

## WHAT IS GT PRO?



**GT PRO** is a highly automated system design tool – a heat balance program specifically intended for design of gas turbine combined cycle power plants and cogeneration systems.

- Use **GT PRO** to explore and design **combined cycles**, **cogeneration systems**, and **simple cycle gas turbine power plants**.
- In combination with **PEACE** (Plant Engineering and Cost Estimator), **GT PRO** provides engineering details and cost estimation.
- **GT PRO** performs design-point calculations only – use **GT MASTER** for simulations of part loads or other off-design conditions.

## What is PEACE?

**PEACE** is Thermoflow's **Plant Engineering And Cost Estimator**, an additional tool that works in conjunction with Thermoflow's heat balance design and simulation programs.

## What does PEACE add to GT PRO?

- **PEACE** brings regional costs, engineering details, and concerns beyond the heat balance performance into a comprehensive description of the plant.
- **PEACE** provides graphic and tabular information about size, weight, and cost of plant equipment.
- **PEACE** produces a detailed total plant cost estimate.
- **PEACE** provides a simple *pro forma* financial projection to estimate cash flows, return on investment, and break-even power cost.
- **PEACE** can be used to impose more detailed hardware effects upon heat balance simulations, particularly piping and pump hardware details.

## Inputs – General Arrangement

The **Navigator** column displays the major input topics. Topics in GT PRO are arranged vertically, and follow a hierarchy, progressing from top to bottom. Selections made in an upper (earlier) topic will condition the selections available in lower (later) topics.

**Tabs** are used as necessary to subdivide topics; green tabs include **PEACE** inputs

Every entry box has been initialized with a reasonable value. You never have to fill an empty box. Instead you edit just those that are of concern to you, trusting the others to have been logically selected.

The screenshot shows the 'Inputs - General Arrangement' window with the following components:

- Navigator Column:** A vertical list of topics including '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', 'Multiple Designs', 'Off Design', and 'Fully-Flexible Design'.
- Tabs:** A horizontal bar at the top with tabs for 'Site', 'Calculation Options', 'Main Steam Piping Losses', 'Miscellaneous Assumptions', 'Regional Costs', 'Site Characteristics', 'Buildings', 'Notes', and 'Change Cycle Type'.
- Input Fields:** A table of input parameters with values and units:
 

| Parameter                | Value | Unit |
|--------------------------|-------|------|
| source pressure          | 50    | psia |
| source temperature       | 59    | F    |
| nsate return pressure    | 50    | psia |
| nsate return temperature | 180   | F    |
| nsate return percentage  | 100   | %    |
| return pressure          | 50    | psia |
| return temperature       | 59    | F    |
- Schematic Diagram:** A diagram of a steam turbine cycle showing 'CW in' (cooling water inlet), 'Condensate' (condensate outlet), and 'CW out' (cooling water outlet).
- Methodology:** A section titled 'Methodology' with a radio button selected for '1. User's thermodynamic assumptions prevail over automatic hardware / engineering results'.
- Guidance:** A section titled 'Guidance' with the text 'Press F1 for help'.

# The program opens to the New Session topic

Select to begin a new design or to revise an existing one.

The screenshot displays the GT PRO software interface. On the left is a sidebar with a 'Navigator' pane containing a list of design topics: 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, Multiple Designs, Off Design, and Fully-Flexible Design. The 'New Session' option is highlighted in blue.

The main panel is divided into several sections:

- New Design:** Contains radio buttons for 'Setup wizard & start visual design' (selected), 'Setup wizard & start classic design', 'Plant Design Expert', and 'Standard defaults'.
- Existing File:** Includes a 'File list' radio button and a text box showing 'Most recent file - GTPRO.GTP'.
- Mode:** Includes radio buttons for 'GT PRO only' and 'GT PRO & PEACE' (selected).
- Approximate Plant Output:** Includes radio buttons for 'Up to 15 MW', '50 to 200 MW' (selected), '10 to 50 MW', and 'Above 200 MW'.
- Cost / Efficiency Balance:** Includes a checked box for 'Set automatically based on approximate plant output' and radio buttons for 'Lower cost', 'Intermediate' (selected), and 'Higher efficiency'.
- Primary Gas Turbine Fuel:** Includes a dropdown menu set to 'CH4' and a 'Modify Fuel' button. Below it, 'Sulphur weight % = 0' is displayed.
- General Plant Configuration:** Includes radio buttons for 'GT Only', 'GT & HRSG only (no ST)', 'GT, HRSG, and non-condensing ST', 'GT, HRSG, and condensing non-reheat ST' (selected), and 'GT, HRSG, and condensing reheat ST'. Below these are checkboxes for 'Include gasification (IGCC)', 'Include pre-combustion CO2 capture', 'Include post-combustion CO2 capture', and 'Use combustion engines instead of turbines'. A 'Desalination System' dropdown is set to 'None'.
- Methodology:** Includes radio buttons for '1. User's thermodynamic assumptions prevail over automatic hardware / engineering results' (selected) and '2. User's assumptions prevail in GT PRO, but hardware / engineering results prevail in GT MASTER'.

In the center of the main panel is a schematic diagram of a power cycle. It shows a 'Gas Turbine' (red trapezoid) connected to a 'Steam Turbine' (blue trapezoid). The steam turbine is connected to a 'Condenser' (grey cylinder). The condenser output goes through a 'Heater' (red cylinder) and then through 'HP' (High Pressure) and 'IP' (Intermediate Pressure) stages before returning to the gas turbine. A note on the right states: 'Left sketch is for illustration only. Steam turbine may have bleeds and additions. HRSG evaporator count and heat exchanger sequence may be modified. Various process streams may be established from ST and/or HRSG.'

At the bottom left, there is a 'Guidance' section with the text 'Press F1 for help' and two hand icons pointing to the 'Start Design' and 'Fully-Flexible Design' buttons.

Click on Start Design to continue.

# At the Start Design topic...

Refine the plant configuration by selecting the number of pressures at which your HRSG will produce steam, and indicating how that steam will be used.

Click any other topic to move on.  
Edit entries in any order you choose, then click **Compute**.  
The internal hierarchy for order of the inputs (top to bottom) will intervene only as necessary for consistency.

# At the Plant Criteria topic...

GT PRO 24.0 - C:\TFlow24\MyFiles\GT PRO.GTP

File View Options Window Excel Link Compare Files 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

Multiple Designs

Off Design

Fully-Flexible Design

**Site**

Calculation Options

Main Steam Piping Losses

Miscellaneous Assumptions

Regional Costs

Site Characteristics

Buildings

Notes

Change Cycle Type

Ambient temperature 59 F

Altitude 0 ft

Ambient pressure 14.7 psia

Ambient relative humidity 60 %

Ambient wet bulb temperature 51.48 F

Line frequency ☐ 50 Hz ☒ 60 Hz

Show ASHRAE Climate Data

Import Plant Criteria Data on green PEACE Tabs 5-7

Makeup water source pressure 50 psia

Makeup water source temperature 59 F

Process condensate return pressure 50 psia

Process condensate return temperature 180 F

Process condensate return percentage 100 %

Process water return pressure 50 psia

Process water return temperature 59 F

Site cooling water temperature

Site allowable cooling water temperature

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

0. None

Methodology

☒ 1. User's thermodynamic assumptions prevail over automatic hardware / engineering results

Of the several Tabs within this topic, the **Site** tab is of greatest importance to the thermal design.

Select the cooling system type of your choice.  
The figure illustrates and confirms your selection.

Water Box

CW in

Condensate

CW out

# Visiting the Regional Costs tab...

File View Options Window Excel Link Compare Files 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

Multiple Designs

Off Design

Fully-Flexible Design

Site

Calculation Options

Main Steam Piping Losses

Miscellaneous Assumptions

**Regional Costs**

Site Characteristics

Buildings

Notes

Change Cycle Type

Method

☒ Simplified ☐ Detailed

Select region most representative of the project site

Within United States

- Alabama
- Alaska
- Arizona
- Arkansas
- California
- Colorado
- Connecticut
- Delaware
- District of Columbia
- Florida
- Georgia
- Hawaii
- Idaho
- Illinois
- Indiana
- Iowa
- Kansas
- Kentucky**
- Louisiana
- Maine
- Maryland
- Massachusetts
- Michigan
- Minnesota
- Mississippi
- Missouri

Cost Multipliers

|                              | Actual | Suggested |
|------------------------------|--------|-----------|
| <b>Specialized equipment</b> | 1.05   | 1.06      |
| <b>Other equipment</b>       | 1.05   | 1.06      |
| <b>Commodity</b>             | 1.05   | 1.06      |
| <b>Labor</b>                 | 1.25   | 1.364     |

☒ Union rates ☐ Non-union rates

Currency

Currency symbol USD

Number of currency units per USD 1

**CAUTION:**

Click on any of the domestic (US) or international locations to view and then initialize values for Cost Multipliers, which condition the GT PRO / PEACE cost estimation relative to the reference, generic US cost estimate.

# At the GT Selection topic ...

GT PRO 24.0 - C:\TFlow24\MyFiles\GTPRO.GTP

File View Options Window Excel Link Compare Files 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

Number of gas turbines: 1 ☐ Single shaft GT/ST configuration

Did you know that if you cannot find a particular engine:  
-> its nominal power may be outside the power range set below

Select a gas turbine from over 285 available engines, including all major vendors.

**Engine Selection Filter**

Show engines rated from 10 MWe Up to 220 MWe

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

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

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

| ID  | Manufacturer & Model | Shafts | RPM   | PR   | TIT F | TET F | Air Flow lb/s | Gen Power kWe | LHV HR BTU/kWh | LHV Eff % | Price*** MM\$ |
|-----|----------------------|--------|-------|------|-------|-------|---------------|---------------|----------------|-----------|---------------|
| 231 | GE10                 | 1      | 11000 | 15.6 | 1970  | 897   | 104           | 11250         | 10965          | 31.1      | 5.6           |
| 150 | GE10                 | 2      | 11000 | 15.6 | 1970  | 900   | 104           | 11700         | 10665          | 32.0      | 5.8           |
| 1   | GE 5371PA            | 1      | 5100  | 10.0 | 1765  | 905   | 272           | 26555         | 11800          | 28.9      | 10.8          |
| 529 | GE GT-6B.03 (**)     | 1      | 5160  | 12.7 | -     | 1004  | 316           | 43566         | 10243          | 33.3      | 16.7          |
| 513 | GE GT-6B.03          | 1      | 5160  | 12.7 | 2100  | 1004  | 316           | 43715         | 10115          | 33.7      | 16.7          |
| 514 | GE GT-6B.03          | 1      | 5160  | 12.7 | 2100  | 1006  | 316           | 44220         | 10055          | 33.9      | 16.9          |
| 520 | GE GT-6F.03          | 1      | 5100  | 16.1 | 2400  | 1098  | 465           | 80650         | 9395           | 36.3      | 30.8          |
| 512 | GE GT-7E.03          | 1      | 3600  | 12.8 | 2100  | 1015  | 636           | 89830         | 10025          | 34.0      | 27.4          |
| 515 | GE GT-7E.03          | 1      | 3600  | 12.8 | 2100  | 1015  | 637           | 90500         | 9985           | 34.2      | 27.6          |
| 201 | GE GT-7F.03          | 1      | 3600  | 15.5 | 2420  | 1107  | 990           | 174560        | 9285           | 36.8      | 33.7          |
| 391 | GE GT-7F.03 (B)      | 1      | 3600  | 15.5 | 2420  | 1107  | 990           | 174750        | 9285           | 36.8      | 33.7          |
| 135 | GE                   |        |       |      |       |       |               |               |                | 37.2      | 33.8          |
| 519 | GE                   |        |       |      |       |       |               |               |                | 38.8      | 38.2          |

Tabulated ratings are at ISO conditions, with no inlet or exhaust pressure losses. Notes in the **Guidance** window add further description.

**General**

**Guidance**

GE GT-7E.03 - Revised 04-14-2014, estimated price updated May 2014.  
Standard Combustor (MNQC)  
Source : GE full load data GTP Web 4.1 04/14, Part load assumed similar to #512  
Change to nominal data : -0.91% to HR  
Max model errors in test range: Mex<0.5% kW<0.5% HR<0.5% Tex<5F (2.8C)  
Test range : 0 to 120 F (-18 to 49 C) full load dry  
Part load model with variable IGV control included



# Within the GT Inputs topic ...

GT PRO 24.0 - C:\FLOW24\MYFILES\GTPRO.GTP

File View Options Window Excel Link Compare Files 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
- Multiple Designs
- Off Design
- Fully-Flexible Design

**Gas Turbine Main Inputs**

☐ Include steam injection

☐ Include water injection

Fuel selection: CH4 Modify Fuel

☒ Include fuel compressor

Fuel line pressure: 250 psia

Filter pressure drop: 4 in H2O

Fuel delivery

**You can:**

- Select to inject water or steam.
- Reselect fuel (default is methane).
- Incorporate inlet air chilling, evaporative cooling, fogging or heating.
- Adjust model performance.
- Revise inlet and exhaust draft losses.
- Connect any GT heat rejection to steam cycle.

Diagram showing a gas turbine (ID515 GE GT-7E.03 (Physical Model)) connected to a duct and stack. The duct and stack draft loss is 2 in H2O. The total draft loss is 9 in H2O. A red arrow points from the filter pressure drop input to the gas turbine inlet.

View GT exhaust loss

Duct & stack draft loss: 2 in H2O

Total draft loss = 9 in H2O

Guidance

Press F1 for help

# At the ST-HRSG topic...

GT PRO 24.0 - C:\TFlow24\MTFILES\GTPRO.GTP

File View Options Window Excel Link Compare Files Help

Navigator

☒ HP process steam from **HP53** ☒ IP process steam from **IP52** ☐ LP process steam Steam generation dictated by **Pinch**

**New Session**

ST Pressures & Temperatures  
☒ Automatic ☐ User-defined

In Automatic mode, combined cycles are designed without supplementary firing to maximise efficiency. If you plan to duct fire for increased power in off-design, you should consider a lower design-point HP pressure for the unfired design to avoid excessive pressures when firing in off-design.

This is the place where main steam conditions and process export streams can be defined. As always, initial values are in place. Turbine inlet conditions are initialized logically by the Setup Wizard in accord with your initial settings.

HRSG Inputs  
 Water Circuits  
 HRSG Layout  
 Cooling System  
 ST Inputs  
 Environment  
 Other PEACE  
 Economics  
 Gasification  
 Desalination

**Compute**

Text Output  
 Graphics Output  
 PEACE Output  
 Multiple Designs  
 Off Design  
 Fully-Flexible Design

DA pressure 17.19 psia  
 to DA  
 P 17.19 psia  
 DA configuration  
 Integral DA/LPB

Illustrative sketch only.  
 Some layout details determined by numerical inputs.

Automatically install a duct burner and fire as needed to achieve superheater or reheater exit steam temperature

1050 psia  
 970 F  
 Stop Valve

P 130 psia  
 T 347.3 F  
 M 0 lb/s

P 50 psia  
 T 281 F  
 M 0 lb/s

P 50 psia  
 T 281 F  
 M 0 lb/s

1st sub  
 2nd sub

Main IP process

IP  
 HP

IPS exit  
 500 F

1025.2 F

Guidance  
 Press F1 for help

# HRSG Inputs

GT PRO 24.0 - C:\TFlow24\MTFILES\GTPRO.GTP

File View Options Window Excel Link Compare Files Help

Navigator

New Session

Start Design

Plant Criteria

GT Selection

GT Inputs

ST-HRSG

HRSG Inputs

Water Circuits

HRSG Layout

HRSG Main Inputs

Thermodynamic Design Assumptions

Hardware Design

Radiant Boiler

Miscellaneous

Equipment Options

Duct Burner Fuel

Gas turbine fuel

Modify fuel

Duct Burner

0. Not in plant

Radiant Boiler / Additional Duct Burner

Not in plant

Min. stack temperature 190 F

Min. approach to sulphur dewpoint 18 F

Steam Generation Dictated By

Pinch Mass flow

HRSG Duct Sizing Criteria

1. HRSG draft loss (Auto length & width)

HRSG-only draft loss 7 in H2O

Total GT exhaust loss 9 in H2O

LP Evaporator Circulation

IP Evaporator Circulation

HP Evaporator Circulation

Natural

HPE Exit T Specification

Approach subcooling

Pinch

27 F

Approach subcooling

7 F

Blowdown percentage

0.5 %

No blowdown recovery

Gas Flow Direction

Horizontal Vertical

Fresh-air dilution 0 %

Exhaust bypass 0 %

Guidance

The Main Inputs tab lets you set conditions of the duct burner, if used, and other key design parameters. 2<sup>nd</sup> and 3<sup>rd</sup> tabs provide more user control if desired, but can be confidently left to the well-reasoned defaults.

# Moving on to the Cooling System...

GT PRO 24.0 - C:\TFlow24\MyFiles\GT PRO.GTP

File View Options Window Excel Link Compare Files 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

Multiple Designs

Off Design

Fully-Flexible Design

Cooling System Main Inputs

Display T-Q Diagram

Condenser & Cooling Tower

Air Cooled Condenser

Condensate Options

Equipment Options

Cooling System Design Method Automatic

Condenser pressure 0.8532 psia

hotwell temperature = 5 F

Hot CW T = 91.48 F

Cooling water temperature rise 25 F

Cold CW T = 66.48 F

Return water approach to wet bulb 15 F

Hotwell subcooling 0 F

T = 96.48 F

CW Pump

Cond Fwd Pump

to HRSG

Cooling Tower Air

Specify wet bulb DT 34 F

Specify L/G ratio 1.25

RH @ wet CT exit 100 %

Cooling tower inlet air Same as ambient

Ambient dry bulb 59 F

Ambient wet bulb 51.48 F

Ambient relative humidity 60 %

Cooling Water

Fresh water

Sea water

Click on the Design Method selector if you wish to exert more control upon the cooling system's design parameters. By default, parameters will be set automatically, in accord with the ambient conditions and your Cost/Efficiency setting.

Guidance

# Looking at the ST Inputs topic...

GT PRO 24.0 - C:\TFlow24\MT FILES\GT PRO.GTP

File View Options Window Excel Link Compare Files 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

Multiple Designs

Off Design

Fully-Flexible Design

ST Main Inputs

Thermodynamic Design

Group Design

Exhaust End Design

ST Leaks

Steam Seal System

Generator

Equipment Options

Number of steam turbines

Automatic

User-defined

1

High Pressure Turbine Ports

Main HPT bleed

Secondary HPT bleed

HPT steam addition

Low Pressure Turbine Ports

Main LPT bleed

Extra LPT bleeds

Secondary LPT bleed

LPT steam addition

Casing Configuration

Crossover pressure

50 psia

0. Automatic

P 615.4 psia

T 1000 F

M 0 lb/s

P 50 psia

T 1000 F

M 0 lb/s

Main HPT bleed

1st sub

2nd sub

P 615.4 psia

T 1000 F

M 0 lb/s

P 615.4 psia

T 1000 F

M 0 lb/s

ST equipped with over-flow bypass

1050 psia

970 F

130 psia

0.8532 psia

2nd sub

1st sub

P 50 psia

T 1000 F

M 0 lb/s

P 50 psia

T 1000 F

M 0 lb/s

Main LPT bleed

Process streams supplied solely by extraction from the steam turbine are defined here. Other details of the turbine can be edited in the underlying tabs.

Guidance

Press F1 for help

# GT PRO Outputs

GT PRO 24.0 - C:\TFLOW24\MYFILES\GTPRO.GTP

File View Edit Options Window Excel Link Compare Files Help

Navigator ☐ **System** Gas Turbine HRSG Steam Turbine Cooling System Environment Gasification Desalination Miscellaneous

**New Session** Plant Summary Summary Table Stream Table Gas Pressure Losses Exergy Analysis Notes Messages

GT PRO 24.0 Seti  
 0 02-26-2015 16:46:07 file=C:\  
 Program revision date: Novemb  
 Plant Configuration: GT, HRSG  
 One GE GT-7E.03 Engine (Phy  
 Steam Property Formulation: IFC-67

Three categories of outputs – **Text**, **Graphics**, and **PEACE**, are provided, each with multiple tabs to help you quickly find the results you need.

| 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)   | 88900           |        | 10107                 |      | 33.76            |       |
| Steam Turbine(s) | 47393           |        |                       |      |                  |       |
| Plant Total      | 136292          | 133356 | 6593                  | 6738 | 51.76            | 50.64 |

| PLANT EFFICIENCIES |                        |   |                                      |
|--------------------|------------------------|---|--------------------------------------|
| PURPA efficiency   | CHP (Total) efficiency | Power gen. eff. on chargeable energy, % | Canadian Class 43 Heat Rate, BTU/kWh |
| %                  | %                      |   |                                      |
| 50.64              | 50.64                  | 50.64                                   | 7315                                 |

GT fuel HHV/LHV ratio = 1.11

GT fuel HHV  
 total plant fu  
 fuel HHV ch  
 fuel LHV ch  
 total energy  
 energy char

The last four buttons let you:

- (1) Produce a series of related designs begun with the current file.
- (2) Begin simulation of the present design, under different conditions, using **GT MASTER**.
- (3) Import the model using **THERMOFLEX**.
- (4) Produce related designs using the E-LINK Microsoft Excel macro.

|          | Gross power output, kW | Gross LHV efficiency, % | Gross LHV Heat Rate BTU/kWh | Exh. flow lb/s | Exh. temp. F |
|----------|------------------------|-------------------------|-----------------------------|----------------|--------------|
| per unit | 88900                  | 33.76                   | 10107                       | 642            | 1025         |

Compute

Text Output  
 Graphics Output  
 PEACE Output  
 Multiple Designs  
 Off Design  
 Fully-Flexible Design  
 Run from Excel

# GT PRO Text Output

GT PRO 24.0 - C:\FLOW24\MYFILES\GTPRO.GTP

File View Edit Options Window Excel Link Compare Files Help

Navigator ☐ **System** Gas Turbine HRSG Steam Turbine Cooling System Environment Gasification Desalination Miscellaneous

**New Session** Plant Summary Summary Table **Stream Table** Gas Pressure Losses Exergy Analysis Notes Messages

**GT PRO Streams**

|   | P      | T      | h         | h*        | M      | s              | Exergy         |
|---|--------|--------|-----------|-----------|--------|----------------|----------------|
|   | psia   | F      | BTU/lb    | BTU/lb    | lb/s   | BTU/lb-R       | BTU/lb         |
| Note: This is a fixed format table. Not all streams are applicable to current heat balance. |        |        | Ref @ 32F | Ref @ 77F |        | H2O: ref @ 32F | Ref @ 77F      |
| Plant Configuration: GT, HRSG, and condensing non-reheat ST                                 |        |        | / Water   | / Vapor   |        | Gas: ref @ 77F | Water as vapor |
| Cycle Type = 6  |        |        |           |           |        |                |                |
| Steam Property Formulation: IFC-67  |        |        |           |           |        |                |                |
| 1 Ambient conditions  | 14.7   | 59.0   | 13.31     | -4.36     | 630.24 | -0.0083        | 0.07           |
| 2 Air after inlet heater or chiller   | 14.55  | 59.0   | 13.31     | -4.36     | 630.24 | -0.0083        | -0.29          |
| 3 GT compressor inlet air (per GT)  | 14.55  | 59.0   | 13.31     | -4.36     | 630.24 | -0.0083        | -0.29          |
| 4 GT compressor discharge (per GT)  | 186.4  | 684.5  | 167.60    | 149.94    | 581.72 | 0.1857         | 143.91         |
| 5 GT turbine inlet (per GT)   | 178.9  | 2101.9 | 630.51    | 565.37    | 592.32 | 0.4196         | 431.63         |
| 6 GT exhaust, after turbine diffuser (per GT)   |        |        |           |           |        | 0.635          | 107.20         |
| 7 Compressor bleed to outside process (per GT)  |        |        |           |           |        | 0.083          | -0.29          |
| 8 GT fuel (per GT), after comp. but bef heating   |        |        |           |           |        |                | 21665.44       |
| 9 Steam injection to GT combustor (all GT's)  |        |        |           |           |        | 0.186          | 454.26         |
| 10 GT injection water stream  | 650    | 59.0   | 28.90     | -1066.39  | 0.00   | 0.0534         | 2.22           |
| 11 GT compressor leakage stream   | -      | -      | -         | -         | 0.00   | -              | -              |
| 12 Compressor water injection, Sprint engines   | -      | -      | -         | -         | -      | -              | -              |
| 13 Steam inj. to LP turbine (total, all GT's)   | 215    | 450.0  | 1238.48   | 143.19    | 0.00   | 1.584          | 390.40         |
| 14 Stack gas  | 14.7   | 230.3  | 100.01    | 38.46     | 641.84 | 0.0627         | 4.64           |
| 15 HP steam to HPT, aft desup, bef stop vlv   | 1050   | 970.0  | 1486.84   | 391.54    | 79.93  | 1.635          | 611.34         |
| 16 HP steam to HPT, after pipe, before desup  | 1050   | 970.0  | 1486.84   | 391.54    | 79.93  | 1.635          | 611.34         |
| 17 HP steam to HPT, before HP pipe  | 1084.1 | 973.7  | 1487.84   | 392.54    | 79.93  | 1.632          | 613.76         |
| 18 HPS3 exit steam  | 1084.1 | 973.7  | 1487.84   | 392.54    | 79.93  | 1.632          | 613.76         |
| 19 HPS3 inlet steam   | 1122.1 | 558.7  | 1188.16   | 92.86     | 79.93  | 1.377          | 451.20         |
| 20 HPS2 exit steam  | 1122.1 | 558.7  | 1188.16   | 92.86     | 79.93  | 1.377          | 451.20         |
| 21 HPS2 inlet steam   | 1122.1 | 558.7  | 1188.16   | 92.86     | 79.93  | 1.377          | 451.20         |
| 22 HPS1 exit steam  | 1122.1 | 558.7  | 1188.16   | 92.86     | 79.93  | 1.377          | 451.20         |
| 23 HPS1 inlet steam   | 1122.1 | 558.7  | 1188.16   | 92.86     | 79.93  | 1.377          | 451.20         |
| 24 HPS0 exit steam  | 1122.1 | 558.7  | 1188.16   | 92.86     | 79.93  | 1.377          | 451.20         |
| 25 HPS0 inlet steam   | 1122.1 | 558.7  | 1188.16   | 92.86     | 79.93  | 1.377          | 451.20         |

Select from the Tabs above to view the category of text output of interest.

Compute

Text Output

Graphics Output

PEACE Output

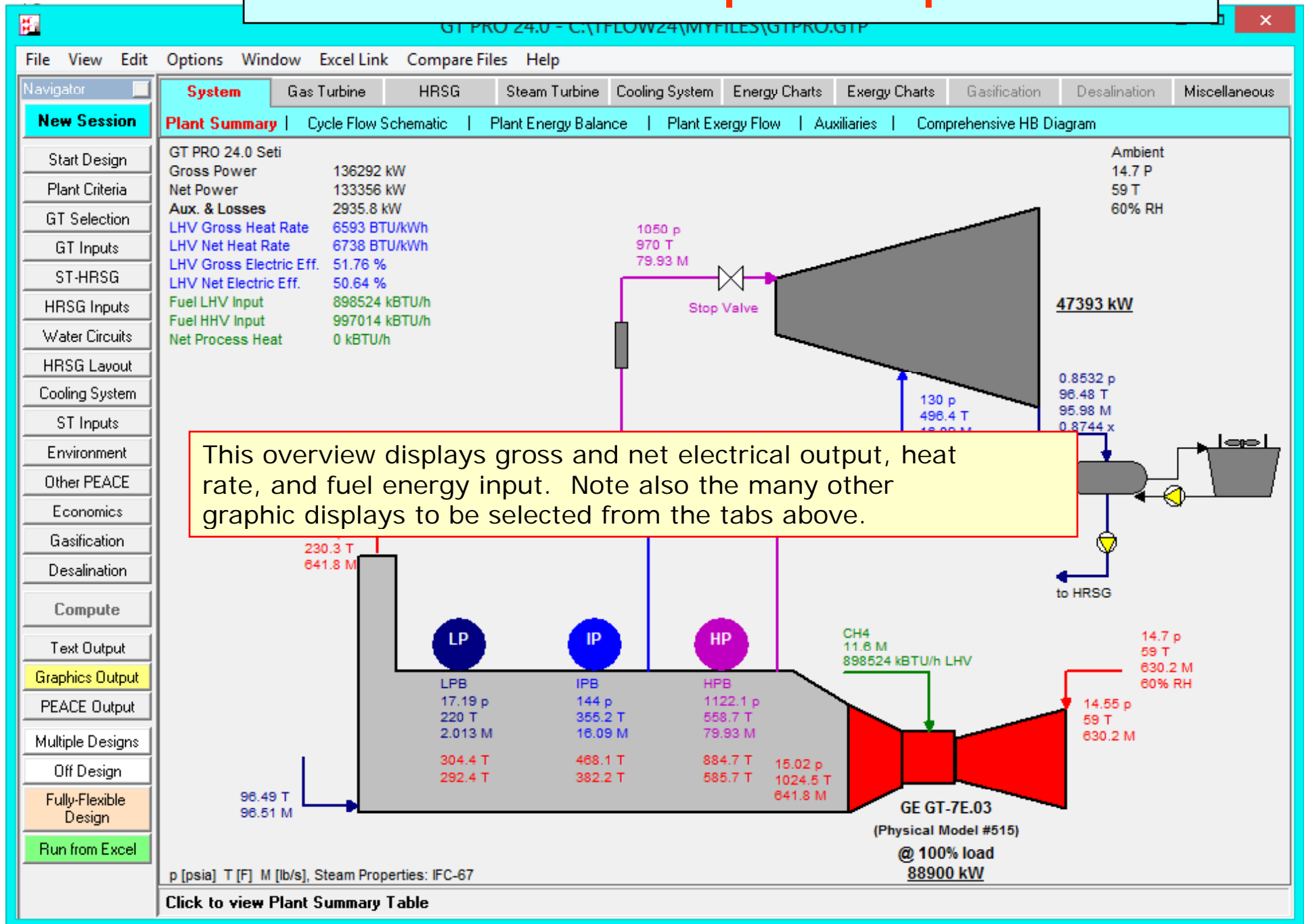
Multiple Designs

Off Design

Fully-Flexible Design

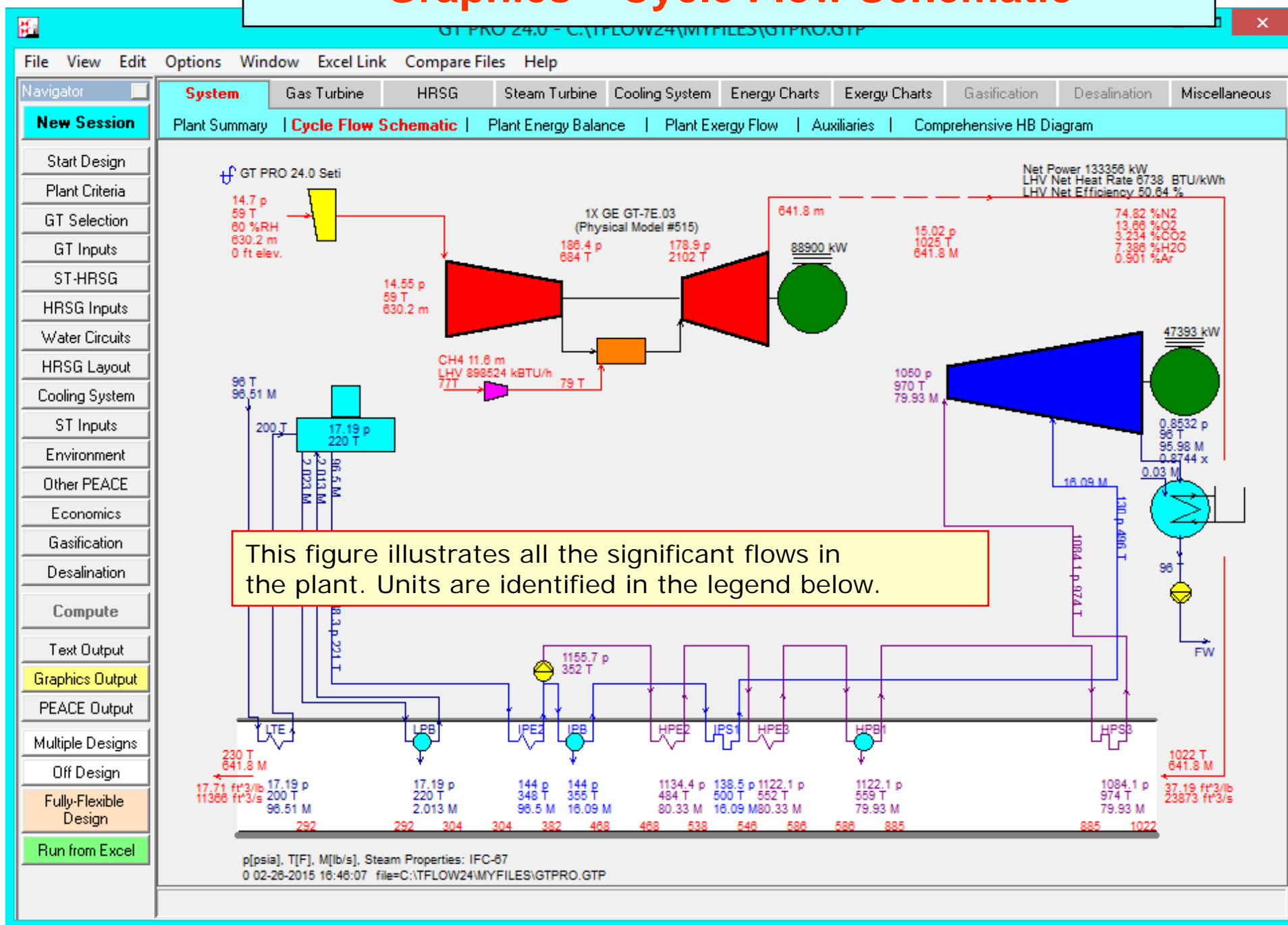
Run from Excel

# GT PRO Graphics Output

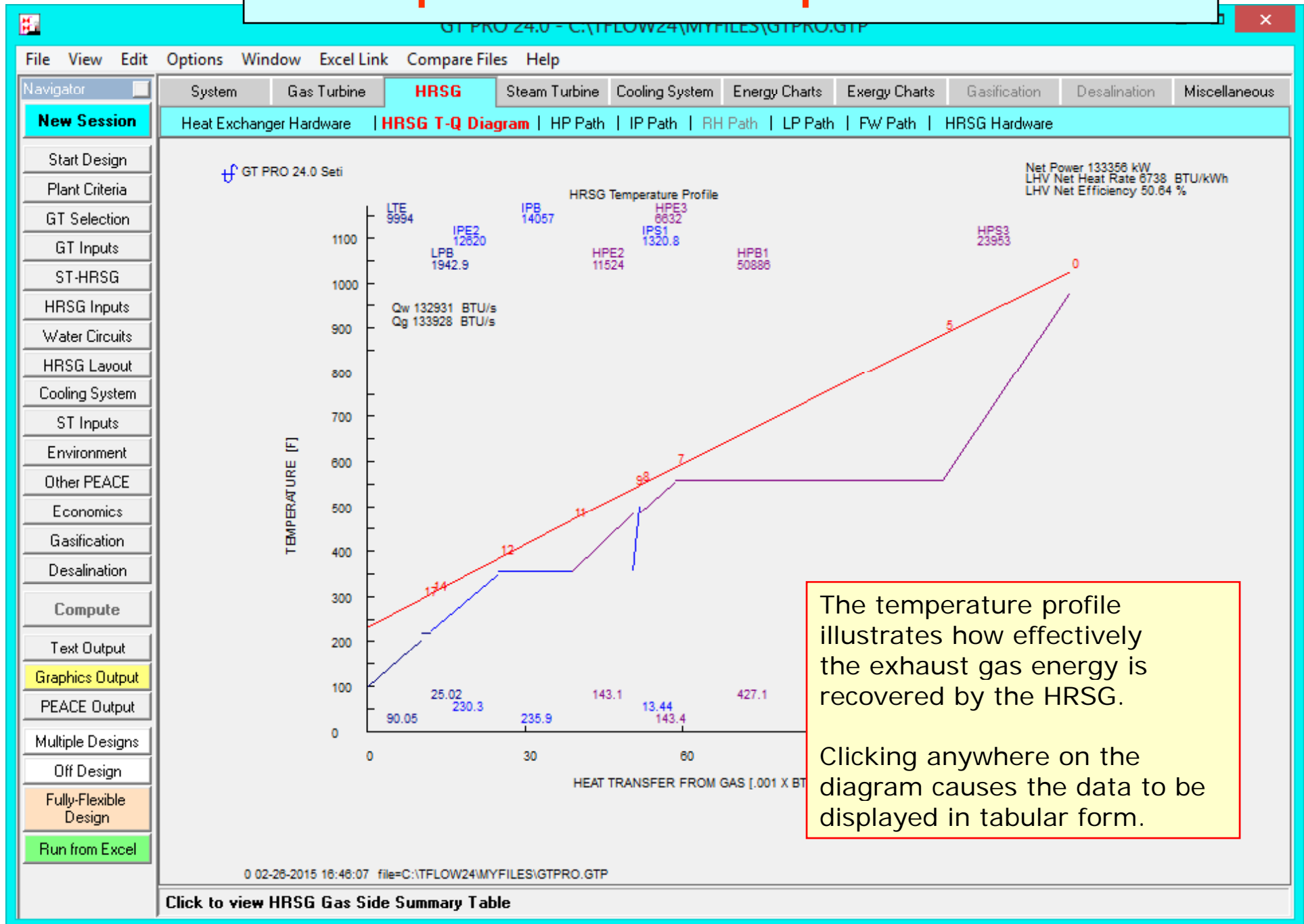




# Graphics – Cycle Flow Schematic



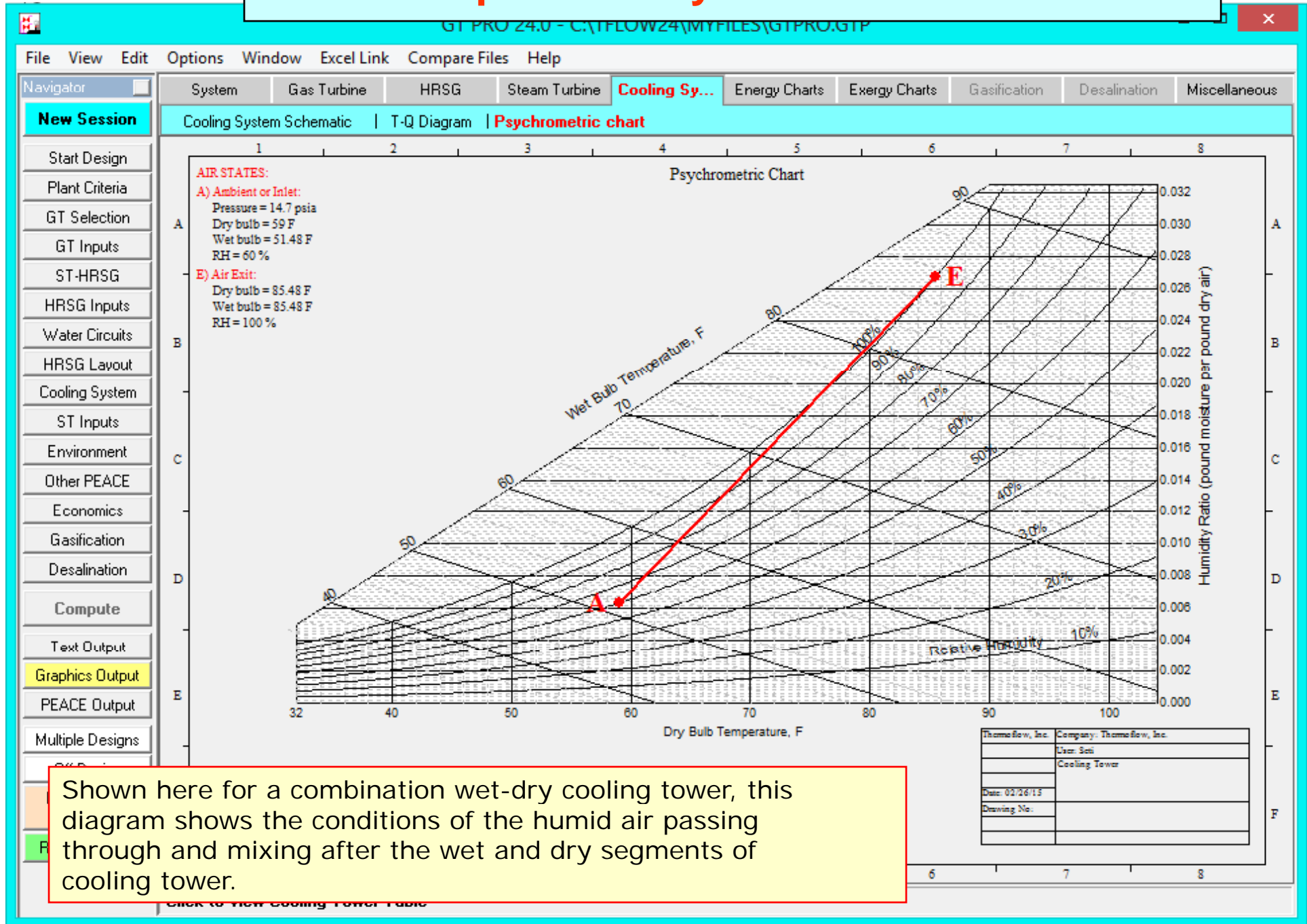
# Graphics – HRSG Temperature Profile



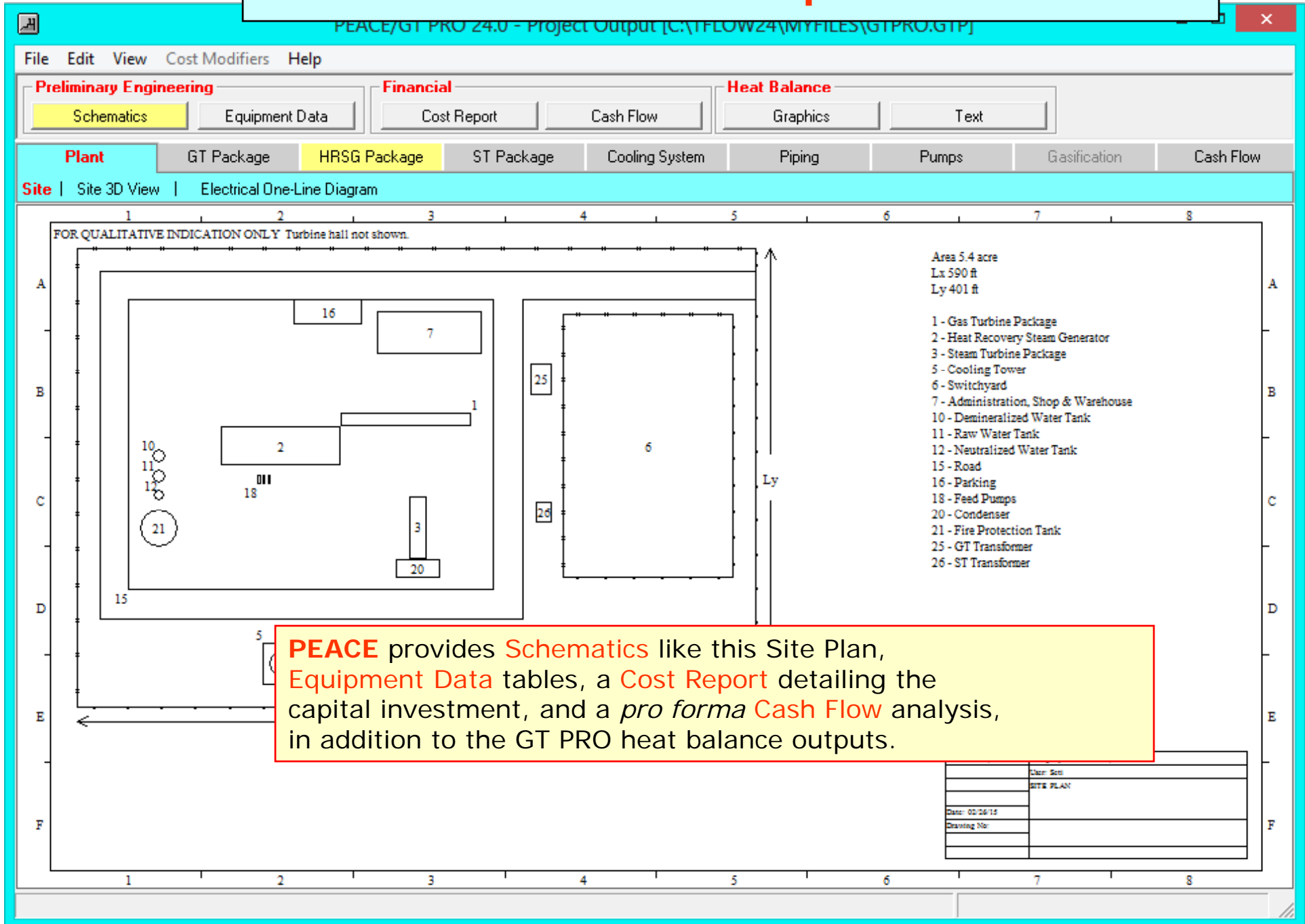
The temperature profile illustrates how effectively the exhaust gas energy is recovered by the HRSG.

Clicking anywhere on the diagram causes the data to be displayed in tabular form.

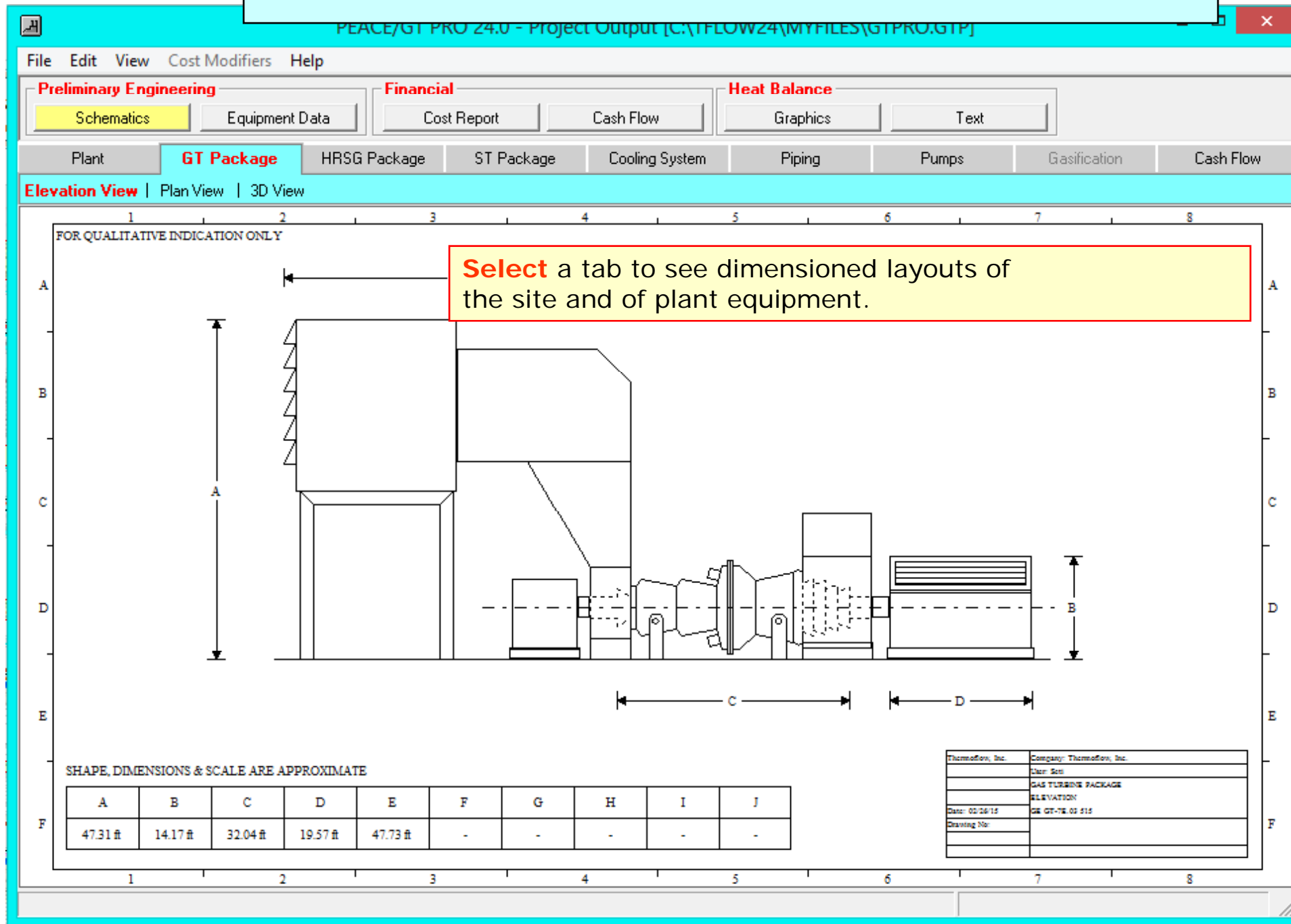
# Graphics – Psychrometric Chart



# PEACE Outputs



# PEACE Schematics



# PEACE Equipment Data

PEACE/GT PRO 24.0 - Project Output [C:\TFLOW24\MT FILES\GT PRO.GTP]

File Edit View Cost Modifiers Help

**Preliminary Engineering** **Financial** **Heat Balance**

Schematics **Equipment Data** Cost Report Cash Flow Graphics Text

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

**Gas Turbine | Chiller**

**Estimated Gas Turbine Data**

**Number of units** 1

**1. Nominal Gas Turbine Description & Performance Data (per unit)**

|   |                |
|---|----------------|
| Model   | GE GT-7E.03    |
| Dry Low NOx Combustion System is Available                      | Yes            |
| Engine Specification is Currently Offered New from Manufacturer | Yes            |
| Generator Output  | 90500 kW       |
| LHV Heat Rate @ Generator Terminals                             | 9985 BTU/kWh   |
| LHV Efficiency @ Generator Terminals                            | 34.17 %        |
| Compressor Inlet Airflow  | 636.5 lb/s     |
| Exhaust Temperature   | 1015 F         |
| Firing Temperature  | 2100 F         |
| Compressor Pressure Ratio                                       | 12.8           |
| Number of Shafts  | 1              |
| Engine Output Shaft Speed                                       | 3,600 RPM      |
| Engine Output Shaft Drive                                       | No             |
| Generator Efficiency  | 98.5 %         |
| Gas Turbine Package Price                                       | 29,532,000 USD |

**2. Site Specific Gas Turbine Performance Data (per unit)**

|                                      |               |
|--------------------------------------|---------------|
| Generator Output                     | 88900 kW      |
| LHV Heat Rate @ Generator Terminals  | 10107 BTU/kWh |
| LHV Efficiency @ Generator Terminals | 33.76 %       |
| Compressor Inlet Airflow             | 630.2 lb/s    |
| Exhaust Temperature                  | 1024.5 F      |
| Estimated Firing Temperature         | 2101.9 F      |
| Compressor Pressure Ratio            | 12.81         |

For each of the equipment categories, selectable by the tabs visible here, these tables indicate size, weight, and nameplate specifications.

# PEACE Cost Report

PEACE/GT PRO 24.0 - Project Output [C:\T\FLOW24\MT\FILES\GTPRO.GTP]

File Edit View Cost Modifiers Help

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

Soft & Miscellaneous Costs Gasification Plant Desalination Plant CO2 Capture Plant

Mechanical Electrical Assembly & Wiring Buildings Engineering & Plant Startup

**Project Cost Summary** Specialized Equipment Other Equipment Civil

| Project Cost Summary   | Reference Cost     | Estimated Cost     |                   |
|--|--------------------|--------------------|-------------------|
| <b>Power Plant:</b>  |                    |                    |                   |
| I Specialized Equipment  | 57,259,000         | 60,121,000         | USD               |
| II Other Equipment   | 4,271,000          | 4,484,000          | USD               |
| III Civil  | 7,689,000          | 8,762,000          | USD               |
| IV Mechanical  | 7,436,000          | 8,746,000          | USD               |
| V Electrical Assembly  | 2,501,000          | 2,954,000          | USD               |
| VI Buildings & Structures  | 3,957,000          | 4,550,000          | USD               |
| VII Engineering & Plant Startup  | 8,280,000          | 8,296,000          | USD               |
| Gasification Plant   | NA                 | NA                 |                   |
| Desalination Plant   | NA                 | NA                 |                   |
| CO2 Capture Plant  | NA                 | NA                 |                   |
| <b>Subtotal - Contractor's Internal Cost</b>                           | <b>91,393,000</b>  | <b>97,914,000</b>  | <b>USD</b>        |
| VIII Contractor's Soft & Miscellaneous Costs                           | 18,723,000         | 20,794,000         | USD               |
| <b>Contractor's Price</b>  | <b>110,116,000</b> | <b>118,709,000</b> | <b>USD</b>        |
| IX Owner's Soft & Miscellaneous Costs                                  | 9,910,000          | 10,684,000         | USD               |
| <b>Total - Owner's Cost (1 USD per US Dollar)</b>                      | <b>120,027,000</b> | <b>129,392,000</b> | <b>USD</b>        |
| <b>Nameplate Net Plant Output</b>                                      | <b>133</b>         | <b>133</b>         | <b>MW</b>         |
| <b>Price per kW - Contractor's</b>                                     | <b>825.7</b>       | <b>890.2</b>       | <b>USD per kW</b> |
| <b>Cost per kW - Owner's</b>   | <b>900</b>         | <b>970.3</b>       | <b>USD per kW</b> |
| * Cost estimates as of April 2014.                                     |                    |                    |                   |
| ** Land cost, utility connection cost, and spare parts costs are zero. |                    |                    |                   |
| The user may want to edit those inputs for better cost estimates.      |                    |                    |                   |

Note: Totals may not tally due to round-off. Currency conversion: 1 USD per US Dollar

Project Summary is shown. Tabs give individual breakdown of costs. Note the two columns: Reference and Estimated Cost.

Click on **Cash Flow** to see a *pro forma* financial projection.

# PEACE Cash Flow

PEACE/GT PRO 24.0 - Project Output [C:\T\FLOW24\MTFILES\GTPRO.GTP]

File Edit View Cost Modifiers Help

**Preliminary Engineering** **Financial** **Heat Balance**

Schematics Equipment Data Cost Report **Cash Flow** Graphics Text

**Financial Summary** Cash Flow USD

| Financial Summary  |             |                     |
|--|-------------|---------------------|
| <b>Caution! These results are based on a single set of nameplate plant performance data applied for user-input number of operating hours per year.</b> |             |                     |
| Annual Electricity Exported  | 867         | 10 <sup>6</sup> kWh |
| Annual Steam Exported  | 0           | GBTU                |
| Annual Fuel Imported   | 5,840       | GBTU LHV            |
| Annual Water Imported  | 225.6       | 10 <sup>6</sup> gal |
| Annual CO2 Emission  | 372.3       | kton                |
| Annual Desal Water Exported  | 0           | MM imperial gal.    |
| Annual Hydrogen Exported   | 0           | GBTU LHV            |
| Annual Syngas Exported   | 0           | GBTU LHV            |
| Annual CO2 Captured  | 0           | kton                |
| Annual CO2 Capture Solvent Consumed  | 0           | kton                |
| Total Investment   | 129,392,000 | USD                 |
| Specific Investment  | 970.3       | USD per kW          |
| Initial Equity   | 38,818,000  | USD                 |
| Cumulative Net Cash Flow   | 252,111,000 | USD                 |
| Internal Rate of Return on Investment (ROI)  | 11.725      | %                   |
| Internal Rate of Return on Equity (ROE)  | 20.529      | %                   |
| Years for Payback of Equity  | 5.69        | years               |
| Net Present Value  | 44,824,000  | USD                 |
| Break-even Electricity Price @ Input Fuel Price (i.e. Levelised Cost of Electricity)   | 0.0582      | USD/kWhr            |
| Break-even Fuel L  |             | MMBTU               |

This **Financial Summary** table displays the overall results of the *pro forma* **Cash Flow** projection detailed in the subsequent tab.

In very little time, you can use these results to explore the influence of design decisions on plant economic performance.

Note: Totals may not tally due to round-off. Currency conversion: 1 USD per US Dollar