

# Survey of DER/CHP Software

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# Survey of DER/CHP Software

- Identify and summarize available software that evaluates or helps design DER/CHP applications for buildings, campuses, industry
- Survey does not address non-CHP building design or simulation software (e.g., Trane Trace, Carrier HAP, EnergyPlus)
- Survey does not include private or in-house tools (e.g., FEMP spreadsheet screening analyses)
- Packages must include economic as well as technical elements
- Categorize DER/CHP software packages by:
  - Intended use
  - Type of calculations
  - Analysis duration and time step
  - DER/CHP technologies
  - Data libraries
  - Types of CHP processes
  - Cost and availability

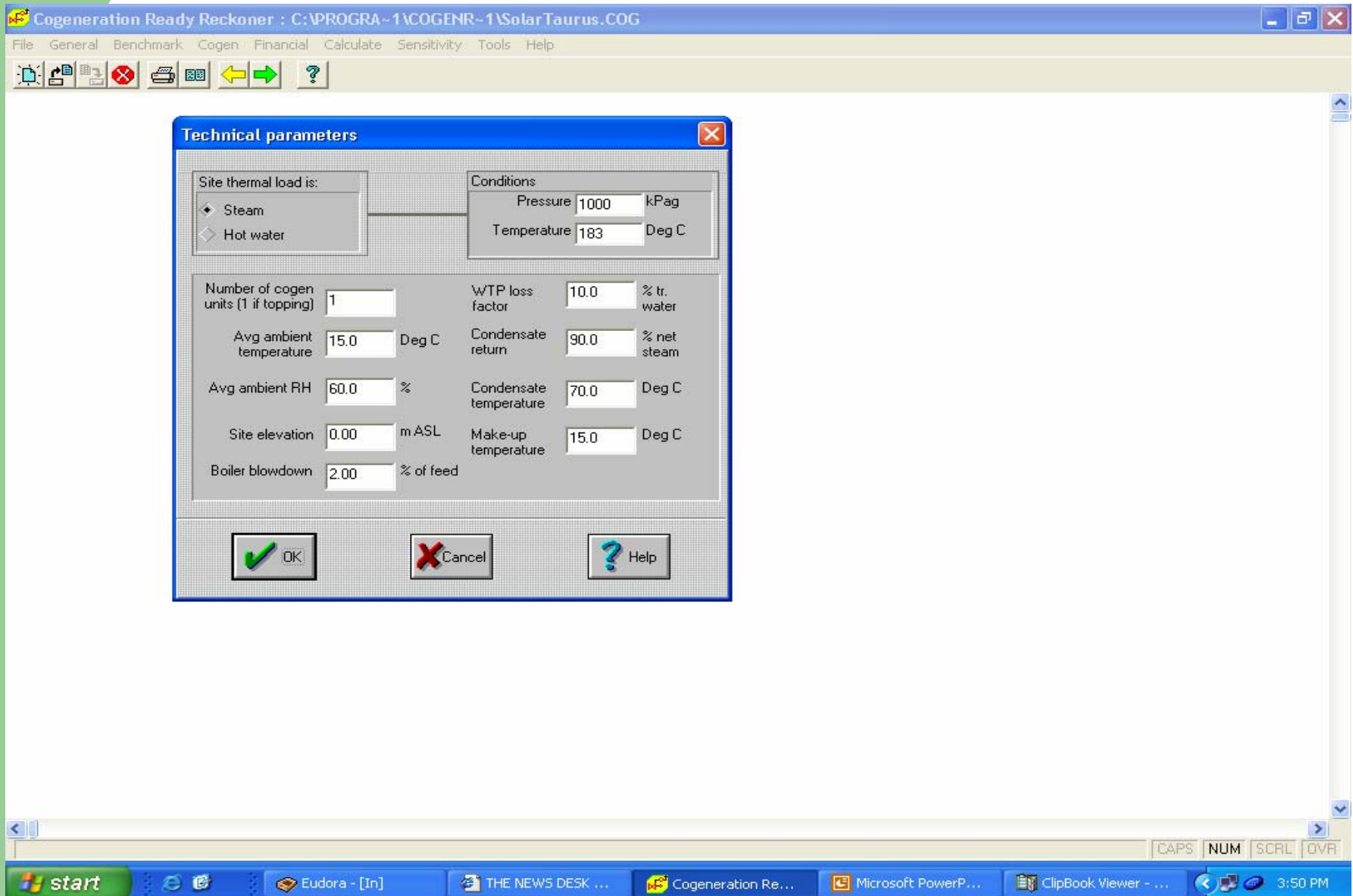
# Software Packages Evaluated

- **Cogeneration Ready Reckoner**
- **RECIPRO**
- **Plant Design Expert (PDE)**
- **Building Energy Analyzer**
- **D-Gen Pro**
- **BCHP Screening Tool**
- **Heatmap CHP**
- **GT Pro**
- **SOAPP-CT.25**

# Cogeneration Ready Reckoner

- Developed initially for Australian Department of Industry, Science, and Resources by Sinclair Knight Merz
- Primary use: Screening of industrial cogeneration applications
- Provides baseline comparison (grid electricity and separate steam boiler)
- Equipment data library: GT and recip engine gen sets
- CHP applications: Process steam, hot water, chilled water
- Analysis duration/time step: 20 years; up to monthly
- Economic analyses: cash flow, payback, NPV, IRR
- Cost: Free (download from <http://www.eere.energy.gov/der/chp/chp-eval2.html>)

# Input to Ready Reckoner Is Through Pop-Up Windows



# Ready Reckoner Output Is Tabular – On Screen, Printer, or File

Cogeneration Ready Reckoner : C:\PROGRA~1\COGENR~1\SolarTaurus.COG

File General Benchmark Cogen Financial Calculate Sensitivity Tools Help

Approx date: Jun-02 Jun-03 Jun-04 Jun-05 Jun-06 Jun-07 Jun-08 Jun-09 Jun-10 Jun-11 Jun-12 Jun-13 Jun-14 Jun-15 Jun-16  
 Year: 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14

**Cogen case annual flows**

	Unit	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
WHB steam	kt/a	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6
Aux boiler steam	kt/a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gross steam	kt/a	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6	64.6
Deaeration steam	kt/a	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58	4.58
Net steam	kt/a	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Gross Gen. Electricity	GWh	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
Process electricity usage	GWh	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
Parasitic electricity	GWh	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Export Electricity	GWh	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
Import Electricity	GWh	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Import Elec. Demand	MW	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83	4.83
Cogen Fuel usage	TJ/a HHV	397	397	397	397	397	397	397	397	397	397	397	397	397	397	397
Aux Boiler Fuel usage	TJ/a HHV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total Fuel usage	TJ/a HHV	397	397	397	397	397	397	397	397	397	397	397	397	397	397	397
Fuel demand	GJ/h HHV	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2	66.2
Ash	kt/a	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CO2 emissions	kt/a	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Net electrical efficiency	% HHV	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3
Net elec effic (f-to-p)	% HHV	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6	47.6
Net thermal efficiency	% HHV	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3	64.3
Condensate returned	kt/a	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0	54.0
Treated water	kt/a	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32	7.32
Raw water	kt/a	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05	8.05
WTP loss	kt/a	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732	0.732
Blowdown	kt/a	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32	1.32
Sewer	kt/a	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05	2.05

start | Eudora - [In] | THE NEWS DESK - Mic... | Cogeneration Ready ... | 3:37 PM

# Ready Reckoner Output

## **Separately for baseline (benchmark) and DER case:**

- Hourly and annual mass flows (e.g., steam, water, CO<sub>2</sub>)
- Hourly and annual fuel flows
- Hourly and annual electricity usage
- Annual operating, capital, and tax-related cash flows

## **In comparison of baseline to DER case:**

- Differential operating, capital, and tax-related cash flows
- Net present value (NPV)
- Internal rate of return (IRR)
- Simple payback
- NPV sensitivity charts for fuel and electricity prices, capital cost, discount rate

# RECIPRO

- Developed by Thermoflow, Inc.
- Primary use: Screening of small commercial/industrial cogeneration applications
- Add-in module to Excel 2000 spreadsheet software
- Provides baseline comparison (grid electricity and separate boiler)
- Equipment data library: Reciprocating engine gen sets
- CHP applications: Hot water, chilled water
- Analysis duration/time step: unlimited; monthly (with single daily load curve per month)
- Economic analyses: cash flow, NPV
- Cost: \$1,500. (<http://www.thermoflow.com/>)



# RECIPRO Input/Output Is On Excel Spreadsheet

The screenshot shows the Microsoft Excel interface with the RECIPRO 2.0 application running. The spreadsheet displays the following data:

Month	On Peak KWH	Off Peak KWH	On Peak USD/KWH	Off Peak USD/KWH	Demand KVA	Demand USD	Cost USD	Total Cost USD
Jan	275000	484000	0.0699	0.0699	1350	10000		63044
Feb	340320	560000	0.0683	0.0683	1400	10000		71492
Mar	323210	528000	0.0676	0.0676	1400	10000		67542
Apr	352356	606000	0.0687	0.0687	1400	10000		75839
May	371000	720000	0.0739	0.0739	1450	10000		90625
Jun	452000	779519	0.0761	0.0761	1800	10000		103719
Jul	452100	810000	0.0783	0.0783	1850	10000		108822
Aug	450000	850000	0.0787	0.0787	1840	10000		112310
Sep	450000	823500	0.0722	0.0722	1822	10000		101947
Oct	440000	710000	0.0638	0.0638	1502	10000		83370
Nov	332111	596000	0.0634	0.0634	1499	10000		68842
Dec	312110	550000	0.0651	0.0651	1399	10000		66123

The RECIPRO 2.0 Navigator Bar includes the following options:

- Electricity Table
- Heat Table
- Summer Months
- A/C Peak Hours
- General Table
- Financial Table
- Load Model Option
- Compute
- Output Options
- Engine Database
- Units Conversion

# RECIPRO Output

- Fuel flows
- Electricity production/consumption
- Heat production/consumption
- Monthly operating, capital, and tax-related cash flows for reference year

# Plant Design Expert (PDE)

- Developed by Thermoflow, Inc.
- Primary use: Preliminary design/screening of industrial cogeneration applications using gas turbines
- Provides baseline comparison (grid electricity and separate boiler)
- *Very* limited user input; most selections made by program
- Equipment data library: Gas turbine performance data
- CHP applications: Process steam, hot water
- Analysis duration/time step: unknown; annual
- Economic analyses: Simplistic IRR only
- Cost: \$3,000. (<http://www.thermoflow.com/>)
- Demo CD available

# PDE Input Is Through On-Screen Windows

PDE - Input Screen 3 of 10

File Options About PDE

### Power and Fuel Requirements

**Power plant type**

Pure Power  
 Cogeneration

**Principal fuel type**

Natural gas  
 Distillate oil

**Is there a limit on fuel supply rate?**

Yes  
 No

Limiting fuel supply rate (LHV basis)  MMBTU/hr

**Plant electric capacity**

Desired  MWe  
 Based on maximum available fuel

Demonstration Copy For Evaluation Only

< Back

Next >

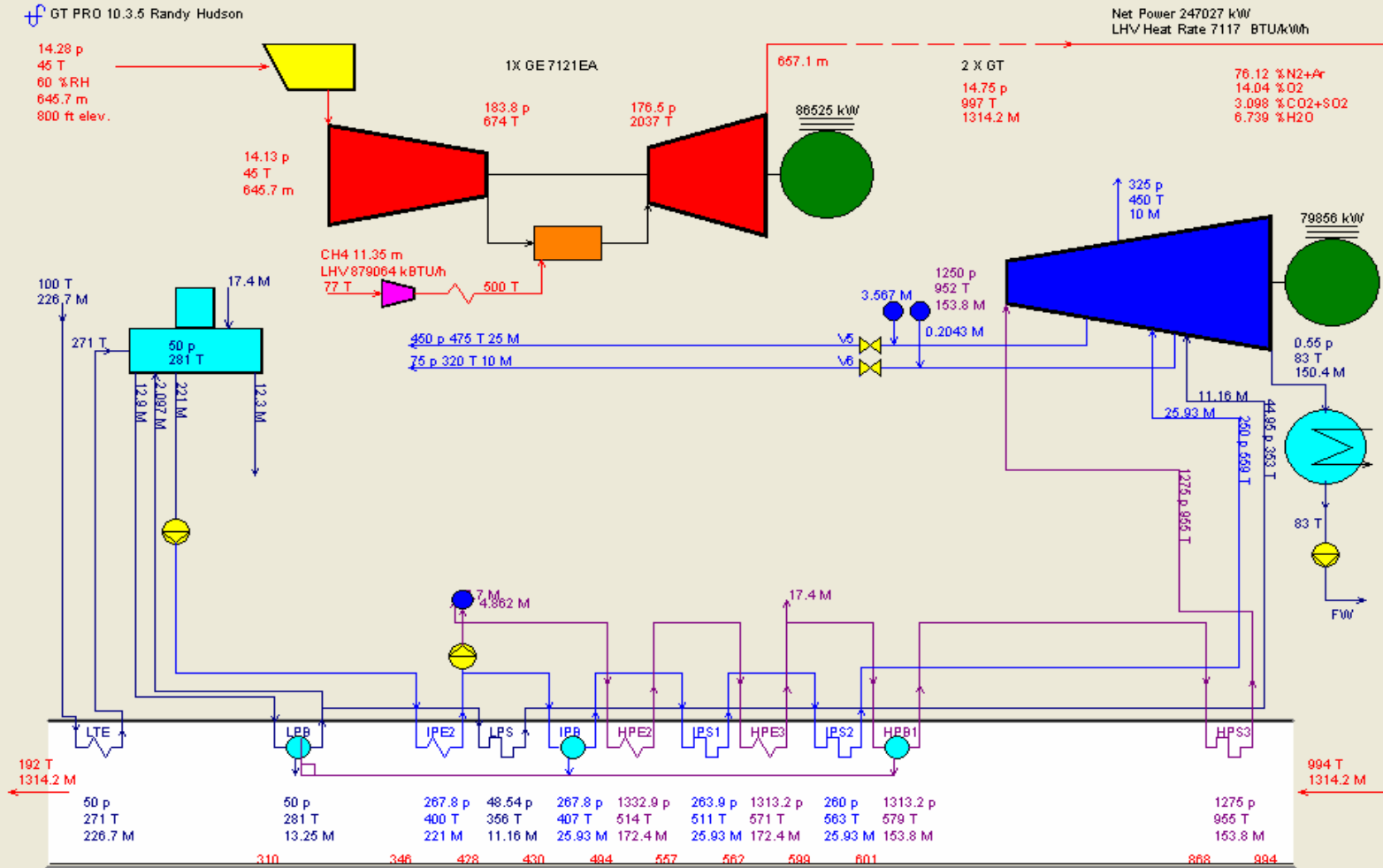
Compute

start Eudora - [In] Microsoft PowerP... Microsoft Excel - ... Plant Design Exp... PDE - Input Scr... 1:19 PM

# PDE Provides Text and Graphical Output

Cycle Flow Schematic - C:\TFlow7\MYFILES\PDTEMP.PDE

File Edit Options Display



p[psia], T[F], M[lb/s], Steam Properties: ThermoFlow - STQUIK

07-10-2002 11:32:37 File = c:\TFlow7\MYFILES\PDTEMP.PDE

# PDE Output

- Preliminary conceptual plant design
- Heat balance
- Power and energy output capacities
- Internal rate of return based on user-supplied cost data

# Building Energy Analyzer (BEA)

- Developed by InterEnergy Software (Gas Technology Institute)
- Primary use: Screening of CHP applications in commercial buildings using DOE-2 simulation engine
- Provides grid-based baseline comparison
- Data libraries: 8 types of generation equipment, 17 types of HVAC equipment, utility rates, weather, 15 specific building types (e.g., hospital, office, hotel, school, retail)
- CHP applications: Hot water, space heating/cooling, thermal storage, dehumidification
- Analysis duration/time step: maximum of 35 years; monthly
- Economic analyses: cash flow, payback, IRR
- Cost: \$800 (<http://www.interenergysoftware.com/>)

# Input to BEA Is Through On-Screen Windows

BEA - PG - Input Module File ;

File Edit Help

## BUILDING ENERGY ANALYZER

Geographical Location		Application Size and Type		more
State	Illinois	Chicago; O'hare Airport IL - Lat./Long. 42N/88W Summer 1%	60030 sq. ft	Retail Store; 1-story slab on grade construction typical of a larger department store with
City	Chicago, IL	Design Dry Bulb/Mean-Coincident	Retail Store	

Baseline Configuration      Alternative Configuration

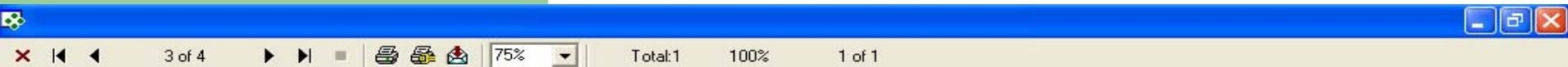
Energy Rates				more
Electric: Chicago ComEd Schedule 6 - T	Electric	Electric: Chicago ComEd Standby Rate 18		
Gas:Chicago: Nicor Gas: Schedule 4	Gas	Gas:Chicago: Nicor Gas: Schedule 4		

Equipment				more
Electric Screw	Cooling	Electric Screw		
Gas	Heating	Gas		
Reheat	HVAC Options	Desiccant Dehumidifier		
Ice on Coil	Cold Storage	None		
Microturbine	Power Generation	Internal Combustion Engine		

Project Description      Calculate



# BEA Output Is Through On-screen or Printed Tables



Print: 7/9/2002 1:12:37PM **Building Energy Analyzer - PG** Run: 7/9/2002 1:02:38 PM  
 Input/Output Data Short Report  
 File: \\andvst1.t.roh Version 1.0 Page 3 of 4

BASELINE		OUTPUT DATA		ALTERNATIVE	
HVAC and POWER GENERATION EQUIPMENT DESIGN CAPACITY					
Cooling Capacity:	203.17	RT	Cooling Capacity:	159.17	RT
Heating Capacity:	0	Btu/hr	Heating Capacity:	3,182,000	Btu/hr
Total Supply Air:	137,488	CFM	Total Supply Air:	137,488	CFM
Outside Air:	9,627	CFM	Outside Air:	9,627	CFM
Cool Storage:	0.00	MMBtu	Cool Storage:	0.00	MMBtu
Power Generation:	0	1W	Power Generation:	101	1W

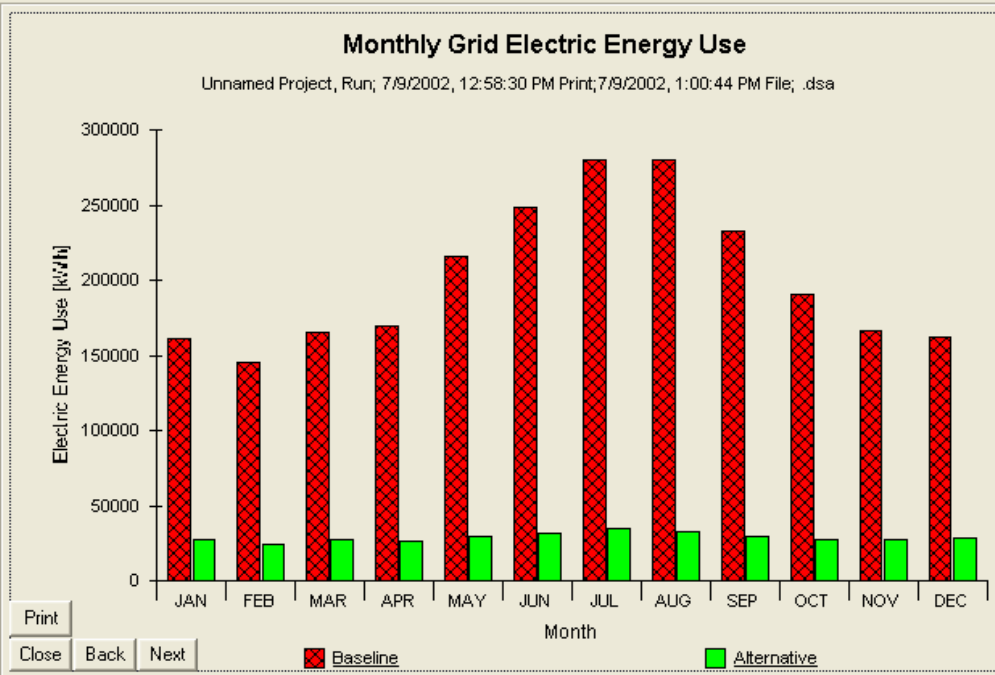
QUALITY OF HUMIDITY CONTROL - TOTAL ANNUALLY DURING OCCUPIED HOURS					
Hours @ RH > 80 %	101		Hours @ RH > 70 %	0	

ANNUAL ELECTRIC ENERGY CONSUMPTION/GENERATION and GRID SUPPLIED ELECTRIC UTILITY COST					
Total Consumption:	2,413,875	kWh	Total Consumption:	630,910	kWh
Utility Supplied:	2,420,228	kWh	Utility Supplied:	349,303	kWh
Generated On-Site:	0	kWh	Generated On-Site:	288,024	kWh
Elect. Gen. Overproduction:	0	0h	Elect. Gen. Overproduction:	2	0h
Cooling:	\$ 122,743		Cooling:	\$ 4,343	
Desiccant Dehumidifier:	\$ 0		Desiccant Dehumidifier:	\$ 0	
Heating/Reheating:	\$ 0		Heating/Reheating:	\$ 277	
Fans:	\$ 5,944		Fans:	\$ 1,547	
Refrigeration:	\$ 0		Refrigeration:	\$ 0	
Other Electric:	\$ 32,083		Other Electric:	\$ 4,790	
Standby Charge:	\$ 0		Standby Charge:	\$ 3,407	
Grid Electric Energy Cost:	\$ 160,774		Grid Electric Energy Cost:	\$ 16,786	

ANNUAL NATURAL GAS ENERGY CONSUMPTION and GAS UTILITY COST					
Total Consumption:	129	MMBtu	Total Consumption:	22,808	MMBtu
Building Consumption:	129	MMBtu	Building Consumption:	19,005	MMBtu
Power Generation Consumption:	0	MMBtu	Power Generation Consumption:	3,803	MMBtu
Renewable Thermal Energy:	0	MMBtu	Renewable Thermal Energy:	1,563	MMBtu
Recovered Thermal Energy:	0	MMBtu	Recovered Thermal Energy:	28	MMBtu
Cooling:	\$ 0		Cooling:	\$ 0	
Desiccant Dehumidifier:	\$ 0		Desiccant Dehumidifier:	\$ 2,934	
Heating/Reheating:	\$ 304		Heating/Reheating:	\$ 53,872	
Power Generation:	\$ 0		Power Generation:	\$ 11,518	
Other Gas:	\$ 344		Other Gas:	\$ 215	
Gas Energy Cost:	\$ 652		Gas Energy Cost:	\$ 70,539	

TOTAL ELECTRIC and GAS UTILITY COSTS					
Annual Energy Cost	\$ 161,426		Annual Energy Cost	\$ 88,765	
			Note: Includes generator O&M cost of \$ 1,440		

# ... And A Selection of Graphs



# Building Energy Analyzer Output

- Tabular reports
  - Two levels of detail
  - Baseline and alternative results on annual or monthly basis
- Nine charts
  - Monthly and annual energy use and cost of electricity and gas
  - Humidity levels
  - Power generation heat recovery utilization

# D-Gen Pro

- Developed by Architectural Energy Corporation and Gas Technology Institute
- Primary use: Preliminary screening of CHP heating applications in commercial buildings
- Provides baseline comparison (grid electricity and separate steam boiler)
- Data libraries: Generation equipment, HVAC equipment, utility rates, climate, 14 specific building types (e.g., hospital, office, hotel, apartment, school, retail)
- CHP applications: Hot water, space heating (no cooling options)
- Analysis duration/time step: unlimited; monthly
- Economic analyses: payback, lifecycle, IRR
- Cost: \$695 (<http://www.interenergysoftware.com/>)

# Input to D-Gen Pro Is Through Pop-Up Windows

The screenshot displays the d-gen PRO software interface for a project titled "[Hospital-So. Calif. With Heat Recovery]". The main window is titled "Enter generator specifications" and contains several sections:

- Select generator (required):** A dropdown menu shows "Kawasaki IES 1200B (1235 kW)". Below it are radio buttons for "size" and "manufacturer".
- Facility installation information (required):** A text box shows "Number of generators installed: 2" and a checkbox for "at least one generator can modulate".
- Deployment strategy:** A "Current setting:" box shows "Demand peak shaving" and a "Set/Modify deployment strategy" button.
- Details of selected generator:** A table of specifications:

Manufacturer	Kawasaki
Model	IES 1200B
Net output	1235 kW
Heat rate	16378 Btu/kWh
Default installed cost	\$2247/kW
Fixed O&M costs	\$6/kW per year
Variable O&M costs	\$0.007/kWh
Rated temperature	59.5°F
Rated altitude	0.0 feet
CO2 emissions	not available
NOx emissions	2.3 g/kWh
SOx emissions	not available
Particulate emissions	not available
- Heat recovery:** A checkbox for "heat recovery system is installed" is checked, with a "Configure" button.

The "Generator Deployment Strategy" pop-up window is open, showing configuration options:

- Configure the deployment strategy by one of the following methods:**
- Automatic deployment strategy (minimize operation cost)
- Demand peak shaving
  - Generator(s) run when the electric load is greater than  kW
  - A slider control for "maximize run time" to "minimize run time".
  - Generators do not run on weekend
- Generator(s) run in the selected time of use periods
  - Checkboxes for "On Peak", "Mid Peak 1", "Mid Peak 2", and "Off Peak".
  - A "Run Rate Wizard" button.
  - Text: "To view time of use periods definition,"

At the bottom of the pop-up window, it says "For specific instructions, press F1" and has a "Done" button.

The Windows taskbar at the bottom shows the date "5/15/2002" and time "11:29 AM", along with several open applications: "start", "Eudora - [In]", "D-Gen Pro Softw...", "Microsoft Excel - ...", "Microsoft PowerP...", and "d-gen PRO - [Hos...]".

# D-Gen Pro Output Is Through On-screen Windows and Printed Reports

View Full Report

55%

2 of 14

d-gen PRO

d-gen PRO version 3.09  
Hospital-So.Calif. With Heat Recovery  
Date: 6/28/2002

### ENERGY CONSUMPTION SUMMARY

Month	Base case		Distributed generation case	
	Electricity consumption (kWh)	Natural gas consumption (MMBtu)	Electricity consumption (kWh)	Natural gas consumption (MMBtu)
Jan	1,783,061	7,889	208,706	26,613
Feb	1,821,119	8,141	122,613	24,325
Mar	1,854,119	7,849	463,048	21,034
Apr	2,063,680	6,801	285,491	29,868
May	1,027,621	6,264	547,414	10,788
Jun	2,134,621	5,911	845,272	22,070
Jul	2,153,247	4,843	771,661	23,411
Aug	2,060,911	4,649	747,761	22,274
Sep	2,327,130	4,576	654,988	28,132
Oct	2,071,709	5,289	575,262	26,221
Nov	1,914,974	6,496	485,936	24,091
Dec	1,788,240	7,704	210,060	26,214
Total	22,890,511	75,782	5,916,291	284,050

#### Purchased Electricity (kWh)

#### Purchased Natural Gas (MMBtu)

d-gen PRO © 1999-2000 GTR

Page 2 of 14

# D-Gen Pro Output

## **Separately for baseline (benchmark) and DER case:**

- Monthly and annual fuel flows
- Monthly and annual electricity usage
- Monthly and annual energy costs

## **In comparison of baseline to DER case:**

- Waste heat utilization summary
- Internal rate of return (IRR)
- Simple payback
- Lifecycle savings

# BCHP Screening Tool

- Under development by DOE/ORNL.
- Primary use: Screening of CHP applications in commercial buildings using DOE-2 simulation engine
- Data libraries: Generation equipment, HVAC equipment, utility rates, weather, 14 specific building types (e.g., hospital, office, hotel, school, retail)
- CHP applications: Hot water, chilled water, space heating
- Analysis duration/time step: 1 year; monthly
- Economic analyses: not available at this time
- Cost: TBD (currently in beta test)



# Input to BCHP Screening Tool Is Through On-screen Spreadsheet

BCHP Screening Tool powered by DoeRayMe - [BCHP Screening Tool - untitled.drm]

File Edit View Insert Window Help

Open Save Print Copy Run

Table Graph Text

INPUT		Parameter	Units	A	B
		Building Type		Hospital	Hospital
		Location		Illinois Chicago 41.98 87.9	Illinois Chicago 41.98 87.9
		Length of Building	feet	150	150
		Width of Building	feet	150	150
		Number of Floors		1	1
		Basement Present		No	No
		Story Height	feet	12	12
		Building Rotation	degrees	0	0
		<b>Equipment</b>			
		Lead Space Cooling		centrifChill York YK_850_...	sfseAbs Trane ABSC-11A-6psig 945
		Lag Space Cooling		centrifChill York YK_850_	sfseAbs Trane ABSC-11A-6psig 945
		Desiccant System		None	None
		Heating Boiler		Steam Firetube Cleaver-Brooks CB-Stm10-800 8	Steam Firetube Cleaver-Brooks CB-Stm10-800 8
		Service Water Heater		Gas Gas-fired hot water boiler Generic 203000	Gas Gas-fired hot water boiler Generic 203000
		Generator		None Non_None 0	Engine Caterpillar G3412 NA 250
		Chilled Water Pumps		Constant Speed	Constant Speed
		Hot Water Pumps		Constant Speed	Constant Speed
		Cooling Tower		TwoSpeed Generic Approach12 200	TwoSpeed Generic Approach12 200
		Cool Storage		None 0	None 0
		Hot Storage		None 0	Chilled water Generic 36 Thermal energy storag
		<b>Equipment Sizing</b>			
		<b>Annual Electricity Consumption</b>			
RESULT		Lights	kWh	-	-
		Equipment	kWh	-	-
		Heating	kWh	-	-
		Cooling	kWh	-	-
		Tower	kWh	-	-

Status 6/27/2002 11:03 AM

start CHP software2.ppt Eudora - [In] THE NEWS DESK... BCHP Screening ... 11:03 AM

# BCHP Screening Tool Output Is Through On-screen Spreadsheet

BCHP Screening Tool powered by DoeRayMe - [BCHP Screening Tool - untitled.drm]

File Edit View Insert Window Help

Open Save Print Copy Run

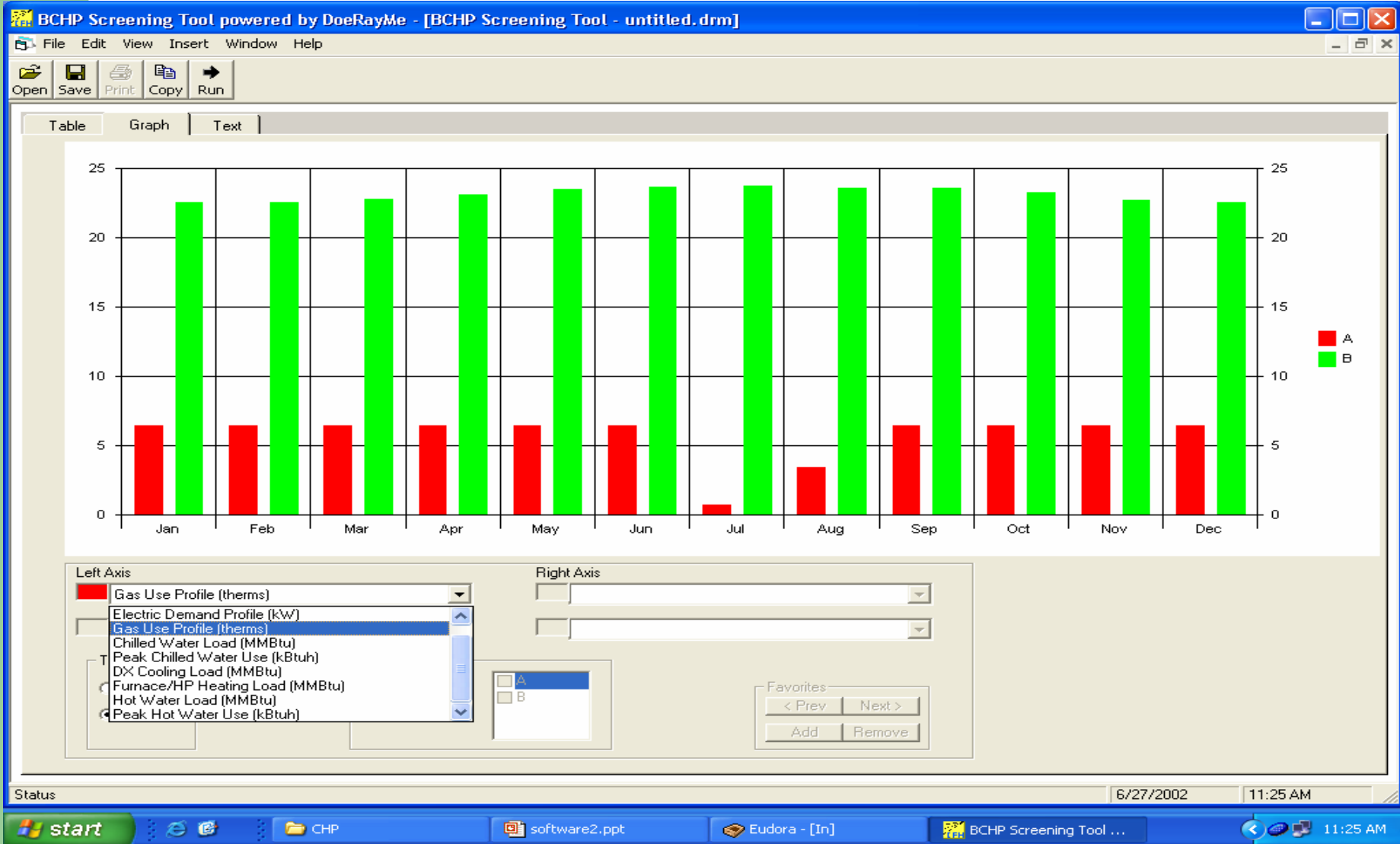
Table Graph Text

INPUT		Parameter	Units	A	B
<b>Building Description</b>		Building Type		Hospital	Hospital
		Location		Illinois Chicago 41.98 87.9	Illinois Chicago 41.98 87.9
<b>RESULT</b>		<b>Annual Electricity Consumption</b>			
	Lights	kWh	323663.	323663.	
	Equipment	kWh	166075.	166075.	
	Heating	kWh			
	Cooling	kWh	44984.	3108.	
	Tower	kWh	18024.	42635.	
	Pump and Misc	kWh	4496.	4496.	
	Ventilation Fans	kWh	97928.	97928.	
	Refrigeration	kWh			
	Supplemental Heat	kWh			
	Service Water Heat	kWh			
	Total	kWh	655169.	637905.	
		<b>Annual Gas Consumption</b>			
	Heating	MMBtu	3143.8	679.6	
	Cooling	MMBtu		13229.3	
	Supplemental Heat	MMBtu			
	Service Water Heat	MMBtu			
	Miscellaneous	MMBtu			
	Generator	MMBtu		2292.5	
	Total	MMBtu	3143.8	16201.3	
		<b>Annual Generation Details</b>			
	Utility Supplied	kWh	655168.9	399789.3	
	On-site Generation	kWh		238115.5	
	Boiler Heat	MMBtu	764.5	6246.9	

Status 6/27/2002 11:22 AM

start software2.ppt Eudora - [In] BCHP Screening Tool ... 11:22 AM

# ... And A Selection of Graphs



# BCHP Screening Tool Output

- Annual and monthly electricity and gas demand and consumption
- Building energy loads
- Economic analysis results not available at this time - under development

# HeatMap CHP

- Developed by Washington State University Cooperative Extension Energy Program (formerly Washington State Energy Office)
- Primary use: Detailed 3-D design simulation of proposed and existing CHP systems using DOE-2 simulation engine
- Provides baseline comparison (existing system)
- Data libraries: weather, building loads, production equipment, fuels, piping
- CHP applications: Process steam, hot water, chilled water, thermal storage
- Analysis duration/time step: 1 year; hourly (8,760 hours)
- Economic analyses: cash flow, revenue requirement, payback
- Cost: \$4,000 (<http://www.energy.wsu.edu/software/HEATMAP/>)
- Requires separate installation of AutoCad software (approx. \$3,000)
- No free trial or demo versions

# Input to HeatMap CHP Is Through Pop-Up Windows

**HEATMAP Production Equipment Library**

Select production equipment  Heating  Cooling

Coal boiler - water

Description: Coal boiler - water

Unit type: Boiler/Coal

Medium: Water

Fuel: Coal (Bituminous)

Electricity input: 4 (kWh/MBtu)

**Emissions (lb/MBtu)**

CO2:	178.0	NOX:	0.1
SOX:	0.4	Particulates:	0.1

**Seasonal Data**

	Summer	Winter	Mid-season
Cogen heat rate (Btu/kWh):	N/A	N/A	N/A
Efficiency (%):	82.0	82.0	82.0

Capacities Add Delete Save Cancel

# HeatMap CHP Output

- Estimated annual and peak consumer loads
- Annual fuel use and cost
- Capacity & cost of energy plant
- Size & cost of distribution system
- Distribution system flow, temperature, pressure, and heat transfer
- Cost of energy
- Cash flow and revenue requirements
- Annual emissions

# GT Pro

- Developed by Thermoflow, Inc.
- Primary use: **Detailed** design of industrial gas turbine applications with/without HRSG and/or combined cycle
- Does not provide baseline comparison (e.g., existing utility system)
- Data libraries: Gas turbines only
- CHP applications: Process steam
- Analysis duration/time step: between 8 and 40 years; annual
- Economic analyses: cash flow, payback, NPV, IRR
- Cost: \$7,000 (<http://www.thermoflow.com/>)
- Demo version available on CD



# Input to GT Pro Is Through On-Screen Windows

GT PRO 10.3.2 DEMONSTRATION - c:\Tflow7\MYFILES\GTPRO.GTP

File View Options Navigator Window Excel Link Help

Navigator
  Thermodynamic Design Assumptions
  Hardware Design
  Radiant Boiler
  Miscellaneous
  Equipment Options

**New Session**

Start Design  
 Plant Criteria  
 GT Selection  
 GT Inputs  
 ST-HRSG  
**HRSG Inputs**  
 Water Circuits  
 HRSG Layout  
 Cooling System  
 ST Inputs  
 Other PEACE  
 Economics

**Compute**

Text Output  
 Graphics Output  
 PEACE Output  
 Multiple Runs  
 Off Design

**HRSG Main Inputs**

Duct Burner Fuel: Gas turbine fuel  
 Duct Burner: Included, specify exit temperature  
 Exit temperature: 0 °F  
 Dilution air as percent of exhaust flow: 0 %  
 Additional Duct Burner (HPB2 burner): Not in plant

Min stack temperature for warning: 200 °F  
 Steam Generation Dictated By:  Pinch  Mass flow  
 Gas Flow Direction:  Horizontal  Vertical

Total GT exhaust draft loss: 10 in H2O  
 HRSG-only draft loss: 8 in H2O

LP: Pinch 15 °F, Approach subcooling 10 °F, Blowdown percentage 0 %  
 IP: Pinch 36 °F, Approach subcooling 10 °F, Blowdown percentage 1 %  
 HP: Pinch 36 °F, Approach subcooling 10 °F, Blowdown percentage 1 %

No blowdown recovery  
 Fresh-air dilution: 0 %  
 Exhaust bypass: 0 %

**Demonstration**

Guidance

start | Eudora - [In] | Microsoft Excel - ... | software2.ppt | Internet Expl... | GT PRO 10.3.2 D... | 4:20 PM

# GT Pro Provides Detailed Text and Graphical Output Through On-screen Windows and Printed Reports

**GT PRO 10.3.2 DEMONSTRATION** - c:\Tf\low7\MYFILES\GTPRO.GTP

File View Edit Options Navigator Window Excel Link Help

HP Water Path | IP Water Path | RH Water Path | LP Water Path | Feedwater Path | DH Circuit | Pumps  
 Main | Cycle Flow Schematic | HRSG Temperature Profile | ST Expansion Path | ST Group Data | Cooling System Schematic | Cooling System T-Q Diagram

**New Session**

- Start Design
- Plant Criteria
- GT Selection
- GT Inputs
- ST-HRSG
- HRSG Inputs
- Water Circuits
- HRSG Layout
- Cooling System
- ST Inputs
- Other PEACE
- Economics

**Compute**

- Text Output
- Graphics Output**
- PEACE Output
- Multiple Runs
- Off Design

**Demonstration**

Gross Power 58010 kW  
 Net Power 56381 kW  
 Aux. & Losses 1628.3 kW  
 Gross Heat Rate 7085 BTU/kWh  
 Net Heat Rate 7289 BTU/kWh  
 Gross Electric Eff. 48.17 %  
 Net Electric Eff. 46.81 %  
 Fuel LHV Input 410970 kBTU/h  
 Fuel HHV Input 456017 kBTU/h  
 Net Process Heat 0 kBTU/h

Ambient  
14.7 P  
59 T  
60% RH

**19785 kW**

1100 p  
850 T  
38.08 M

Stop Valve

150 p  
447.1 T  
7.739 M

1 p  
101.7 T  
45.73 M

to HRSG

14.7 p  
246 T  
306.7 M

LP

LPB  
17.19 p  
220 T  
0.9652 M

317.6 T  
305.5 T

IP

IPB  
159.1 p  
363.1 T  
7.739 M

485.4 T  
399.1 T

HP

HPB  
1167 p  
563.7 T  
38.08 M

896.4 T  
599.7 T

CH4  
5.305 M  
410970 kBTU/h LHV

15.06 p  
1005.4 T  
306.7 M

14.55 p  
59 T  
301.4 M

**GE 6541B  
@ 100% load  
38224 kW**

101.5 T  
48.28 M

p [psia] T [°F] M [lb/s]

# GT Pro Output

- ***Voluminous*** text and graphic output to screen or printer
- Output includes:
  - design and operation parameters
  - heat and mass balances
  - project economics
  - preliminary engineering details

# SOAPP-CT.25

- Developed by Electric Power Research Institute (EPRI)
- Primary use: Conceptual design of industrial gas turbine applications with/without HRSG
- Provides baseline comparison in the form of avoided cost
- Data libraries: Gas turbines, HRSG
- CHP applications: Process steam
- Analysis duration/time step: up to 40 years; up to monthly
- Economic analyses: cash flow, payback, NPV, IRR
- Cost: \$7,500 (<http://www.soapp.com/soapp/dg/>)
- No free trial or demo versions

# Input to SOAPP-CT.25 Is Through On-Screen Windows

**QuickStart Tool - Step 2 of 7**

Cycle Type:

Site Location:

Combustion Turbine

Model:

Frequency:

Number of CT's:  (Range: 1 to 6)

HP Steam Pressure:  (Range: 20.0 to 1465.0)

HP Steam Temperature:  (Range: 506.0 to 970.0)

# SOAPP-CT.25 Provides Detailed Text Output Through On-screen Windows and Printed Reports

Available Reports		SOAPP-CT.25 WorkStation										
Performance		Capital Cost Report										
<ul style="list-style-type: none"> <li>Combustion Turbine                             <ul style="list-style-type: none"> <li>Primary Fuel, Maximum</li> <li>Primary Fuel, Performance</li> <li>Primary Fuel, Minimum</li> </ul> </li> <li>Heat Recovery Steam Generators                             <ul style="list-style-type: none"> <li>Primary Fuel, Maximum</li> <li>Primary Fuel, Performance</li> <li>Primary Fuel, Minimum</li> </ul> </li> </ul>		Project: Sample Cases - Onsite Customers										
<ul style="list-style-type: none"> <li>Equipment                             <ul style="list-style-type: none"> <li>Equipment List</li> <li>Performance Summary</li> <li>Emissions Summary</li> <li>Motor List/Aux Power</li> <li>Site Parameters List</li> </ul> </li> <li>Schedule                             <ul style="list-style-type: none"> <li>Schedule Summary</li> </ul> </li> <li>Capital Cost                             <ul style="list-style-type: none"> <li>Capital Cost Breakdown</li> </ul> </li> <li>Operations &amp; Maintenance                             <ul style="list-style-type: none"> <li>O&amp;M Summary</li> </ul> </li> <li>Financial                             <ul style="list-style-type: none"> <li>Return on Equity</li> <li>Base Year</li> <li>Capital Outlay Schedule</li> <li>Project IRR</li> </ul> </li> </ul>		Conceptual Design: Cogen, 1 x 27 MW, NG, Quarterly										
		System/Subsystem/Equip System	Account	Equip Description	Quantit	Units	Equip (\$)	Material	Material (\$)	Labor (hrs)	Labor Code	Labor (\$)
		<b>Heat Recovery Steam Generators</b>										
		<b>HRSG System</b>										
		Heat Recovery Steam Generators										
		111.1.1.00		HRSG incl surfaces, galleries, steel	1	each	2,385,500	na	0	6,184	SGEN	417,173
		111.1.1.01		Duct Burner System	1	each	78,000	na	0	290	SGEN	19,563
		Ductwork										
		111.1.2.01		Bypass Stack	1	each	451,100	na	0	711	SGEN	47,964
		Feedwater and Water Supply System										
		111.1.3.01.1		HP Feedwater Pumps and Motors	1	each	25,300	na	0	19	PUMP	998
		111.1.3.01.3		LP Feedwater Pumps and Motors	1	each	800	na	0	2	PUMP	105
		111.1.3.02.1		Condensate Heater	1	each	0	na	0	na	na	0
		111.1.3.02.2		Deaerator	1	each	41,900	na	0	359	SGEN	24,218
		Misc Equipment and Systems										
		111.1.6.00		Cycle Water Make-up Pumps and Motors	2	each	251,800	na	0	240	PUMP	12,605
		111.1.6.01		Chemical Feed System (incl pumps and tanks)	1	each	169,500	na	0	775	WTRT	40,362
		111.1.6.03		HRSG Blowdown Tank(s)	1	lot	0	na	45,000	186	TANK	10,396
		111.1.6.04		HRSG Area Duplex Sump Pump Units	2	each	22,000	na	0	72	PUMP	3,781
		Water Sampling System										
		111.1.7.00		Water Sampling System	1	each	69,600	na	0	325	WTRT	16,926
		Piping Systems (inc hangers and fittings)										
		111.1.8.01.11		High Pressure HRSG Steam Header Piping	56	LF	0	Pipe8A106B	2,400	86	SPNG	5,252
		111.1.8.01.12		High Pressure HRSG Steam Leads Piping	167	LF	0	Pipe8A106B	7,100	256	SPNG	15,634
		111.1.8.01.41		Condensate Header Piping	214	LF	0	Pipe4A106B	4,900	363	SPNG	22,168
		111.1.8.01.51		High Pressure Feedwater Header Piping	241	LF	0	Pipe4A106B	5,600	409	SPNG	24,978
		111.1.8.01.52		High Pressure Feedwater Leads Piping	256	LF	0	Pipe4A106B	5,900	435	SPNG	26,565
		111.1.8.01.71		Low Pressure Feedwater Header Piping	241	LF	0	Pipe4A106B	5,600	356	SPNG	21,741
		111.1.8.01.72		Low Pressure Feedwater Leads Piping	256	LF	0	Pipe4A106B	5,900	378	SPNG	23,084
		111.1.8.02		Valves	1	lot	0	na	52,300	305	SPNG	18,626
		111.1.8.03		Piping Thermal Insulation	1	lot	0	na	6,300	545	PINS	26,302
		<b>Condensing System</b>										
		Condensate Pumps and Motors										
		111.3.2.00		Condensate Pumps and Motors	1	each	7,500	na	0	18	PUMP	945
		<b>Structures for Combustion Turbine Area</b>										
		<b>On-site Improvements</b>										
		Earthwork										
		210.2.1.01		Clear and Grub	2	acres	0	na	0	36	ETWK	5,229
		210.2.1.02		Site Drainage incl Storm Sewer System	1	lot	0	na	1,200	28	YDRN	1,705
		210.2.1.03		Grading incl Cut and Fill	2	acres	0	na	0	10	ETWK	1,453
		210.2.1.04		Site Fencing	1,246	LF	0	Fence	0	262	LAND	11,195
		210.2.1.06		Landscaping	1	lot	0	na	200	27	LAND	1,154
		On-site Roads and Parking Areas										
		210.2.2.01		Permanent Roadways	160	LF	0	Road	0	368	PBIT	24,958
		210.2.2.02		Permanent Parking Areas	1,478	SY	0	Parking	0	739	PBIT	50,119
		Outdoor Tanks and Foundations										
		210.2.3.01.1		Fuel Oil Storage Tank - Earthwork	1	lot	0	na	0	0	EXFD	0
		210.2.3.01.2		Fuel Oil Storage Tank - Concrete Ring Foundation	1	lot	0	na	0	0	FORM	0
		210.2.3.01.3		Fuel Oil Storage Tank - Erosion Control on Dike	1	lot	0	na	0	0	MSTR	0
		210.2.3.02.1		Treated Water Tank - Earthwork	2,416	SF	0	na	0	97	EXFD	7,179
		210.2.3.02.2		Treated Water Tank - Concrete Ring Foundation	1	lot	0	na	13,400	943	FORM	42,944
		210.2.3.03.1		Waste Neutralization Tank - Earthwork	324	SF	0	na	0	15	EXFD	1,110
		210.2.3.03.2		Waste Neutralization Tank - Concrete Ring Fnd	1	lot	0	na	800	87	FORM	3,734

# SOAPP-CT.25 Output

- Text output to screen or printer
- 33 individual reports in the seven categories:
  - Design Inputs
  - Heat Balance Results
  - Equipment Design Information
  - Project Schedule
  - Capital Cost Estimate
  - O&M Cost Estimate
  - Financial Analysis and Cash Flow

## Other software on the horizon

- **Process Heating Screening Tool** – being developed by E3M, Inc. for ORNL, the windows-based tool will evaluate the potential of using waste heat from combustion turbines for direct process heating applications. Three process heating applications typically found in process industries will be modeled for use with a library of typical combustion turbines. Expected release in 2003.



# Software Summary

## Screening Tools

Software Name	Primary Application	Cost	Reference
Cogeneration Ready Reckoner	Industrial CHP	Free	<a href="http://www.eere.energy.gov/der/chp/chp-eval2.html">http://www.eere.energy.gov/der/chp/chp-eval2.html</a>
RECIPRO	CHP using recip engines	\$1,500.	<a href="http://www.thermoflow.com/">http://www.thermoflow.com/</a>
PDE	Industrial CHP using gas turbines	\$3,000.	<a href="http://www.thermoflow.com/">http://www.thermoflow.com/</a>
BCHP Screening Tool *	Building CHP	TBD	<a href="http://www.bchp.org/finance-economic.html#screen">http://www.bchp.org/finance-economic.html#screen</a>
Building Energy Analyzer	Building CHP	\$800.	<a href="http://www.interenergysoftware.com/">http://www.interenergysoftware.com/</a>
D-Gen Pro	Building CHP	\$695.	<a href="http://www.interenergysoftware.com/">http://www.interenergysoftware.com/</a>

\* Under development

# Software Summary (cont'd.)

## Design Tools

Software Name	Primary Application	Cost	Reference
HeatMap CHP	Industrial CHP/ District Energy	\$4,000	<a href="http://www.energy.wsu.edu/software/HEATMAP/">http://www.energy.wsu.edu/software/HEATMAP/</a>
GT Pro	Industrial CHP using gas turbines	\$7,000	<a href="http://www.thermoflow.com/">http://www.thermoflow.com/</a>
SOAPP-CT.25	Industrial CHP using gas turbines	\$7,500	<a href="http://www.soapp.com/soapp/dg/">http://www.soapp.com/soapp/dg/</a>