Evaluating Distributed Generation Opportunities Using SOAPP-CT.25

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ABSTRACT

In distributed generation, a small generating unit(s) is usually located near the end-user customer—at an existing substation, near a group of large energy users, or even on the site of commercial, industrial, or institutional energy users. Small combustion turbines firing natural gas have been the most popular candidates for distributed generation.

When evaluating the economic viability of distributed generation applications, one must simultaneously consider the incoming revenue streams and outgoing cost streams for the new combustion turbine plant. Revenue streams include the capacity, electricity, and thermal energy sold to the open market, as well as the "avoided costs" of energy not being purchased from the local utility. Cost streams include the operating costs of the generating unit, the costs of fuel, and the costs of any backup capacity and backup electricity purchased from the local utility.

The SOAPP-CT.25 WorkStation was recently used to evaluate distributed generation opportunities in upstate New York in the New York State Electric & Gas utility service area. This software product quickly modeled each distributed generation opportunity and produced performance reports, equipment sizing reports, capital and operating cost reports, and financial pro formas. This paper will explore the evaluation methodology of distributed generation using SOAPP-CT.25.

INTRODUCTION

What is Distributed Generation?

Distributed generation (DG) is defined as any small scale power generation technology that provides electric power at a site closer to customers than central station generation, and is usually connected to the transmission or distribution system.

During the first part of the 20th century, on-site power generation was commonplace as most electricity was produced and consumed near large end users such as factories. By the mid-1900s, large base-loaded central generating stations were being built to serve the growing industry in the United States. Out of this grew a regulated framework of vertically integrated electric utilities that provided efficient electricity generation with a reliable transmission and distribution network.

Today's deregulated energy market has created significant opportunities for the return of DG. Individual energy users will soon have their choice of energy suppliers, or even the option of on-site generation. In response to this new competitive environment, electric utilities and energy service providers must find a way to retain customers. Partnering in DG projects (an "inside-the-fence" partnership) with existing commercial or industrial customers is a unique service offering for electric utilities or energy service providers.

DG has several distinct benefits to both the end-user of energy as well as traditional electric utilities or energy service companies.

Benefits to an end-user of energy:

- Offset expensive peak-power with less expensive power generated on-site
- Reliable source of back-up power
- Improved power quality and reliability
- Retire inefficient heating boilers and use a heat recovery steam generator to produce hot water or steam
- Ability to externally sell power or thermal energy to the open market

Benefits to electric utilities or energy service companies:

- Retaining and adding value to current customer relationships through new, differentiated energy services and improved power quality and reliability
- Meeting growing local peak demands for existing customers without adding transmission and distribution upgrades with long payback schedules or new investments in central station generation
- Serving new commercial, industrial, or remote customers on a transmission and distribution system that already operates at near capacity
- Growing new business within or outside the utility franchise

Technologies Considered for Distributed Generation

A number of efficient and clean technologies could be considered for DG. Available options for DG include diesel engines, internal combustion engines, small combustion turbines, microturbines, fuel cells, wind turbines, and photovoltaic solar panels.

Of these technologies, small combustion turbines may be the most attractive for commercial, industrial, or institutional customers. The maturity of the technology, the ability to efficiently recover waste heat, and the flexibility to fire different fuels make small combustion turbines a good candidate for these types of applications. Small combustion turbines based on jet aircraft engine designs (aeroderivative turbines) and proven heavy-frame (industrial) combustion turbines are now commercially available in sizes ranging 0.5 to 30 MW, and can be deployed in as little as 16 months.

The SOAPP-CT.25 WorkStation evaluation tool focuses on using small combustion turbines ranging from 0.5 to 30 MW in DG applications.

CONSIDERATIONS IN EVALUATING DG OPPORUNITIES

When determining whether an existing customer site is suitable for DG, it is necessary to consider both the technical and economic aspects of the site and of the DG unit to see if it is a good fit. Evaluating these aspects requires both engineering expertise and financial analysis skills to make a sound business decision.

Technical Considerations – Project Site
When investigating DG applications at an existing customer site (typically a commercial, industrial, or institutional facility) the first item to consider is if there is available footprint area for the combustion turbine plant. Although some small combustion turbines are packaged trailer-mounted plants, some plants can take up considerable space at an existing customer site.

Another consideration is the existence of any electrical constraints at the existing customer site. The size of the electrical feed lines into the customer site will impact the size of the DG unit that can be considered. For instance, a 4.8-kV feed at a customer can typically accommodate a 2 to 3 MW DG unit, without significant upgrades.

A final technical consideration is the availability of on-site fuel. The proximity of a natural gas pipeline to the customer site can make or break a DG project. Other options include having fuel oil, diesel or an alternative fuel delivered to the site.

Technical Considerations – Plant Design
When deciding what type of combustion turbine to install, several considerations need to be considered for the plant design. The size of the unit to install is often dictated by the customer requirements and electrical constraints, but additional considerations include the ability to oversize the unit and sell energy to the open market.

Another technical consideration is whether or not to include heat recovery as part of the plant design. The type of heat recovery steam generator (HRSG) to be used—one pressure, two pressure, or three pressure—is a function of the steam requirements, sensitivity to increased plant efficiency, and sensitivity to increased capital cost.

Devices can be added upstream and downstream of the combustion turbine to improve its performance or to decrease air emissions. Inlet air filtering or inlet air coolers can be added depending on the site conditions. If the site is subjected to stringent air regulations, a selective catalytic reduction device and/or carbon monoxide reduction catalyst can be added to reduce air emissions from the combustion turbine train.

A final technical consideration is the combustion turbine unit output that can be expected at the customer site. The published International Standards Organization (ISO) performance of small combustion turbines varies significantly with the customer site. The performance is typically a function of the ambient temperature, site elevation, and pressure drop from devices that are upstream or downstream of the combustion turbine.

Economic Considerations

After the combustion turbine plant design is finalized, the economic viability of the entire DG project must be determined. Typically, a project site includes an existing commercial, industrial, or institutional facility that has an electrical and/or thermal load. The needs of the facility are typically currently met through a local utility and perhaps through a source of thermal energy such as a boiler.

When a new combustion turbine plant is installed at an existing customer site, the following cost streams and revenue streams must be simultaneously considered:

The cost streams associated with a DG project include:

- **Initial plant investment –** distribution of capital outlay, including interest and taxes paid
- **Fuel costs –** primary fuel for the DG unit and secondary fuel to have available for the DG unit
- **Operating and Maintenance (O&M) Costs –** annual fixed O&M costs (regardless of how much the DG unit is operated) and variable O&M costs (function of DG unit operation)
- **Customer Electricity Costs –**electricity (kWh) required by the customer that is currently purchased from the local utility
- **Customer Capacity Costs –**capacity (kW) required by the customer that is currently purchased from the local utility
- **Customer Thermal Energy Costs –**thermal energy (Btu required by the customer that is currently purchased from an external source
- **Backup Electricity Costs –** backup electricity (kWh) needed by customers that have sensitive operations requiring backup electricity
- **Backup Capacity Costs –** backup capacity (kW) needed by customers that have sensitive operations requiring backup capacity

The revenue streams associated with a DG project include:

- **Avoided Electricity Costs –** electricity (kWh) consumed by the customer that is <u>not</u> purchased from the local utility anymore
- **Avoided Capacity Costs –** capacity (kW) required by the customer that is <u>not</u> purchased from the local utility anymore

- **Avoided Thermal Energy Costs –** thermal energy (Btu) consumed by the customer that is not purchased from an external source anymore
- **External Sales of Electricity** – electricity (kWh) generated by the DG unit and sold to the external market
- **External Sales of Capacity –** capacity (kW) generated by the DG unit and sold to the external market
- **External Sales of Thermal Energy** – thermal energy (Btu) generated by the DG unit and sold to the external market

Figure 1 provides an illustration of how these different streams interact to determine the economic viability of the DG project.

HOW CAN SOAPP-CT.25 HELP?

Traditional Evaluation Methods
Evaluation of the technical considerations of a combustion turbine installation typically requires a feasibility study by an engineering firm. The study would include obtaining combustion turbine manufacturer data for each model considered. Heat balance program runs would then need to be performed to estimate the site-specific plant performance for each combination of combustion turbine, HRSG, and associated upstream and downstream devices.

An estimating group within the firm would typically be used to determine the total plant cost estimate and site-specific plant operating costs. The plant cost estimate would need to include the combustion turbine as well as all balance-of-plant equipment. In the case where balance-of-plant equipment from the existing facility can be shared, this must be accounted for in the cost estimate.

Finally, the financial analysis to determine whether or not the combustion turbine installation is an economically attractive investment can be calculated in an extensive spreadsheet. The net cash flow (CF) for each year of the project must be determined, and the total return on the project can be determined by manipulating the net present value (NPV) equation:

$$\text{NPV} = 0 = \sum_{n=1}^{t} \frac{CF_n}{(1+IRR)^n}$$

A New Approach – the SOAPP-CT.25 WorkStation
The SOAPP-CT.25 WorkStation completely integrates the above technical and financial analysis tasks into one fully automated software product. The complex interaction of site conditions, economic and market factors, and financial strategies along with equipment, process, and plant design requires a sophisticated analysis tool.

The SOAPP-CT.25 WorkStation was developed by SEPRIL, LLC of Chicago, Illinois under the sponsorship of the Gas Research Institute and EPRI. This software product is the latest addition to the award-winning SOAPP family of interactive software products, and was developed in response to the rapid increase of small combustion turbine DG applications in the energy industry.

The analyses performed by SOAPP-CT.25 are completely integrated. You input basic process information on the existing plant (customer), new equipment selections, key design criteria and other project site and economic information, and SOAPP-CT.25 validates your inputs, configures all process connections, and performs heat and material balances. The site-specific heat balance calculations perform an entire unit heat balance—and determine flows, state point conditions at each connection port of each component, and the power output of the generating unit. SOAPP-CT.25 subsequently uses this information to size new plant equipment, using algorithms derived from design practice and manufacturers' data. Plant construction cost estimates are developed by SOAPP-CT.25 from equipment cost estimates correlated to the sizing information. O&M and fuel cost estimates are in turn derived from the preceding results and additional correlations.

Finally, SOAPP-CT.25 performs a financial analysis using the completed conceptual design information. The financial analysis can be performed based on different project ownership types (Investor Owned Utility or Independent Power Producer) as well as different analysis types (Solve for Return on Equity or Solve for Cost of Electricity).

SPECIFIC EVALUATION EXAMPLE

In January 1998, a team comprised of SEPRIL, Sargent & Lundy, and the Gas Research Institute investigated DG opportunities for New York State Electric & Gas (NYSEG) in upstate New York. The SOAPP-CT.25 WorkStation was used as the primary evaluation tool by the project team.

The goal of the study was to identify the impacts of implementing DG at specific customer sites to address potential transmission constraints in the NYSEG service area. DG helps to mitigate constraints in transmission and distribution systems by shedding significant customer load from the lines. NYSEG identified three separate sites to accomplish this task: two university campuses and one light industrial facility. The methodology used to evaluate DG at the three sites included a data collection phase and an analysis phase.

Data Collection

First, the project team collected as much data as possible on the three sites being considered for DG. Specific information collected for each site included:

- Availability of natural gas on-site, and price of natural gas and cost of any pipeline extension
- Ambient temperature and environmental information
- Electrical load and price information
- Thermal load and price information
- Financial information – return on debt, debt/equity fraction, property taxes

The primary sources of information included customer billing records, topographic maps, and meteorological information. The client preferences for project financing were obtained in phone interviews. For instances where project-specific information was not available, the default information from SOAPP-CT.25 was used.

Inputs into SOAPP-CT.25

The information obtained in the data collection phase was then entered into SOAPP-CT.25. The project team created several "conceptual designs" for each customer site identified by NYSEG. The different conceptual designs mixed and matched different combustion turbine plant designs with the specific characteristics for each site.

The structure of the SOAPP-CT.25 inputs allows easy mixing and matching of input information, since each conceptual design is comprised of the following stand-alone components:

- Facility – characteristics of DG unit
- Customer – characteristics of the site
- Economic – characteristics of the financial structure of project
- Periodic – seasonal or periodic inputs for the project

Figure 2 illustrates how these inputs are entered into SOAPP-CT.25. The input forms are similar to a spreadsheet, with data entry fields and drop-down boxes. The input mechanism of the software includes automatic validation: as you enter each input, SOAPP-CT.25 checks to see if the other inputs still make sense. This feature allows even inexperienced users to piece together a technically feasible conceptual design.

SOAPP-CT.25 models both simple cycle and cogeneration (heat recovery) applications of combustion turbines. For the NYSEG study, we investigated employing different combustion turbine models in a cogeneration mode, to obtain economic credit for thermal energy.

Another useful feature of SOAPP-CT.25 was the ability to enter certain inputs of the conceptual design on a periodic basis. These periodic inputs include fuel price as well as the price of electricity, capacity, and thermal energy throughout the year. SOAPP-CT.25 allows the user to split the year into 1 to 12 periods, to account for seasonal price differences. Figure 3 illustrates how seasonal (quarterly) natural gas prices are entered into SOAPP-CT.25, and subsequently escalated by 3%/year throughout the life of the project.

Results from SOAPP-CT.25
The reports tab in SOAPP-CT.25 includes the following reports for each conceptual design:

- Performance Reports
- Equipment Reports
- Schedule Reports
- Capital Cost Reports
- O&M Cost Reports
- Financial Reports

When a specific report is selected, SOAPP-CT.25 performs the required calculations and generates either an on-screen display or a hard copy of the report. For the NYSEG study, we focused on the financial reports for each conceptual design we created.

Several different indicators from the financial reports can be used to evaluate the economic viability of a DG project. The selection of the indicator depends on the client's sensitivity to capital cost, O&M costs, fuel costs, etc. The different indicators that can be used include: project return on equity, cost of electricity, net present value, and payback period.

For the NYSEG study, we utilized project return on equity to rank the economic viability of each project. Figure 4 illustrates the financial pro forma information available on the Return on Equity report.

CONCLUSIONS

Today's deregulated energy market has created significant opportunities for the return of DG. Although several different generating technologies can be considered for DG, small combustion turbines are one of the most commercially viable technologies for commercial, industrial, and institutional customers.

Many different technical and economic aspects of a proposed DG project must be considered when determining the viability of a project. SOAPP-CT.25 accounts for the complex interaction of site conditions, economic and market factors, and financial strategies along with equipment, process, and plant design.

The advantage of using SOAPP-CT.25 over traditional evaluation methods is the complete integration of all technical and financial analysis tasks, and the ability to change your design "on the fly". SOAPP-CT.25 was used to evaluate specific DG opportunities identified by NYSEG in upstate New York. The evaluation methodology using SOAPP-CT.25 resulted in the study being completed in fraction of the time of a traditional feasibility study. Additionally, SOAPP-CT.25 provided the ability for the client to quickly and easily modify project parameters and see the overall impact of those changes.

FIGURES

Figure 1

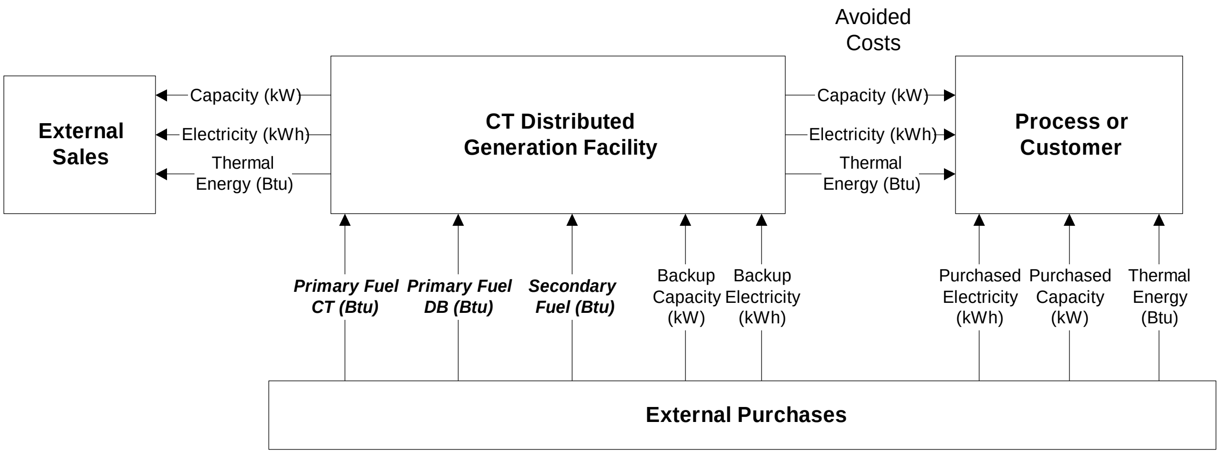
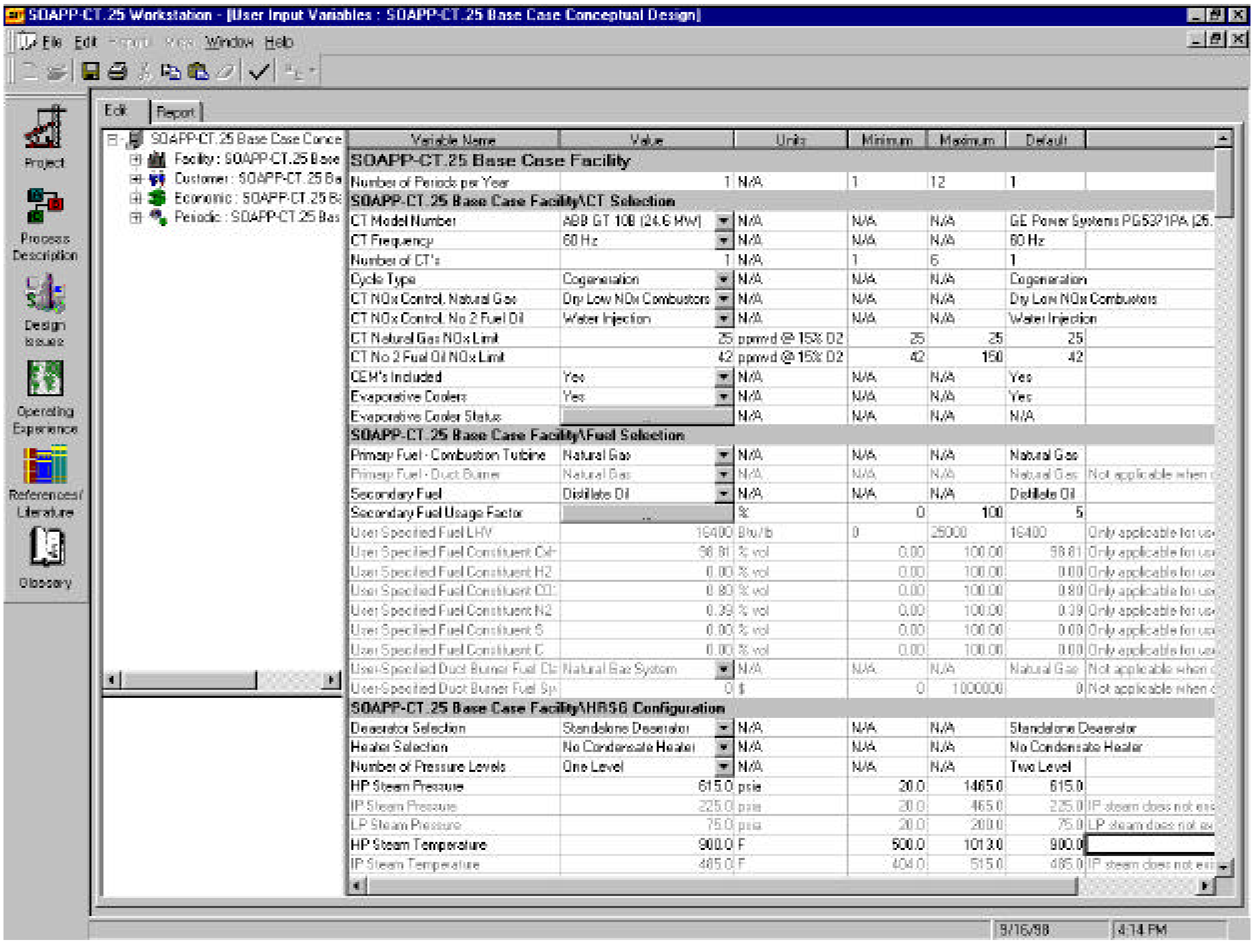
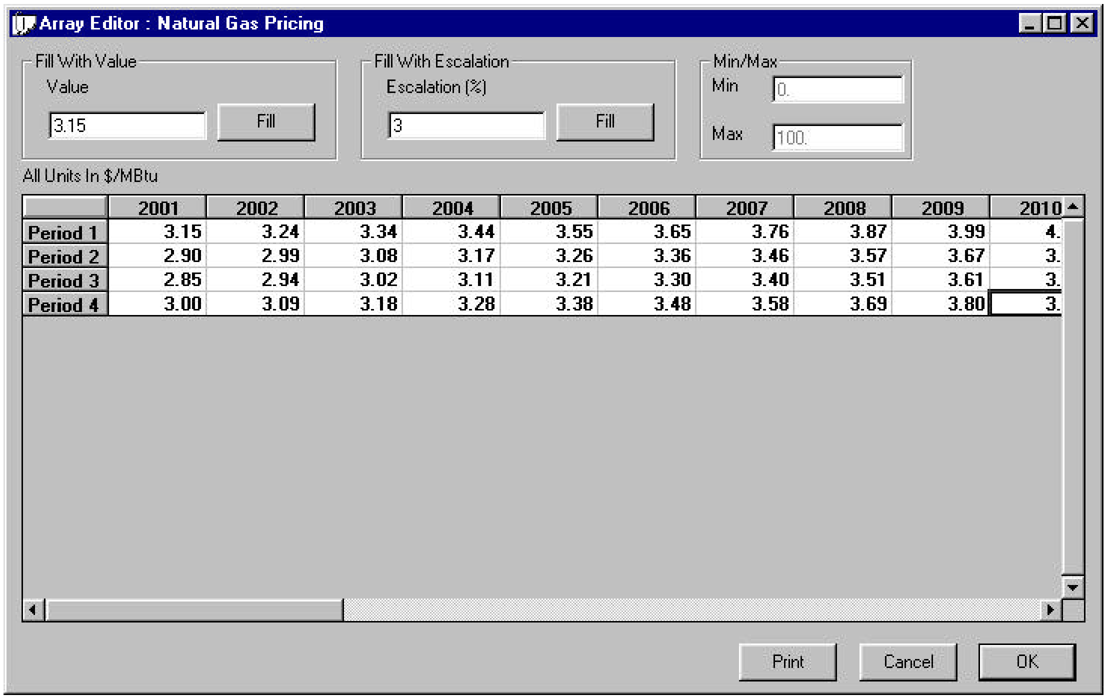


Figure 2



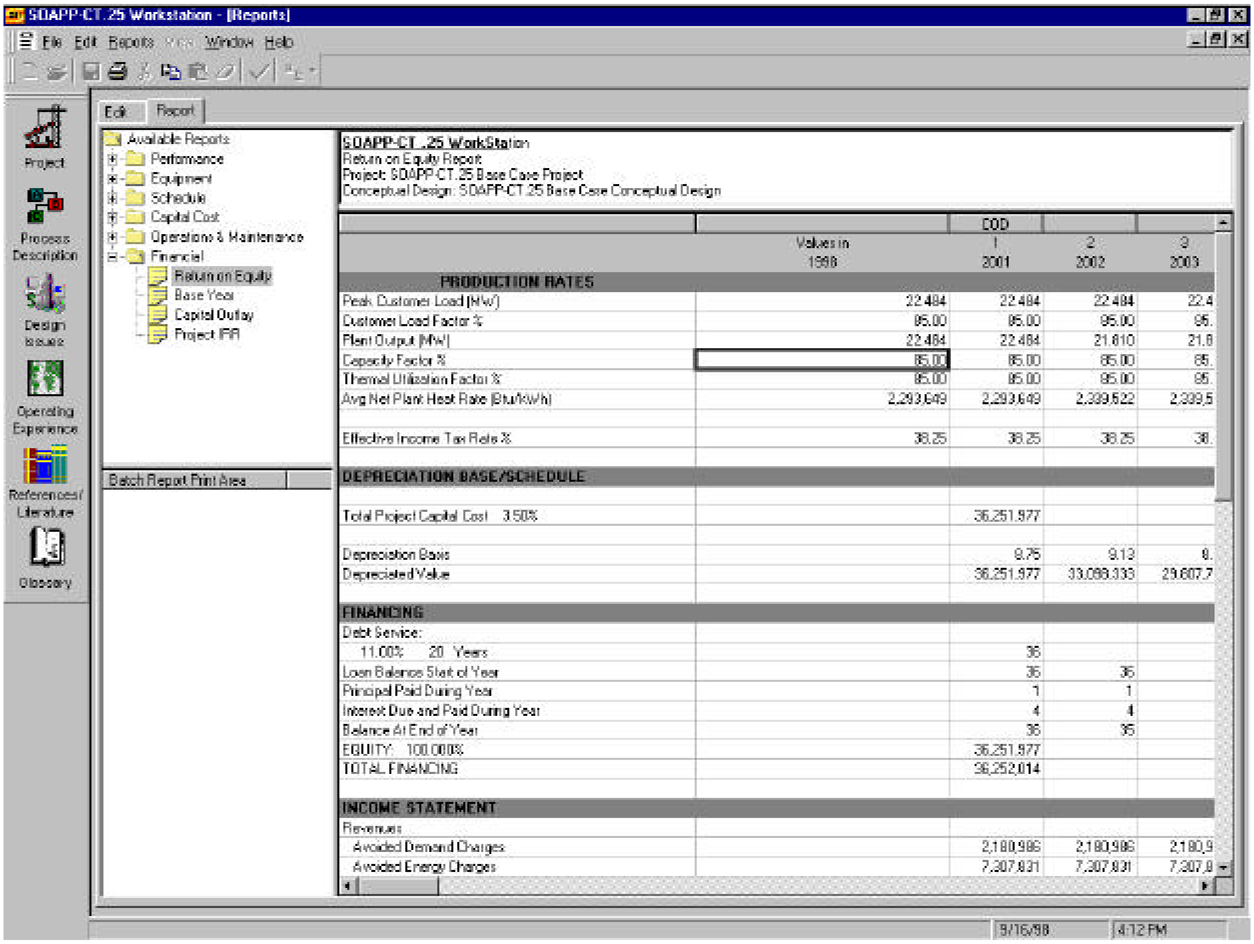
Variable Name	Value	Units	Minimum	Maximum	Default	
SOAPP-CT.25 Base Case Facility						
Number of Periods per Year	1	N/A	1	12	1	
SOAPP-CT.25 Base Case Facility\CT Selection						
CT Model Number	ABB GT 10B (24.6 MW)	N/A	N/A	N/A	GE Power Systems PG5371PA (25.	
CT Frequency	60 Hz	N/A	N/A	N/A	60 Hz	
Number of CT's	1	N/A	1	6	1	
Cycle Type	Cogeneration	N/A	N/A	N/A	Cogeneration	
CT NOx Control, Natural Gas	Dry Low NOx Combustors	N/A	N/A	N/A	Dry Low NOx Combustors	
CT NOx Control, No 2 Fuel Oil	Water Injection	N/A	N/A	N/A	Water Injection	
CT Natural Gas NOx Limit	25	ppmvd @ 15% O2	25	25	25	
CT No 2 Fuel Oil NOx Limit	42	ppmvd @ 15% O2	42	150	42	
CEM's Included	Yes	N/A	N/A	N/A	Yes	
Evaporative Coolers	Yes	N/A	N/A	N/A	Yes	
Evaporative Cooler Status	...	N/A	N/A	N/A	N/A	
SOAPP-CT.25 Base Case Facility\Fuel Selection						
Primary Fuel - Combustion Turbine	Natural Gas	N/A	N/A	N/A	Natural Gas	
Primary Fuel - Duct Burner	Natural Gas	N/A	N/A	N/A	Natural Gas	Not applicable when c
Secondary Fuel	Distillate Oil	N/A	N/A	N/A	Distillate Oil	
Secondary Fuel Usage Factor	...	%	0	100	5	
User Specified Fuel LHV	16400	Btu/lb	0	25000	16400	Only applicable for us
User Specified Fuel Constituent CH	98.81	% vol	0.00	100.00	98.81	Only applicable for us
User Specified Fuel Constituent H2	0.00	% vol	0.00	100.00	0.00	Only applicable for us
User Specified Fuel Constituent CO	0.80	% vol	0.00	100.00	0.80	Only applicable for us
User Specified Fuel Constituent N2	0.39	% vol	0.00	100.00	0.39	Only applicable for us
User Specified Fuel Constituent S	0.00	% vol	0.00	100.00	0.00	Only applicable for us
User Specified Fuel Constituent C	0.00	% vol	0.00	100.00	0.00	Only applicable for us
User-Specified Duct Burner Fuel Cl	Natural Gas System	N/A	N/A	N/A	Natural Gas	Not applicable when c
User-Specified Duct Burner Fuel Sp	0	$	0	1000000	0	Not applicable when c
SOAPP-CT.25 Base Case Facility\HRSG Configuration						
Deaerator Selection	Standalone Deaerator	N/A	N/A	N/A	Standalone Deaerator	
Heater Selection	No Condensate Heater	N/A	N/A	N/A	No Condensate Heater	
Number of Pressure Levels	One Level	N/A	N/A	N/A	Two Level	
HP Steam Pressure	615.0	psia	20.0	1465.0	615.0	
IP Steam Pressure	225.0	psia	20.0	465.0	225.0	IP steam does not exi
LP Steam Pressure	75.0	psia	20.0	200.0	75.0	LP steam does not ex
HP Steam Temperature	900.0	F	500.0	1013.0	900.0	
IP Steam Temperature	485.0	F	404.0	515.0	485.0	IP steam does not exi

Figure 3



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Period 1	3.15	3.24	3.34	3.44	3.55	3.65	3.76	3.87	3.99	4.
Period 2	2.90	2.99	3.08	3.17	3.26	3.36	3.46	3.57	3.67	3.
Period 3	2.85	2.94	3.02	3.11	3.21	3.30	3.40	3.51	3.61	3.
Period 4	3.00	3.09	3.18	3.28	3.38	3.48	3.58	3.69	3.80	3.

Figure 4


SOAPP-CT.25 Workstation - [Reports]
File Edit Reports View Window Help
Edit Report
Available Reports
Performance
Equipment
Schedule
Capital Cost
Operations & Maintenance
Financial
Return on Equity
Base Year
Capital Outlay
Project IRR
Batch Report Print Area
Project
Process Description
Design Issues
Operating Experience
References/ Literature
Glossary
SOAPP-CT .25 WorkStation
Return on Equity Report
Project: SOAPP-CT.25 Base Case Project
Conceptual Design: SOAPP-CT.25 Base Case Conceptual Design
COD
Values in 1998
1 2001
2 2002
3 2003
PRODUCTION RATES
Peak Customer Load (MW) 22.484 22.484 22.484
Customer Load Factor % 85.00 85.00 85.00
Plant Output (MW) 22.484 22.484 21.810
Capacity Factor % 85.00 85.00 85.00
Thermal Utilization Factor % 85.00 85.00 85.00
Avg Net Plant Heat Rate (Btu/kWh) 2,293,649 2,293,649 2,339,522
Effective Income Tax Rate % 38.25 38.25 38.25
DEPRECIATION BASE/SCHEDULE
Total Project Capital Cost 3.50% 36,251,977
Depreciation Basis 9.75 9.13
Depreciated Value 36,251,977 33,098,333
FINANCING
Debt Service:
11.00% 20 Years 36
Loan Balance Start of Year 36 36
Principal Paid During Year 1 1
Interest Due and Paid During Year 4 4
Balance At End of Year 36 35
EQUITY: 100.000% 36,251,977
TOTAL FINANCING 36,252,014
INCOME STATEMENT
Revenues
Avoided Demand Charges 2,180,986 2,180,986
Avoided Energy Charges 7,307,831 7,307,831
9/16/98
4:12 PM