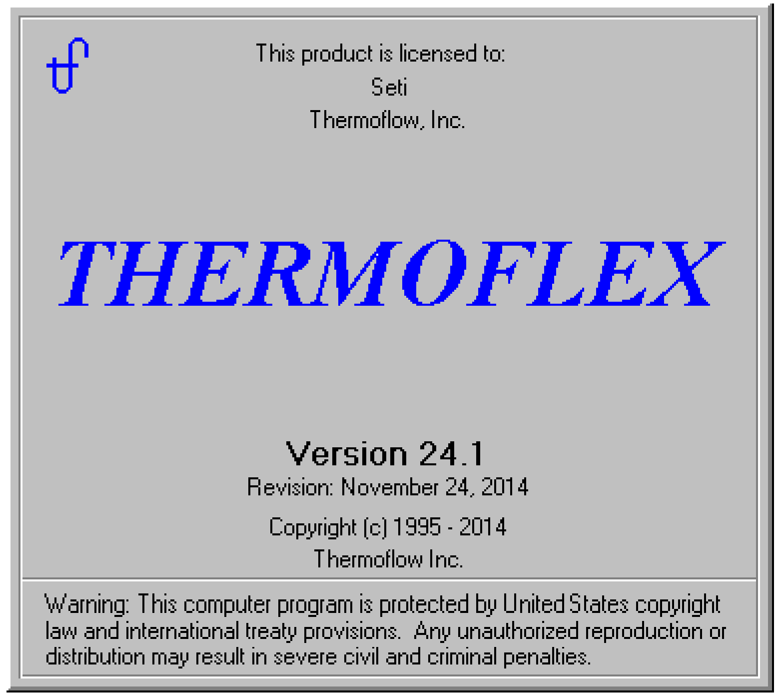
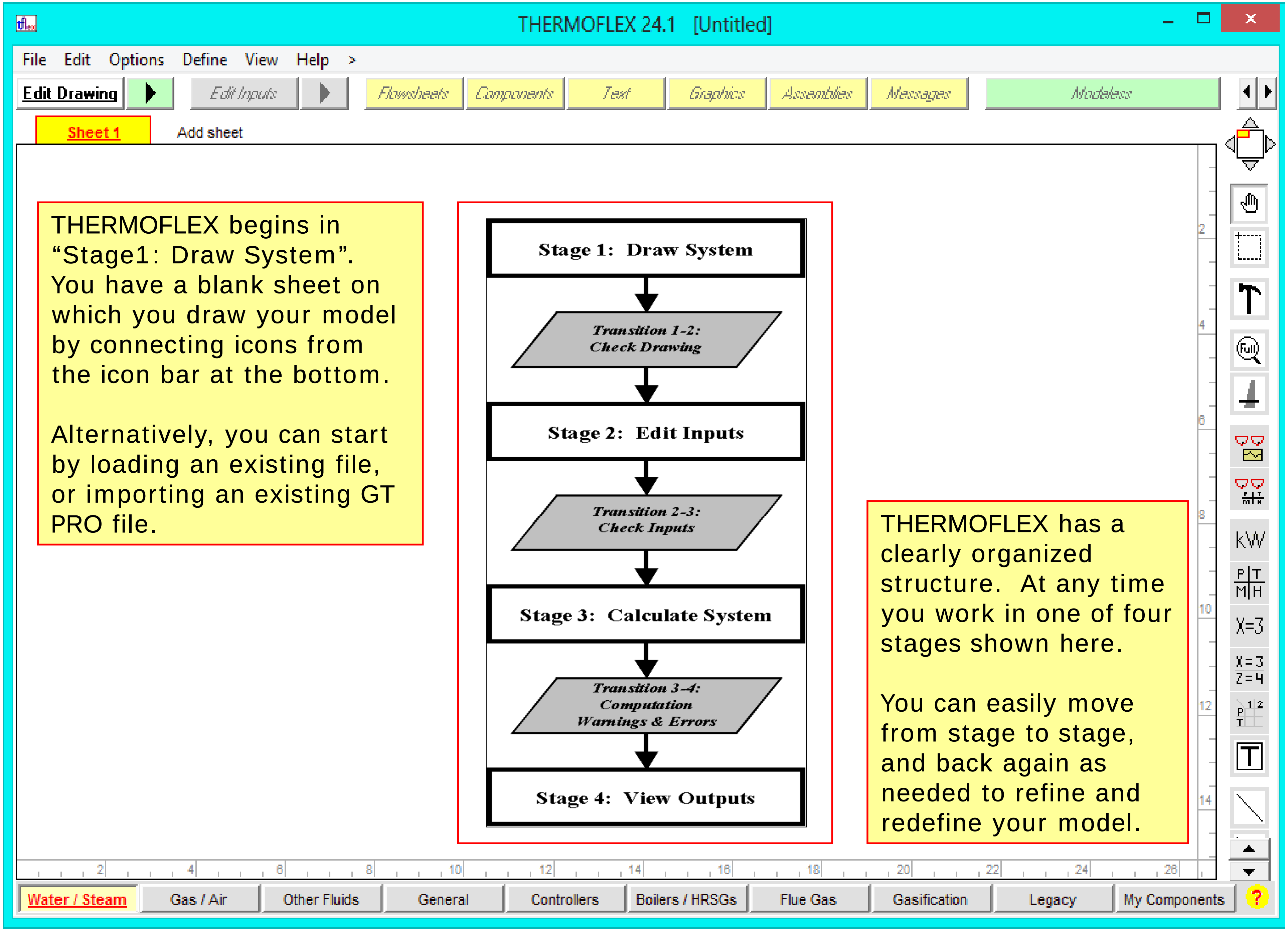
Thermoflow Inc.

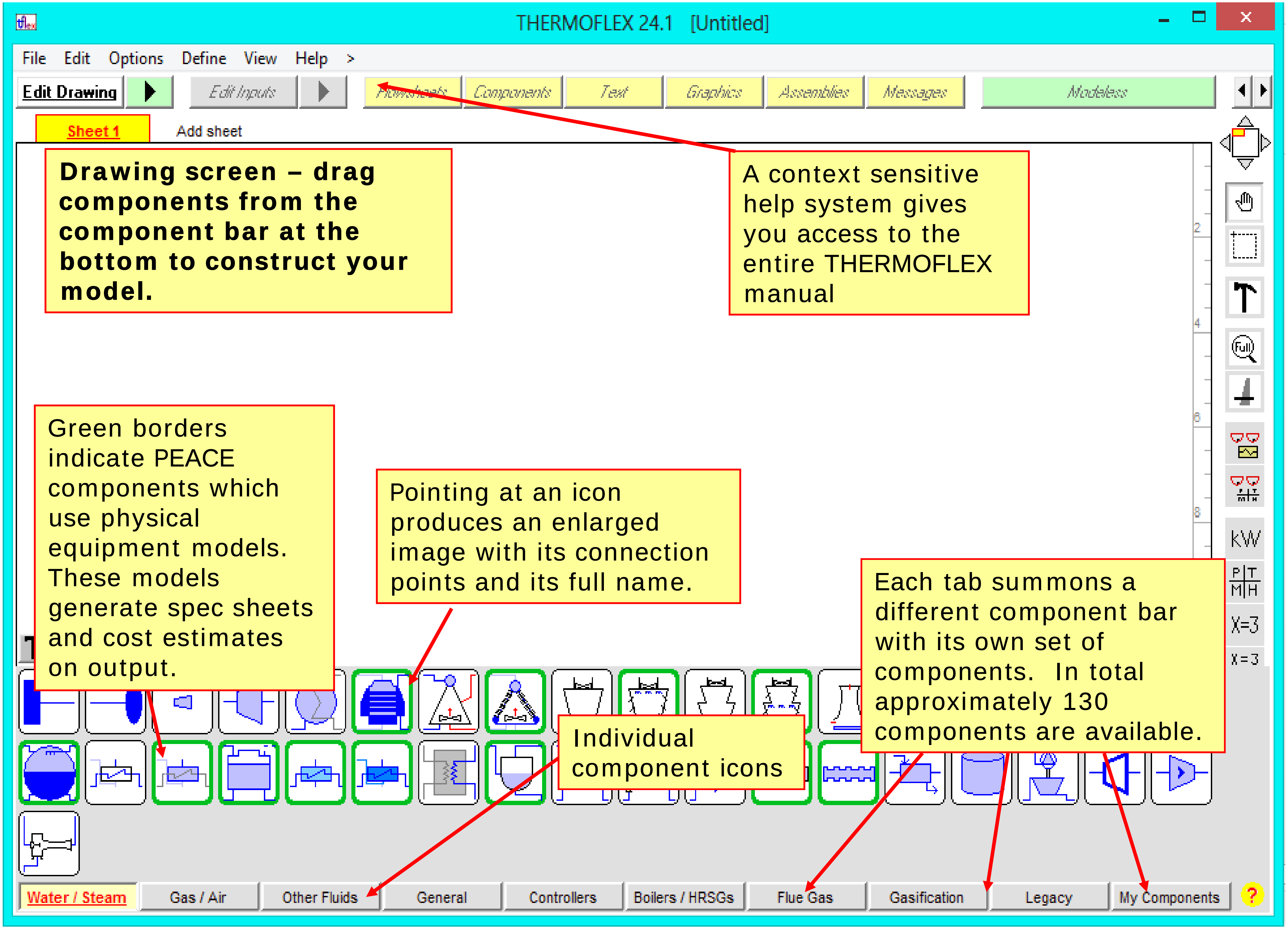


WHAT IS THERMOFLEX?

- THERMOFLEX is a fully-flexible program for heat balance modeling & engineering. Models are built graphically assembling components "lego-style".
- THERMOFLEX is used to model **Combined Cycles**, **Conventional Steam Plants**, **Process Plants, and more.**
- Performs both design and off-design calculations.
- Contains powerful "Logical Components" to model off-design controls
- In combination with PEACE (Plant Engineering and Construction Estimator), it provides engineering details and cost estimation.
- THERMOFLEX works alone, or in concert with GT PRO, GT MASTER, and/or STEAM MASTER.

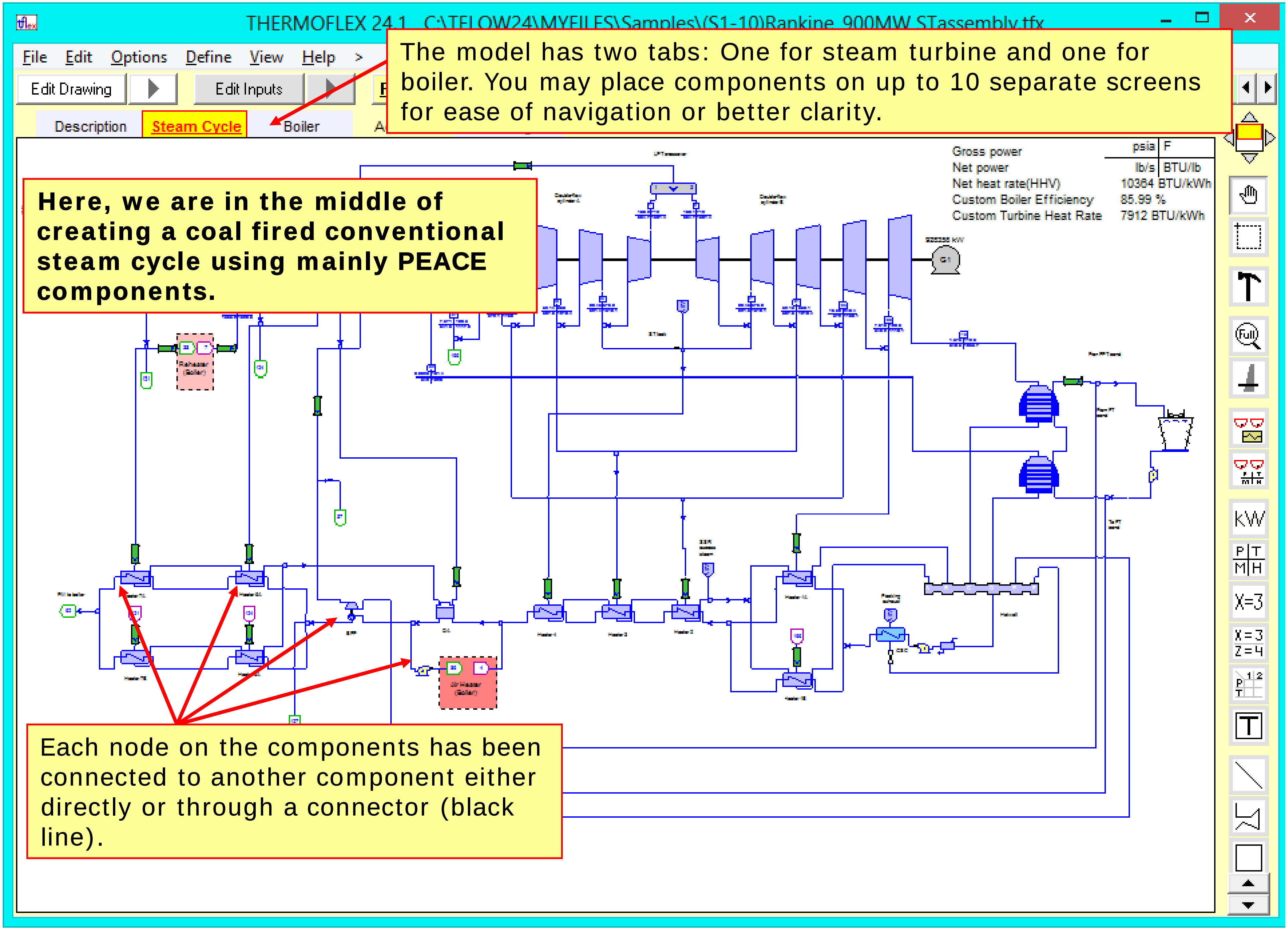

THERMOFLEX 24.1 [Untitled]
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Modeless
Sheet 1
Add sheet
THERMOFLEX begins in "Stage1: Draw System". You have a blank sheet on which you draw your model by connecting icons from the icon bar at the bottom.
Alternatively, you can start by loading an existing file, or importing an existing GT PRO file.
Stage 1: Draw System
Transition 1-2: Check Drawing
Stage 2: Edit Inputs
Transition 2-3: Check Inputs
Stage 3: Calculate System
Transition 3-4: Computation Warnings & Errors
Stage 4: View Outputs
THERMOFLEX has a clearly organized structure. At any time you work in one of four stages shown here.
You can easily move from stage to stage, and back again as needed to refine and redefine your model.
Water / Steam
Gas / Air
Other Fluids
General
Controllers
Boilers / HRSGs
Flue Gas
Gasification
Legacy
My Components

THERMOFLEX

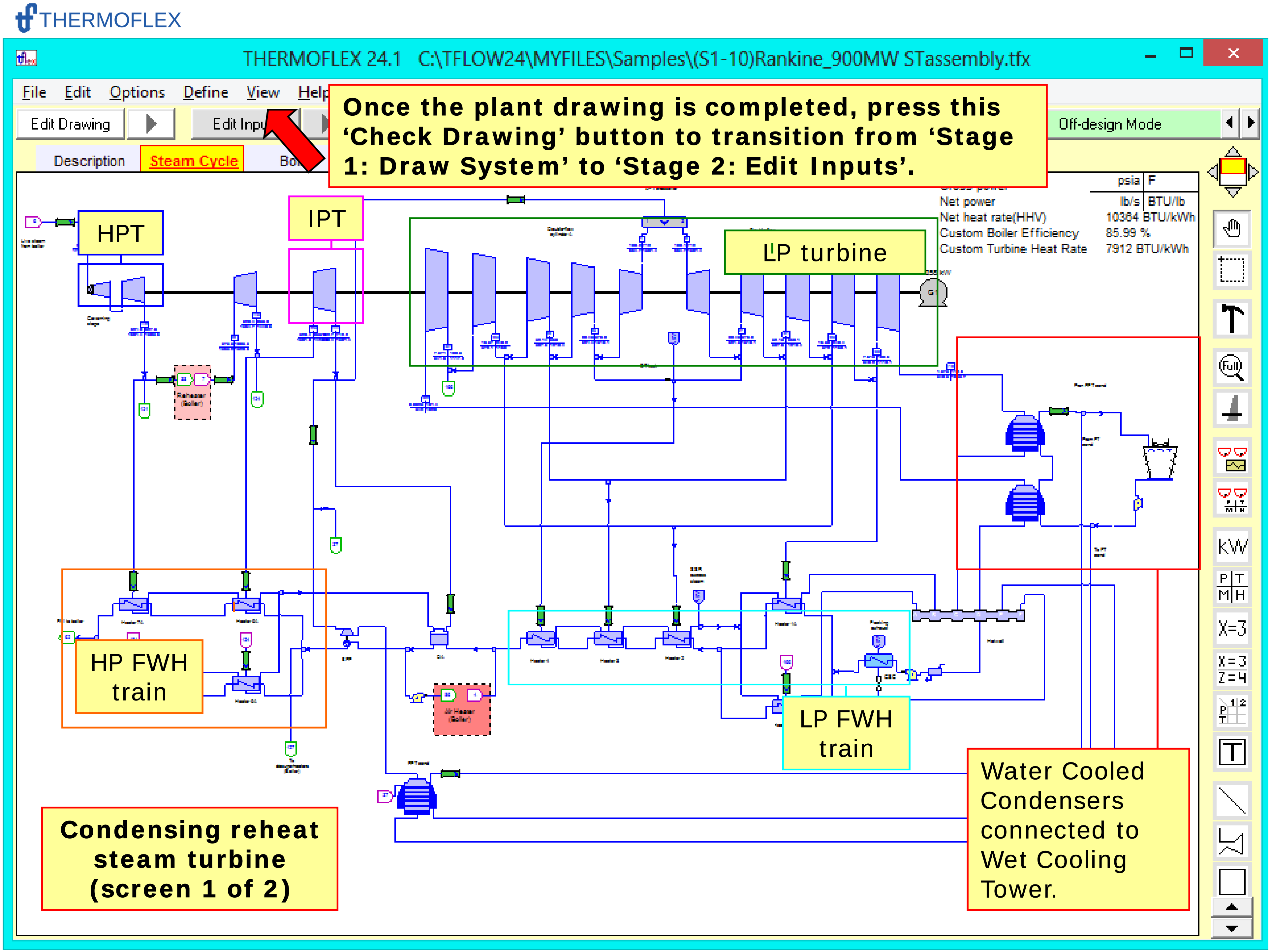


THERMOFLEX 24.1 [Untitled]
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Modeless
Sheet 1
Add sheet
Drawing screen – drag components from the component bar at the bottom to construct your model.
A context sensitive help system gives you access to the entire THERMOFLEX manual
Green borders indicate PEACE components which use physical equipment models. These models generate spec sheets and cost estimates on output.
Pointing at an icon produces an enlarged image with its connection points and its full name.
Each tab summons a different component bar with its own set of components. In total approximately 130 components are available.
Individual component icons
kW
P T
M H
X=3
X=3
Water / Steam
Gas / Air
Other Fluids
General
Controllers
Boilers / HRSGs
Flue Gas
Gasification
Legacy
My Components
?

THERMOFLEX

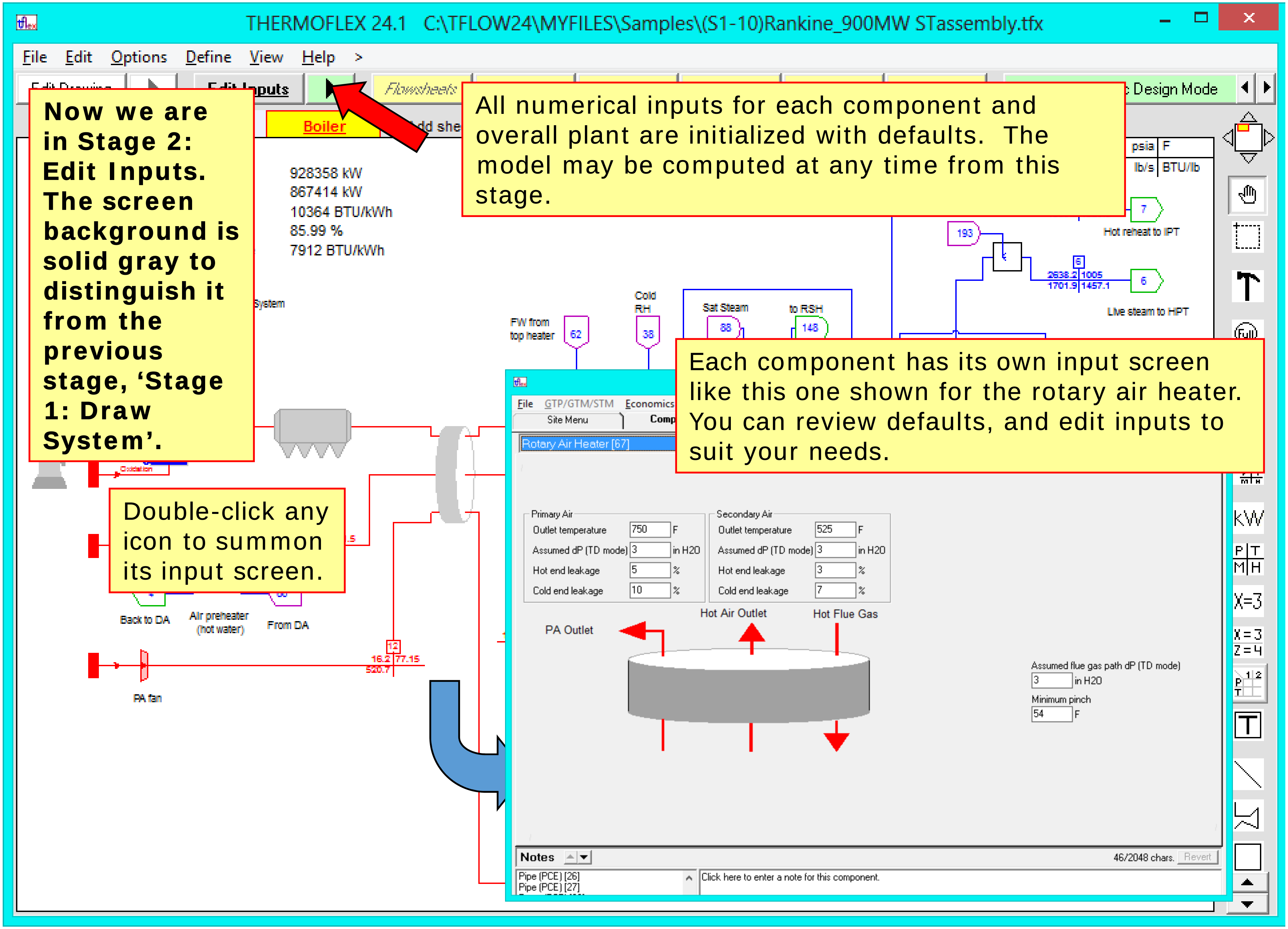


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine 900MW STassembly.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Description
Steam Cycle
Boiler
The model has two tabs: One for steam turbine and one for boiler. You may place components on up to 10 separate screens for ease of navigation or better clarity.
Here, we are in the middle of creating a coal fired conventional steam cycle using mainly PEACE components.
Gross power
Net power
Net heat rate(HHV) 10364 BTU/kWh
Custom Boiler Efficiency 85.99 %
Custom Turbine Heat Rate 7912 BTU/kWh
psia F
lb/s BTU/lb
Each node on the components has been connected to another component either directly or through a connector (black line).
KW
X=3

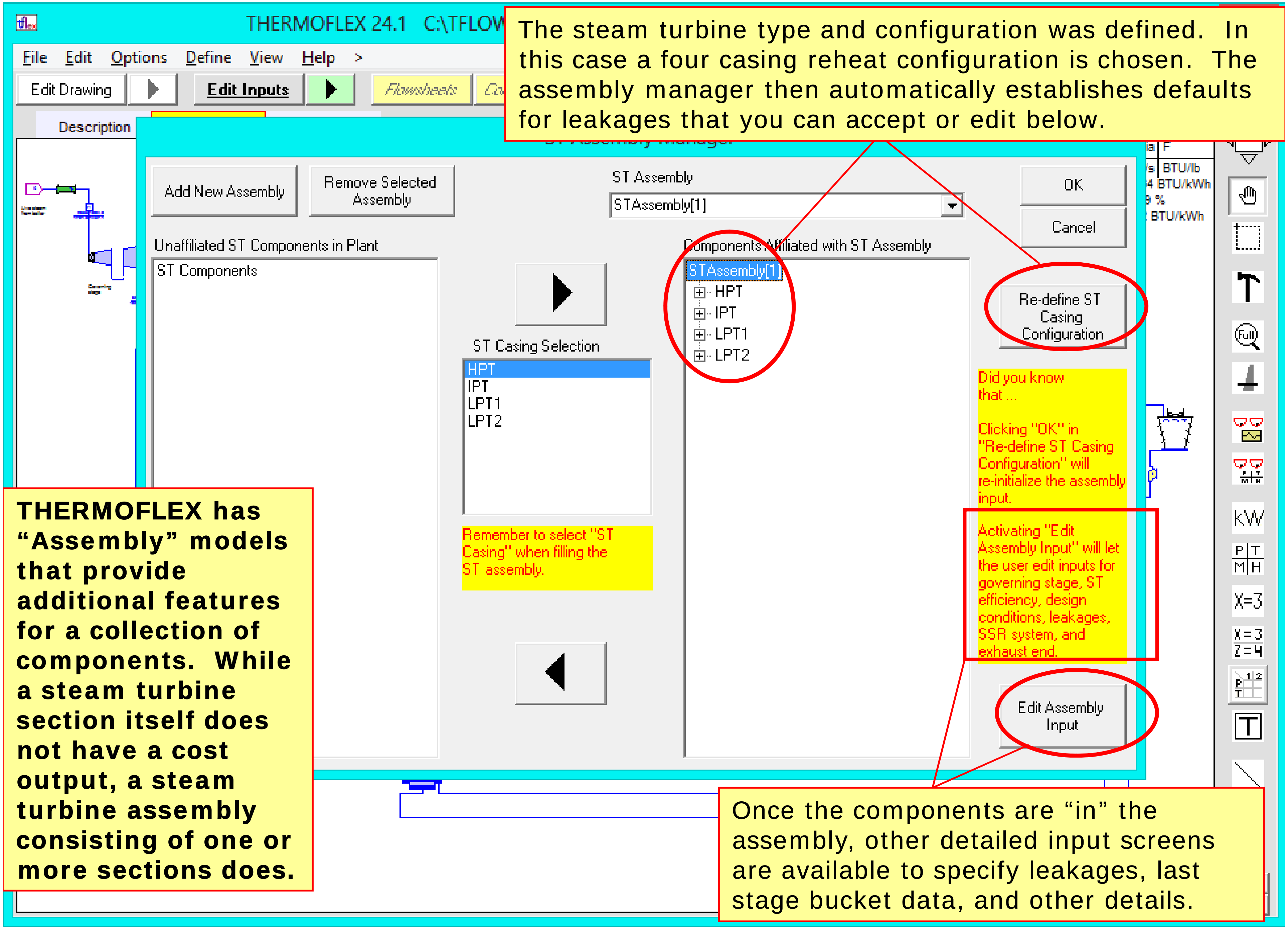


http://www.Thermoflow.ir

THERMOFLEX



http://www.Thermoflow.ir

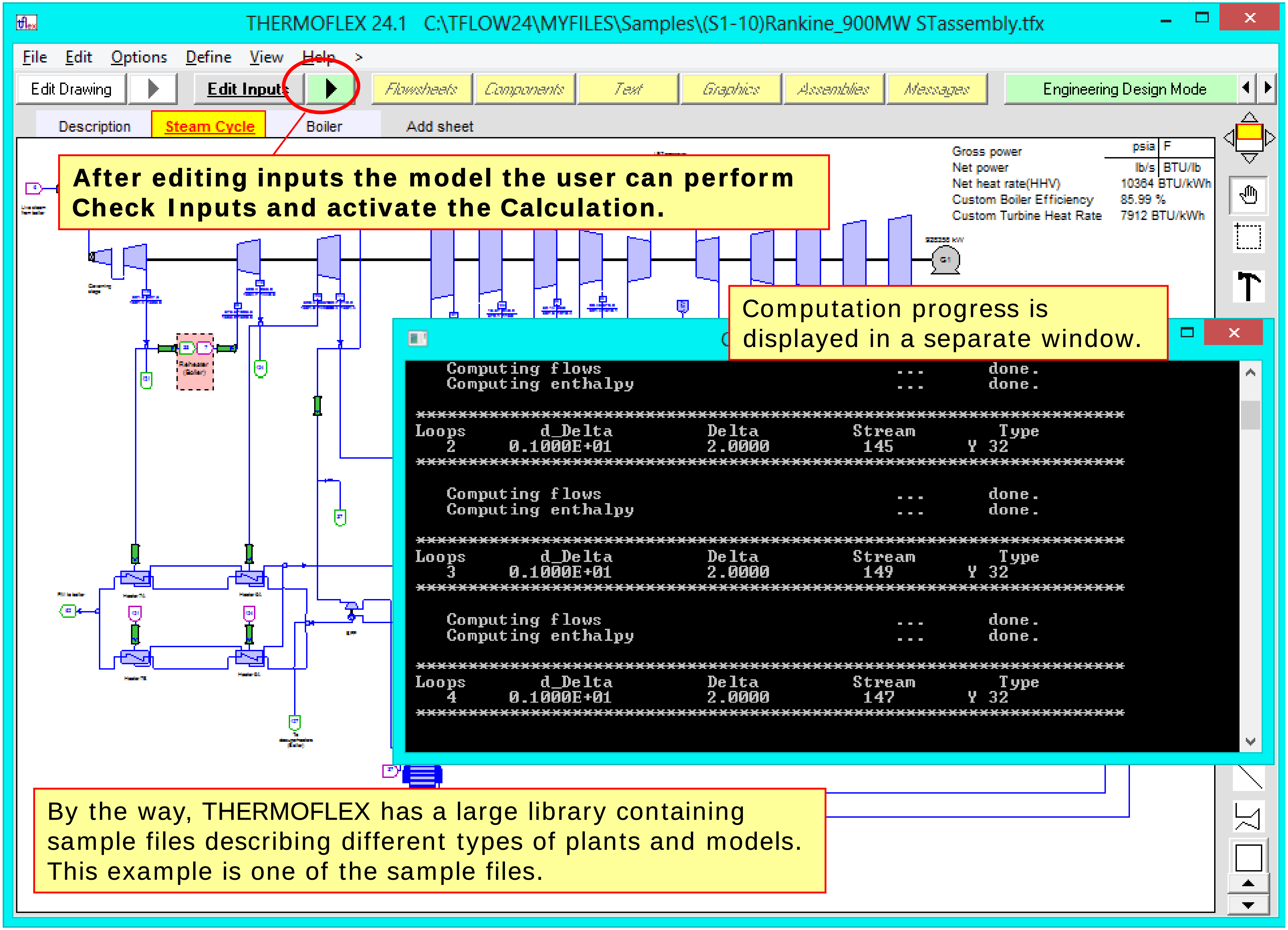


The steam turbine type and configuration was defined. In this case a four casing reheat configuration is chosen. The assembly manager then automatically establishes defaults for leakages that you can accept or edit below.

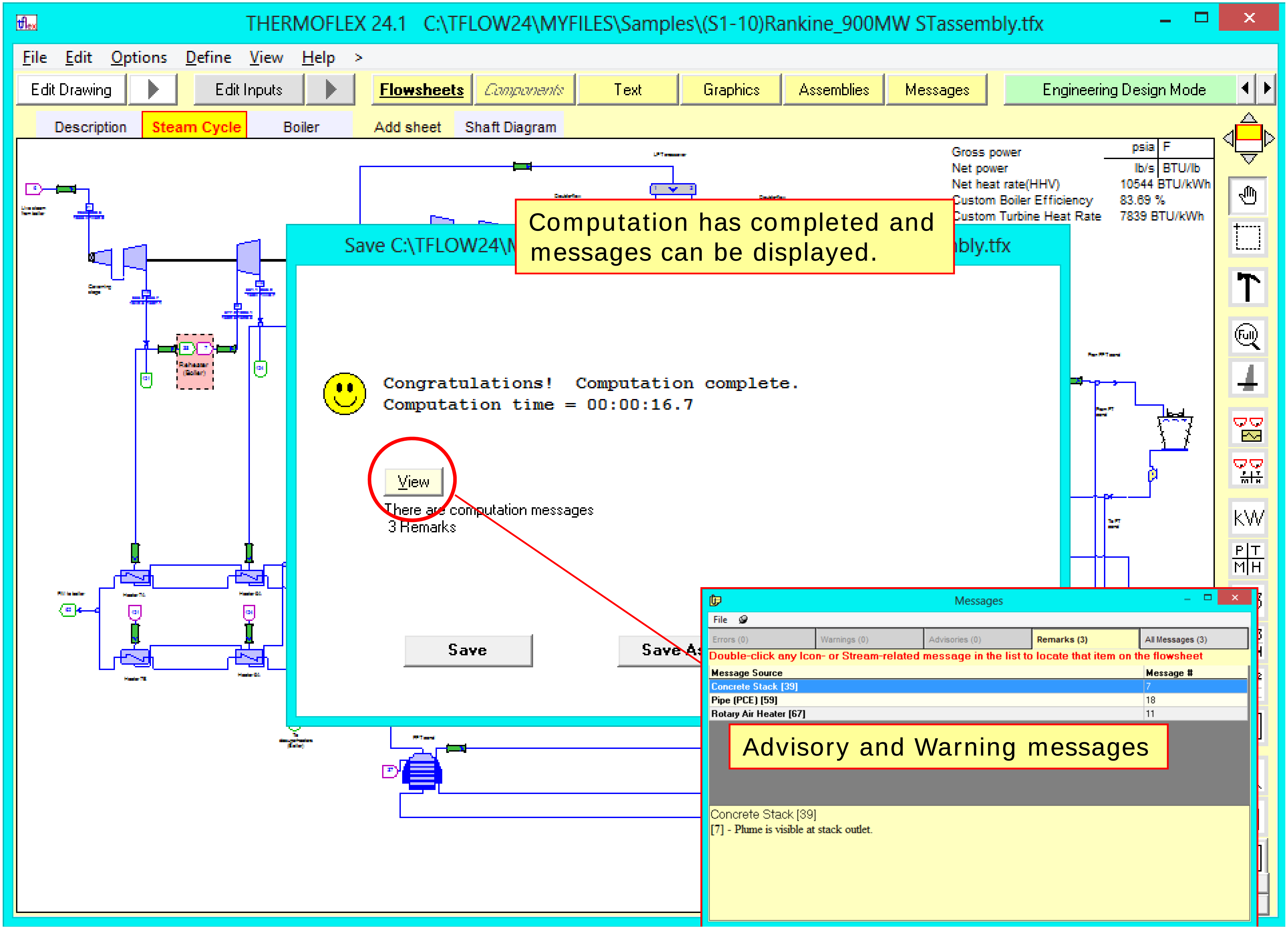
THERMOFLEX has "Assembly" models that provide additional features for a collection of components. While a steam turbine section itself does not have a cost output, a steam turbine assembly consisting of one or more sections does.

Once the components are "in" the assembly, other detailed input screens are available to specify leakages, last stage bucket data, and other details.

THERMOFLEX

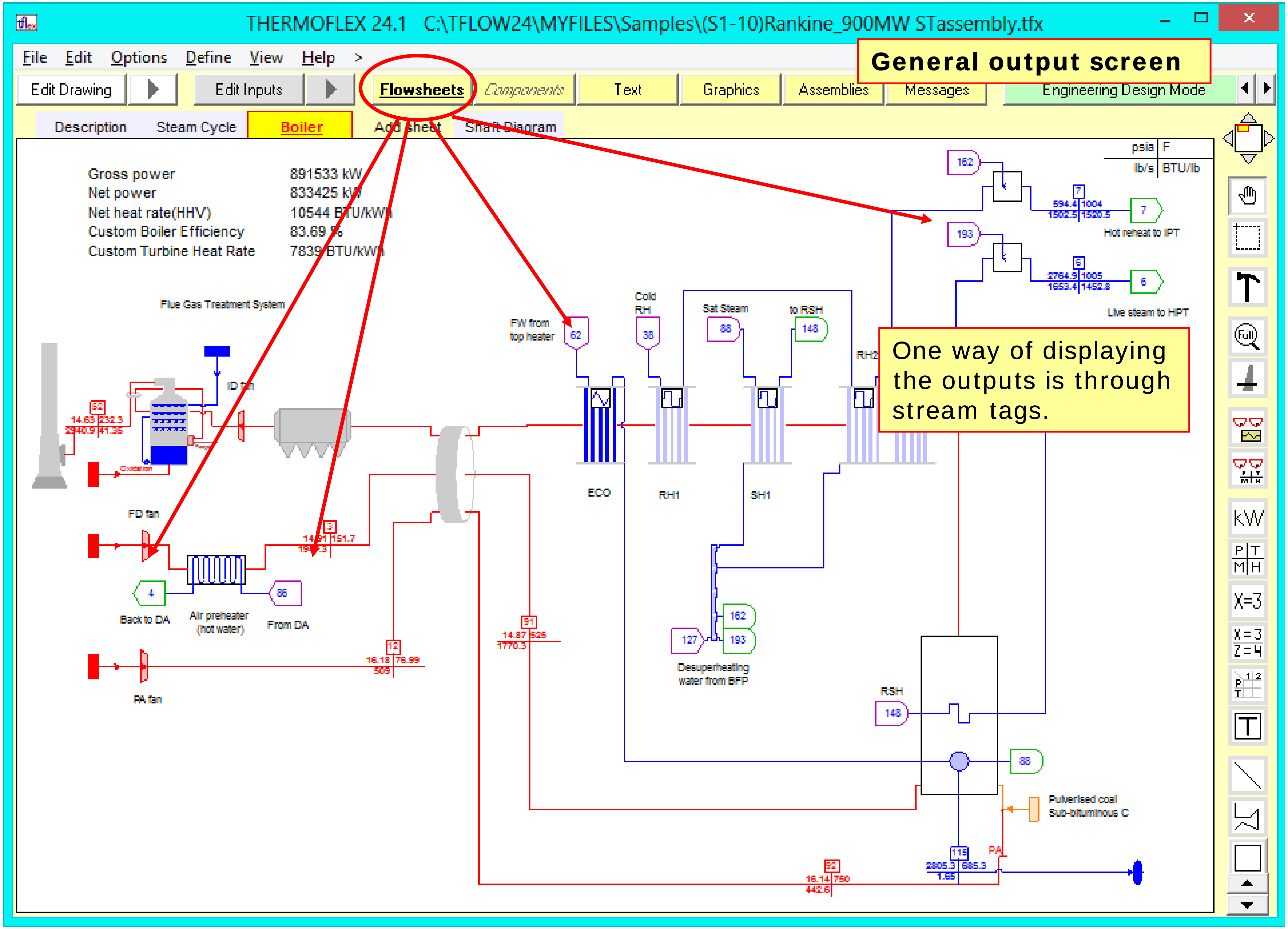

THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine_900MW STassembly.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Engineering Design Mode
Description
Steam Cycle
Boiler
Add sheet
Gross power
Net power
Net heat rate(HHV) 10364 BTU/kWh
Custom Boiler Efficiency 85.99 %
Custom Turbine Heat Rate 7912 BTU/kWh
psia F
lb/s BTU/lb
After editing inputs the model the user can perform Check Inputs and activate the Calculation.
Computation progress is displayed in a separate window.
Computing flows ... done.
Computing enthalpy ... done.
Loops d_Delta Delta Stream Type
2 0.1000E+01 2.0000 145 Y 32
Computing flows ... done.
Computing enthalpy ... done.
Loops d_Delta Delta Stream Type
3 0.1000E+01 2.0000 149 Y 32
Computing flows ... done.
Computing enthalpy ... done.
Loops d_Delta Delta Stream Type
4 0.1000E+01 2.0000 147 Y 32
By the way, THERMOFLEX has a large library containing sample files describing different types of plants and models. This example is one of the sample files.

THERMOFLEX

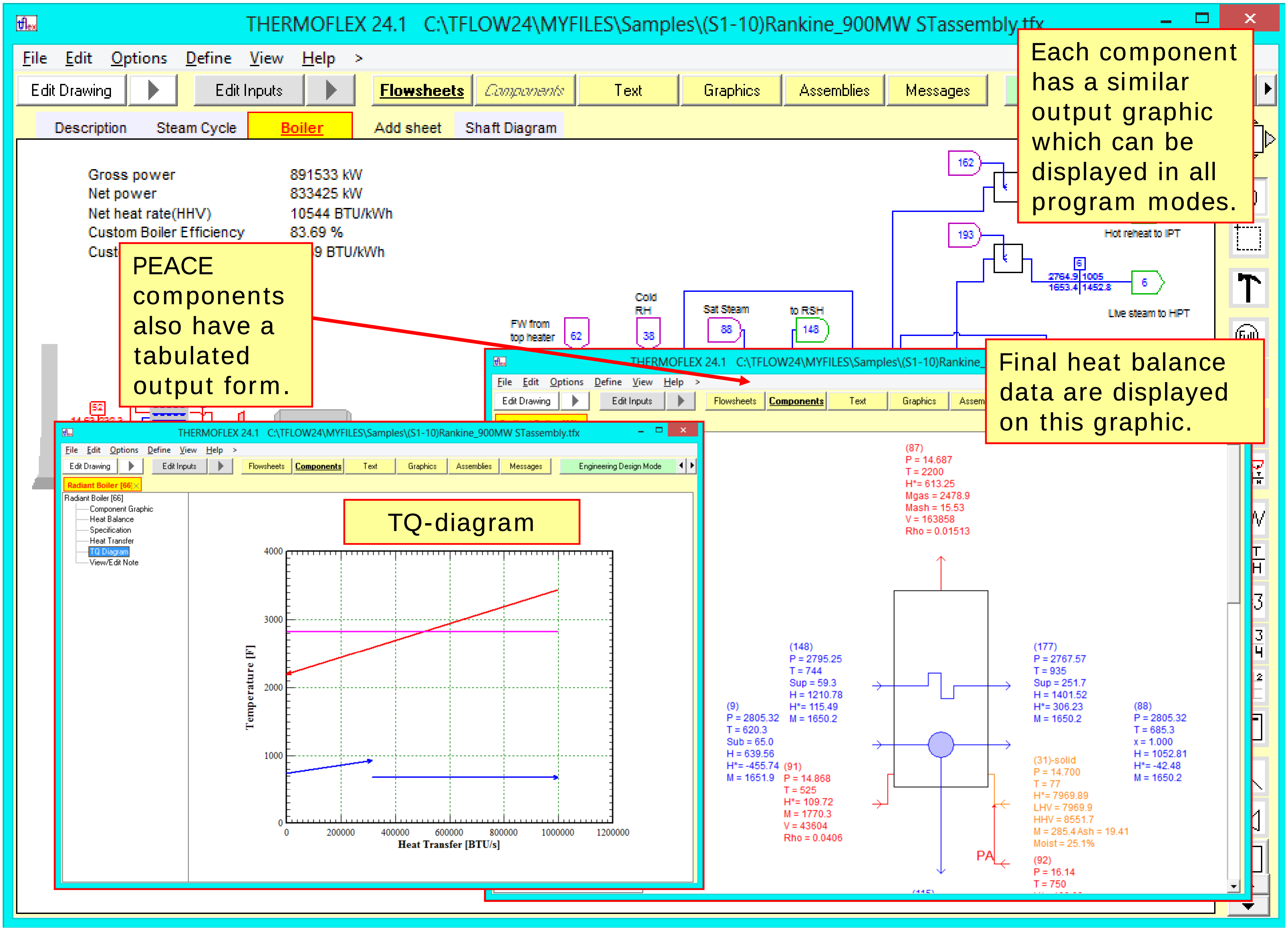


http://www.Thermoflow.ir

THERMOFLEX


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine_900MW STassembly.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Engineering Design Mode
General output screen
Description
Steam Cycle
Boiler
Add sheet
Shaft Diagram
Gross power 891533 kW
Net power 833425 kW
Net heat rate(HHV) 10544 BTU/kWh
Custom Boiler Efficiency 83.69 %
Custom Turbine Heat Rate 7839 BTU/kWh
psia F
lb/s BTU/lb
Hot reheat to IPT
Live steam to HPT
Flue Gas Treatment System
ID fan
FD fan
PA fan
Back to DA
Air preheater (hot water)
From DA
FW from top heater
Cold RH
Sat Steam
to RSH
ECO
RH1
SH1
RH2
Desuperheating water from BFP
RSH
Pulverised coal Sub-bituminous C
One way of displaying the outputs is through stream tags.

THERMOFLEX


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine_900MW STassembly.tfx
Each component has a similar output graphic which can be displayed in all program modes.
Gross power 891533 kW
Net power 833425 kW
Net heat rate(HHV) 10544 BTU/kWh
Custom Boiler Efficiency 83.69 %
PEACE components also have a tabulated output form.
Final heat balance data are displayed on this graphic.
TQ-diagram
Temperature [F]
Heat Transfer [BTU/s]

THERMOFLEX

THERMOFLEX 24.1 C:\TFLOW24\

File Edit Options Define View Help >

Edit Drawing | Edit Inputs | Flowsheets | **Components** | Text | Graphics | Assemblies | Messages | Engineering Design Mode

One of four tabs with tables describing details of the evaporator and one drawing showing the tube bundle.

Superheater (PCE)

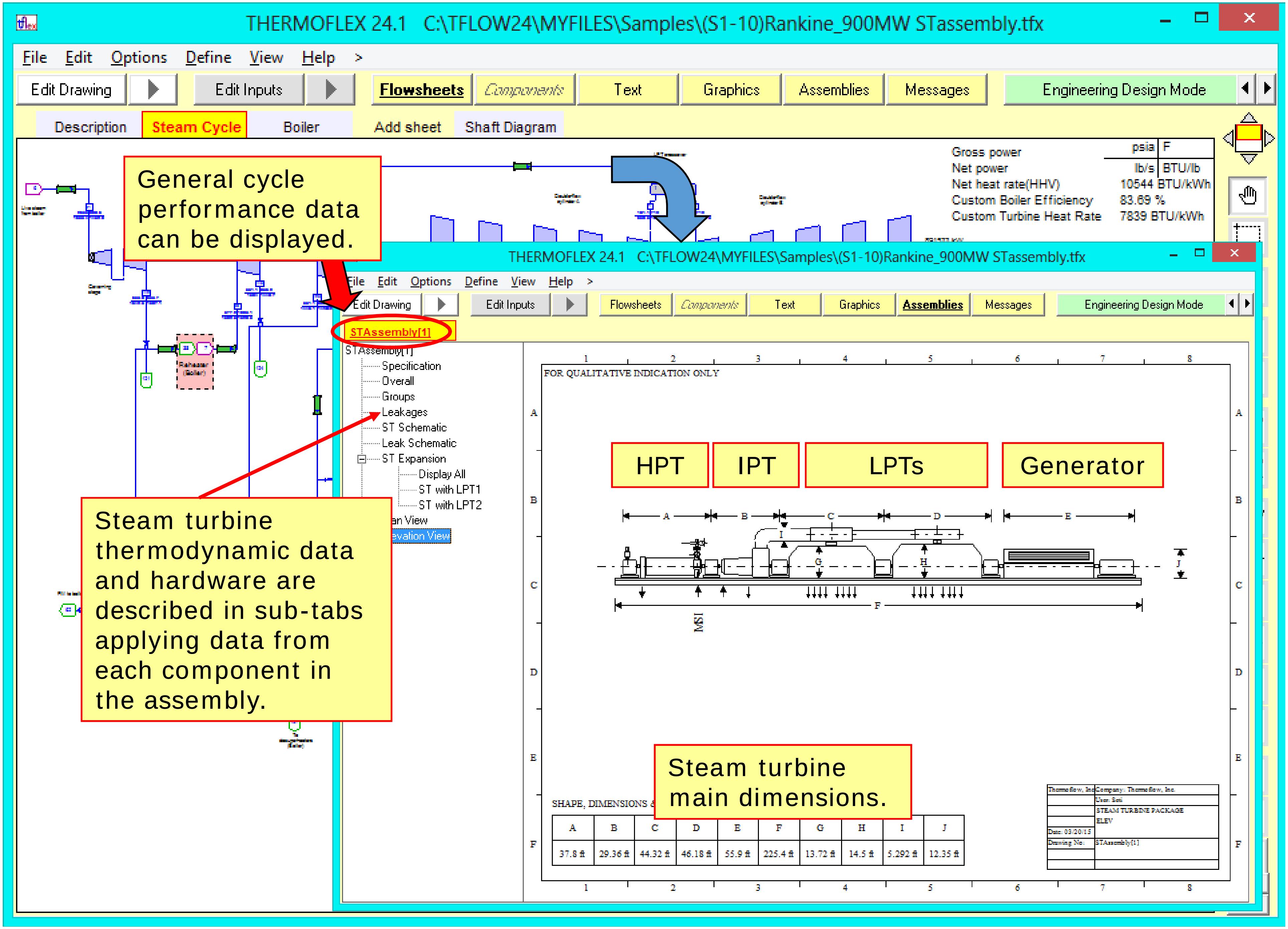
- Superheater (PCE) [99]
  - Component Graphic
  - Heat Balance
  - Specification
  - Hardware
  - Heat Transfer
  - Hardware Graphics
  - Tube Bundle Overview
  - TQ Diagram
  - View/Edit Note

Second HP superheater hardware designed by the program in Design mode.

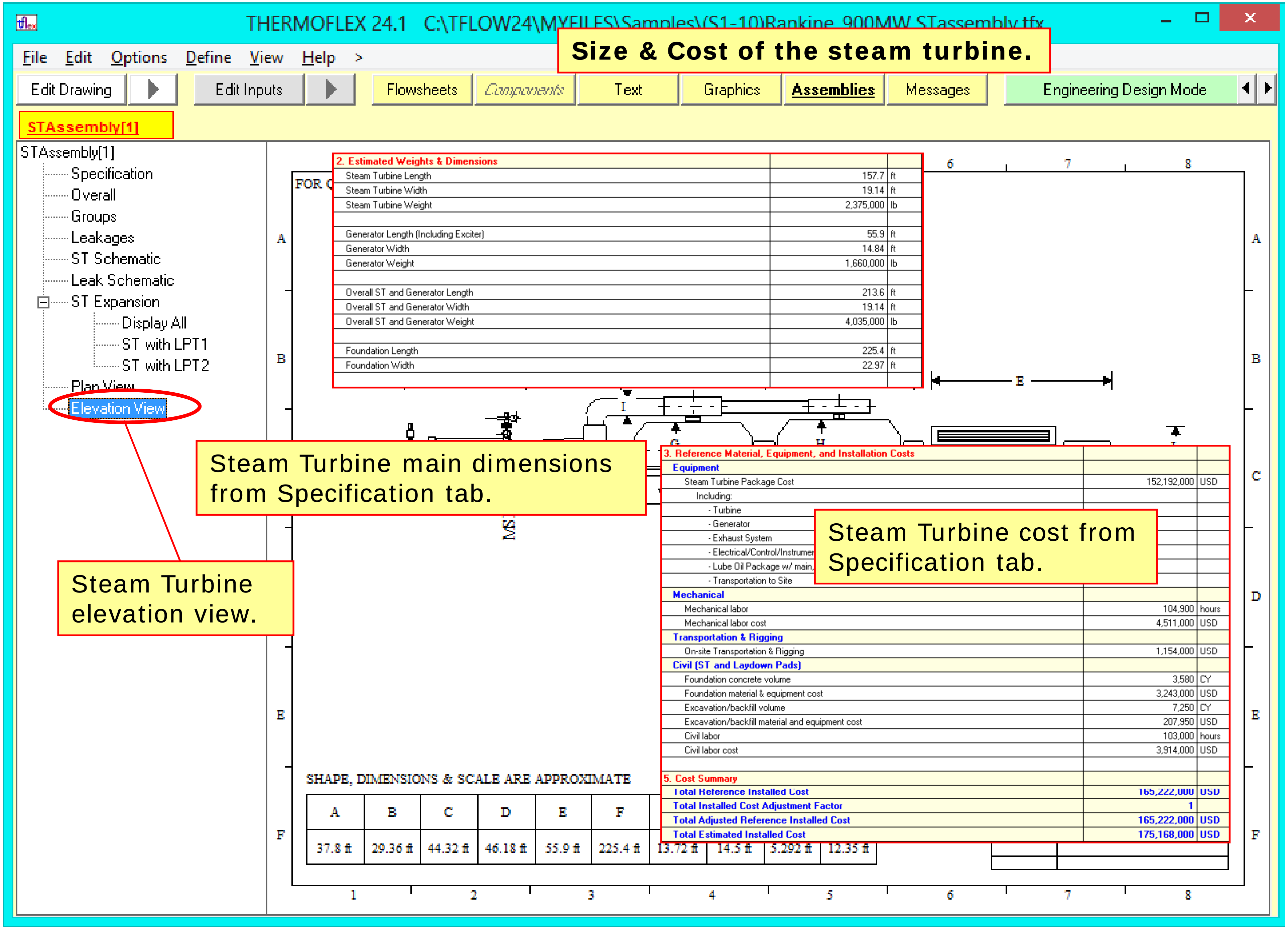
Estimated Heat Exchanger Hardware Data		
Superheater (PCE) [99]		
Tubes		
Fin-tube type	Bare	
Tube arrangement	In line	
Tube material	T91	
Number of tube rows (longitudinal)	20	
Number of tubes per row (transverse)	34	
Number of rows per waterside flow pass	20	
	3	in
	72.07	ft
	45.53	ft
	2.5	in
	0.3304	in
	25.44	in
Tube metal conductivity @ 500F (260C)	15.6	BTU/hr-ft-F
Tube metal conductivity slope	0.0017	BTU/hr-ft-F^2
Overall Data		
Gas path frontal area	3281	ft^2
Min. gas free flow cross section / frontal area	0.9017	
H.T. surface area / min. free flow cross section	0.3424	
Primary tube surface / total heat transfer surf.	1	
Water si	12.55	ft^2
Heat exc	20265	ft^2
Heat exc	20265	ft^2

These tabulated outputs are available for PEACE components only.

THERMOFLEX


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine_900MW STassembly.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Engineering Design Mode
Description
Steam Cycle
Boiler
Add sheet
Shaft Diagram
General cycle performance data can be displayed.
Gross power
Net power
Net heat rate(HHV) 10544 BTU/kWh
Custom Boiler Efficiency 83.69 %
Custom Turbine Heat Rate 7839 BTU/kWh
psia F
lb/s BTU/lb
STAssembly[1]
STAssembly[1]
Specification
Overall
Groups
Leakages
ST Schematic
Leak Schematic
ST Expansion
Display All
ST with LPT1
ST with LPT2
an View
evation View
Steam turbine thermodynamic data and hardware are described in sub-tabs applying data from each component in the assembly.
FOR QUALITATIVE INDICATION ONLY
HPT
IPT
LPTs
Generator
Steam turbine main dimensions.
SHAPE, DIMENSIONS &
A B C D E F G H I J
37.8 ft 29.36 ft 44.32 ft 46.18 ft 55.9 ft 225.4 ft 13.72 ft 14.5 ft 5.292 ft 12.35 ft
STEAM TURBINE PACKAGE
ELEV

THERMOFLEX

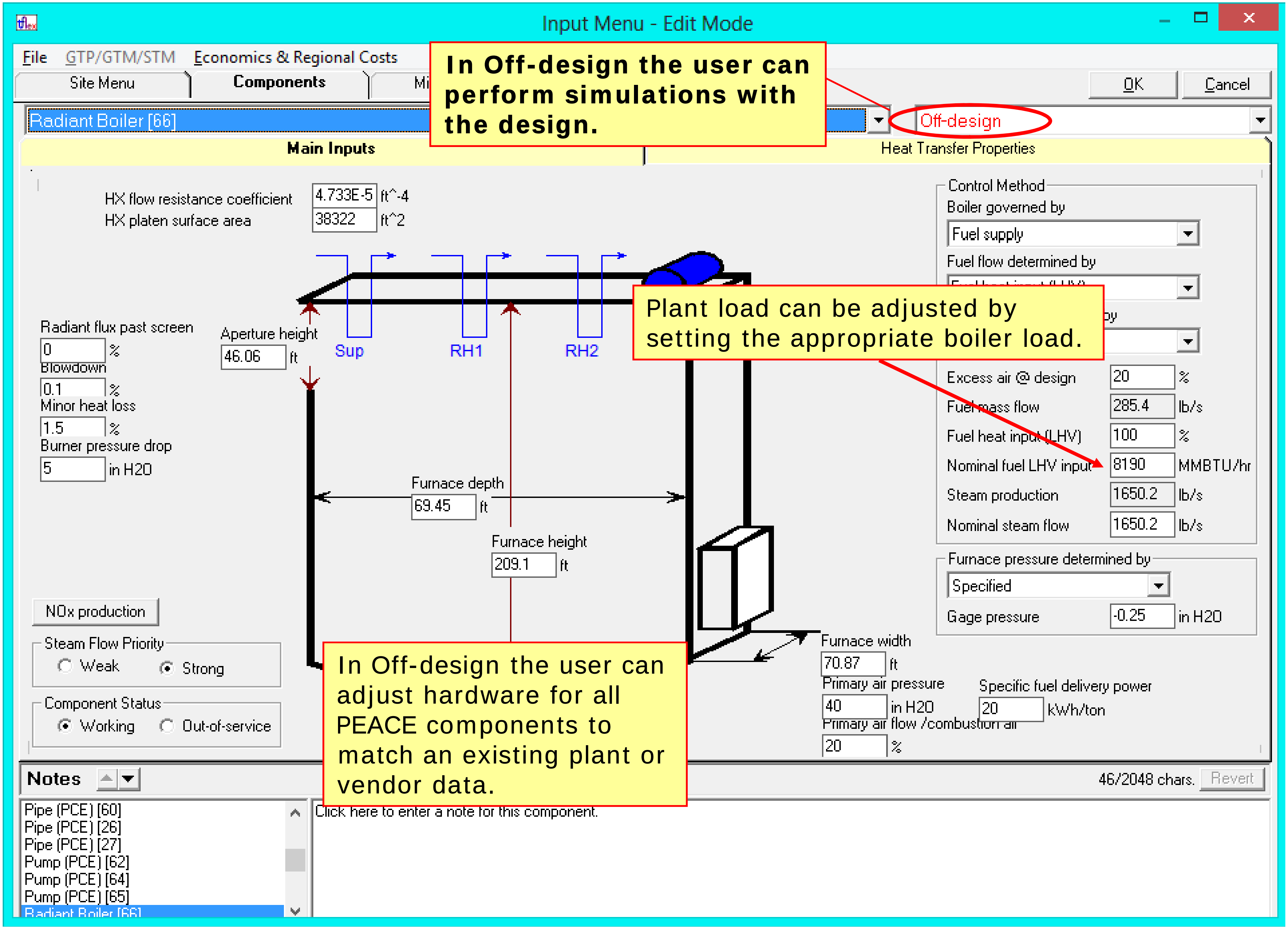


2. Estimated Weights & Dimensions		
Steam Turbine Length	157.7	ft
Steam Turbine Width	19.14	ft
Steam Turbine Weight	2,375,000	lb
Generator Length (Including Exciter)	55.9	ft
Generator Width	14.84	ft
Generator Weight	1,660,000	lb
Overall ST and Generator Length	213.6	ft
Overall ST and Generator Width	19.14	ft
Overall ST and Generator Weight	4,035,000	lb
Foundation Length	225.4	ft
Foundation Width	22.97	ft

3. Reference Material, Equipment, and Installation Costs		
Equipment		
Steam Turbine Package Cost	152,192,000	USD
Including:		
- Turbine		
- Generator		
- Exhaust System		
- Electrical/Control/Instrumen		
- Lube Oil Package w/ main,		
- Transportation to Site		
Mechanical		
Mechanical labor	104,900	hours
Mechanical labor cost	4,511,000	USD
Transportation & Rigging		
On-site Transportation & Rigging	1,154,000	USD
Civil (ST and Laydown Pads)		
Foundation concrete volume	3,580	CY
Foundation material & equipment cost	3,243,000	USD
Excavation/backfill volume	7,250	CY
Excavation/backfill material and equipment cost	207,950	USD
Civil labor	103,000	hours
Civil labor cost	3,914,000	USD
5. Cost Summary		
Total Reference Installed Cost	**165,222,000**	**USD**
Total Installed Cost Adjustment Factor	**1**	
Total Adjusted Reference Installed Cost	**165,222,000**	**USD**
Total Estimated Installed Cost	**175,168,000**	**USD**

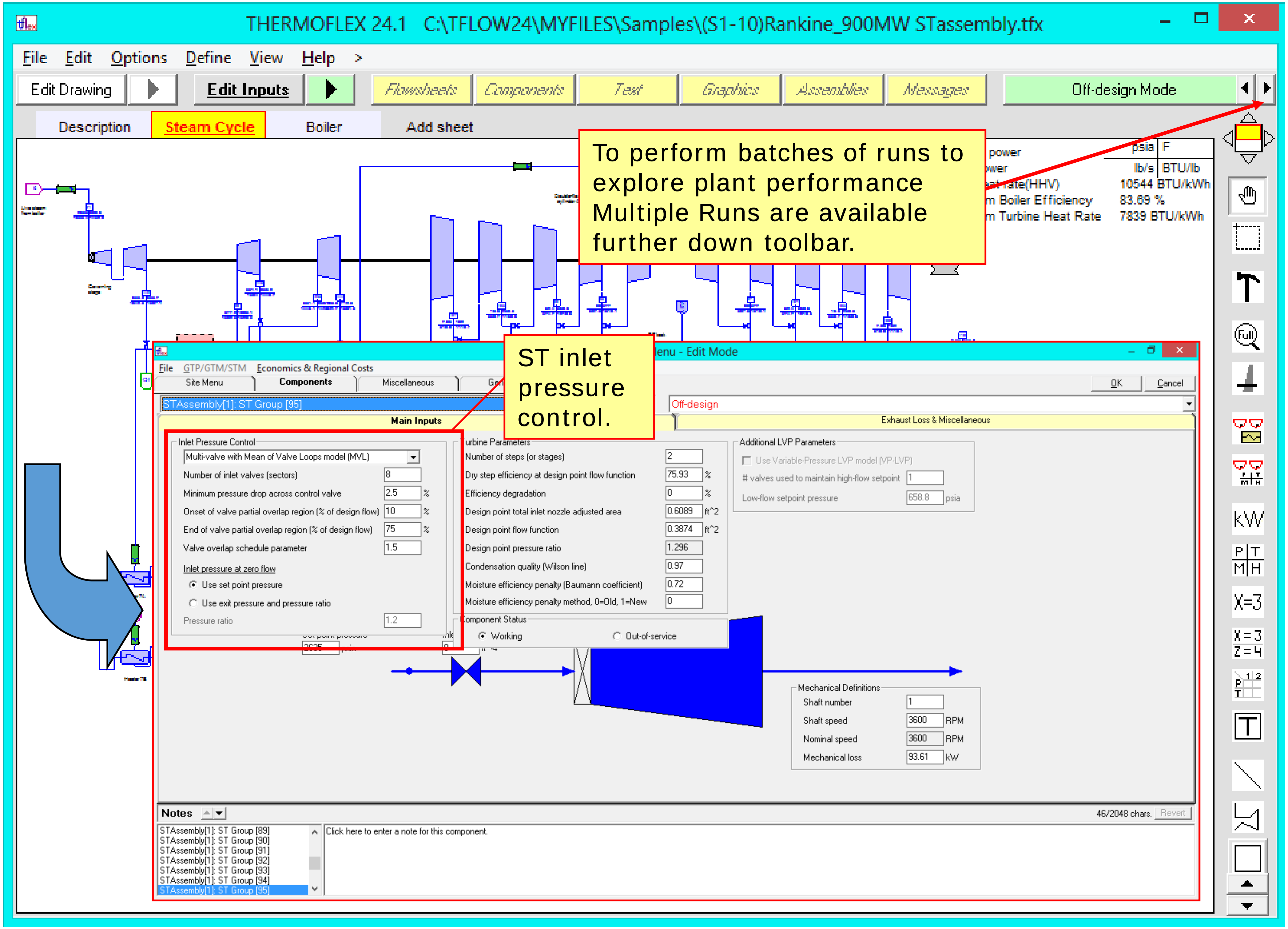
A	B	C	D	E	F				
37.8 ft	29.36 ft	44.32 ft	46.18 ft	55.9 ft	225.4 ft	13.72 ft	14.5 ft	5.292 ft	12.35 ft

THERMOFLEX



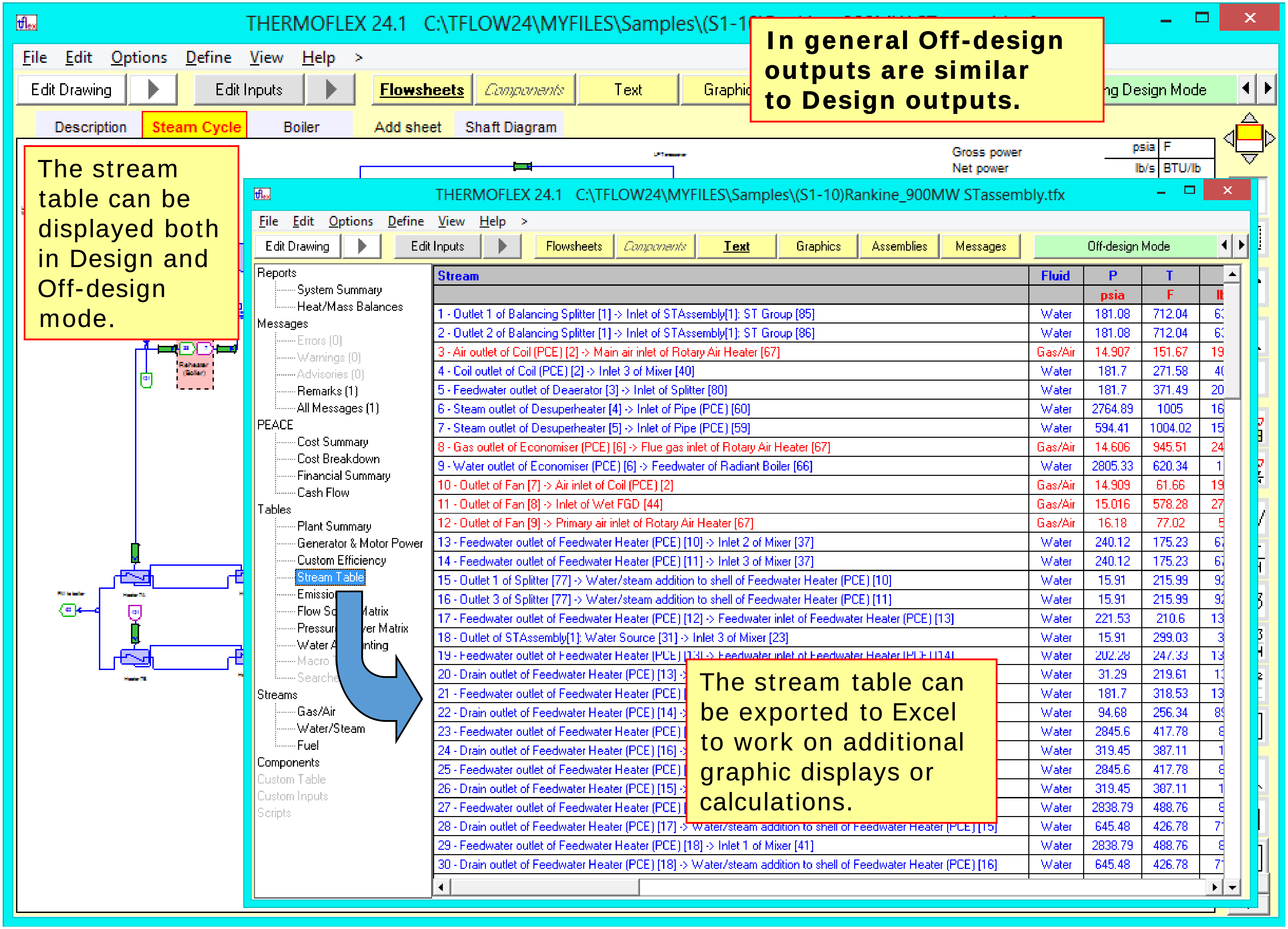
Input Menu - Edit Mode
File
GTP/GTM/STM
Economics & Regional Costs
Site Menu
Components
OK
Cancel
Radiant Boiler [66]
Off-design
Main Inputs
Heat Transfer Properties
In Off-design the user can perform simulations with the design.
Plant load can be adjusted by setting the appropriate boiler load.
In Off-design the user can adjust hardware for all PEACE components to match an existing plant or vendor data.
HX flow resistance coefficient 4.733E-5 ft^-4
HX platen surface area 38322 ft^2
Radiant flux past screen 0 %
Blowdown 0.1 %
Minor heat loss 1.5 %
Burner pressure drop 5 in H2O
Aperture height 46.06 ft
Sup
RH1
RH2
Furnace depth 69.45 ft
Furnace height 209.1 ft
Furnace width 70.87 ft
Primary air pressure 40 in H2O
Primary air flow /combustion air 20 %
Specific fuel delivery power 20 kWh/ton
NOx production
Steam Flow Priority
Weak
Strong
Component Status
Working
Out-of-service
Control Method
Boiler governed by
Fuel supply
Fuel flow determined by
Excess air @ design 20 %
Fuel mass flow 285.4 lb/s
Fuel heat input (LHV) 100 %
Nominal fuel LHV input 8190 MMBTU/hr
Steam production 1650.2 lb/s
Nominal steam flow 1650.2 lb/s
Furnace pressure determined by
Specified
Gage pressure -0.25 in H2O
Notes
46/2048 chars.
Revert
Pipe (PCE) [60]
Pipe (PCE) [26]
Pipe (PCE) [27]
Pump (PCE) [62]
Pump (PCE) [64]
Pump (PCE) [65]
Radiant Boiler [66]
Click here to enter a note for this component.

THERMOFLEX



THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine_900MW STassembly.tfx
File Edit Options Define View Help
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Off-design Mode
Description
Steam Cycle
Boiler
Add sheet
To perform batches of runs to explore plant performance Multiple Runs are available further down toolbar.
ST inlet pressure control.
STAssembly[1]: ST Group [95]
Off-design
Main Inputs
Exhaust Loss & Miscellaneous
Inlet Pressure Control
Multi-valve with Mean of Valve Loops model (MVL)
Number of inlet valves (sectors) 8
Minimum pressure drop across control valve 2.5 %
Onset of valve partial overlap region (% of design flow) 10 %
End of valve partial overlap region (% of design flow) 75 %
Valve overlap schedule parameter 1.5
Inlet pressure at zero flow
Use set point pressure
Use exit pressure and pressure ratio
Pressure ratio 1.2
Number of steps (or stages) 2
Dry step efficiency at design point flow function 75.93 %
Efficiency degradation 0 %
Design point total inlet nozzle adjusted area 0.6089 ft^2
Design point flow function 0.3874 ft^2
Design point pressure ratio 1.296
Condensation quality (Wilson line) 0.97
Moisture efficiency penalty (Baumann coefficient) 0.72
Moisture efficiency penalty method, 0=Old, 1=New 0
Additional LVP Parameters
Use Variable-Pressure LVP model (VP-LVP)
valves used to maintain high-flow setpoint 1
Low-flow setpoint pressure 658.8 psia
Component Status
Working
Out-of-service
Mechanical Definitions
Shaft number 1
Shaft speed 3600 RPM
Nominal speed 3600 RPM
Mechanical loss 93.61 kW
Notes
Click here to enter a note for this component.
10544 BTU/kWh
83.69 %
7839 BTU/kWh

THERMOFLEX



Stream	Fluid	P psia	T F
1 - Outlet 1 of Balancing Splitter [1] -> Inlet of STAssembly[1]: ST Group [85]	Water	181.08	712.04
2 - Outlet 2 of Balancing Splitter [1] -> Inlet of STAssembly[1]: ST Group [86]	Water	181.08	712.04
3 - Air outlet of Coil [PCE] [2] -> Main air inlet of Rotary Air Heater [67]	Gas/Air	14.907	151.67
4 - Coil outlet of Coil [PCE] [2] -> Inlet 3 of Mixer [40]	Water	181.7	271.58
5 - Feedwater outlet of Deaerator [3] -> Inlet of Splitter [80]	Water	181.7	371.49
6 - Steam outlet of Desuperheater [4] -> Inlet of Pipe [PCE] [60]	Water	2764.89	1005
7 - Steam outlet of Desuperheater [5] -> Inlet of Pipe [PCE] [59]	Water	594.41	1004.02
8 - Gas outlet of Economiser [PCE] [6] -> Flue gas inlet of Rotary Air Heater [67]	Gas/Air	14.606	945.51
9 - Water outlet of Economiser [PCE] [6] -> Feedwater of Radiant Boiler [66]	Water	2805.33	620.34
10 - Outlet of Fan [7] -> Air inlet of Coil [PCE] [2]	Gas/Air	14.909	61.66
11 - Outlet of Fan [8] -> Inlet of Wet FGD [44]	Gas/Air	15.016	578.28
12 - Outlet of Fan [9] -> Primary air inlet of Rotary Air Heater [67]	Gas/Air	16.18	77.02
13 - Feedwater outlet of Feedwater Heater [PCE] [10] -> Inlet 2 of Mixer [37]	Water	240.12	175.23
14 - Feedwater outlet of Feedwater Heater [PCE] [11] -> Inlet 3 of Mixer [37]	Water	240.12	175.23
15 - Outlet 1 of Splitter [77] -> Water/steam addition to shell of Feedwater Heater [PCE] [10]	Water	15.91	215.99
16 - Outlet 3 of Splitter [77] -> Water/steam addition to shell of Feedwater Heater [PCE] [11]	Water	15.91	215.99
17 - Feedwater outlet of Feedwater Heater [PCE] [12] -> Feedwater inlet of Feedwater Heater [PCE] [13]	Water	221.53	210.6
18 - Outlet of STAssembly[1]: Water Source [31] -> Inlet 3 of Mixer [23]	Water	15.91	299.03
19 - Feedwater outlet of Feedwater Heater [PCE] [13] -> Feedwater inlet of Feedwater Heater [PCE] [14]	Water	202.28	247.33
20 - Drain outlet of Feedwater Heater [PCE] [13] ->	Water	31.29	219.61
21 - Feedwater outlet of Feedwater Heater [PCE]	Water	181.7	318.53
22 - Drain outlet of Feedwater Heater [PCE] [14] ->	Water	94.68	256.34
23 - Feedwater outlet of Feedwater Heater [PCE]	Water	2845.6	417.78
24 - Drain outlet of Feedwater Heater [PCE] [16] ->	Water	319.45	387.11
25 - Feedwater outlet of Feedwater Heater [PCE]	Water	2845.6	417.78
26 - Drain outlet of Feedwater Heater [PCE] [15] ->	Water	319.45	387.11
27 - Feedwater outlet of Feedwater Heater [PCE]	Water	2838.79	488.76
28 - Drain outlet of Feedwater Heater [PCE] [17] -> Water/steam addition to shell of Feedwater Heater [PCE] [15]	Water	645.48	426.78
29 - Feedwater outlet of Feedwater Heater [PCE] [18] -> Inlet 1 of Mixer [41]	Water	2838.79	488.76
30 - Drain outlet of Feedwater Heater [PCE] [18] -> Water/steam addition to shell of Feedwater Heater [PCE] [16]	Water	645.48	426.78

In general Off-design outputs are similar to Design outputs.

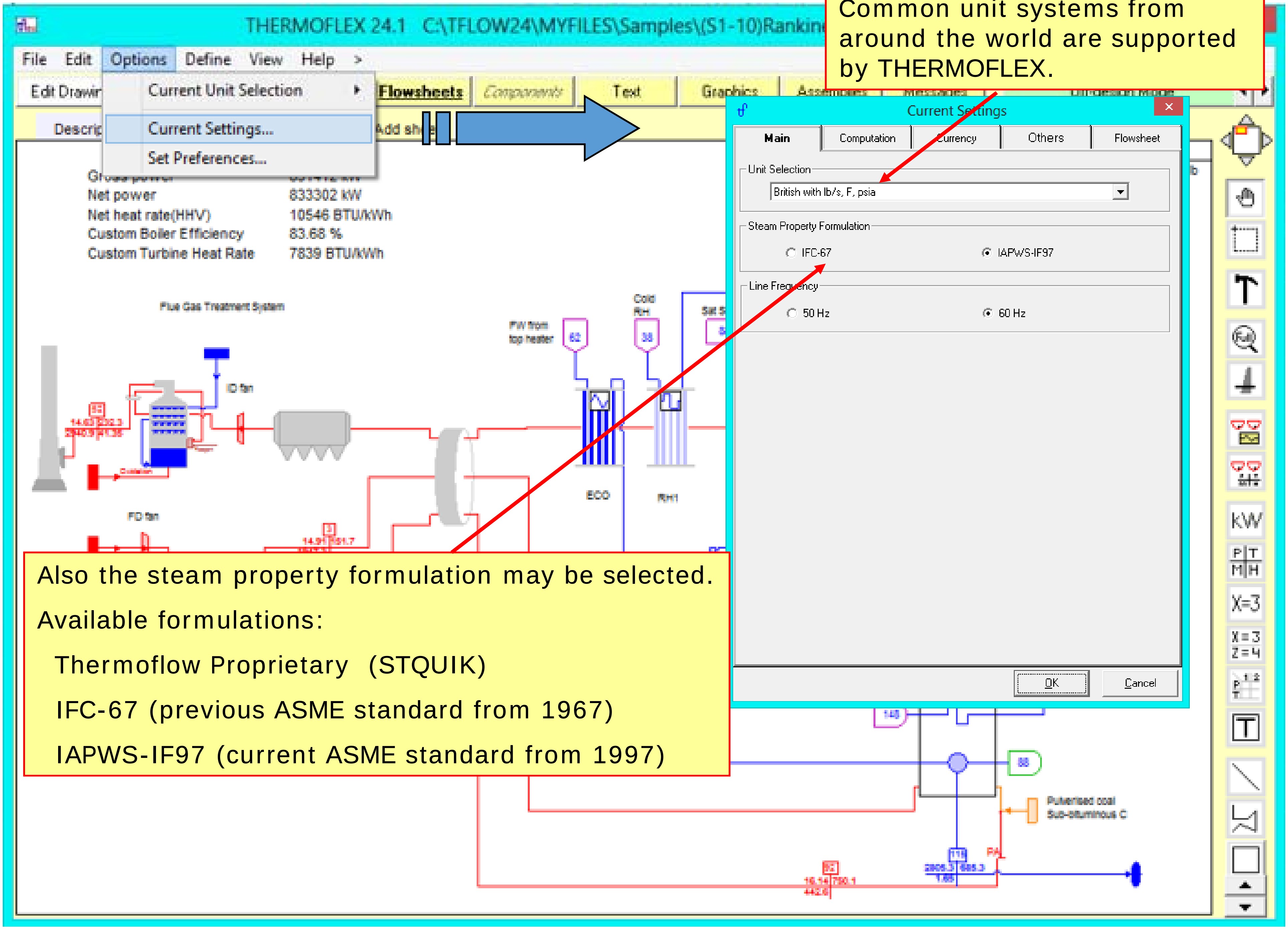
The stream table can be displayed both in Design and Off-design mode.

The stream table can be exported to Excel to work on additional graphic or calculations.

http://www.Thermoflow.ir

THERMOFLEX

Common unit systems from around the world are supported by THERMOFLEX.



Also the steam property formulation may be selected.

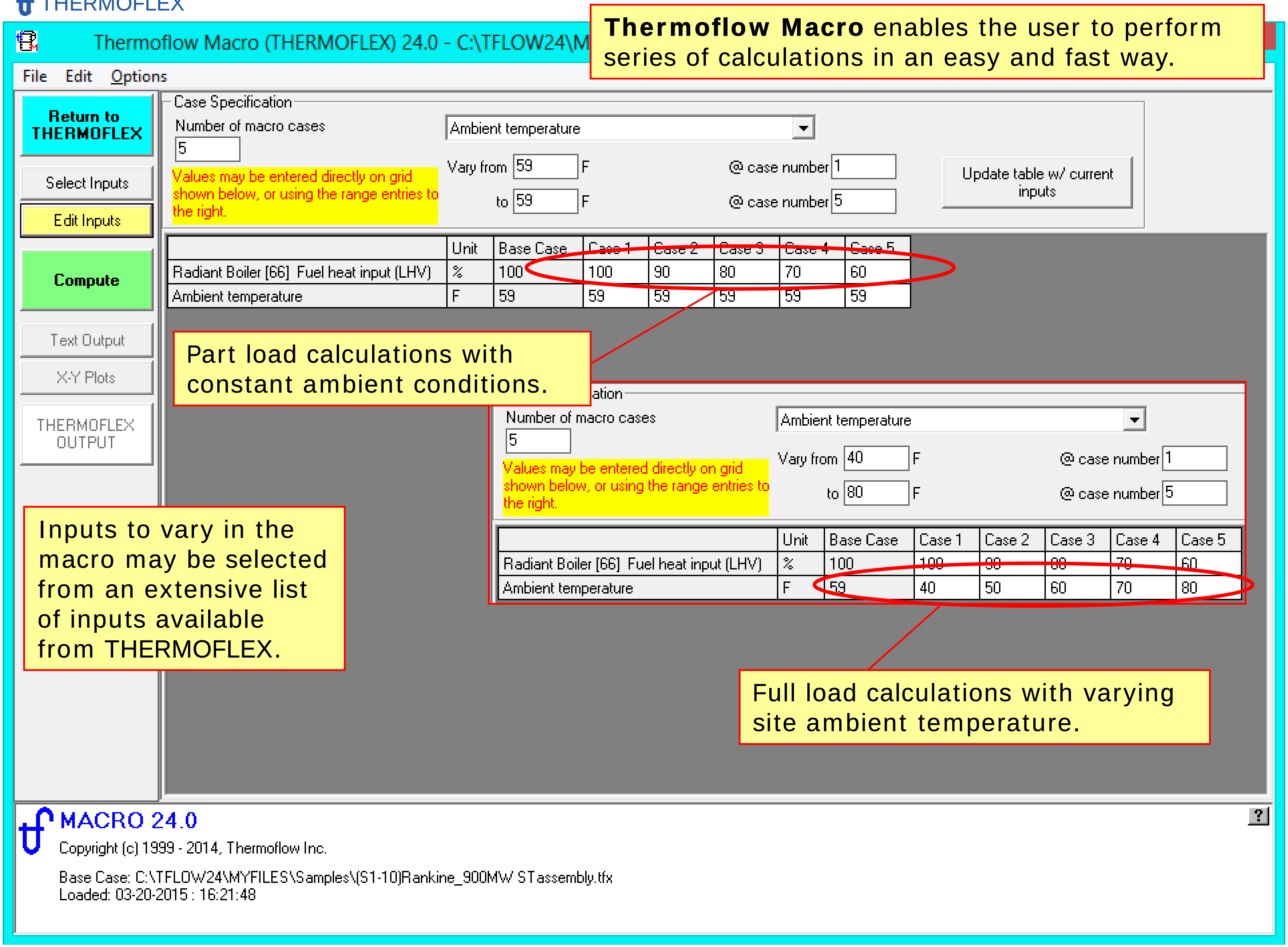
Available formulations:

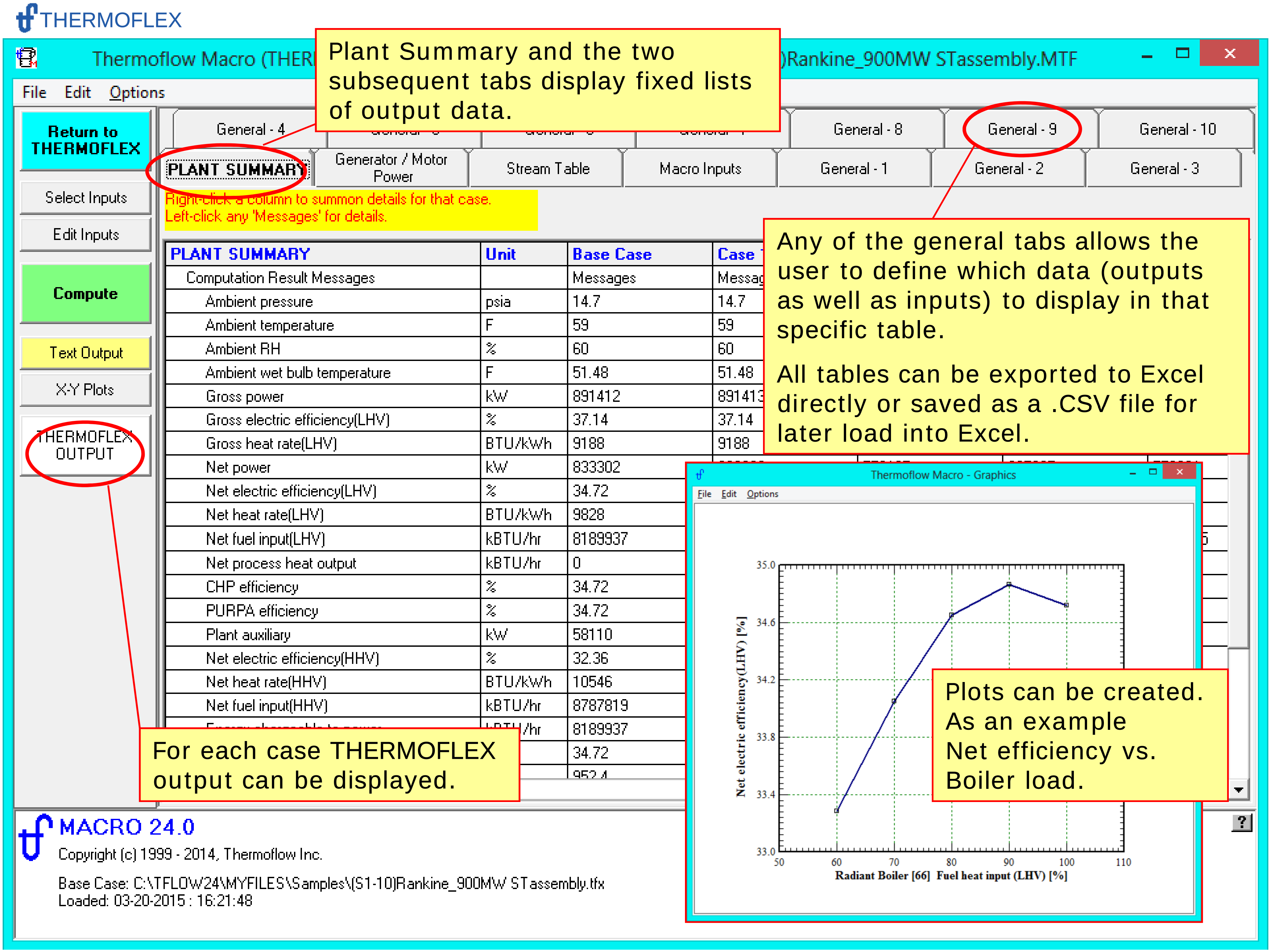
Thermoflow Proprietary (STQUIK)

IFC-67 (previous ASME standard from 1967)

IAPWS-IF97 (current ASME standard from 1997)

http://www.Thermoflow.ir


Thermoflow Macro (THERMOFLEX) 24.0 - C:\TFLOW24\M
Thermoflow Macro enables the user to perform series of calculations in an easy and fast way.
File Edit Options
Return to THERMOFLEX
Select Inputs
Edit Inputs
Compute
Text Output
X-Y Plots
THERMOFLEX OUTPUT
Case Specification
Number of macro cases
5
Values may be entered directly on grid shown below, or using the range entries to the right.
Ambient temperature
Vary from 59 F
to 59 F
@ case number 1
@ case number 5
Update table w/ current inputs
Unit | Base Case | Case 1 | Case 2 | Case 3 | Case 4 | Case 5
Radiant Boiler [66] Fuel heat input (LHV) | % | 100 | 100 | 90 | 80 | 70 | 60
Ambient temperature | F | 59 | 59 | 59 | 59 | 59 | 59
Part load calculations with constant ambient conditions.
Number of macro cases
5
Values may be entered directly on grid shown below, or using the range entries to the right.
Ambient temperature
Vary from 40 F
to 80 F
@ case number 1
@ case number 5
Unit | Base Case | Case 1 | Case 2 | Case 3 | Case 4 | Case 5
Radiant Boiler [66] Fuel heat input (LHV) | % | 100 | 100 | 90 | 80 | 70 | 60
Ambient temperature | F | 59 | 40 | 50 | 60 | 70 | 80
Inputs to vary in the macro may be selected from an extensive list of inputs available from THERMOFLEX.
Full load calculations with varying site ambient temperature.
MACRO 24.0
Copyright (c) 1999 - 2014, Thermoflow Inc.
Base Case: C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine_900MW STassembly.tfx
Loaded: 03-20-2015 : 16:21:48



THERMOFLEX
Thermoflow Macro (THER
)Rankine_900MW STassembly.MTF
File Edit Options
Return to THERMOFLEX
Select Inputs
Edit Inputs
Compute
Text Output
X-Y Plots
THERMOFLEX OUTPUT
General - 4
General - 8
General - 9
General - 10
PLANT SUMMARY
Generator / Motor Power
Stream Table
Macro Inputs
General - 1
General - 2
General - 3
Right-click a column to summon details for that case.
Left-click any 'Messages' for details.
Plant Summary and the two subsequent tabs 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.
PLANT SUMMARY | Unit | Base Case | Case
Computation Result Messages | | Messages | Messag
Ambient pressure | psia | 14.7 | 14.7
Ambient temperature | F | 59 | 59
Ambient RH | % | 60 | 60
Ambient wet bulb temperature | F | 51.48 | 51.48
Gross power | kW | 891412 | 891413
Gross electric efficiency(LHV) | % | 37.14 | 37.14
Gross heat rate(LHV) | BTU/kWh | 9188 | 9188
Net power | kW | 833302
Net electric efficiency(LHV) | % | 34.72
Net heat rate(LHV) | BTU/kWh | 9828
Net fuel input(LHV) | kBTU/hr | 8189937
Net process heat output | kBTU/hr | 0
CHP efficiency | % | 34.72
PURPA efficiency | % | 34.72
Plant auxiliary | kW | 58110
Net electric efficiency(HHV) | % | 32.36
Net heat rate(HHV) | BTU/kWh | 10546
Net fuel input(HHV) | kBTU/hr | 8787819
8189937
34.72
For each case THERMOFLEX output can be displayed.
Thermoflow Macro - Graphics
File Edit Options
Net electric efficiency(LHV) [%]
Radiant Boiler [66] Fuel heat input (LHV) [%]
Plots can be created. As an example Net efficiency vs. Boiler load.
MACRO 24.0
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Base Case: C:\TFLOW24\MYFILES\Samples\(S1-10)Rankine_900MW STassembly.tfx
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