
Tube arrangement
Staggered
Fin material
TP 409
Tube material
T91
Gas/water flow sequence
Counter flow
User-defined materials
Fins
Tubes
OK
Cancel
Copy HX
View HPS3 Tube Plan
View HRSG tube plan
Tube length 60 ft
Transverse width 26.97 ft
# of tube rows (longitudinal) 2
# of tubes per row (transverse) 108
# of rows per water side flow pass 1
Longitudinal row pitch, Pl 3.75 in
Transverse tube pitch, Pt 2.983 in
2 tube rows
Pl = 3.75 in
Pt = 2.983 in
108 tubes per row
Gas
0 6 in
Tube outer diameter 1.5 in
Tube wall thickness 0.134 in
Fin thickness 0.039 in
Fin spacing 0.106 in
# of fins 6.898 per inch
Fin height 0.375 in
HX total outside area 38684 ft^2
View derived quantities
Segment width 0.1562 in
# of segments 0
Un-cut height/fin height 0.2
0 2 in


GT MASTER 24.0 - C:\TFLOW24\MYFILES\GTMAS.GTM
File View Options Tools Window New Session Control Loops Excel Link Compar
Main Inputs
Unit Selection
Steam Property Formulation
Current Exergy Reference & Method
Project Captions
Set Preferences...
1 British with lb/s
2 British with kpph
3 SI with K, kg/s
4 SI with C, kg/s
5 SI with C, t/h
6 Metric Engineering
Re-design in GT PRO
COMPUTE
Process Hot Water
Stack Water Heate
Sources &
Makeup w
Before LTE (FW Tank)
Before LTE (FW Tank)
HP feedpun
Cond. Hotwell
DA pegging source
HPB
Desup.
LP
IP
HP
DA maximum pressure setpoint
55
psia
DA minimum pressure setpoint
55
psia
DA configuration
DA condenser (no DA)
Integral DA/LPB
Standalone DA
LTE
to stack
Gas
Common unit systems from around the world are supported by GT MASTER.
Pressing Compute will activate the calculation engine and (after convergence) display the outputs from the calculation.
Also the steam property formulation may be selected.
Available formulations:
Thermoflow Proprietary (STQUIK)
IFC-67 (previous ASME standard from 1967)
IAPWS-IF97 (current ASME standard from 1997)


Output is displayed in three groups: Text (text and tables of thermodynamic results and hardware), Graphics (graphical display of same), and PEACE (spec sheets, cost breakdown, economic projections).
File View Edit Options Tools Window New
Text Output
Graphics Output
PEACE Output
Multiple Runs
System
Gas Turbine
HRSG
Plant Summary | Summary Table | Steam Table | Gas Pressure Losses | Exergy Analysis | Notes | Messages | Annual Model
Each topic holds a large number of tabs each describing part of the plant results.
At any time the user can go back to edit the inputs.
GT MASTER 24.0 Seti
Program revision date: November 24, 2014
Steam Property Formulation: IFC-67
SYSTEM SUMMARY
Power Output kW
LHV Heat Rate BTU/kWh
Elect. Eff. LHV%
@ gen. term.
net
Gas Turbine(s) 169740 9427 36.20
Steam Turbine(s) 98440
Plant Total 268180 262273 5966 6101 57.19 55.93
PLANT EFFICIENCIES
PURPA efficiency
CHP (Total) efficiency
Power gen
%
chargeable
55.93 55.93 55.9
GT fuel HHV/LHV ratio = 1.11
DB fuel HHV/LHV ratio = 1.11
Total plant fuel HHV heat input / LHV heat input = 1.11
Fuel HHV chemical energy input (77F/25C) = 1775452 kBTU/h
Fuel LHV chemical energy input (77F/25C) = 1600063 kBTU/h
Total energy input (chemical LHV + ext. addn.) = 1600063 kBTU/h
Energy chargeable to power (93.0% LHV alt. boiler) = 1600063 kBTU/h
444462
BTU/s
Text display of the outputs is organized in a way to give the user both a good overview and detailed information about the plant performance.
Plant Summary will give the main plant data, whereas the subsequent tabs will display more detailed information.
GAS TURBINE PERFORMANCE - GE GT-7F.03 (Curve Fit OEM Data Model #391)
Gross power output, kW
Gross LHV efficiency, %
Gross LHV Heat Rate BTU/kWh
Exh. flow lb/s
Exh. temp. F
per unit 169740 36.20 9427 1001 1114
Total 169740 1001

GT MASTER

Multiple runs may be performed applying the Thermoflow Macro for studies of parameter variations.

File View Edit Options Tools Window

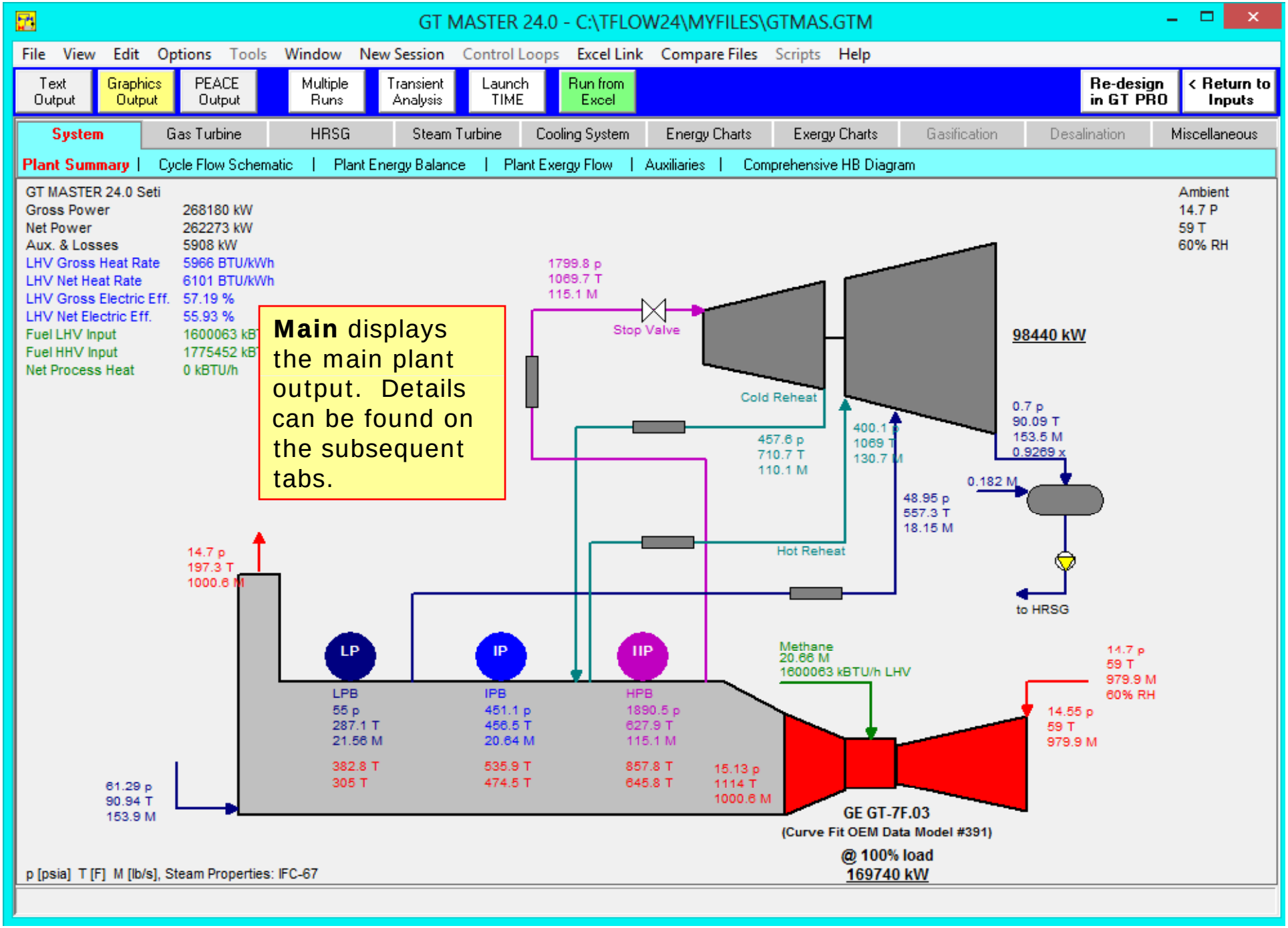
Text Output | Graphics Output | PEACE Output | Multiple Runs | Transient Analysis | Launch TIME | Transfer to Excel | Design in GT PRO | < Return to Inputs

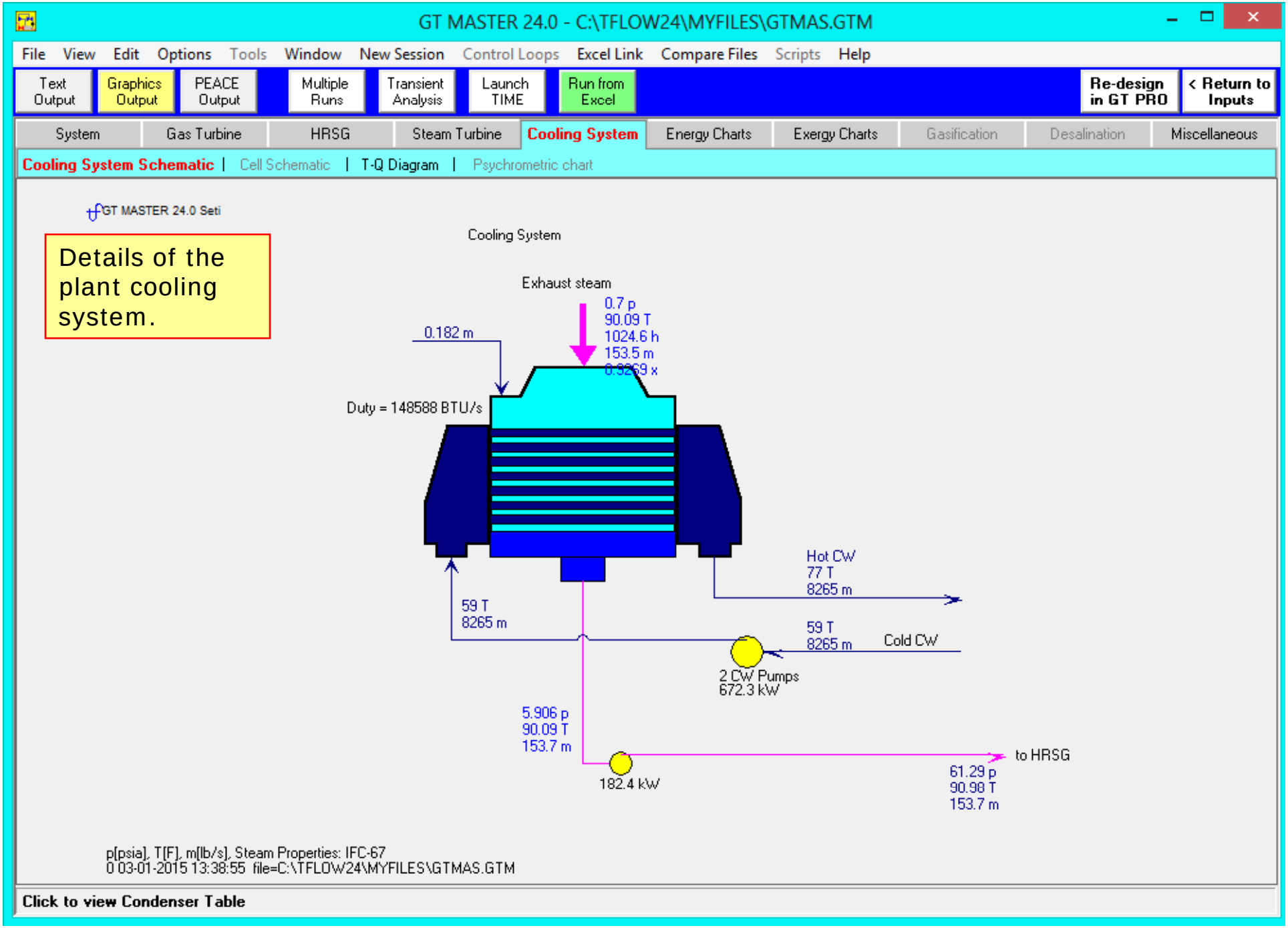
System | Gas Turbine | HRSG | Steam Turbine | Cooling System | Environment | Gasification | Desalination | Miscellaneous

Steam Cycle Summary | HRSG Hardware | HRSG Gas Summary | Duct Burner Fuel | Water Wall

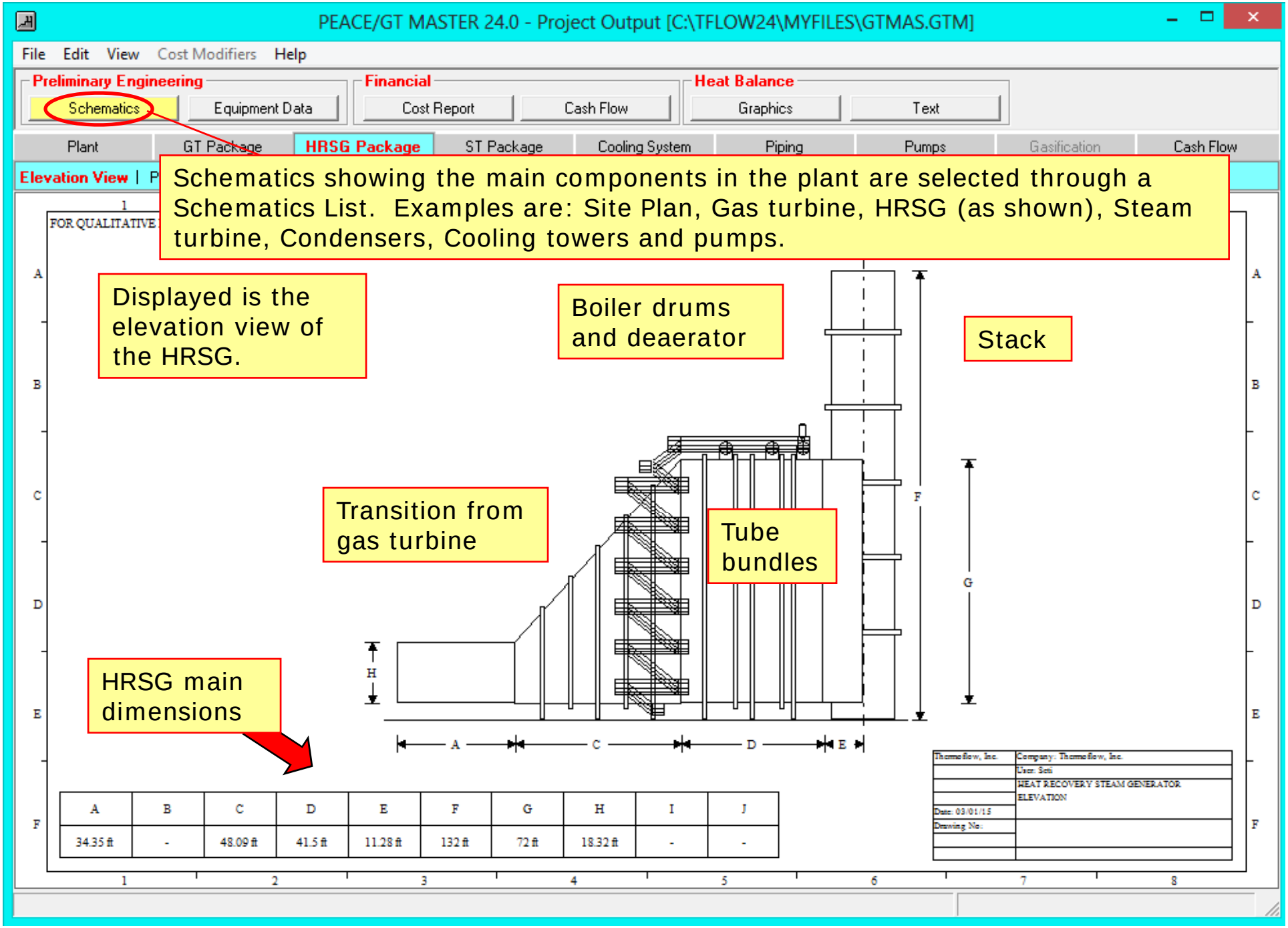
This table will give the user an overview of all HX in the HRSG by showing the HX hardware information side by side.

HRSG Hardware	1. HPS3	2. RH3	3. HPS1	4. RH1	5. HPS0	6. HPB1	7. IPS2	8. HPE3	9. LPS
Gas zone / path	[0 / 2]	[1 / 0]	[2 / 2]	[3 / 0]	[4 / 2]	[5 / 2]	[6 / 1]	[7 / 2]	[8 / 0]
Tubing	Solid fins	Serrated fins	Serrated fins	Serrated fins	Serrated fins	Serrated fins	Serrated fins	Serrated fins	Serrated fins
Tube arrangement	Staggered	Staggered	Staggered	Staggered	Staggered	Staggered	Staggered	Staggered	Staggered
Fin material	TP409	TP409	TP409	TP409	TP409	CS	CS	CS	CS
Tube material	T22	T22	T22	T22	T22	CS	CS	CS	CS
Gas/water flow sequence (0=counter, 1=parallel flow)	0	0	0	0	0	0	0	0	0
1. Number of tube rows (longitudinal)	4	6	11	1	6	1	6	1	1
2. Number of tubes per row (transverse)	80	108	96	108	96	80	80	80	80
3. Number of rows per water side flow pass	2	1	11	1	1	1	1	1	1
4. Longitudinal row pitch [in]	5	3.75	4.219	3.75	4.219	5	5	5	5
5. Gas path transverse width [ft]	26.97	26.97	26.97	26.97	26.97	26.97	26.97	26.97	26.97
6. Tube length [ft]	60	60	60	60	60	60	60	60	60
7. Tube outer diameter [in]	2	1.5	1.5	1.5	1.5	2	2	2	2
8. Tube wall thickness [in]	0.134	0.105	0.11	0.105	0.134	0.134	0.083	0.134	0.105
9. Fin height [in]	0.375	0.5	0.5	0.5	0.5	0.625	0.5	0.625	0.5
10. Fin spacing [in]	0.106	0.2302	0.2557	0.5827	0.1472	0.1124	2.159	0.1198	0.1152
11. Fin thickness [in]	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039	0.039
12. Number of fins per inch	6.898	3.715	3.393	1.609	5.371	6.606	0.4549	6.297	6.486
13. Serrated fin segment width [in]	0	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563	0.1563
14. Number of serrated fin segments	0	42.21	32.16	42.21	32.16	32.66	32.16	32.66	42.21
15. Un-serrated height / fin height	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
16. Fin thermal conductivity @ 500 F (260 C) [BTU/hr-ft-F]	15.1	15.1	15.1	15.1	15.1	27	27	27	27
17. Fin thermal conductivity slope [BTU/hr-ft-F^2]	0.0024	0.0024	0.0024	0.0024	0.0024	-0.008	-0.008	-0.008	-0.008
18. Tube thermal conductivity @ 500 F (260 C) [BTU/hr-ft-F]	15.6	15.6	15.6	21.3	21.3	27	27	27	27
19. Tube thermal conductivity slope [BTU/hr-ft-F^2]	0.0017	0.0017	0.0017	-0.0035	-0.0035	-0.008	-0.008	-0.008	-0.008
20. Heat exchanger effectiveness adjustment factor	1	1	1	1	1	1	1	1	1
21. Pass inlet & exit DP (0=1 vel. head, 1=180 deg. bend)	0	0	0	0	0	0	0	0	0
22. Water/steam side fouling factor [h-ft^2-F/BTU]	5.0E-04	5.0E-04	5.0E-04	5.0E-04	5.0E-04	5.0E-04	5.0E-04	5.0E-04	5.0E-04
23. Gas side fouling factor [h-ft^2-F/BTU]	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03
24. Gas side convective h.t.c. adjustment factor	1	1	1	1	1	1	1	1	1


GT MASTER 24.0 - C:\TFLOW24\MYFILES\GTMAS.GTM
File View Edit Options Tools Window New Session Control Loops Excel Link Compare Files Scripts Help
Text Output
Graphics Output
PEACE Output
Multiple Runs
Transient Analysis
Launch TIME
Run from Excel
Re-design in GT PRO
< Return to Inputs
System
Gas Turbine
HRSG
Steam Turbine
Cooling System
Energy Charts
Exergy Charts
Gasification
Desalination
Miscellaneous
Plant Summary | Cycle Flow Schematic | Plant Energy Balance | Plant Exergy Flow | Auxiliaries | Comprehensive HB Diagram
GT MASTER 24.0 Seti
Gross Power 268180 kW
Net Power 262273 kW
Aux. & Losses 5908 kW
LHV Gross Heat Rate 5966 BTU/kWh
LHV Net Heat Rate 6101 BTU/kWh
LHV Gross Electric Eff. 57.19 %
LHV Net Electric Eff. 55.93 %
Fuel LHV Input 1600063 kB
Fuel HHV Input 1775452 kB
Net Process Heat 0 kBTU/h
Ambient
14.7 P
59 T
60% RH
Main displays the main plant output. Details can be found on the subsequent tabs.
1799.8 p
1069.7 T
115.1 M
Stop Valve
98440 kW
Cold Reheat
457.6 p
710.7 T
110.1 M
400.1 p
1069 T
130.7 M
0.7 p
90.09 T
153.5 M
0.9269 x
0.182 M
48.95 p
557.3 T
18.15 M
Hot Reheat
to HRSG
14.7 p
197.3 T
1000.6 M
LP
IP
IIP
LPB
55 p
287.1 T
21.56 M
382.8 T
305 T
IPB
451.1 p
456.5 T
20.64 M
535.9 T
474.5 T
HPB
1890.5 p
627.9 T
115.1 M
857.8 T
645.8 T
15.13 p
1114 T
1000.6 M
Methane
20.66 M
1600063 kBTU/h LHV
14.7 p
59 T
979.9 M
60% RH
14.55 p
59 T
979.9 M
61.29 p
90.94 T
153.9 M
GE GT-7F.03
(Curve Fit OEM Data Model #391)
@ 100% load
169740 kW
p [psia] T [F] M [lb/s], Steam Properties: IFC-67


GT MASTER 24.0 - C:\TFLOW24\MYFILES\GTMAS.GTM
File View Edit Options Tools Window New Session Control Loops Excel Link Compare Files Scripts Help
Text Output
Graphics Output
PEACE Output
Multiple Runs
Transient Analysis
Launch TIME
Run from Excel
Re-design in GT PRO
< Return to Inputs
System Gas Turbine HRSG Steam Turbine Cooling System Energy Charts Exergy Charts Gasification Desalination Miscellaneous
Cooling System Schematic | Cell Schematic | T-Q Diagram | Psychrometric chart
GT MASTER 24.0 Seti
Details of the plant cooling system.
Cooling System
Exhaust steam
0.7 p
90.09 T
1024.6 h
153.5 m
0.182 m
Duty = 148588 BTU/s
Hot CW
77 T
8265 m
59 T
8265 m
59 T
8265 m
Cold CW
2 CW Pumps
672.3 kW
5.906 p
90.09 T
153.7 m
182.4 kW
to HRSG
61.29 p
90.98 T
153.7 m
p[psia], T[F], m[lb/s], Steam Properties: IFC-67
0 03-01-2015 13:38:55 file=C:\TFLOW24\MYFILES\GTMAS.GTM
Click to view Condenser Table

GT MASTER



http://www.Thermoflow.ir

GT MASTER

PEACE/GT MASTER 24.0 - Project Output [C:\TFLOW24\MYFILES\GTMAS.GTM]

File Edit View Cost Modifiers Help

Preliminary Engineering: Schematics | Equipment Data
Financial: Cost Report | Cash Flow
Heat Balance: Graphics | Text

Plant | Gas Turbine | HRSG | Steam Turbine | Cooling System | Gasification | Desalination | Miscellaneous

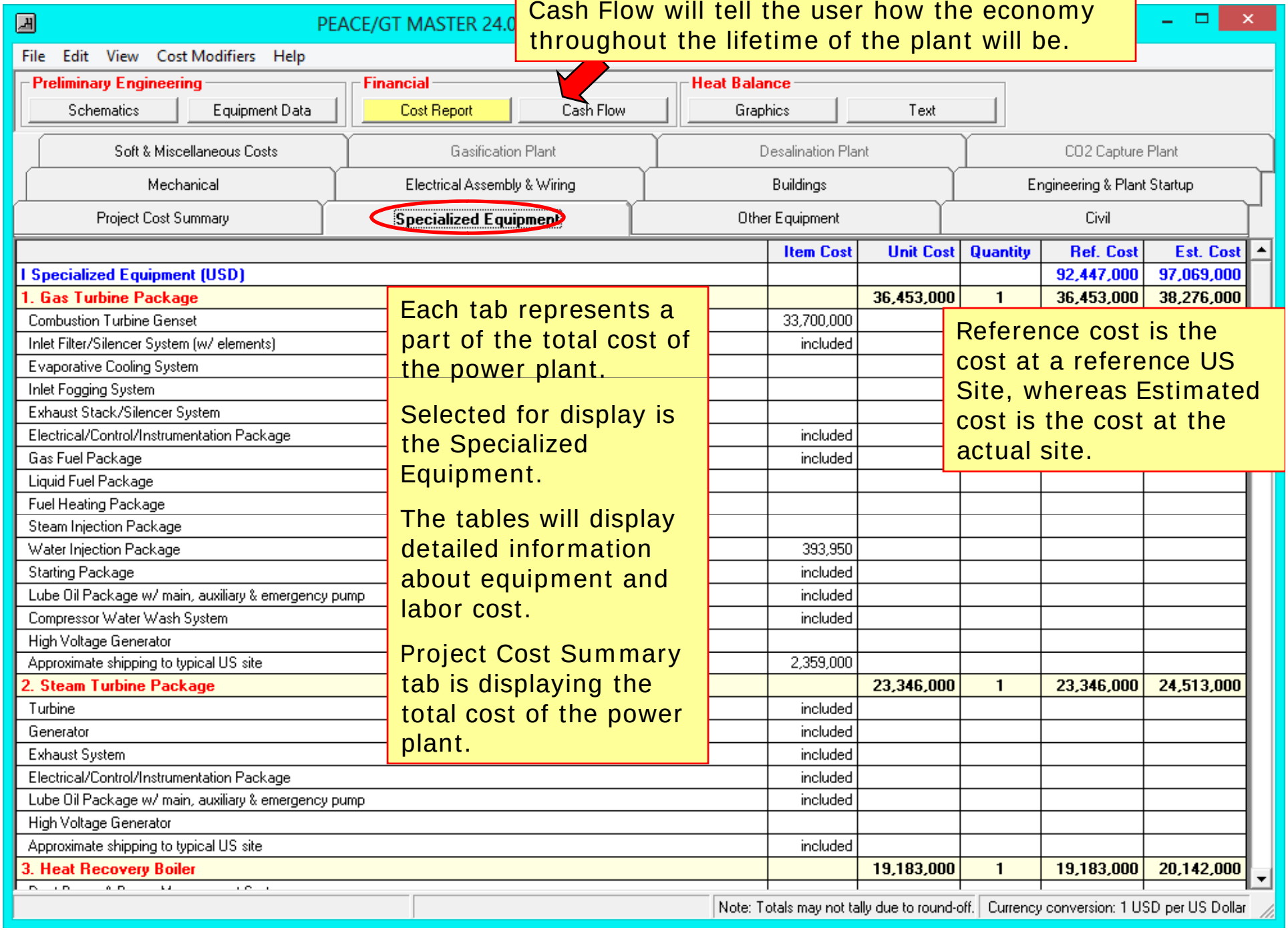
Steam Turbine

Estimated Steam Turbine Data		
Number of Units	1	
1. Steam Turbine Description		
Nameplate Capacity	114.8	MVA
Power Factor	0.9	
Steam Turbine Type	Condensing, Reheat	
Nameplate Throttle Pressure	1890	psia
Nameplate Throttle Temperature	1070	F
Nameplate Throttle Massflow	115.1	lb/s
Exhaust End Type	Axial	
Number of LPT Exhaust Annuli	1	
Last Stage Bucket Length	37.77	in
Last Stage Pitch Diameter	98.11	in
Number of Ports	1	
Number of Auto-Extraction Ports	0	
2. Estimated Weights, Dimensions & Cost		
Steam Turbine Length	32.9	ft
Steam Turbine Width	14.7	ft
Steam Turbine Weight	308,800	lb
Generator Length (Including Exciter)	32.7	ft
Generator Width	11.3	ft
Generator Weight	346,700	lb
Overall ST and Generator Length	65.6	ft
Overall ST and Generator Width	14.7	ft
Overall ST and Generator Weight	655,500	lb

Each tab represents a major part of the power plant. Selected for display is the steam turbine.

The tables will display detailed information about sizes and weight of the selected element or group of elements of the plant.

GT MASTER



Cash Flow will tell the user how the economy throughout the lifetime of the plant will be.

Each tab represents a part of the total cost of the power plant.

Selected for display is the Specialized Equipment.

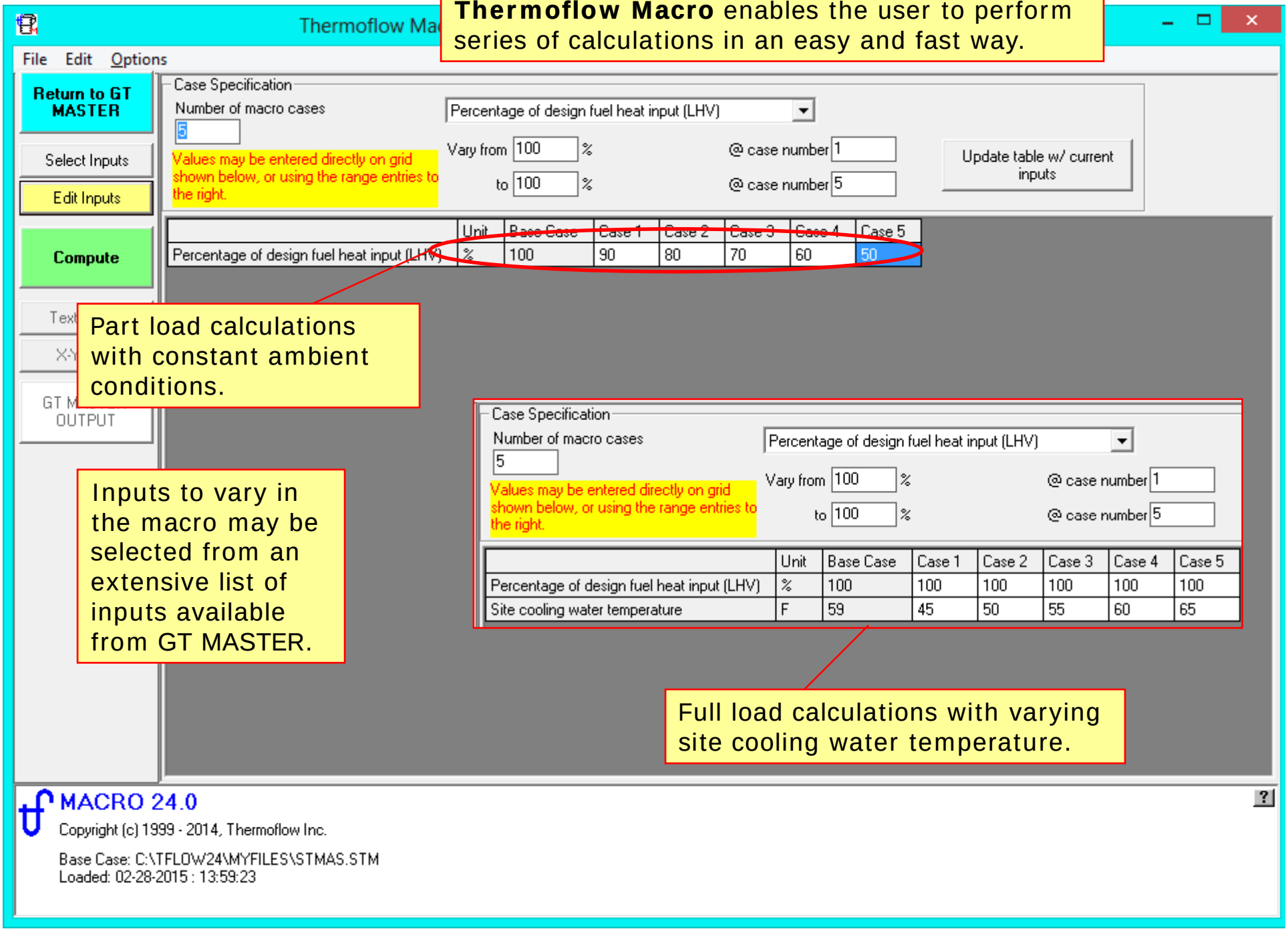
The tables will display detailed information about equipment and labor cost.

Project Cost Summary tab is displaying the total cost of the power plant.

Reference cost is the cost at a reference US Site, whereas Estimated cost is the cost at the actual site.

GT MASTER

Thermoflow Macro enables the user to perform series of calculations in an easy and fast way.



Plant Summary and the subsequent 7 tables display fixed lists of output data.

Any of the general tabs allows the user to define which data (outputs as well as inputs) to display in that specific table.

All tables can be exported to Excel directly or saved as a .CSV file for later load into Excel.

Plots can be created. As an example Plant net eff vs. GT load.

For each case GT MASTER output can be displayed.

Thermoflow Ma

File Edit Options

Return to GT MASTER

Select Inputs

Edit Inputs

Compute

Text Output

X-Y Plots

GT MASTER OUTPUT

General - 4 | General - 5 | General - 6 | General - 7 | General - 8 | General - 9 | General - 10

Cost Report | Major Equipment | Cost Breakdowns | Macro Inputs | General - 1 | General - 2 | General - 3

Plant Summary | Steam Turbine | Cooling System | Steam Process / Addition

Right-click a column to summon details for that case.
Left-click any 'Messages' for details.

Plant Summary	Unit	Base Case	Case 1	Case 2	C
Computation Result Messages		OK	OK	OK	O
Ambient pressure	psia	14.7	14.7	14.7	1
Ambient temperature	F	59	59	59	5
Ambient relative humidity	%	60	60	60	6
Number Boiler/ST units in plant		1	1		
Plant gross output	kW	350082	31		
Plant net output	kW	332989	30		
Plant gross heat rate (LHV)	BTU/kWh	7918	79		
Plant net heat rate (LHV)	BTU/kWh	8325	83		
Plant gross elec eff (LHV)	%	43.09	43		
Plant net elec eff (LHV)	%	40.99	41		
U.S. PURPA eff (LHV)	%	40.99	41		
CHP Total eff (LHV)	%	40.99	41		
Plant gross heat rate (HHV)	BTU/kWh	8189	81		
Plant net heat rate (HHV)	BTU/kWh	8609	86		
Plant gross elec eff (HHV)	%	41.67	41		
Plant net elec eff (HHV)	%	39.64	39		
U.S. PURPA eff (HHV)	%	39.64	39		
CHP Total eff (HHV)	%	39.64	39		
Plant total fuel input (LHV)	kBTU/hr	2772082	24		
Plant total fuel input (HHV)	kBTU/hr	2866736	25		

MACRO 24.0

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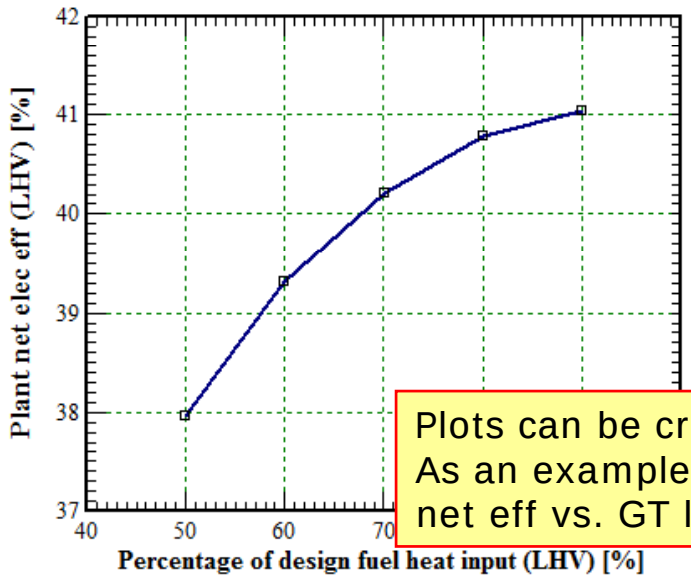
File Edit Options



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