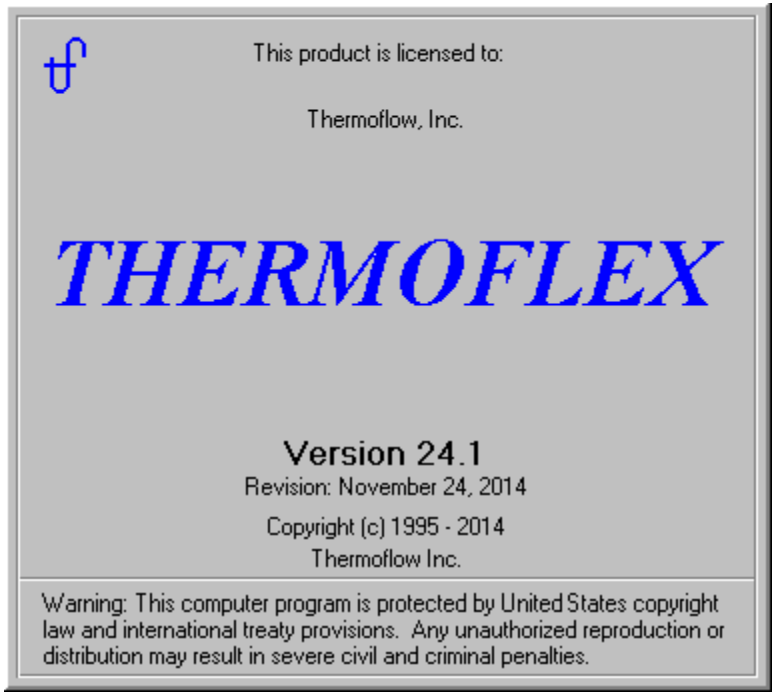
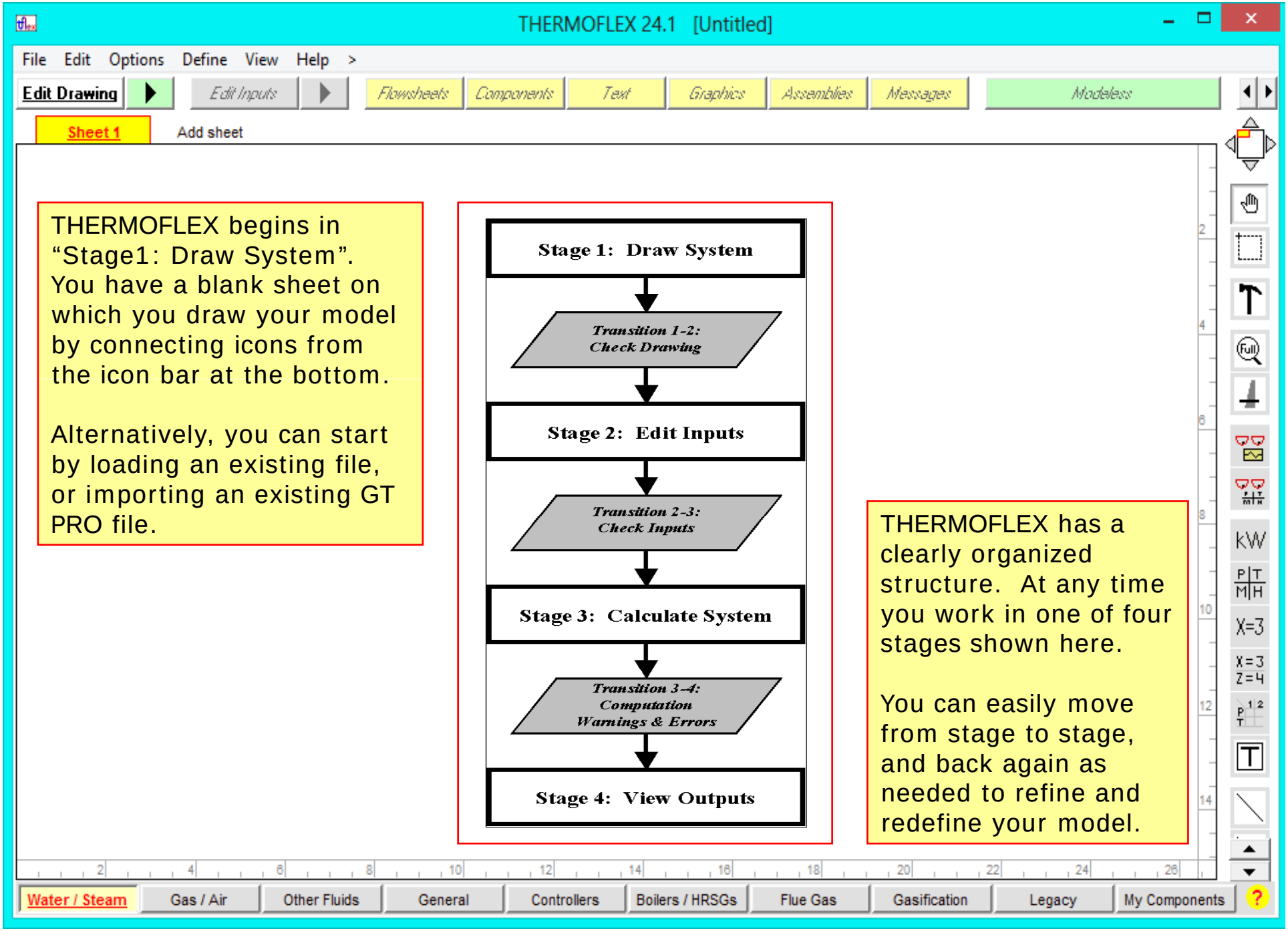
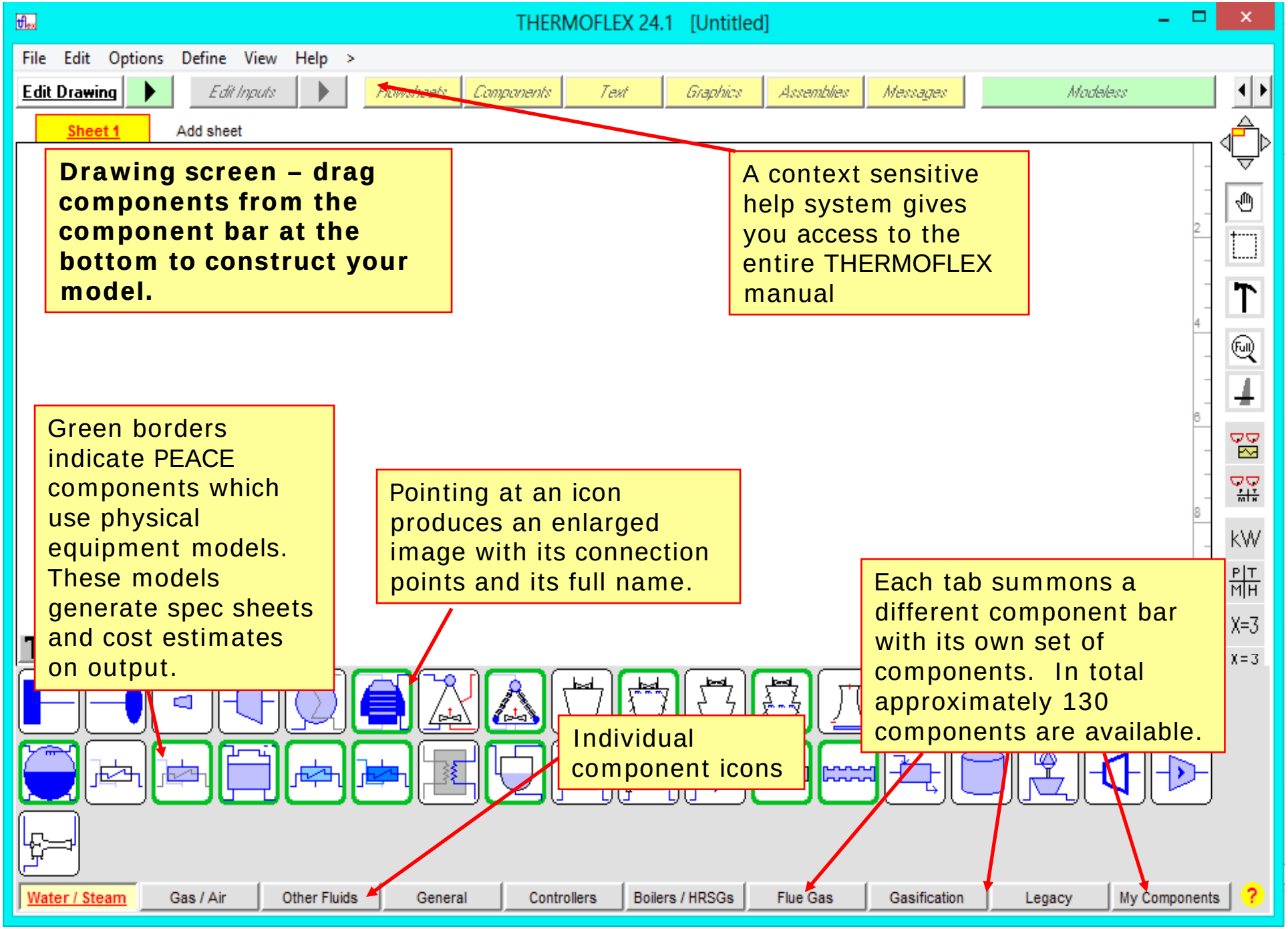
Thermoflow Inc.

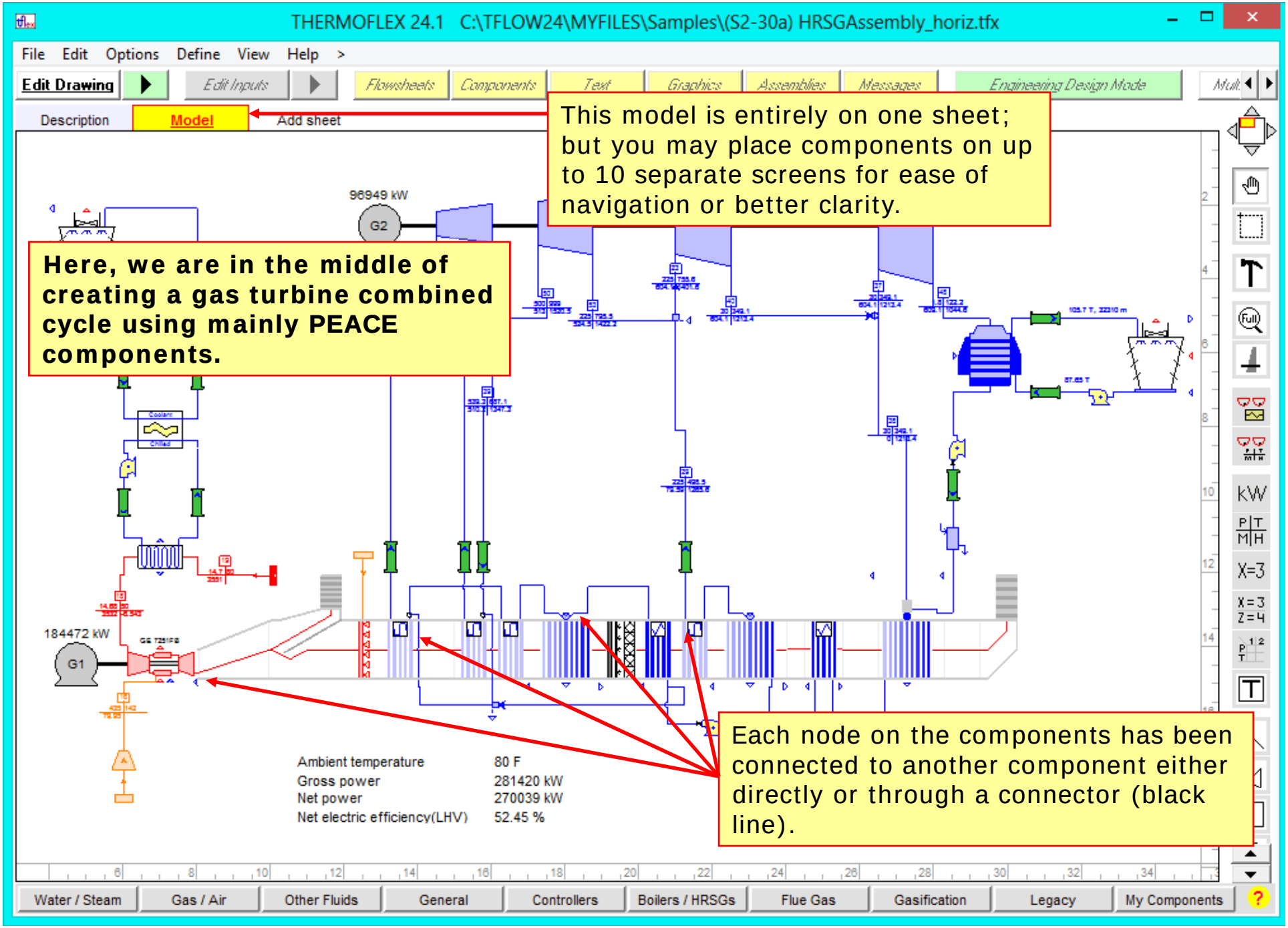
WHAT IS THERMOFLEX?

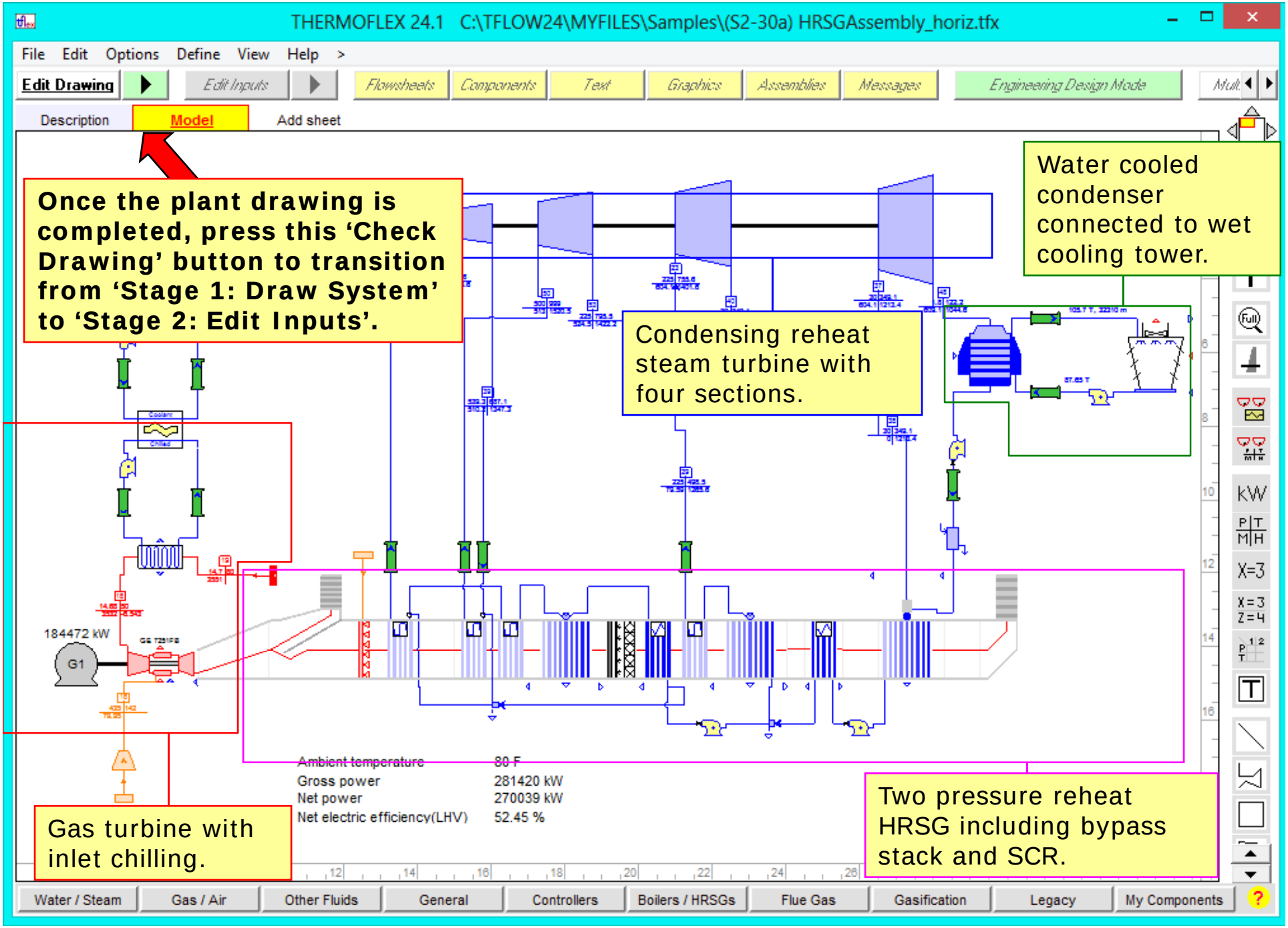


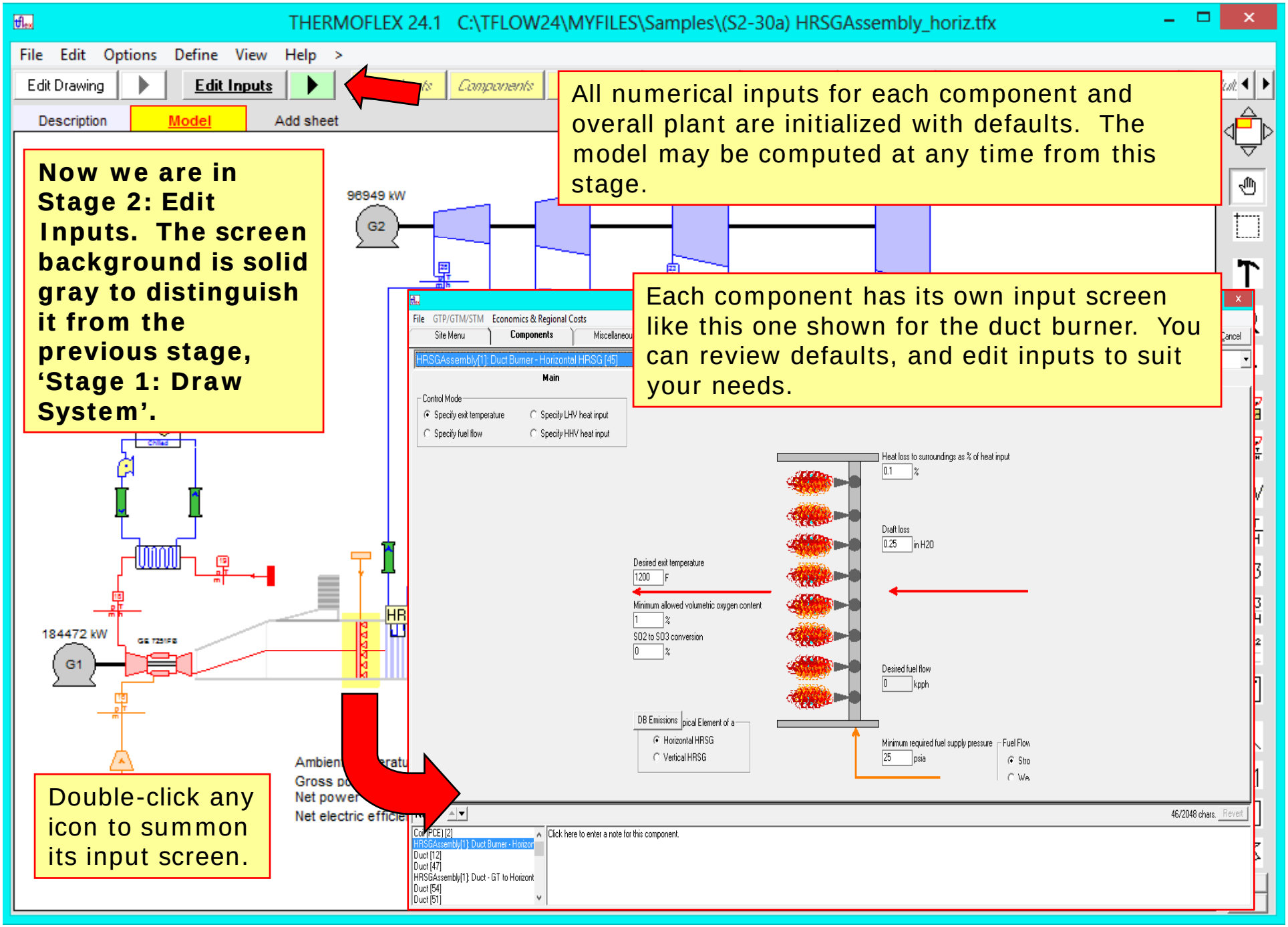
- THERMOFLEX is a fully-flexible program for heat balance modeling & engineering. Models are built graphically assembling components “lego-style”.
- THERMOFLEX is used to model **Combined Cycles**, **Conventional Steam Plants**, **Process Plants, and more.**
- Performs both design and off-design calculations.
- 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.

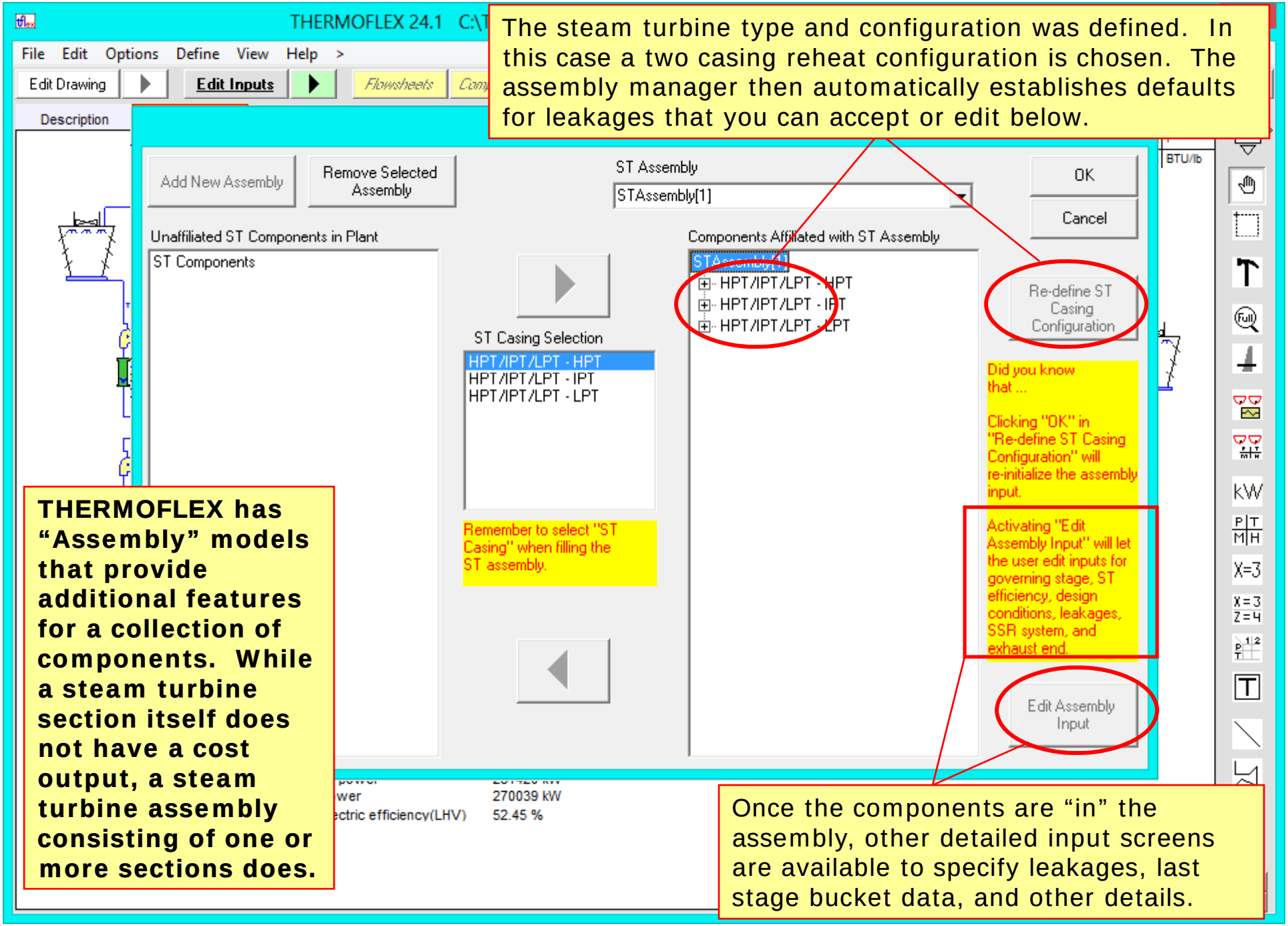

THERMOFLEX 24.1 [Untitled]
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Modeless
Sheet 1
Add sheet
THERMOFLEX begins in "Stage1: Draw System". You have a blank sheet on which you draw your model by connecting icons from the icon 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 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
Water / Steam
Gas / Air
Other Fluids
General
Controllers
Boilers / HRSGs
Flue Gas
Gasification
Legacy
My Components


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Engineering Design Mode
Description
Model
Add sheet
This model is entirely on one sheet; but 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 gas turbine combined cycle using mainly PEACE components.
96949 kW
G2
184472 kW
G1
Ambient temperature 80 F
Gross power 281420 kW
Net power 270039 kW
Net electric efficiency(LHV) 52.45 %
Each node on the components has been connected to another component either directly or through a connector (black line).
Water / Steam
Gas / Air
Other Fluids
General
Controllers
Boilers / HRSGs
Flue Gas
Gasification
Legacy
My Components


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Engineering Design Mode
Description
Model
Add sheet
Once the plant drawing is completed, press this 'Check Drawing' button to transition from 'Stage 1: Draw System' to 'Stage 2: Edit Inputs'.
Water cooled condenser connected to wet cooling tower.
Condensing reheat steam turbine with four sections.
184472 kW
G1
Ambient temperature 80 F
Gross power 281420 kW
Net power 270039 kW
Net electric efficiency(LHV) 52.45 %
Gas turbine with inlet chilling.
Two pressure reheat HRSG including bypass stack and SCR.
Water / Steam
Gas / Air
Other Fluids
General
Controllers
Boilers / HRSGs
Flue Gas
Gasification
Legacy
My Components

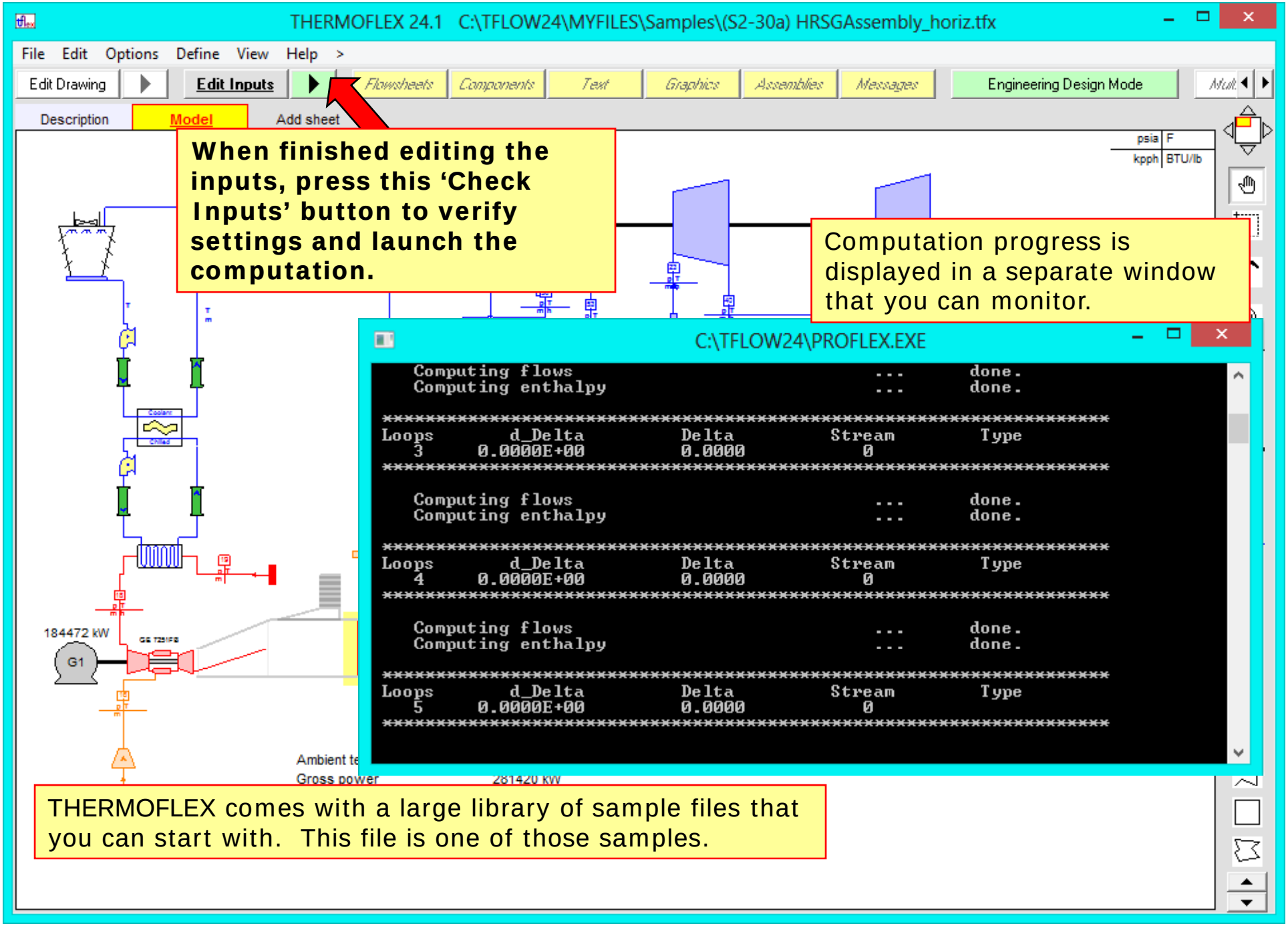

THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Description
Model
Add sheet
Now we are in Stage 2: Edit Inputs. The screen background is solid gray to distinguish it from the previous stage, 'Stage 1: Draw System'.
All numerical inputs for each component and overall plant are initialized with defaults. The model may be computed at any time from this stage.
Each component has its own input screen like this one shown for the duct burner. You can review defaults, and edit inputs to suit your needs.
Double-click any icon to summon its input screen.
96949 kW
G2
184472 kW
G1
HRSGAssembly[1]: Duct Burner - Horizontal HRSG [45]
Main
Control Mode
Specify exit temperature
Specify fuel flow
Specify LHV heat input
Specify HHV heat input
Heat loss to surroundings as % of heat input
Draft loss
Desired exit temperature
Minimum allowed volumetric oxygen content
SO2 to SO3 conversion
Desired fuel flow
Horizontal HRSG
Vertical HRSG
Minimum required fuel supply pressure

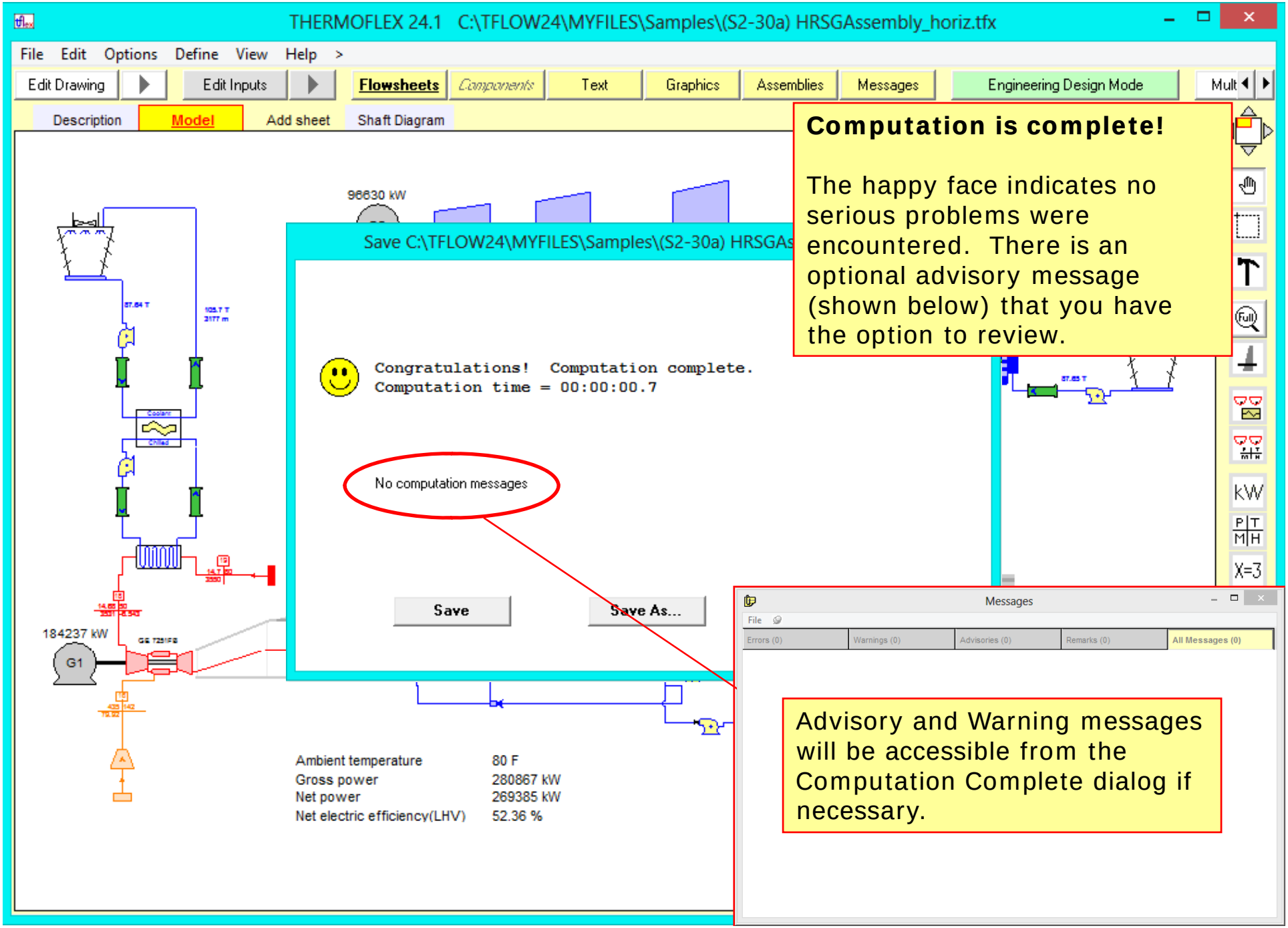


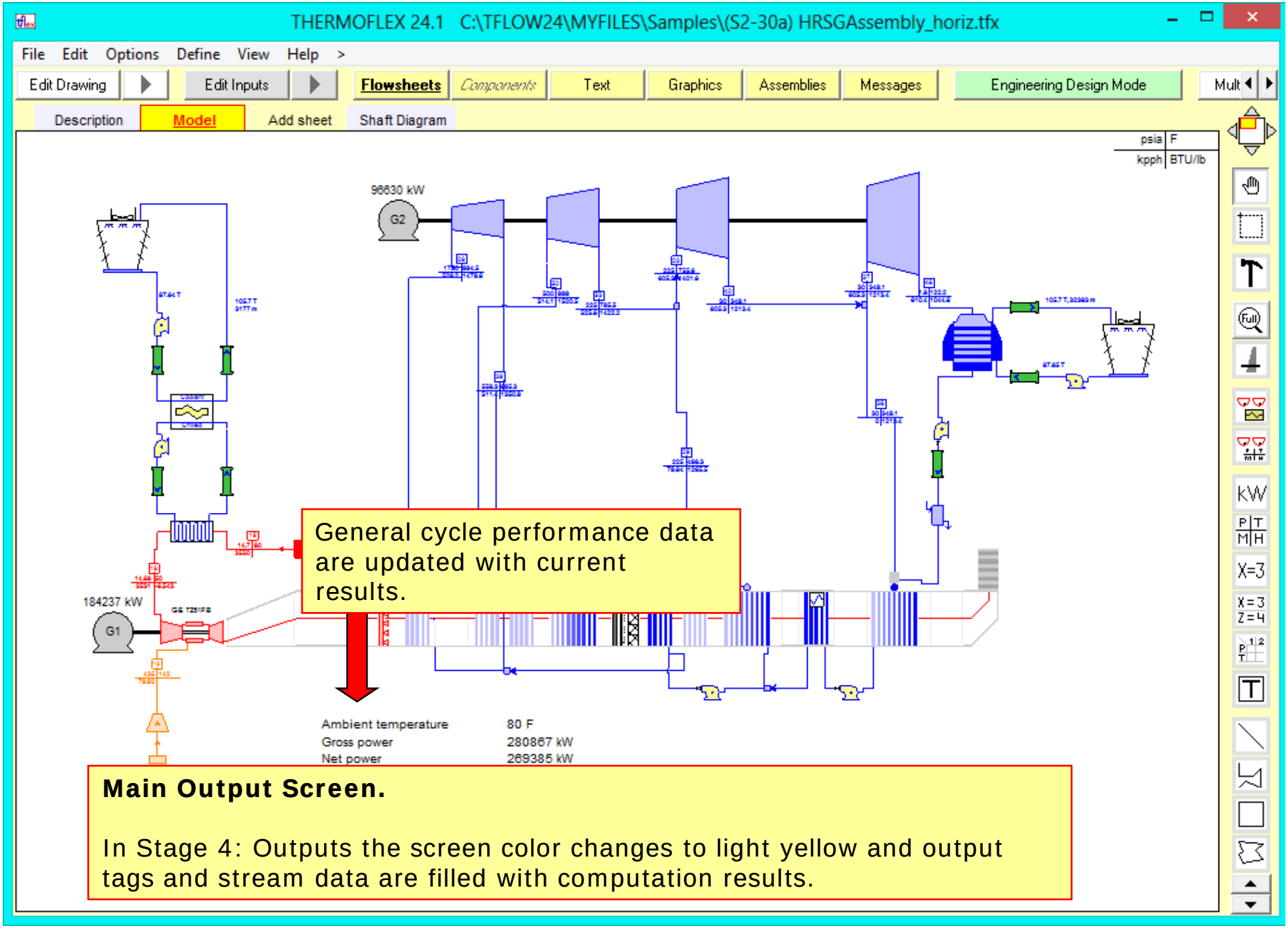
The steam turbine type and configuration was defined. In this case a two casing reheat configuration is chosen. The assembly manager then automatically establishes defaults for leakages that you can accept or edit below.

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.

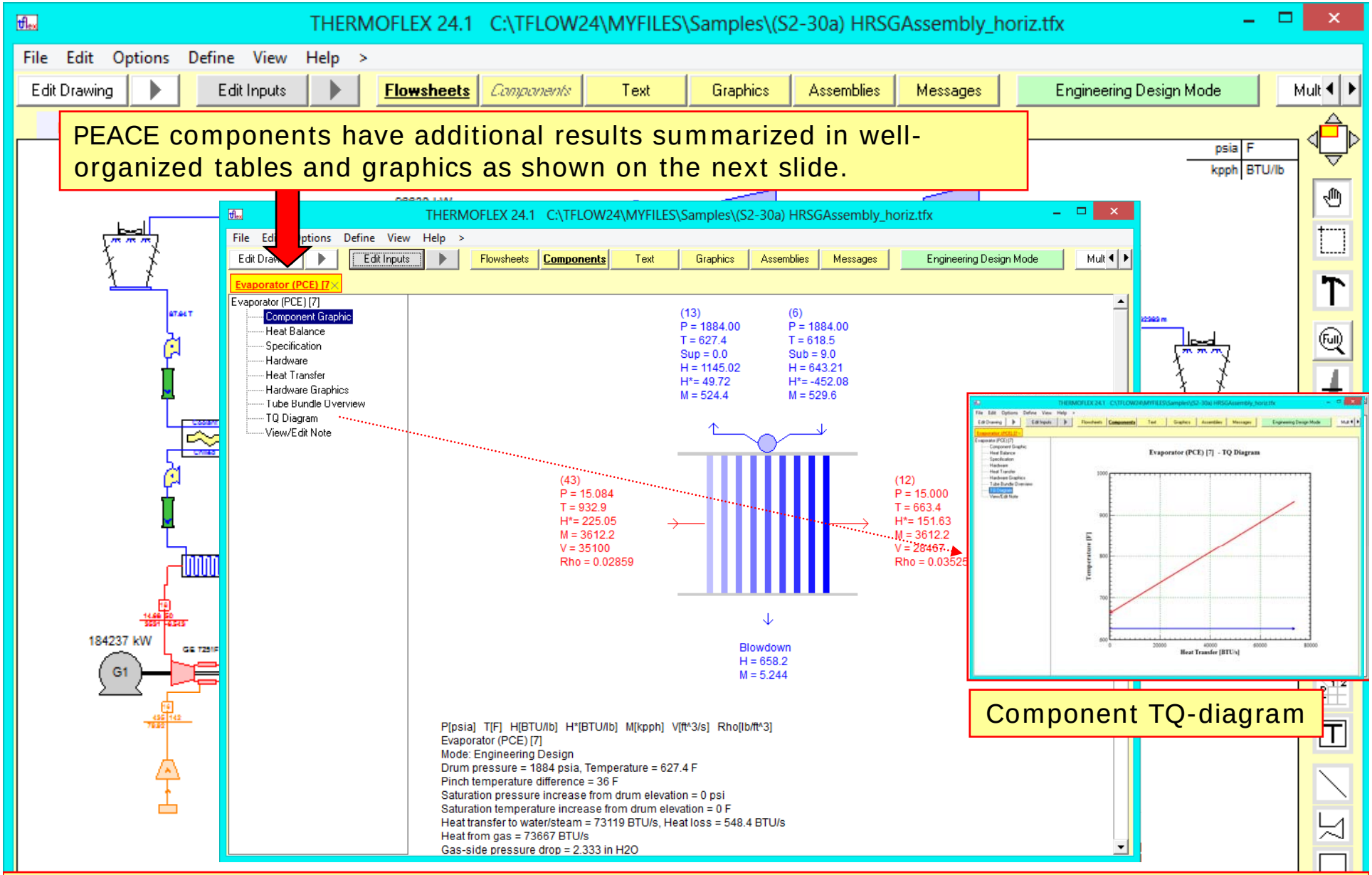

THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets Components Text Graphics Assemblies Messages
Engineering Design Mode
Description Model Add sheet
When finished editing the inputs, press this 'Check Inputs' button to verify settings and launch the computation.
Computation progress is displayed in a separate window that you can monitor.
C:\TFLOW24\PROFLEX.EXE
Computing flows ... done.
Computing enthalpy ... done.
Loops d_Delta Delta Stream Type
3 0.0000E+00 0.0000 0
4 0.0000E+00 0.0000 0
5 0.0000E+00 0.0000 0
184472 kW
G1
Ambient te
Gross power 281420 kW
THERMOFLEX comes with a large library of sample files that you can start with. This file is one of those samples.


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets
Components
Text
Graphics
Assemblies
Messages
Engineering Design Mode
Description
Model
Add sheet
Shaft Diagram
96630 kW
184237 kW
G1
Save C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAs
Congratulations! Computation complete.
Computation time = 00:00:00.7
No computation messages
Save
Save As...
Ambient temperature 80 F
Gross power 280867 kW
Net power 269385 kW
Net electric efficiency(LHV) 52.36 %
Messages
File
Errors (0)
Warnings (0)
Advisories (0)
Remarks (0)
All Messages (0)
Computation is complete!
The happy face indicates no serious problems were encountered. There is an optional advisory message (shown below) that you have the option to review.
Advisory and Warning messages will be accessible from the Computation Complete dialog if necessary.

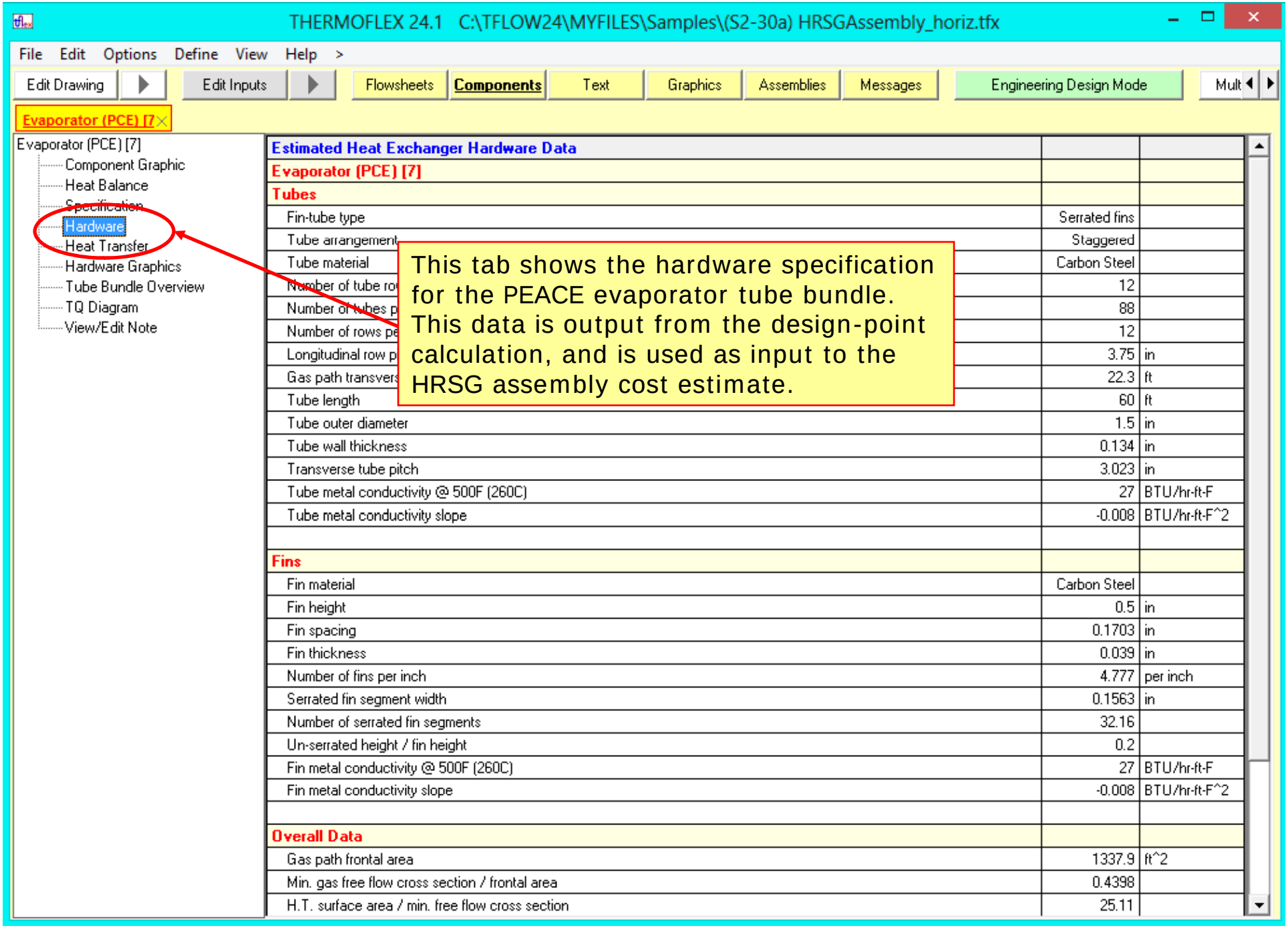


Main Output Screen.

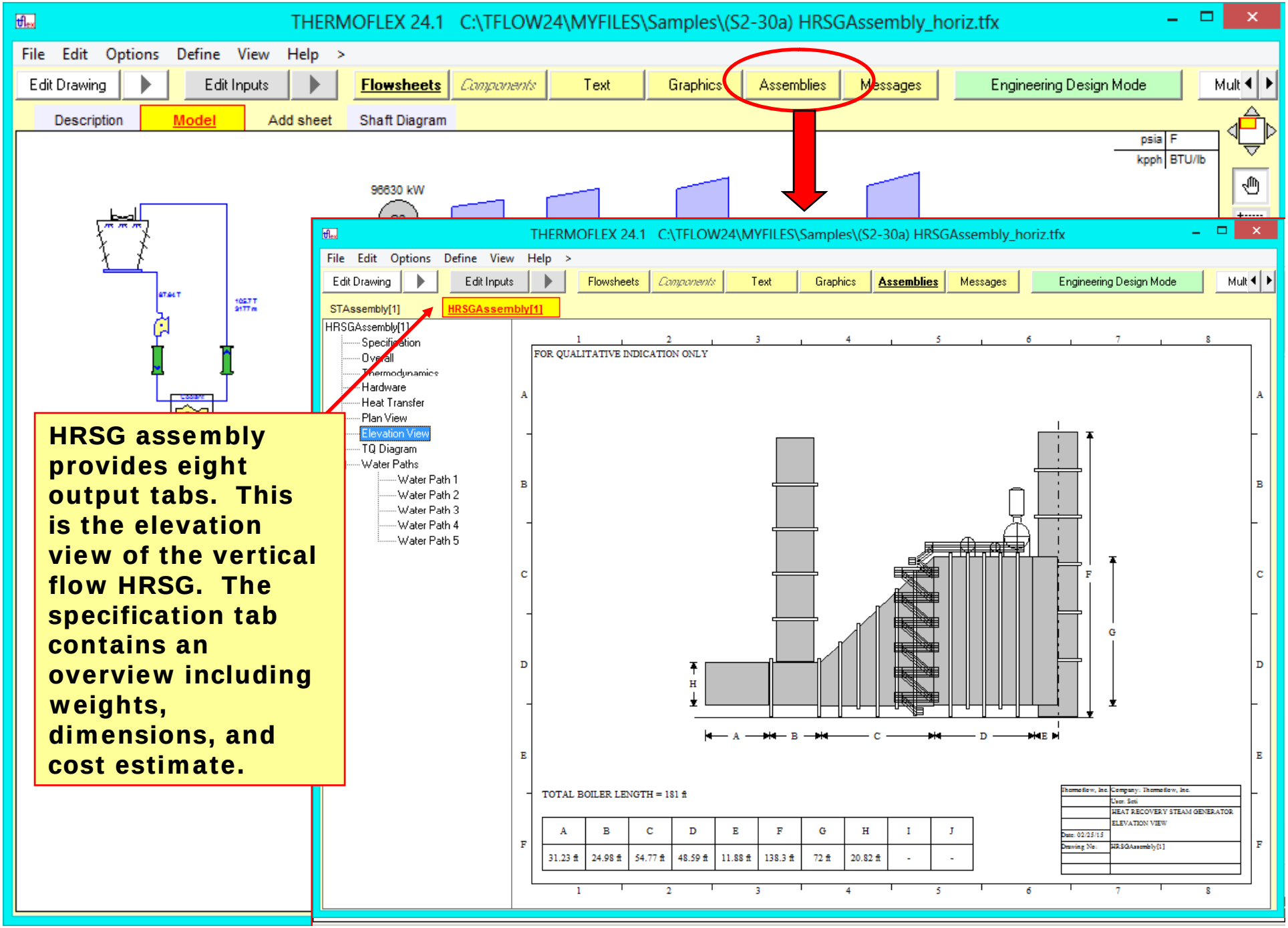
In Stage 4: Outputs the screen color changes to light yellow and output tags and stream data are filled with computation results.



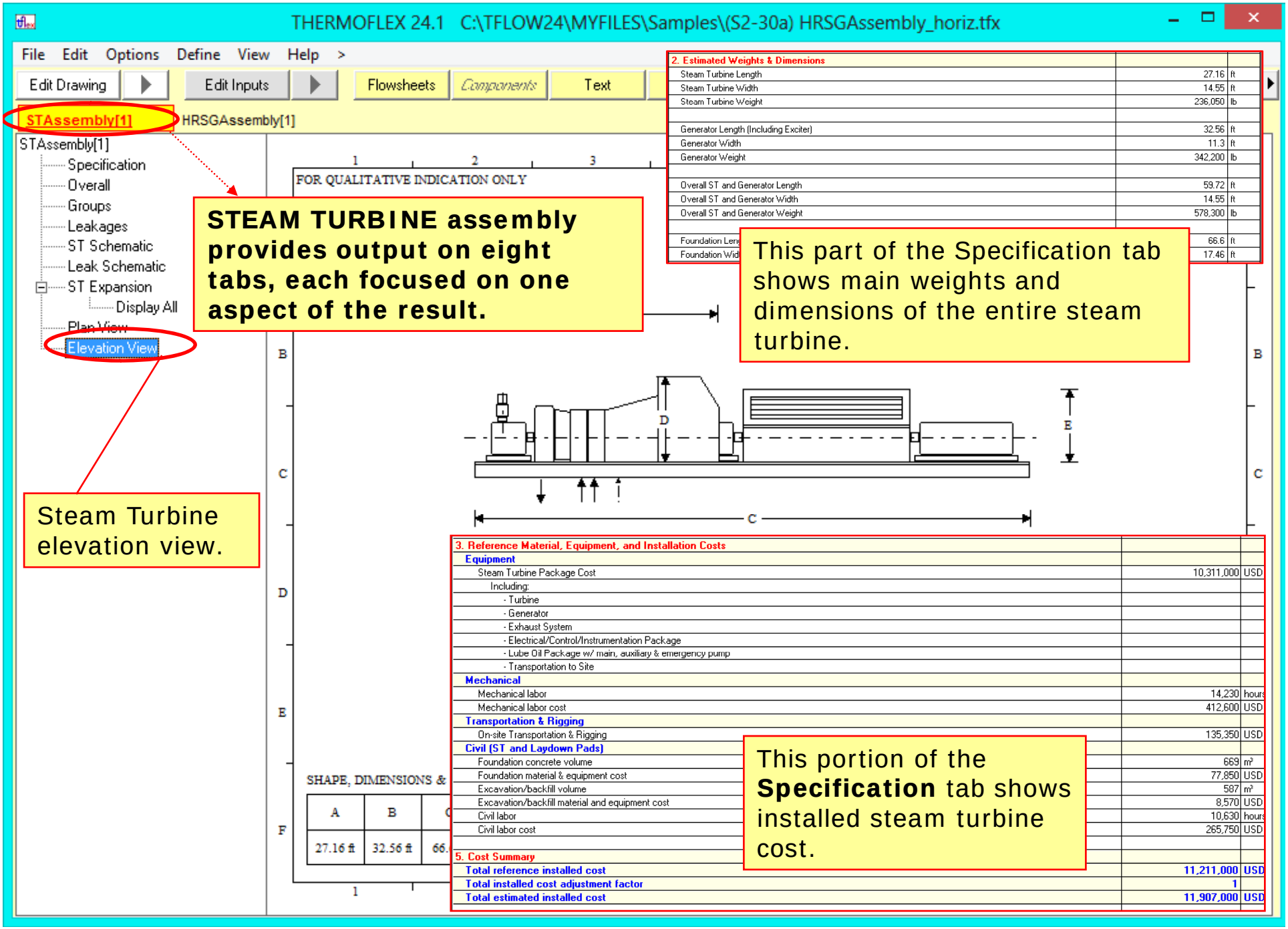
Click any component to summon a detailed result graphic display. Each node on the graphic shows the computed state. Blue nodes show for water/steam data and red nodes show air/combustion products states.



Estimated Heat Exchanger Hardware Data		
Evaporator (PCE) [7]		
Tubes		
Fin-tube type	Serrated fins	
Tube arrangement	Staggered	
Tube material	Carbon Steel	
Number of tube ro	12	
Number of tubes p	88	
Number of rows pe	12	
Longitudinal row p	3.75	in
Gas path transvers	22.3	ft
Tube length	60	ft
Tube outer diameter	1.5	in
Tube wall thickness	0.134	in
Transverse tube pitch	3.023	in
Tube metal conductivity @ 500F (260C)	27	BTU/hr-ft-F
Tube metal conductivity slope	-0.008	BTU/hr-ft-F^2
Fins		
Fin material	Carbon Steel	
Fin height	0.5	in
Fin spacing	0.1703	in
Fin thickness	0.039	in
Number of fins per inch	4.777	per inch
Serrated fin segment width	0.1563	in
Number of serrated fin segments	32.16	
Un-serrated height / fin height	0.2	
Fin metal conductivity @ 500F (260C)	27	BTU/hr-ft-F
Fin metal conductivity slope	-0.008	BTU/hr-ft-F^2
Overall Data		
Gas path frontal area	1337.9	ft^2
Min. gas free flow cross section / frontal area	0.4398	
H.T. surface area / min. free flow cross section	25.11	

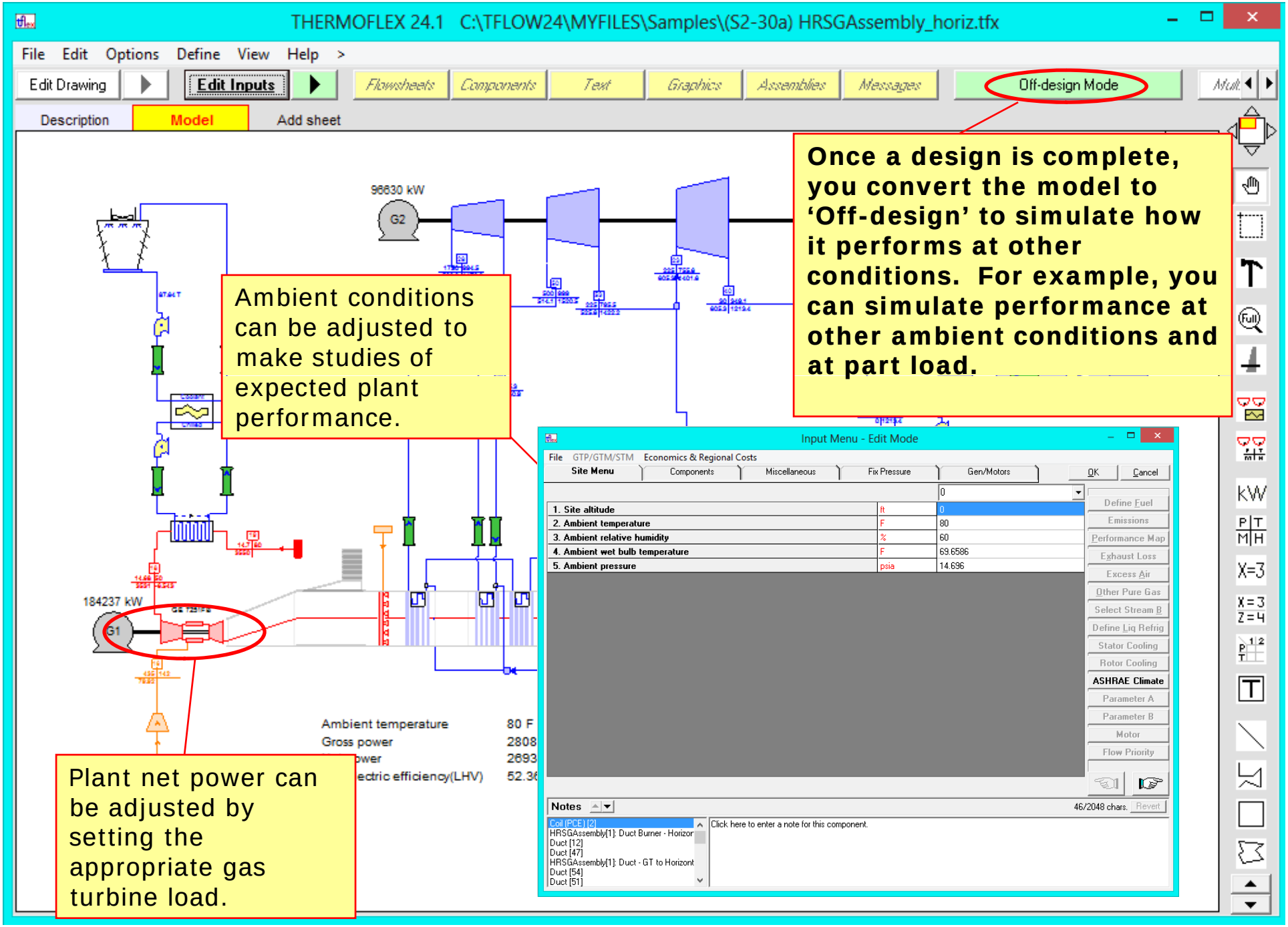


HRSG assembly provides eight output tabs. This is the elevation view of the vertical flow HRSG. The specification tab contains an overview including weights, dimensions, and cost estimate.



2. Estimated Weights & Dimensions		
Steam Turbine Length	27.16	ft
Steam Turbine Width	14.55	ft
Steam Turbine Weight	236,050	lb
Generator Length (Including Exciter)	32.56	ft
Generator Width	11.3	ft
Generator Weight	342,200	lb
Overall ST and Generator Length	59.72	ft
Overall ST and Generator Width	14.55	ft
Overall ST and Generator Weight	578,300	lb
Foundation Len	66.6	ft
Foundation Wid	17.46	ft

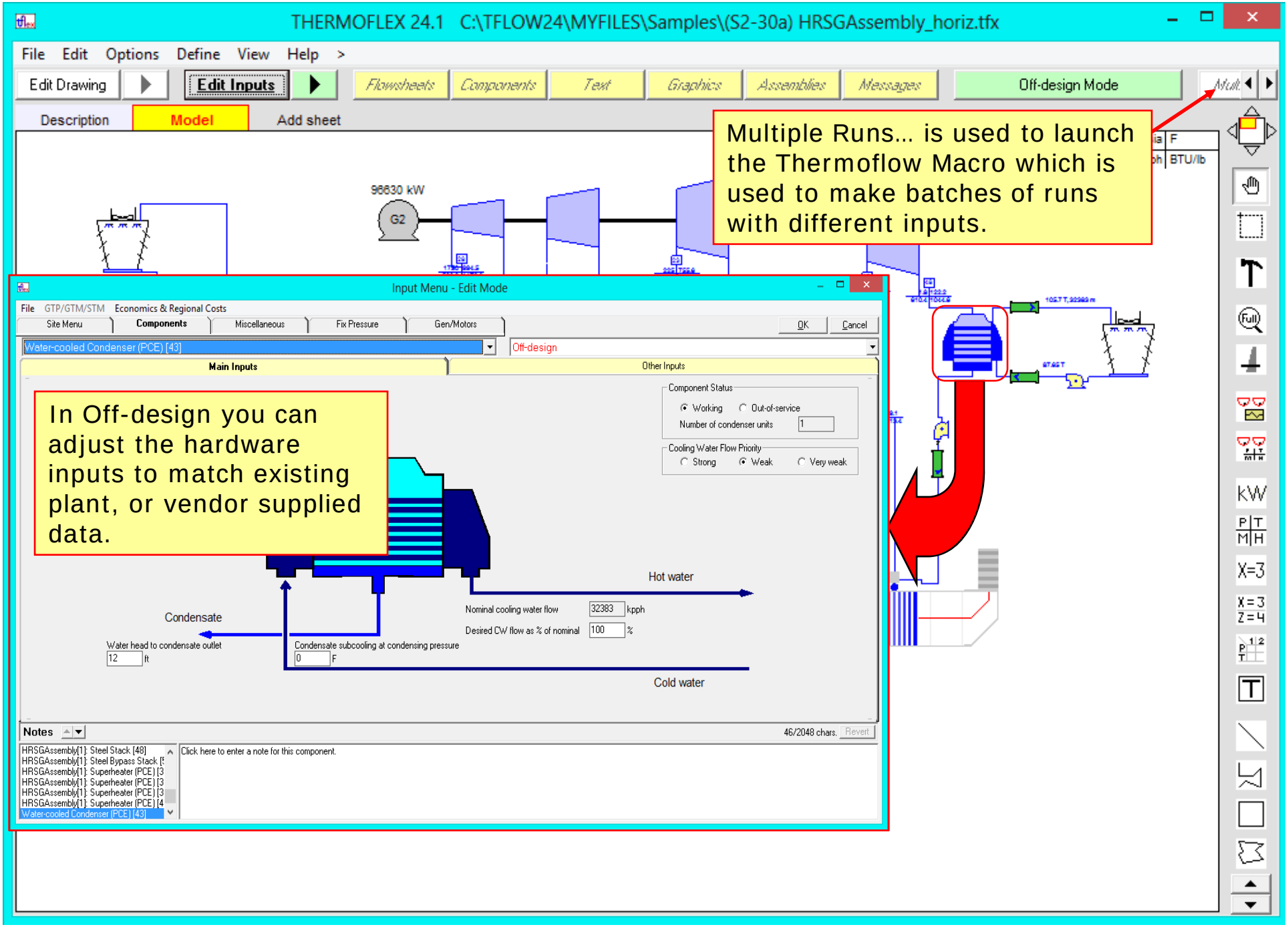
3. Reference Material, Equipment, and Installation Costs		
Equipment		
Steam Turbine Package Cost	10,311,000	USD
Including:		
- Turbine		
- Generator		
- Exhaust System		
- Electrical/Control/Instrumentation Package		
- Lube Oil Package w/ main, auxiliary & emergency pump		
- Transportation to Site		
Mechanical		
Mechanical labor	14,230	hours
Mechanical labor cost	412,600	USD
Transportation & Rigging		
On-site Transportation & Rigging	135,350	USD
Civil (ST and Laydown Pads)		
Foundation concrete volume	669	m³
Foundation material & equipment cost	77,850	USD
Excavation/backfill volume	587	m³
Excavation/backfill material and equipment cost	8,570	USD
Civil labor	10,630	hours
Civil labor cost	265,750	USD
5. Cost Summary		
Total reference installed cost	11,211,000	USD
Total installed cost adjustment factor	1	
Total estimated installed cost	11,907,000	USD

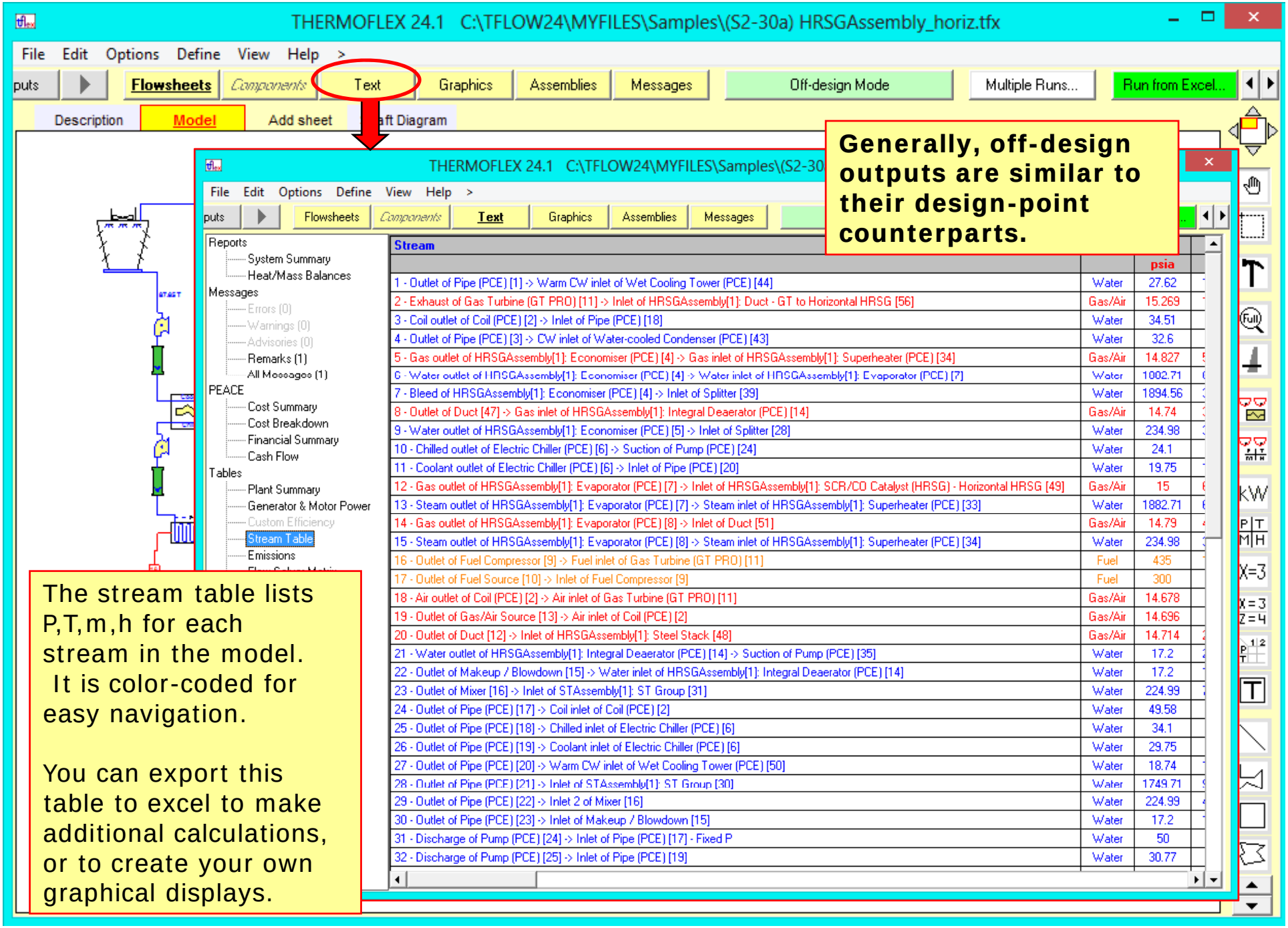


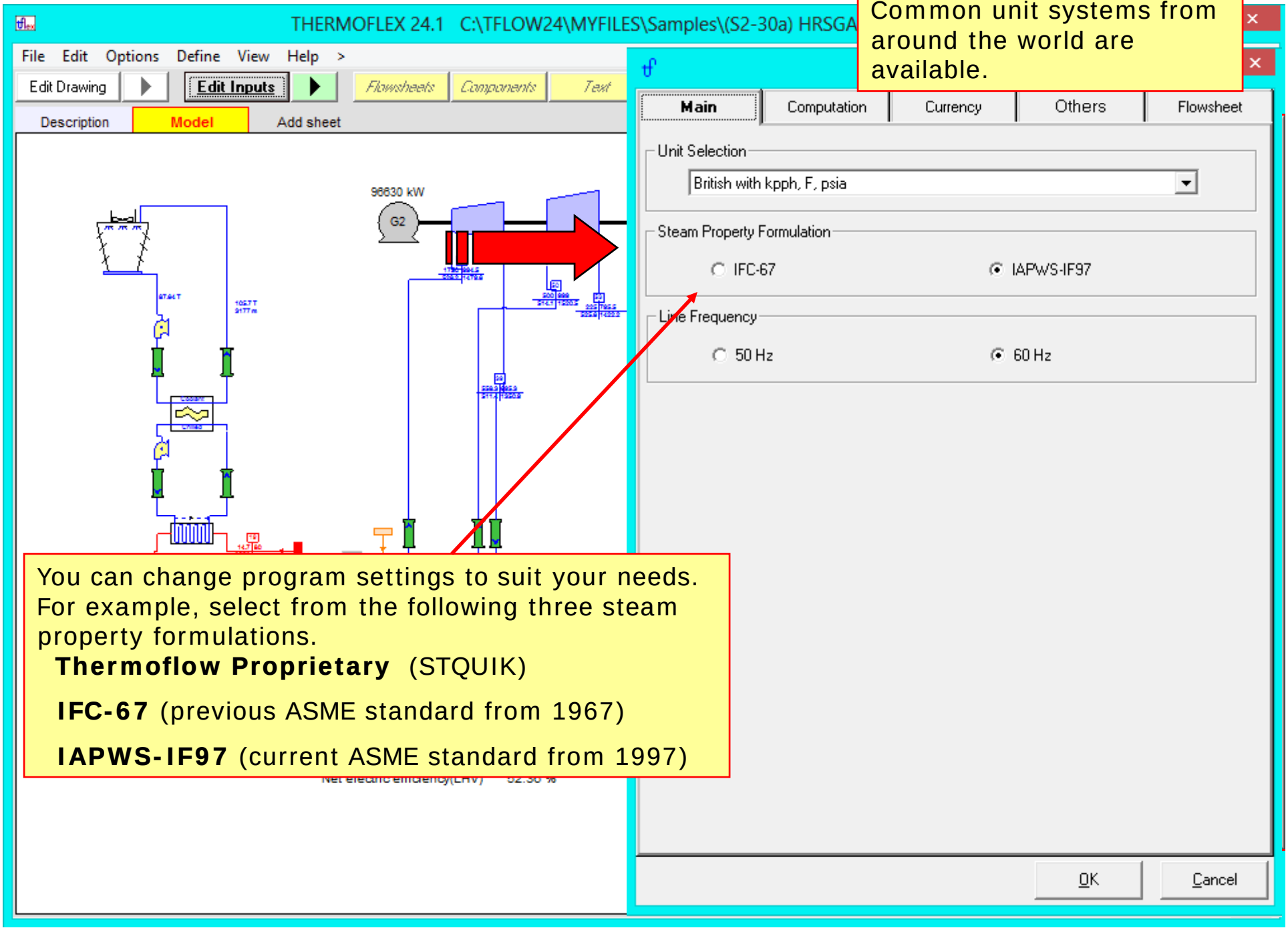
Ambient conditions can be adjusted to make studies of expected plant performance.

Once a design is complete, you convert the model to 'Off-design' to simulate how it performs at other conditions. For example, you can simulate performance at other ambient conditions and at part load.

Plant net power can be adjusted by setting the appropriate gas turbine load.


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
File Edit Options Define View Help >
Edit Drawing
Edit Inputs
Flowsheets Components Text Graphics Assemblies Messages
Off-design Mode
Description Model Add sheet
96630 kW
G2
Multiple Runs... is used to launch the Thermoflow Macro which is used to make batches of runs with different inputs.
Input Menu - Edit Mode
File GTP/GTM/STM Economics & Regional Costs
Site Menu Components Miscellaneous Fix Pressure Gen/Motors
OK Cancel
Water-cooled Condenser (PCE) [43]
Off-design
Main Inputs Other Inputs
Component Status
Working Out-of-service
Number of condenser units 1
Cooling Water Flow Priority
Strong Weak Very weak
In Off-design you can adjust the hardware inputs to match existing plant, or vendor supplied data.
Hot water
Nominal cooling water flow 32383 kpph
Desired CW flow as % of nominal 100 %
Condensate
Water head to condensate outlet 12 ft
Condensate subcooling at condensing pressure 0 F
Cold water
Notes
46/2048 chars. Revert
HRSGAssembly[1]: Steel Stack [48]
HRSGAssembly[1]: Steel Bypass Stack [
HRSGAssembly[1]: Superheater (PCE) [3
HRSGAssembly[1]: Superheater (PCE) [3
HRSGAssembly[1]: Superheater (PCE) [3
HRSGAssembly[1]: Superheater (PCE) [4
Water-cooled Condenser (PCE) [43]
Click here to enter a note for this component.


THERMOFLEX 24.1 C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
File Edit Options Define View Help
Flowsheets Components Text Graphics Assemblies Messages Off-design Mode Multiple Runs... Run from Excel...
Description Model Add sheet
Generally, off-design outputs are similar to their design-point counterparts.
Reports
System Summary
Heat/Mass Balances
Messages
Errors (0)
Warnings (0)
Advisories (0)
Remarks (1)
All Messages (1)
PEACE
Cost Summary
Cost Breakdown
Financial Summary
Cash Flow
Tables
Plant Summary
Generator & Motor Power
Custom Efficiency
Stream Table
Emissions
Stream
psia
1 - Outlet of Pipe (PCE) [1] -> Warm CW inlet of Wet Cooling Tower (PCE) [44] Water 27.62
2 - Exhaust of Gas Turbine (GT PRO) [11] -> Inlet of HRSGAssembly[1]: Duct - GT to Horizontal HRSG [56] Gas/Air 15.269
3 - Coil outlet of Coil (PCE) [2] -> Inlet of Pipe (PCE) [18] Water 34.51
4 - Outlet of Pipe (PCE) [3] -> CW inlet of Water-cooled Condenser (PCE) [43] Water 32.6
5 - Gas outlet of HRSGAssembly[1]: Economiser (PCE) [4] -> Gas inlet of HRSGAssembly[1]: Superheater (PCE) [34] Gas/Air 14.827
6 - Water outlet of HRSGAssembly[1]: Economiser (PCE) [4] -> Water inlet of HRSGAssembly[1]: Evaporator (PCE) [7] Water 1092.71
7 - Bleed of HRSGAssembly[1]: Economiser (PCE) [4] -> Inlet of Splitter [39] Water 1894.56
8 - Outlet of Duct [47] -> Gas inlet of HRSGAssembly[1]: Integral Deaerator (PCE) [14] Gas/Air 14.74
9 - Water outlet of HRSGAssembly[1]: Economiser (PCE) [5] -> Inlet of Splitter [28] Water 234.98
10 - Chilled outlet of Electric Chiller (PCE) [6] -> Suction of Pump (PCE) [24] Water 24.1
11 - Coolant outlet of Electric Chiller (PCE) [6] -> Inlet of Pipe (PCE) [20] Water 19.75
12 - Gas outlet of HRSGAssembly[1]: Evaporator (PCE) [7] -> Inlet of HRSGAssembly[1]: SCR/CO Catalyst (HRSG) - Horizontal HRSG [49] Gas/Air 15
13 - Steam outlet of HRSGAssembly[1]: Evaporator (PCE) [7] -> Steam inlet of HRSGAssembly[1]: Superheater (PCE) [33] Water 1882.71
14 - Gas outlet of HRSGAssembly[1]: Evaporator (PCE) [8] -> Inlet of Duct [51] Gas/Air 14.79
15 - Steam outlet of HRSGAssembly[1]: Evaporator (PCE) [8] -> Steam inlet of HRSGAssembly[1]: Superheater (PCE) [34] Water 234.98
16 - Outlet of Fuel Compressor [9] -> Fuel inlet of Gas Turbine (GT PRO) [11] Fuel 435
17 - Outlet of Fuel Source [10] -> Inlet of Fuel Compressor [9] Fuel 300
18 - Air outlet of Coil (PCE) [2] -> Air inlet of Gas Turbine (GT PRO) [11] Gas/Air 14.678
19 - Outlet of Gas/Air Source [13] -> Air inlet of Coil (PCE) [2] Gas/Air 14.696
20 - Outlet of Duct [12] -> Inlet of HRSGAssembly[1]: Steel Stack [48] Gas/Air 14.714
21 - Water outlet of HRSGAssembly[1]: Integral Deaerator (PCE) [14] -> Suction of Pump (PCE) [35] Water 17.2
22 - Outlet of Makeup / Blowdown [15] -> Water inlet of HRSGAssembly[1]: Integral Deaerator (PCE) [14] Water 17.2
23 - Outlet of Mixer [16] -> Inlet of STAssembly[1]: ST Group [31] Water 224.99
24 - Outlet of Pipe (PCE) [17] -> Coil inlet of Coil (PCE) [2] Water 49.58
25 - Outlet of Pipe (PCE) [18] -> Chilled inlet of Electric Chiller (PCE) [6] Water 34.1
26 - Outlet of Pipe (PCE) [19] -> Coolant inlet of Electric Chiller (PCE) [6] Water 29.75
27 - Outlet of Pipe (PCE) [20] -> Warm CW inlet of Wet Cooling Tower (PCE) [50] Water 18.74
28 - Outlet of Pipe (PCE) [21] -> Inlet of STAssembly[1]: ST Group [30] Water 1749.71
29 - Outlet of Pipe (PCE) [22] -> Inlet 2 of Mixer [16] Water 224.99
30 - Outlet of Pipe (PCE) [23] -> Inlet of Makeup / Blowdown [15] Water 17.2
31 - Discharge of Pump (PCE) [24] -> Inlet of Pipe (PCE) [17] - Fixed P Water 50
32 - Discharge of Pump (PCE) [25] -> Inlet of Pipe (PCE) [19] Water 30.77
The stream table lists P,T,m,h for each stream in the model. It is color-coded for easy navigation.
You can export this table to excel to make additional calculations, or to create your own graphical displays.



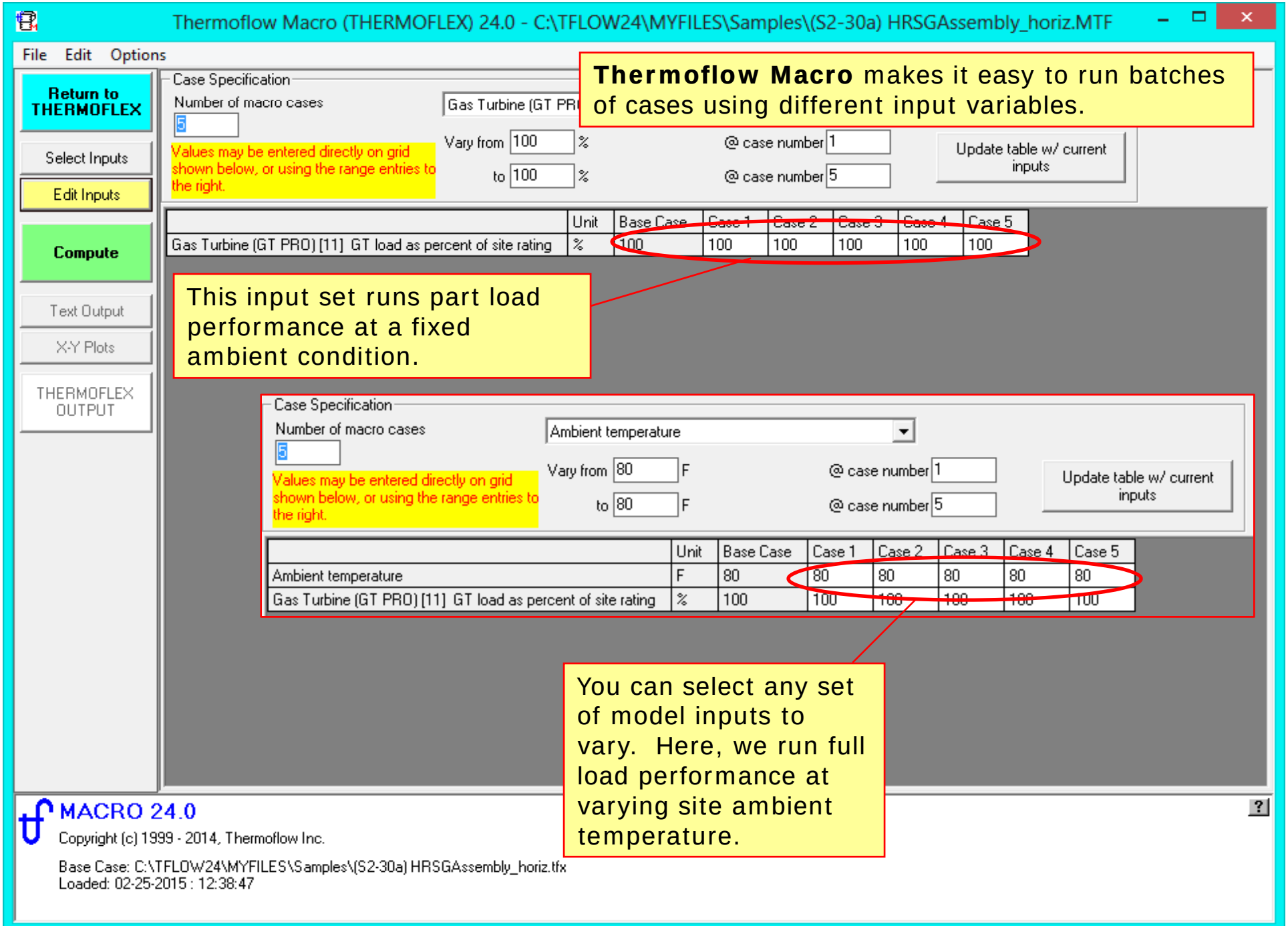
Common unit systems from around the world are available.

You can change program settings to suit your needs. For example, select from the following three steam property formulations.

Thermoflow Proprietary (STQUIK)

IFC-67 (previous ASME standard from 1967)

IAPWS-IF97 (current ASME standard from 1997)


Thermoflow Macro (THERMOFLEX) 24.0 - C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.MTF
File Edit Options
Return to THERMOFLEX
Select Inputs
Edit Inputs
Compute
Text Output
X-Y Plots
THERMOFLEX OUTPUT
Thermoflow Macro makes it easy to run batches of cases using different input variables.
Case Specification
Number of macro cases
5
Values may be entered directly on grid shown below, or using the range entries to the right.
Gas Turbine (GT PR
Vary from 100 %
to 100 %
@ case number 1
@ case number 5
Update table w/ current inputs
Unit Base Case Case 1 Case 2 Case 3 Case 4 Case 5
Gas Turbine (GT PRO) [11] GT load as percent of site rating % 100 100 100 100 100 100
This input set runs part load performance at a fixed ambient condition.
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 80 F
to 80 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
Ambient temperature F 80 80 80 80 80 80
Gas Turbine (GT PRO) [11] GT load as percent of site rating % 100 100 100 100 100 100
You can select any set of model inputs to vary. Here, we run full load performance at varying site ambient temperature.
MACRO 24.0
Copyright (c) 1999 - 2014, Thermoflow Inc.
Base Case: C:\TFLOW24\MYFILES\Samples\(S2-30a) HRSGAssembly_horiz.tfx
Loaded: 02-25-2015 : 12:38:47

Plant Summary and the two subsequent tabs display pre-formatted output reports.

All tables can be exported to Excel directly or saved as a .CSV file for use with other software.

The “General” tabs allow you to select which data (outputs as well as inputs) to display on that specific table.

This button lets you see the entire set of THERMOFLEX outputs for a given case.

X-Y plots can be created to show relations between any set of variables. Here the plant’s net heat rate versus GT load is shown.

Please contact Thermoflow for further information and a Demonstration CD.

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