

# **VA Hospitals Dallas: Combined Heat and Power Feasibility Study**



Presented by

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## Disclaimer

The Gulf Coast Clean Energy Application Center employed its best professional effort in this study and it is offered on a best effort basis only. Neither the Houston Advanced Research Center, the U.S Department of Energy, nor any of their employees make any warranties, express or implied, nor assume any legal liability or responsibility for the accuracy, completeness, or usefulness of any information in this report. Reference herein to any companies, specific commercial products, processes, or services by trade name, trademark, manufacturer, or otherwise does not constitute or imply any endorsement or recommendation. The Detailed Analysis report is not an investment grade audit. This analysis will establish whether CHP is technically an economically viable for the site, but the results may not reflect the best or optimal CHP configuration. Facility personnel should

work with qualified developers, equipment suppliers, or engineering firms to establish detailed configurations for optimal performance and assumes all risk of using any and all portions of the information provided in the report.

## Executive Summary

Page Southerland Page (PSP) requested a Combined Heat & Power detailed analysis from the U.S. DOE Gulf Coast Clean Energy Application Center (GC RAC) for the VA hospital in Dallas.

The goal of the Detailed Analysis is to show the technical and economic feasibility of CHP at a specific site and not to determine an optimal equipment set or configuration. A wealth of hourly electric and thermal data was supplied to the GC RAC and an hour-by-hour analysis of the CHP system output vs. the electric and thermal loads was conducted. Three new buildings are scheduled to be constructed and their estimated hourly electric and thermal loads have been included as part of the analysis.

As part of the analyses, different prime-mover makes and sizes, having varying heat rates and steam production were applied to the electric and thermal loads. Primarily, gas turbines were analyzed with sizes ranging from 4.4 MW – 7.5 MW. Among the systems that were analyzed, resultant annual savings ranged between \$2.0 – \$2.6 million, with a simple payback between 4.3 and 5.6 years.

Additionally, the installation of the CHP system significantly reduces the Carbon footprint of the campus, whilst reducing greenhouses and water as well. Key benefits are bulleted below

- 46 tons of Nox reductions per year
- 92 tons of SOx reductions per year
- 30,580 tons of CO2 reductions per year
- 317,605 MMBtu of Fossil fuel reductions per year

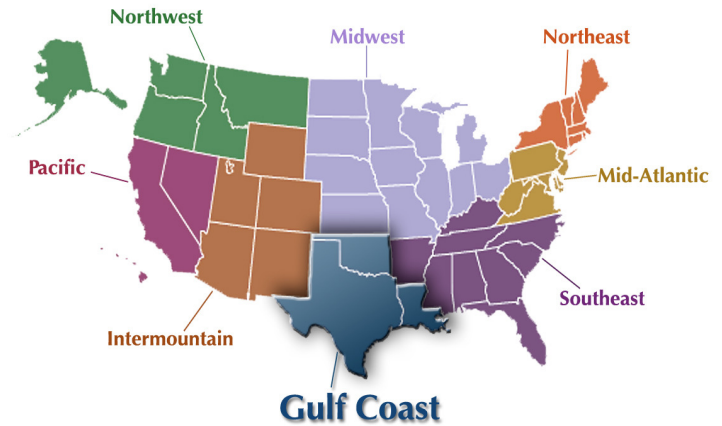
The reductions are equivalent to removing the carbon that would be absorbed by 6,301 acres of forest or the carbon emitted by 5,051 cars.

The GC RAC believes that the VA hospital in Dallas has excellent potential to host a Combined Heat and Power project. The remainder of the report details the methodology and results of the analysis in much greater depth. The GC RAC looks forward to discussing the results of this analysis with PSP and the VA Hospital and providing further assistance as needed.

## Introduction

This report was prepared by the U.S. Department of Energy's Gulf Coast Clean Energy Application Center (GC RAC). Located at the Houston Advanced Research Center in The Woodlands, Texas, the GC RAC is one of eight centers established by the U.S. Department of Energy to promote the use of combined heat and power (CHP) through outreach programs, project specific support, and policy development initiatives. The figure below, which shows all eight regions, highlights the states of Texas, Louisiana, and Oklahoma served by the GC RAC.

The goal of this CHP feasibility study is to establish whether CHP is technically and economically *viable*. The detailed analysis uses simulation software to determine building loads on an hour-by-hour basis. Detailed load information facilitates an in depth comparison of the conventional separate heat and power approach to the combined heat and power option. The analysis evaluates the life cycle capital and operating costs of both approaches using the discounted cash flow method. The analysis results in a financial pro forma and internal rate of return for the CHP project. This report documents the approach and results of a detailed CHP analysis undertaken by the GC RAC to assess the viability of implementing CHP at the VA Hospital in Dallas, Texas.

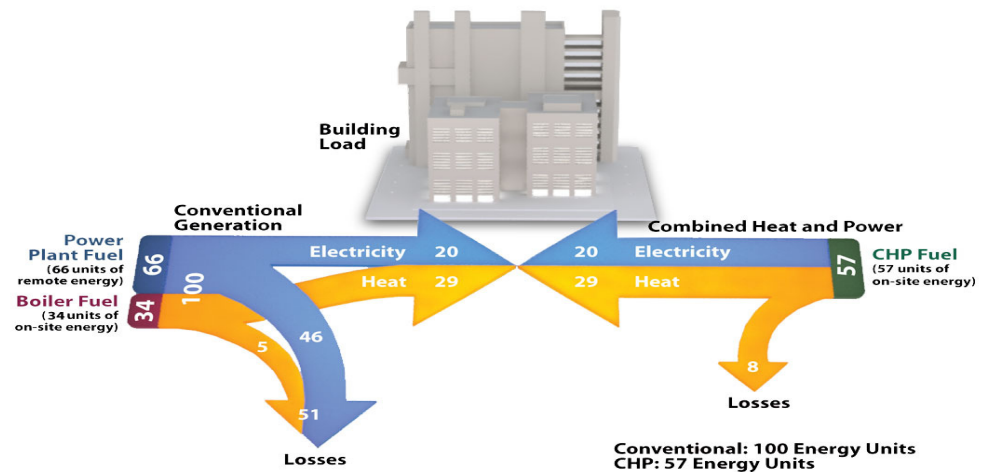


## Combined Heat and Power Overview

The combined heat and power (CHP) approach can provide chill water, steam, and electricity to the VA Hospital at a much higher energy efficiency than the present supply approach. In the current practice, electricity is purchased from the grid and steam is produced by combusting natural gas in on-site boilers. In contrast to this approach, the CHP approach can be used to generate electricity on-site, while using the resulting heat to off-set boiler and electric chiller use. The CHP approach typically consume 40% less fuel than the conventional separate heat and power approach, which results in cost savings and environmental benefits. CHP systems provide a similar degree of cooling and heating comfort and indoor air quality, while delivering a superior level of power reliability and power quality. A schematic comparing the two approaches is provided at the right.

In its simplest form, CHP involves a conventional natural gas fired engine<sup>1</sup> that turns a generator to make electricity. Hot gases created by combusting the natural gas are captured by a heat exchanger to produce steam. If the site has a

steam need equal to or larger than the amount produced by the CHP system, then all of the resulting steam can be used to reduce boiler operations, thereby saving the natural gas normally consumed in the boiler. The most common alternate use is to make chill water by using the steam to drive a steam powered chiller, such as an absorption chiller or steam turbine chiller, which is the approach considered in this report. In some cases, excess steam can be used to generate additional electricity, using a steam turbine or organic rankine cycle technology, although this option is not considered in this analysis. In many cases, CHP systems also include a thermal energy storage (TES) tank in the design. The addition of TES allows greater flexibility for making and storing chill water economically.



<sup>1</sup> In this case, “engine” is a general term that could refer to number of different types of prime movers including combustion turbines, micro-turbines, reciprocating engines, and fuel cells. For purposes of this study, only combustion turbines are evaluated.

## Facility Profile

VA Dallas is Hospital is a full service hospital and part of the VA North Texas health Care System. Currently, the hospital is served by a combination of steam driven and electric chillers to meet its cooling demand. On-site boilers provide steam to drive the steam chillers and for other heating needs at the hospital. Three new buildings are scheduled for construction, thereby adding to the existing electric and thermal loads. All of the data has been aggregated based on input from PSP. Table 1 summarizes this aggregated electricity consumption and gas use for existing and proposed constructions at the hospital Campus.

**Table 1. Electric Consumption and Gas Use – Existing & New Construction**

Month	Existing Peak Demand (kW)	New Construction Peak Demand (kW)	Existing Electricity Consumption (kWh)	New Construction Electricity Consumption (kWh)	Existing Gas Use (MMBtu)	New Construction Gas Use (MMBtu)
January	7,109	1,346	3,925,123	377,857	21,216	1,218
February	7,492	1,472	3,741,365	396,962	17,078	1,120
March	7,989	1,584	4,327,629	548,599	17,746	968
April	8,667	1,507	4,379,399	607,594	15,017	619
May	8,546	1,672	4,468,789	660,161	28,474	485
June	9,415	1,827	5,041,777	783,833	28,259	525
July	9,338	1,907	5,525,091	842,282	25,383	425
August	9,217	1,872	5,233,579	780,740	33,229	447
September	9,016	1,754	4,480,469	741,876	33,224	461
October	9,098	1,609	4,280,957	604,286	22,110	628
November	7,992	1,483	4,071,148	477,414	13,769	848
December	7,109	1,353	3,925,123	395,327	20,544	1,287

Figure 1. *Hourly Electricity Load Profile: Existing & New Construction*

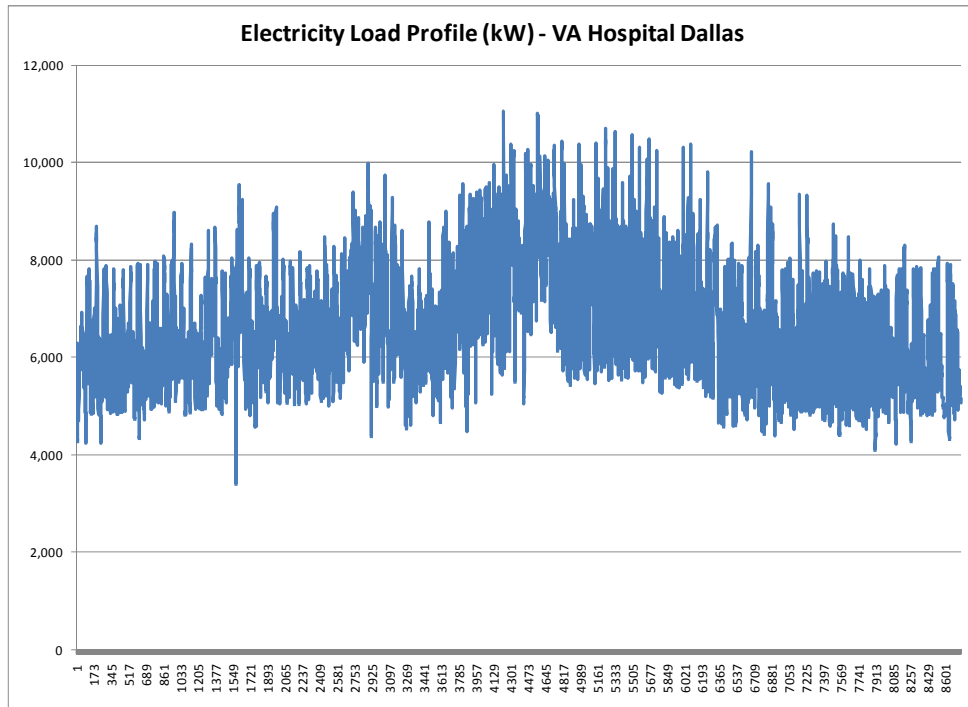
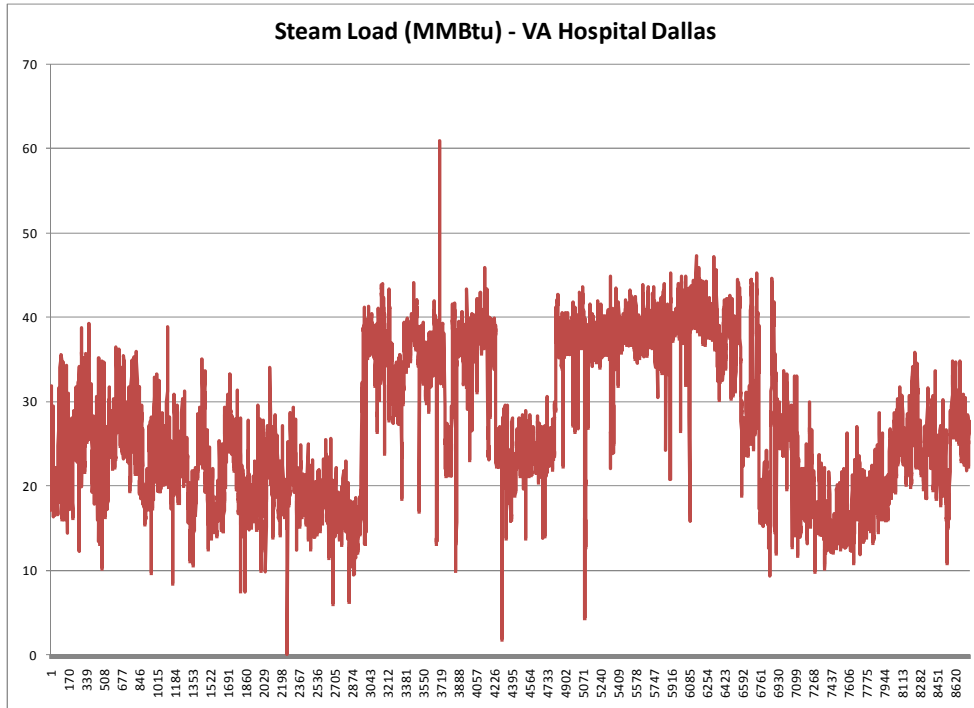


Figure 2. *Hourly Steam Load Profile: Existing & New Construction*



The GC RAC was unable to obtain the most recent 12 months utility bills. The most recent bill that the GC RAC had was September 2009. Gas prices over the past year have been fairly stable and as a result, gas rates have been modified to more accurately reflect current prices. Recent average Houston Ship Channel price for gas was \$4.25/MMBtu, transportation costs were estimated from utility bills to be \$0.75/MMBtu, resulting in a total gas cost of \$5.00/MMBtu. While these assumptions are simple, there is a potential to increase the IRR, if the VA were to engage in more sophisticated mechanisms of gas purchases such as “varying block purchases of natural gas” at a pre-determined price and length of time, hedging, futures natural gas contracts, etc. The investigation of the same is beyond the scope of the current study, but it is recommended that such financial vehicles be examined further, both to potentially increase the IRR as well as to protect against natural gas price volatility. Table 2 lists the rates assumed as part of the analysis. *It must be noted that the GC RAC assumed that existing unit gas costs were \$5.00/MMBtu. If these existing costs are higher, then the savings have the potential to increase notably, resulting in shorter paybacks.*

Table 2. Rates

Parameter	Cost (\$/unit)
Blended Electricity Charge (\$/kWh)	\$0.082
Gas Costs (\$/MMBtu)	\$5.00

## CHP System Overview

A number of different plant configurations were analyzed as part of the detailed analysis. The configurations differed in the utilization of the recovered waste heat, the size of the CHP plant and the associated capital required. CHP configurations were chosen to minimize power exports from the hospital while maximizing heat utilization. *Any limited power exports that occurred in the analysis were not monetized due to their relatively small impact on the financial analysis(3%-6%).* The product data for the analyzed turbines is summarized in Table 3. Detailed specifications and budgetary quote for the equipment can be found in Table 3.

Table 3. Analyzed Turbines : Product Data

	Option 1	Option 2	Option 3	Option 4
<b>Manufacturer</b>	Solar Turbines	Solar Turbines	Solar Turbines	Solar Turbines
<b>Model</b>	Mercury 50	Taurus 60	Taurus 65	Taurus 70
<b>Full Load Capacity (kW)</b>	4,600	5,700	6,300	7,500
<b>Fuel Input (therms)</b>	405	610	638	779
<b>Steam Output (lbs/hr)</b>	13,800	29,800	32,100	36,200

## Steam Chiller Operation

As per data received, the GC RAC observed that the existing steam chillers are operated primarily during summer months (May through October). The installation of the CHP plant, would result in increased steam availability. The Analysis investigated the implications of operating the CHP system under the current steam chiller operation (summer only), as well as the operating scenario under which the steam chillers would run year round. The results and comparisons have been presented in the subsequent sections of the report. Figure 3 & Figure 4 show the hourly steam chiller tonnage for the two scenarios.

Figure 3. *Steam Chiller Profile : Existing Operations*

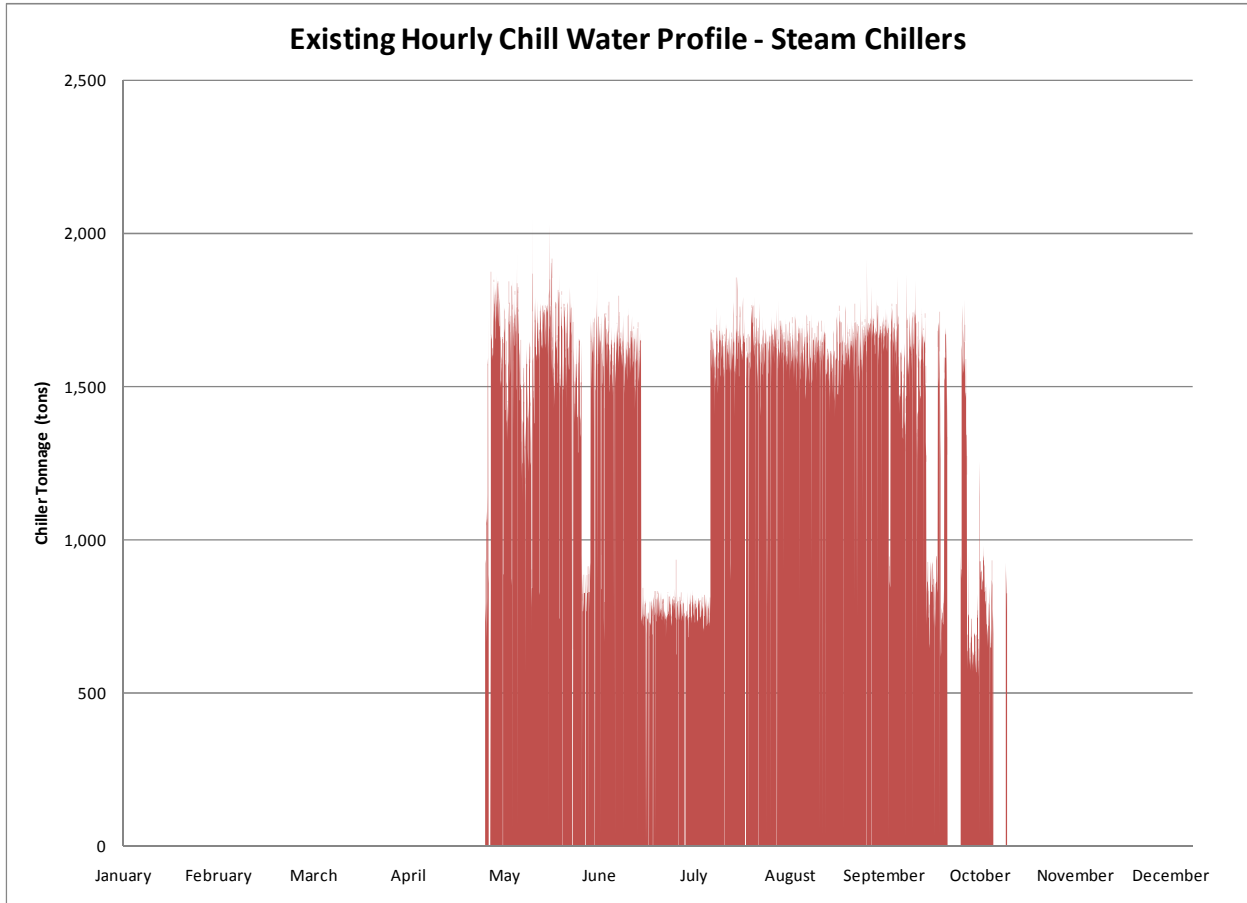
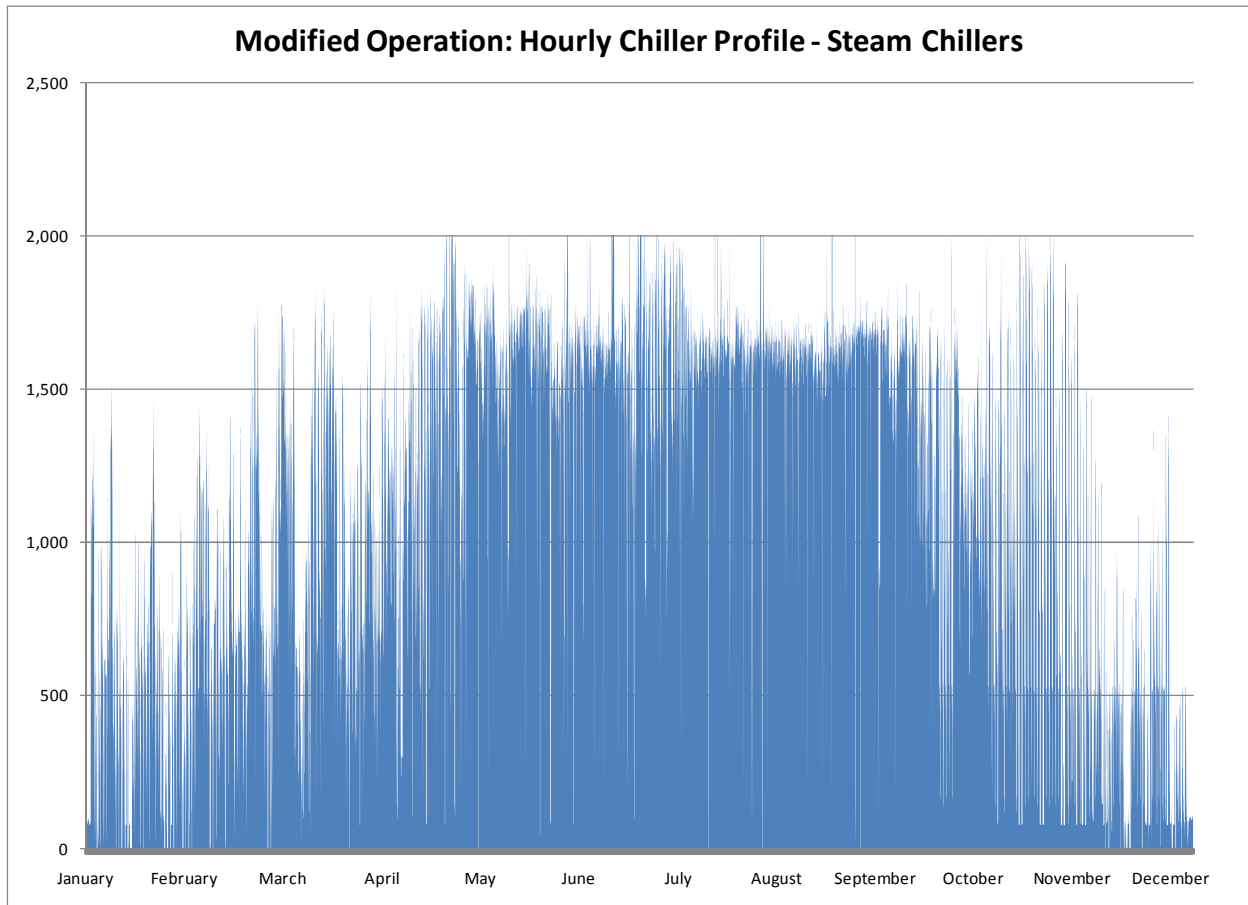


Figure 4. *Steam Chiller Profile : Year round Baseline Operation*



## Results

The hour by hour analysis of the performance of the turbines was matched with two scenarios; a) Existing Steam Chiller Operation & b) Scenario where Steam Chillers are baseloaded. The scenarios differed primarily in the amount of heat and corresponding electricity requirements that was needed at each hourly interval. Table 4 & Table 5 summarizes the plant outputs, fuel consumed, electricity inputs from the grid and corresponding Internal Rate of Return for the two scenarios. Detailed hourly data, monthly summaries and financial analysis can be found in Appendix B.

Table 4. Technical & Economic Summary:CHP configuration vs. Existing Steam Chiller Operation

	Mercury 50	Taurus 60	Taurus 65	Taurus 70
Annual Average On-Site Electric Utilization (%)	100%	98%	96%	87%
Annual Average On-Site Heat utilization (%)	100%	83%	80%	74%
Annual Electricity produced by CHP Plant (kWh)	38,027,347	46,110,620	51,736,372	64,537,742
Annual Fuel Consumption for the CHP Plant (therms)	12,374	18,637	19,835	24,041
Annual Electricity Imports from the Grid (kWh)	21,257,022	13,915,183	9,710,996	3,295,062
Annual Savings (\$)	\$1,988,479	\$2,291,187	\$2,513,052	\$2,501,953
Estimated Capital Costs (\$)	\$10,180,700	\$11,796,100	\$11,598,700	\$13,939,400
SPB (yrs)	5.12	5.15	4.62	5.57
Internal Rate of Return (IRR)	21.68%	20.88%	22.92%	17.80%

Table 5. Technical & Economic Summary:CHP configuration vs. Modified Steam Chiller Operation

	Mercury 50	Taurus 60	Taurus 65	Taurus 70
Annual Average On-Site Electric Utilization (%)	100%	97%	94%	82%
Annual Average On-Site Heat utilization (%)	100%	96%	94%	91%
Annual Electricity produced by CHP Plant (kWh)	38,027,347	46,110,620	51,736,372	64,537,742
Annual Fuel Consumption for the CHP Plant (therms)	3,473,924	5,232,437	5,568,623	6,749,585
<b>Additional Electricity Savings by Year Round Steam Chiller Operation (kWh)</b>	<b>18,287</b>	<b>2,380,065</b>	<b>2,978,742</b>	<b>3,687,366</b>
Annual Electricity Imports from the Grid (kWh)	21,238,756	11,943,998	7,864,090	2,529,800
Annual Savings (\$)	\$1,989,940	\$2,448,882	\$2,660,804	\$2,563,174
Estimated Capital Costs (\$)	\$10,180,700	\$11,796,100	\$11,598,700	\$13,939,400
SPB (yrs)	5.12	4.82	4.36	5.44
Internal Rate of Return (IRR)	21.69%	22.41%	24.36%	18.33%

Amongst all the different scenarios that were run, the shortest payback and the highest IRR was observed for the Taurus 65 (6.3 MW Gas Turbine) in conjunction with “baseloading” the steam chillers to operate them year round.

## Special Comments

### Permitting

The site will need to permit the CHP Plant for NO<sub>x</sub> emissions. Since the site is located in a non-attainment area, selective catalytic reduction (SCR) is expected to be needed to be installed as part of the overall installation of the CHP plant. The basic principle of SCR is the reduction of NO<sub>x</sub> to N<sub>2</sub> and H<sub>2</sub>O by the reaction of NO<sub>x</sub> and ammonia (NH<sub>3</sub>) within a catalyst bed. PSP expressed concern about possible ammonia leaks, especially considering that a school was in the vicinity of the proposed CHP Plant. State of the art SCR systems using aqueous ammonia are considered to be safe in urban settings, although coordination with local fire and building code officials may be required. Two recent projects in downtown urban hospitals in Houston (The Methodist Hospital and Thermal Energy Corporation (TECO) at the Texas Medical Center) have both recently implemented CHP with such SCR technologies.

### Project Economics

Certain factors can enhance or discourage project economics and are discussed below.

- **Capital budget plans** – Potential future costs incurred to replace aging chillers, cooling towers, backup generators, boilers, and related equipment or to expand the facility capabilities can be offset by a new CHP plant. To the extent this equipment can be avoided, these costs can be subtracted from the capital cost of a CHP plant, thereby reducing the simple payback.

- **Life Cycle Analysis**

Detailed Life Cycle Analysis spreadsheets of the analyzed CHP configurations are provided in Appendix B. The Operations & Maintenance (O&M) costs were assumed to be \$10/ MWh. Based on feedback from PSP, the interest/bond rate was assumed to be 5%. It was also assumed that electricity and gas prices will escalate at 3% per year. The life cycle analysis was done for a period of 20 years.

- **Standby Charges**

The VA may require standby service from Oncor to allow for continued electrical service in the event the on-site generator is unavailable for service due to scheduled or unscheduled outages. Some utilities have imposed high standby rates to discourage the installation of distributed generation. While these charges are capped at the full demand charge on the generating unit, many times the actual charge can be negotiated to a much lower value. If VA Hospitals decides to pursue CHP, then Oncor, the transmission and distribution service provider that serves the electric needs for the campus, must be involved early in the project development cycle, and these standby charges may need to be negotiated/finalized such that they are not detrimental to overall project economics.

- **Natural Gas Service**

High pressure natural gas service (>200 psig) is required for gas turbines that have been analyzed in this report. The GC RAC does not have information with regards to its availability at the VA campus. The Budgetary Quotes included in Appendix C include the installation of gas compressors, which range in costs between \$471,000 (for the Mercury 50) to \$812,000 (for the Taurus 70). If the installation of the gas compressors can be avoided, by accessing high pressure natural gas pipelines, then the payback can be shortened.

- **Oncor's Commercial Standard Offer Program** – The Public Utilities Commission recognizes cogeneration as a valid energy efficiency measure, included in the Texas Energy Efficiency Incentive Program (EEIP). While discussions are ongoing to increase the amount of incentives offered for combined heat and power, certain small but not insignificant incentives currently exist for projects that capture the waste heat from the turbine to offset electricity. As an added note, The Methodist Hospital CHP project received an incentive of roughly \$404,000 from CenterPoint Energy. Since the VA already operates the steam chillers in summer, incentives would be applicable only if the VA changed its steam chiller operation to make it year round or if they were to add additional steam chillers, as part of the project in lieu of electric chiller purchases. For purposes of illustration, the Taurus 65 operation & baseloaded steam chiller would receive an incentive of roughly \$300,000 reducing the simple payback to around 4.25 years.

### **Dual fuel Turbines**

Based on feedback from PSP, the GC RAC gleaned that the VA hospitals wanted to ensure that the prime-mover be dual fuel to further their commitments to renewable energy. Detailed Budgetary Quotes were obtained from Solar turbines and these can be found Appendix C. While the Taurus 60 and Taurus 70 were dual fuel turbines, the Mercury 50 and Taurus 65 are limited in design and performance and can run on natural gas only. It was observed that the dual fuel machines were more expensive than the gas-only turbines. Feedback from Solar Turbines indicated that both from a technical performance and an economic standpoint, gas-only machines were a better choice. Consequently, burning bio-diesel to augment boiler operations may be a better option to help meet VA's renewable energy commitments.

### **Turbine Inlet Cooling (TIC)**

TIC is cooling of the ambient air before it enters the compressor that supplies high-pressure air to the combustion chamber from which hot air at high pressure enters the combustion turbine.

When ambient temperature is above 59°F, some specific benefits of TIC include the following:

- Increased power output
- Reduced capital cost (\$/kW) per unit of power plant output capacity
- Increased fuel efficiency
- Increased steam output in cogeneration systems
- Increased power output of steam turbines in combined-cycle systems
- Improved predictability of power output by eliminating the weather variable

The GC RAC ran a preliminary analysis for turbine inlet cooling and recommends that the option be studied in greater detail. If chill water piping is available in close proximity to the CHP plant, the economics for TIC seem to be very favorable.

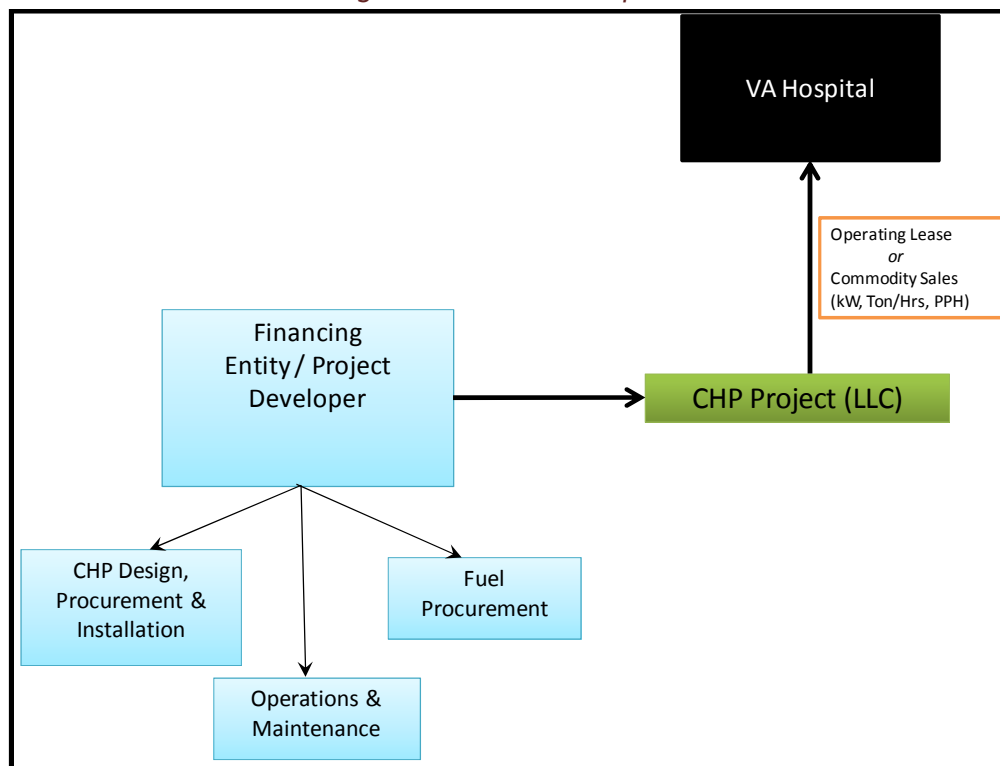
### Third Party Ownership

Due to potential budget deficit situations, alternate financing mechanisms of the CHP Plant could be investigated. Figure 5 lists a scenario where a project developer would own and operate the plant, and sell commodities (electricity, steam, or chill water) to the VA Hospital. This has the potential to minimize upfront capital and risk associated with the installation and may allow the VA to partially capture preferential tax benefits unavailable to government agencies.

The City of Dallas Water Utilities recently unveiled its new renewable biogas cogeneration plant at the Southside Wastewater Treatment Plant (SWWTP). The CHP system, which was financed and is owned and operated by the third party developer (Ameresco), offered a low-risk approach, while producing economic benefits to the City of Dallas and to the Dallas Water Utilities. The plant generates electricity, recover waste heat, and utilize this thermal energy by using the SWWTP-produced biogas. The GC RAC has additional information with regards to the project, if VA Hospital were interested in exploring this route. Details with regards to the project can be found in the link below

[http://www.epa.gov/chp/documents/meeting\\_110110\\_baptista.pdf](http://www.epa.gov/chp/documents/meeting_110110_baptista.pdf)

Figure 5. Partnership Model



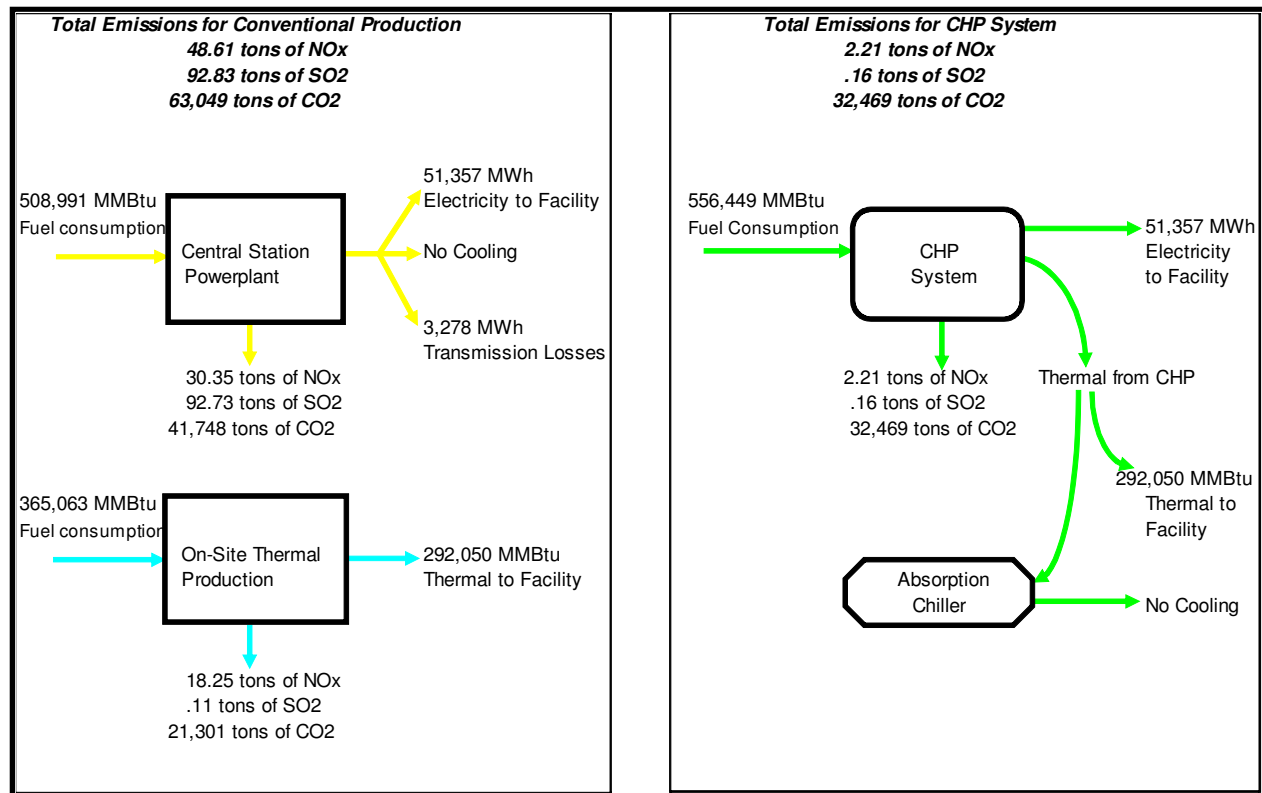
## Environmental Analysis

The CHP plant helps in reductions of major greenhouse gases. The Environmental Protection Agency's Emissions Calculator was used to analyze the reductions of NO<sub>x</sub>, SO<sub>x</sub> and CO<sub>2</sub>. Table 6 quantifies these reductions. The benefits listed are for the Taurus 65 (6.3 MW Gas Turbine). 0 compares the emissions between conventional grid/boiler utility model and combined heat and power.

Table 6. Environmental Benefits : CHP System

Annual Emissions Analysis					
	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
<b>NOx (tons/year)</b>	2.21	30.35	18.25	46.40	95%
<b>SO2 (tons/year)</b>	0.16	92.73	0.11	92.67	100%
<b>CO2 (tons/year)</b>	32,469	41,748	21,301	30,580	49%
<b>Carbon (metric tons/year)</b>	8,028	10,323	5,267	7,561	49%
<b>Fuel Consumption (MMBtu/year)</b>	556,449	508,991	365,063	317,605	36%
<b>Acres of Forest Equivalent</b>	6,301				
<b>Number of Cars Removed</b>	5,051				

Figure 6. Emissions Comparison between Conventional Approach and CHP System



## Next Steps

The Detailed Analysis indicates strong economic and technical feasibility of CHP at the VA Hospitals in Dallas. If necessary, the GC RAC is available to further clarify any sections contained here-in the report, further illustrate analysis procedures, provide excel files and address barriers for project development.

## Appendix A. Useful Links & More Information

### U.S. DOE Gulf Coast Clean Energy Application Center

- <http://www.gulfcoastcleanenergy.org/>

### U.S. DOE Industrial Technologies Program

- <http://www1.eere.energy.gov/industry/distributedenergy/>

### U.S. EPA CHP Partnership

- <http://www.epa.gov/chp/>

### Texas CHP Initiative

- <http://www.texaschpi.org/>

### U.S. Clean Heat and Power Association

- <http://www.uschpa.org/>

## Appendix B. Detailed Analysis : Charts and Graphs

The tables & figures in the Appendix are structured as follows

### **I. Analyzed CHP configurations & Existing Steam Chiller Operation**

- Monthly Plant Output (kWh) - *Table*
- Monthly CHP Fuel Consumption (therms) - *Table*
- Electricity Imports from the Grid (kWh) - *Table*
- Monthly Energy Costs (\$) - *Table*
- Monthly Savings (\$) - *Table*
- Hourly Electric Output (kw) - *Figures*
- Energy Chargeable to Power (Btu/kWh) - *Figures*
- Fuel Cost Chargeable to Power (\$/kWh) - *Figures*
- IRR Calculations - *Figures*

### **II. Analyzed CHP configurations & Modified Steam Chiller Operation**

- Monthly Plant Output (kWh) - *Table*
- Monthly CHP Fuel Consumption (therms) - *Table*
- Electricity Imports from the Grid (kWh) - *Table*
- Monthly Energy Costs (\$) - *Table*
- Monthly Savings (\$) - *Table*
- IRR Calculations - *Figures*

## Detailed Figures & Tables: CHP Configurations AND Existing Steam Chiller Operation

**Table 1. Mercury 50: Monthly Energy Consumption & Costs Summary (No change to Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	3,506,704	314,380	915,771	\$287,815	\$180,011
February	3,114,218	280,248	1,070,477	\$265,621	\$161,536
March	3,316,725	301,119	1,525,793	\$307,563	\$173,224
April	3,108,375	284,330	1,734,993	\$301,488	\$163,883
May	3,133,948	288,360	1,838,445	\$379,528	\$163,358
June	2,945,550	272,964	2,600,571	\$432,093	\$155,304
July	2,974,954	277,262	3,039,113	\$450,819	\$159,231
August	2,992,437	278,482	2,770,830	\$470,213	\$159,412
September	2,958,308	273,855	1,994,218	\$410,085	\$154,489
October	3,238,262	295,642	1,543,775	\$326,854	\$169,966
November	3,249,169	294,158	1,300,868	\$267,672	\$169,869
December	3,488,697	313,123	922,168	\$285,628	\$178,195
<b>Totals</b>	<b>38,027,347</b>	<b>3,473,924</b>	<b>21,257,022</b>	<b>\$4,185,377</b>	<b>\$1,988,479</b>

**Table 2. Taurus 60: Monthly Energy Consumption & Costs Summary (No change to Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	4,252,106	473,521	365,539	\$270,221	\$197,605
February	3,776,190	422,110	507,809	\$253,267	\$173,890
March	4,021,744	453,546	868,998	\$296,845	\$183,941
April	3,769,106	428,259	1,083,660	\$300,827	\$164,544
May	3,800,114	434,329	1,186,512	\$335,906	\$206,980
June	3,571,671	411,140	1,975,270	\$386,797	\$200,600
July	3,607,324	417,613	2,406,743	\$414,441	\$195,609
August	3,628,524	419,451	2,134,744	\$415,507	\$214,118
September	3,587,139	412,481	1,382,551	\$358,477	\$206,097
October	3,926,602	445,297	907,945	\$302,799	\$194,021
November	3,939,827	443,062	695,151	\$277,160	\$160,381
December	4,230,271	471,627	400,261	\$270,422	\$193,401
<b>Totals</b>	<b>46,110,620</b>	<b>5,232,437</b>	<b>13,915,183</b>	<b>\$3,882,669</b>	<b>\$2,291,187</b>

**Table 3. Taurus 65: Monthly Energy Consumption & Costs Summary (No change to Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	4,770,887	503,945	154,997	\$266,342	\$201,484
February	4,236,907	449,231	255,322	\$245,740	\$181,416
March	4,512,419	482,687	507,688	\$282,170	\$198,616
April	4,228,958	455,775	692,460	\$283,284	\$182,087
May	4,263,749	462,235	777,640	\$307,824	\$235,062
June	4,007,434	437,556	1,548,526	\$357,456	\$229,941
July	4,047,438	444,445	1,967,716	\$388,207	\$221,843
August	4,071,224	446,401	1,693,350	\$381,619	\$248,006
September	4,024,790	438,983	984,661	\$328,145	\$236,429
October	4,405,669	473,907	547,405	\$285,887	\$210,933
November	4,420,508	471,529	376,418	\$265,878	\$171,663
December	4,746,388	501,930	204,815	\$268,253	\$195,571
<b>Totals</b>	<b>51,736,372</b>	<b>5,568,623</b>	<b>9,710,996</b>	<b>\$3,660,805</b>	<b>\$2,513,052</b>

**Table 4. Taurus 70: Monthly Energy Consumption & Costs Summary (No change to Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	5,951,369	610,818	9,263	\$306,643	\$161,182
February	5,285,264	544,501	24,568	\$274,330	\$152,827
March	5,628,948	585,052	80,801	\$298,997	\$181,789
April	5,275,349	552,433	132,615	\$286,826	\$178,545
May	5,318,749	560,263	178,054	\$298,321	\$244,564
June	4,999,012	530,350	683,642	\$324,041	\$263,356
July	5,048,914	538,700	1,016,428	\$352,982	\$257,068
August	5,078,586	541,071	782,563	\$339,523	\$290,102
September	5,020,663	532,080	274,029	\$301,345	\$263,229
October	5,495,785	574,411	95,010	\$297,383	\$199,437
November	5,514,295	571,528	10,154	\$286,576	\$150,965
December	5,920,809	608,376	7,934	\$304,934	\$158,890
<b>Totals</b>	<b>64,537,742</b>	<b>6,749,585</b>	<b>3,295,062</b>	<b>\$3,671,904</b>	<b>\$2,501,953</b>

Figure 1. Hourly Electric Output: Analyzed configurations (No Change to Steam Chiller Operation)

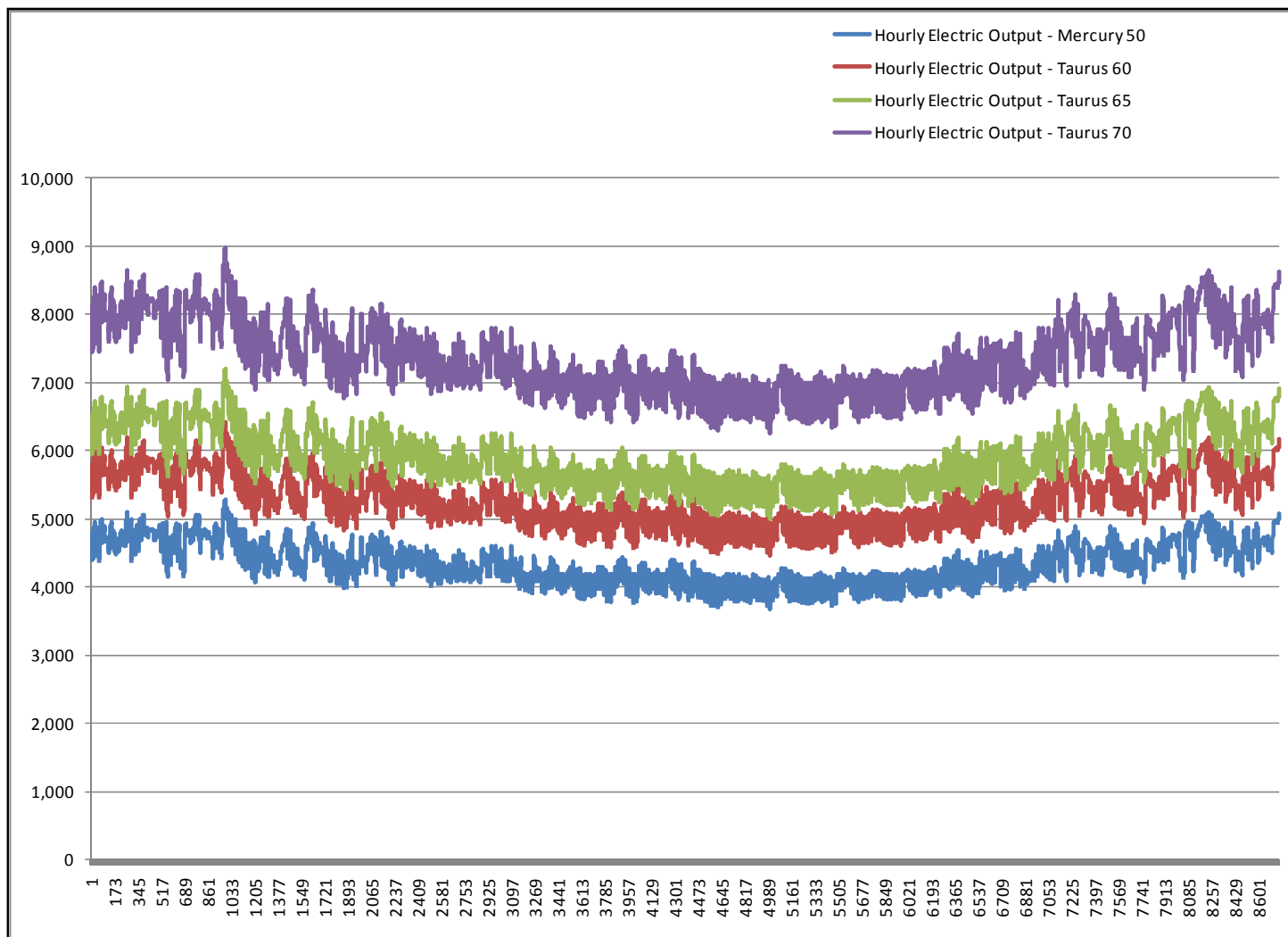


Figure 2. Energy Chargeable to Power (Btu/kWh):Mercury 50 (Unchanged Steam Chiller Operation)

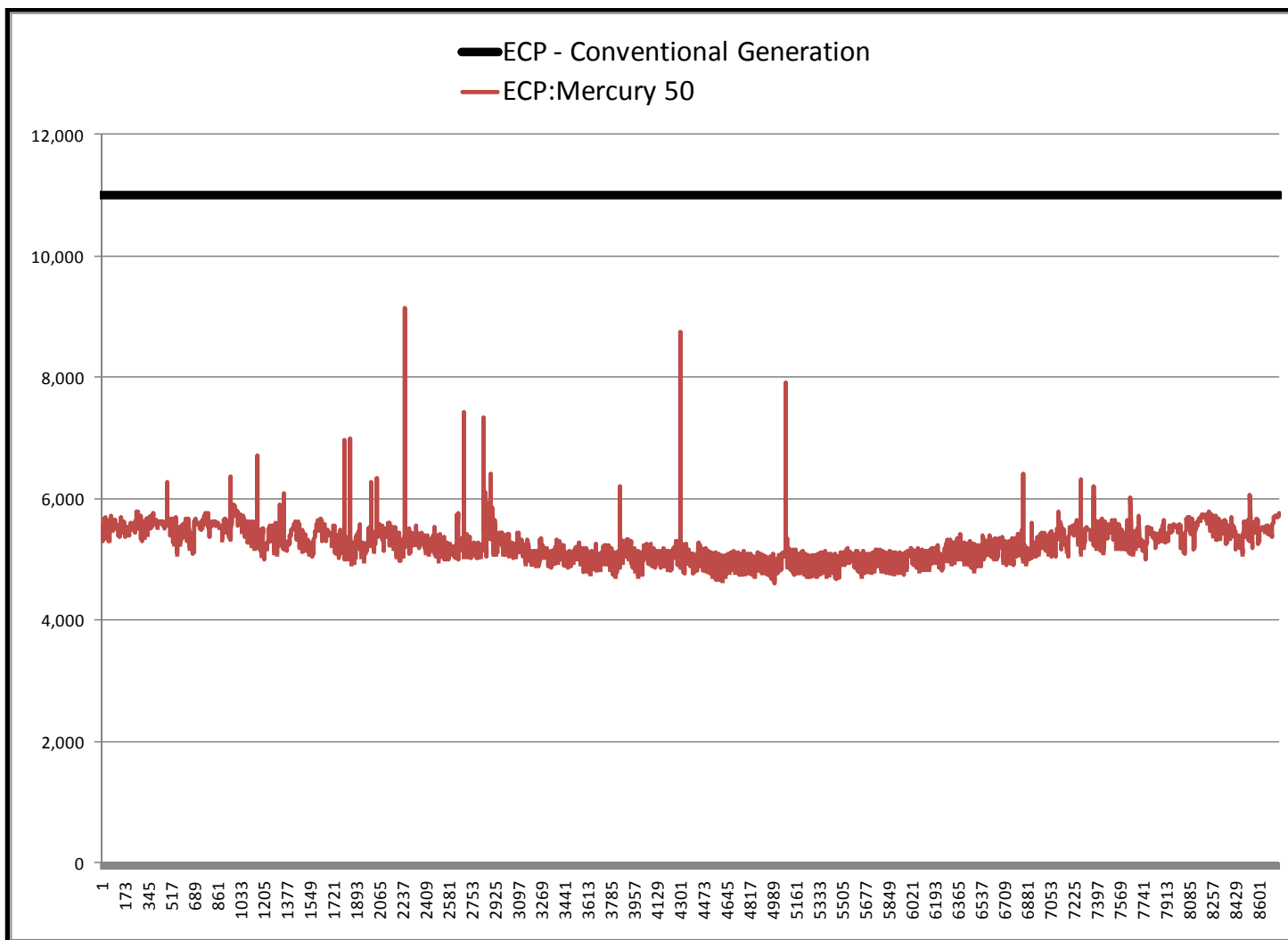


Figure 3. Energy Chargeable to Power (Btu/kWh):Taurus 65 (Unchanged Steam Chiller Operation)  
Figure 4.

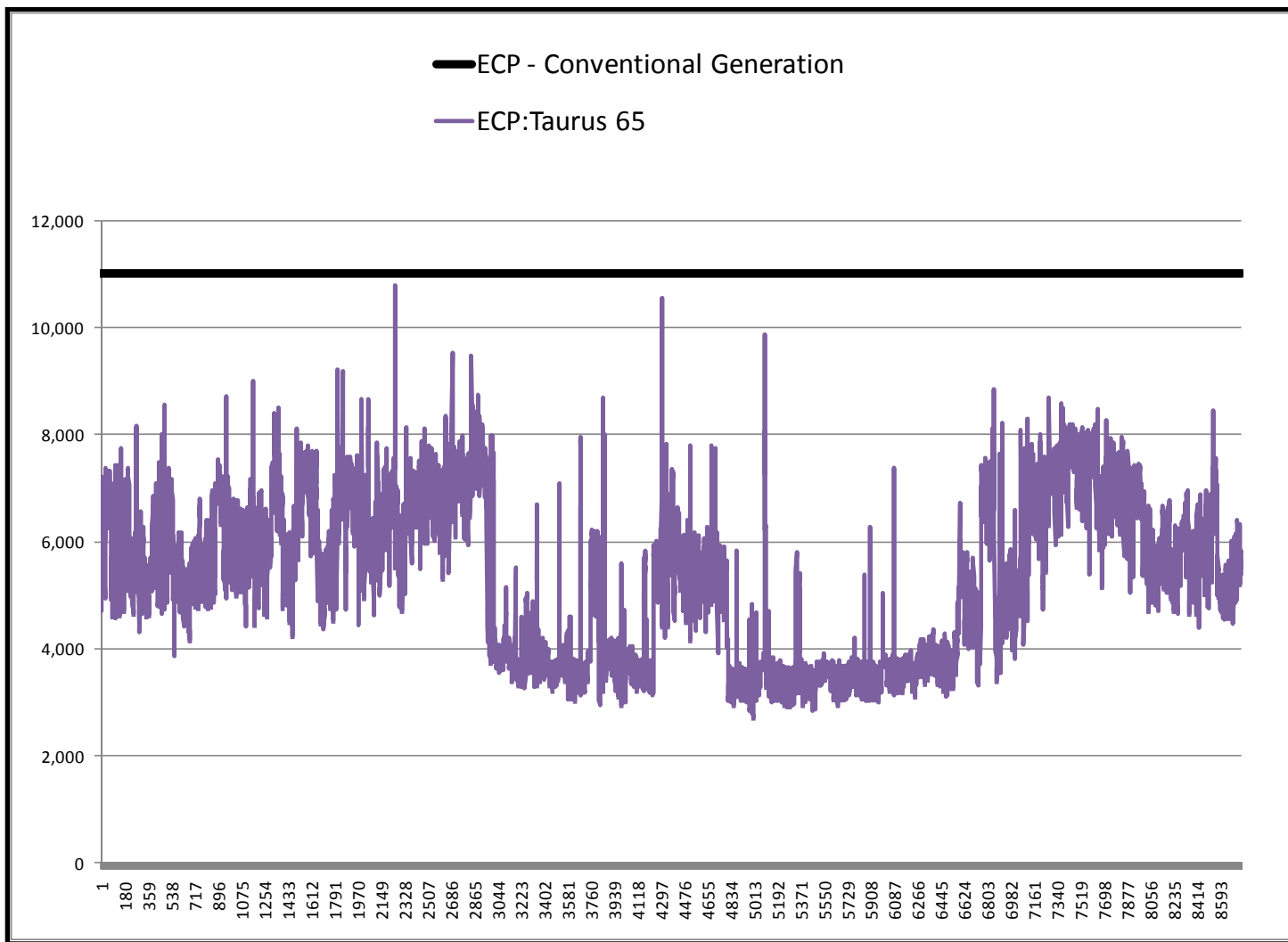


Figure 5. Cost Chargeable to Power (\$/kWh):Mercury 50 (Unchanged Steam Chiller Operation)

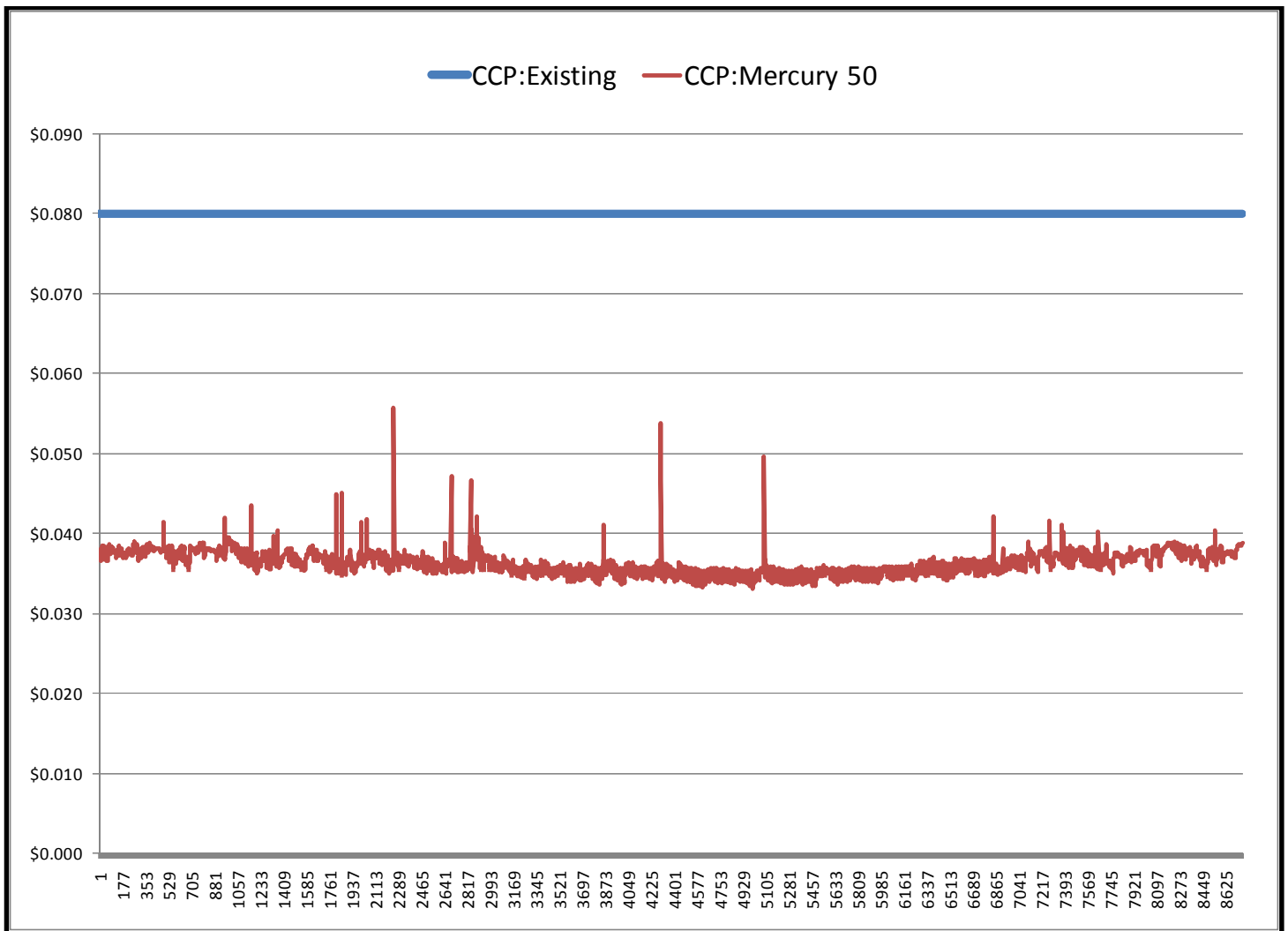


Figure 6. Cost Chargeable to Power (\$/kWh):Taurus 65 (Unchanged Steam Chiller Operation)

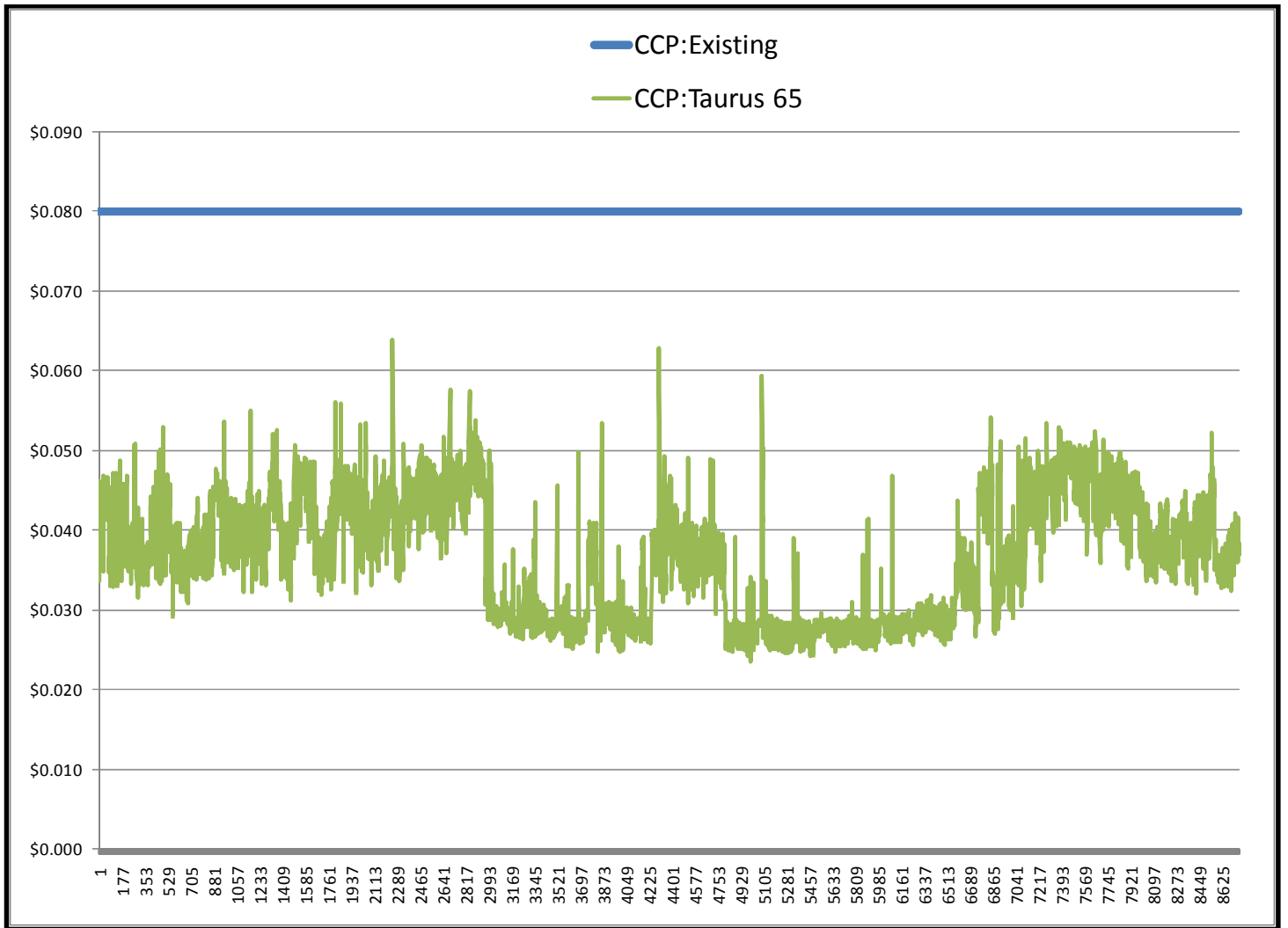


Figure 7. Internal Rate of Return Calculations:Mercury 50 (Unchanged Steam Chiller Operation)

Interest or Bond Rate	5.0%		Project:	VA Hospitals Dallas
First Cost of Plant (1000\$)	\$10,181		Scenario:	Mercury 50
Avoided First Costs (1000\$)	-		Steam Chiller Operation	No Change
Annual Power Generation	38,027	MWH	IRR =	21.68%
Projected Change in Electric Charges	3%			
Projected Change in Fuel Charges	3%			
Financing and Cash Flow Period	20	Years		

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$10,181																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$1,701	\$1,752	\$1,804	\$1,858	\$1,914	\$1,971	\$2,031	\$2,091	\$2,154	\$2,219	\$2,285	\$2,354	\$2,425	\$2,497	\$2,572	\$2,649	\$2,729	\$2,811	\$2,895	\$2,982	\$3,071
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$2,485	\$2,715	\$2,797	\$2,881	\$2,967	\$3,056	\$3,148	\$3,242	\$3,339	\$3,440	\$3,543	\$3,649	\$3,759	\$3,871	\$3,987	\$4,107	\$4,230	\$4,357	\$4,488	\$4,622	\$4,761
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$3,429	\$3,532	\$3,638	\$3,747	\$3,860	\$3,975	\$4,095	\$4,218	\$4,344	\$4,474	\$4,609	\$4,747	\$4,889	\$5,036	\$5,187	\$5,343	\$5,503	\$5,668	\$5,838	\$6,013
Change in Gas Cost	1000\$	-\$1,150	-\$1,184	-\$1,220	-\$1,256	-\$1,294	-\$1,333	-\$1,373	-\$1,414	-\$1,456	-\$1,500	-\$1,545	-\$1,592	-\$1,639	-\$1,688	-\$1,739	-\$1,791	-\$1,845	-\$1,900	-\$1,957	-\$2,016
Net Average Year Annual Savings	1000\$	\$2,280	\$2,348	\$2,418	\$2,491	\$2,566	\$2,643	\$2,722	\$2,804	\$2,888	\$2,974	\$3,064	\$3,155	\$3,250	\$3,348	\$3,448	\$3,551	\$3,658	\$3,768	\$3,881	\$3,997
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$380	\$390	\$400	\$410	\$420	\$430	\$441	\$452	\$463	\$475	\$487	\$499	\$511	\$524	\$537	\$551	\$565	\$579	\$593	\$608
Maintenance Cost of Generator System	1000\$	\$190	\$195	\$200	\$205	\$210	\$215	\$221	\$226	\$232	\$238	\$243	\$249	\$256	\$262	\$268	\$275	\$282	\$289	\$297	\$1,751
Cumul. Maint. Sinking Fund Balance	1000\$	\$190	\$385	\$585	\$790	\$0	\$215	\$436	\$662	\$893	\$0	\$243	\$493	\$749	\$1,011	\$0	\$275	\$558	\$847	\$1,143	\$0
<b>EBIDA</b>	1000\$	\$2,089	\$2,153	\$2,219	\$2,286	\$1,356	\$2,427	\$2,501	\$2,578	\$2,656	\$1,606	\$2,820	\$2,906	\$2,994	\$3,085	\$1,900	\$3,276	\$3,376	\$3,478	\$3,584	\$2,246
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$10,181	\$2,089	\$2,153	\$2,219	\$2,286	\$1,356	\$2,427	\$2,501	\$2,578	\$2,656	\$1,606	\$2,820	\$2,906	\$2,994	\$3,085	\$1,900	\$3,276	\$3,376	\$3,478	\$3,584	\$2,246
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817
Available Cash After All Loan Payments	1000\$	\$1,272	\$1,336	\$1,402	\$1,469	\$539	\$1,611	\$1,684	\$1,761	\$1,839	\$789	\$2,003	\$2,089	\$2,177	\$2,269	\$1,083	\$2,459	\$2,559	\$2,661	\$2,767	\$1,429
Cumul. Net Income After Loan Payments		\$1,272	\$2,609	\$4,010	\$5,479	\$6,019	\$7,629	\$9,314	\$11,075	\$12,914	\$13,703	\$15,706	\$17,795	\$19,972	\$22,241	\$23,324	\$25,783	\$28,342	\$31,003	\$33,771	\$35,200
Principle Repayment Component	\$1,000	-\$308	-\$323	-\$339	-\$356	-\$374	-\$393	-\$413	-\$433	-\$455	-\$478	-\$502	-\$527	-\$553	-\$581	-\$610	-\$640	-\$672	-\$706	-\$741	-\$778
Principal Balance	\$1,000	\$9,873	\$9,550	\$9,210	\$8,854	\$8,479	\$8,086	\$7,674	\$7,241	\$6,786	\$6,308	\$5,807	\$5,280	\$4,727	\$4,146	\$3,537	\$2,897	\$2,225	\$1,519	\$778	\$0

Figure 8. Internal Rate of Return Calculations:Taurus 60 (Unchanged Steam Chiller Operation)

Interest or Bond Rate	5.0%		Project:	VA Hospitals Dallas
First Cost of Plant (1000\$)	\$11,796		Scenario:	Taurus 60
Avoided First Costs (1000\$)	-		Steam Chiller Operation	No Change
Annual Power Generation	46,111	MWH	IRR =	20.88%
Projected Change in Electric Charges	3%			
Projected Change in Fuel Charges	3%			
Financing and Cash Flow Period	20	Years		

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$11,796																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$1,113	\$1,147	\$1,181	\$1,216	\$1,253	\$1,291	\$1,329	\$1,369	\$1,410	\$1,452	\$1,496	\$1,541	\$1,587	\$1,635	\$1,684	\$1,734	\$1,786	\$1,840	\$1,895	\$1,952	\$2,011
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$2,769	\$3,026	\$3,117	\$3,211	\$3,307	\$3,406	\$3,508	\$3,614	\$3,722	\$3,834	\$3,949	\$4,067	\$4,189	\$4,315	\$4,444	\$4,577	\$4,715	\$4,856	\$5,002	\$5,152	\$5,307
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$4,034	\$4,155	\$4,280	\$4,408	\$4,541	\$4,677	\$4,817	\$4,962	\$5,110	\$5,264	\$5,422	\$5,584	\$5,752	\$5,924	\$6,102	\$6,285	\$6,474	\$6,668	\$6,868	\$7,074
Change in Gas Cost	1000\$	-\$1,461	-\$1,505	-\$1,550	-\$1,596	-\$1,644	-\$1,693	-\$1,744	-\$1,797	-\$1,850	-\$1,906	-\$1,963	-\$2,022	-\$2,083	-\$2,145	-\$2,210	-\$2,276	-\$2,344	-\$2,414	-\$2,487	-\$2,561
Net Average Year Annual Savings	1000\$	\$2,573	\$2,651	\$2,730	\$2,812	\$2,896	\$2,983	\$3,073	\$3,165	\$3,260	\$3,358	\$3,459	\$3,562	\$3,669	\$3,779	\$3,893	\$4,009	\$4,130	\$4,254	\$4,381	\$4,513
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$461	\$473	\$484	\$497	\$509	\$522	\$535	\$548	\$562	\$576	\$590	\$605	\$620	\$636	\$652	\$668	\$685	\$702	\$719	\$737
Maintenance Cost of Generator System	1000\$	\$231	\$236	\$242	\$248	\$254	\$261	\$267	\$274	\$281	\$289	\$295	\$303	\$310	\$318	\$326	\$334	\$342	\$351	\$360	\$2,124
Cumul. Maint. Sinking Fund Balance	1000\$	\$231	\$467	\$709	\$957	\$0	\$261	\$528	\$802	\$1,083	\$0	\$295	\$598	\$908	\$1,226	\$0	\$334	\$676	\$1,027	\$1,387	\$0
<b>EBIDA</b>	1000\$	\$2,343	\$2,414	\$2,488	\$2,564	\$1,430	\$2,723	\$2,805	\$2,891	\$2,979	\$1,699	\$3,163	\$3,260	\$3,359	\$3,461	\$2,016	\$3,675	\$3,787	\$3,903	\$4,022	\$2,389
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$11,796	\$2,343	\$2,414	\$2,488	\$2,564	\$1,430	\$2,723	\$2,805	\$2,891	\$2,979	\$1,699	\$3,163	\$3,260	\$3,359	\$3,461	\$2,016	\$3,675	\$3,787	\$3,903	\$4,022	\$2,389
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947
Available Cash After All Loan Payments	1000\$	\$1,396	\$1,468	\$1,541	\$1,617	\$484	\$1,776	\$1,859	\$1,944	\$2,033	\$752	\$2,217	\$2,313	\$2,413	\$2,515	\$1,069	\$2,729	\$2,841	\$2,956	\$3,075	\$1,442
Cumul. Net Income After Loan Payments		\$1,396	\$2,864	\$4,406	\$6,023	\$6,506	\$8,282	\$10,141	\$12,086	\$14,118	\$14,871	\$17,087	\$19,401	\$21,813	\$24,328	\$25,397	\$28,126	\$30,967	\$33,923	\$36,998	\$38,440
Principle Repayment Component	\$1,000	-\$357	-\$375	-\$393	-\$413	-\$434	-\$455	-\$478	-\$502	-\$527	-\$553	-\$581	-\$610	-\$641	-\$673	-\$706	-\$742	-\$779	-\$818	-\$859	-\$901
Principal Balance	\$1,000	\$11,439	\$11,065	\$10,671	\$10,258	\$9,825	\$9,370	\$8,891	\$8,390	\$7,862	\$7,309	\$6,728	\$6,118	\$5,477	\$4,804	\$4,098	\$3,356	\$2,578	\$1,760	\$901	\$0

Figure 9. Internal Rate of Return Calculations:Taurus 65 (Unchanged Steam Chiller Operation)

Interest or Bond Rate	5.0%		Project:	VA Hospitals Dallas
First Cost of Plant (1000\$)	\$11,599		Scenario:	Taurus 65
Avoided First Costs (1000\$)	-		Steam Chiller Operation	No Change
Annual Power Generation	51,736	MWH	IRR =	22.92%
Projected Change in Electric Charges	3%			
Projected Change in Fuel Charges	3%			
Financing and Cash Flow Period	20	Years		

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$11,599																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$777	\$800	\$824	\$849	\$874	\$901	\$928	\$955	\$984	\$1,014	\$1,044	\$1,075	\$1,108	\$1,141	\$1,175	\$1,210	\$1,247	\$1,284	\$1,323	\$1,362	\$1,403
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$2,884	\$3,151	\$3,246	\$3,343	\$3,444	\$3,547	\$3,653	\$3,763	\$3,876	\$3,992	\$4,112	\$4,235	\$4,362	\$4,493	\$4,628	\$4,767	\$4,910	\$5,057	\$5,209	\$5,365	\$5,526
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$4,381	\$4,512	\$4,647	\$4,787	\$4,930	\$5,078	\$5,231	\$5,388	\$5,549	\$5,716	\$5,887	\$6,064	\$6,246	\$6,433	\$6,626	\$6,825	\$7,030	\$7,241	\$7,458	\$7,682
Change in Gas Cost	1000\$	-\$1,586	-\$1,633	-\$1,682	-\$1,733	-\$1,785	-\$1,838	-\$1,894	-\$1,950	-\$2,009	-\$2,069	-\$2,131	-\$2,195	-\$2,261	-\$2,329	-\$2,399	-\$2,471	-\$2,545	-\$2,621	-\$2,700	-\$2,781
Net Average Year Annual Savings	1000\$	\$2,795	\$2,879	\$2,965	\$3,054	\$3,146	\$3,240	\$3,337	\$3,437	\$3,540	\$3,647	\$3,756	\$3,869	\$3,985	\$4,104	\$4,227	\$4,354	\$4,485	\$4,619	\$4,758	\$4,901
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$517	\$530	\$544	\$557	\$571	\$585	\$600	\$615	\$630	\$646	\$662	\$679	\$696	\$713	\$731	\$749	\$768	\$787	\$807	\$827
Maintenance Cost of Generator System	1000\$	\$259	\$265	\$272	\$279	\$287	\$293	\$300	\$307	\$315	\$323	\$331	\$339	\$348	\$357	\$366	\$375	\$384	\$394	\$403	\$413
Cumul. Maint. Sinking Fund Balance	1000\$	\$259	\$524	\$796	\$1,074	\$1,357	\$1,645	\$1,938	\$2,236	\$2,539	\$2,847	\$3,160	\$3,478	\$3,801	\$4,129	\$4,462	\$4,800	\$5,143	\$5,491	\$5,844	\$6,202
<b>EBIDA</b>	1000\$	\$2,536	\$2,614	\$2,693	\$2,775	\$2,860	\$2,947	\$3,037	\$3,130	\$3,225	\$3,323	\$3,425	\$3,529	\$3,637	\$3,748	\$3,861	\$3,976	\$4,094	\$4,215	\$4,339	\$4,465
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$11,599	\$2,536	\$2,614	\$2,693	\$2,775	\$2,860	\$2,947	\$3,037	\$3,130	\$3,225	\$3,323	\$3,425	\$3,529	\$3,637	\$3,748	\$3,861	\$3,976	\$4,094	\$4,215	\$4,339	\$4,465
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931
Available Cash After All Loan Payments	1000\$	\$1,605	\$1,683	\$1,763	\$1,845	\$1,930	\$2,017	\$2,106	\$2,199	\$2,294	\$2,391	\$2,490	\$2,591	\$2,694	\$2,800	\$2,908	\$3,018	\$3,130	\$3,244	\$3,361	\$3,480
Cumul. Net Income After Loan Payments	1000\$	\$1,605	\$3,288	\$5,051	\$6,895	\$8,816	\$10,815	\$12,892	\$15,047	\$17,281	\$19,594	\$21,986	\$24,457	\$26,998	\$29,609	\$32,291	\$35,044	\$37,869	\$40,766	\$43,735	\$46,776
Principle Repayment Component	\$1,000	-\$351	-\$368	-\$387	-\$406	-\$426	-\$448	-\$470	-\$494	-\$518	-\$544	-\$571	-\$600	-\$630	-\$661	-\$695	-\$729	-\$766	-\$804	-\$844	-\$886
Principal Balance	\$1,000	\$11,248	\$10,880	\$10,493	\$10,087	\$9,660	\$9,213	\$8,743	\$8,249	\$7,731	\$7,187	\$6,615	\$6,015	\$5,385	\$4,724	\$4,029	\$3,300	\$2,535	\$1,731	\$886	\$0

Figure 10. Internal Rate of Return Calculations:Taurus 70 (Unchanged Steam Chiller Operation)

Interest or Bond Rate	5.0%		Project:	VA Hospitals Dallas
First Cost of Plant (1000\$)	\$13,939		Scenario:	Taurus 70
Avoided First Costs (1000\$)	-		Steam Chiller Operation	No Change
Annual Power Generation	64,538	MWH	IRR =	17.80%
Projected Change in Electric Charges	3%			
Projected Change in Fuel Charges	3%			
Financing and Cash Flow Period	20	Years		

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$13,939																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$264	\$272	\$280	\$288	\$297	\$306	\$315	\$324	\$334	\$344	\$354	\$365	\$376	\$387	\$399	\$411	\$423	\$436	\$449	\$462	\$476
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$3,408	\$3,724	\$3,836	\$3,951	\$4,070	\$4,192	\$4,318	\$4,447	\$4,580	\$4,718	\$4,859	\$5,005	\$5,155	\$5,310	\$5,469	\$5,633	\$5,802	\$5,976	\$6,156	\$6,340	\$6,531
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$4,909	\$5,057	\$5,208	\$5,365	\$5,526	\$5,691	\$5,862	\$6,038	\$6,219	\$6,406	\$6,598	\$6,796	\$7,000	\$7,210	\$7,426	\$7,649	\$7,878	\$8,114	\$8,358	\$8,609
Change in Gas Cost	1000\$	-\$2,159	-\$2,224	-\$2,290	-\$2,359	-\$2,430	-\$2,503	-\$2,578	-\$2,655	-\$2,735	-\$2,817	-\$2,901	-\$2,988	-\$3,078	-\$3,170	-\$3,265	-\$3,363	-\$3,464	-\$3,568	-\$3,675	-\$3,786
Net Average Year Annual Savings	1000\$	\$2,750	\$2,833	\$2,918	\$3,006	\$3,096	\$3,189	\$3,284	\$3,383	\$3,484	\$3,589	\$3,696	\$3,807	\$3,922	\$4,039	\$4,160	\$4,285	\$4,414	\$4,546	\$4,683	\$4,823
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$645	\$662	\$678	\$695	\$712	\$730	\$748	\$767	\$786	\$806	\$826	\$847	\$868	\$890	\$912	\$935	\$958	\$982	\$1,007	\$1,032
Maintenance Cost of Generator System	1000\$	\$323	\$331	\$339	\$348	\$357	\$365	\$374	\$384	\$393	\$403	\$413	\$423	\$434	\$445	\$456	\$467	\$479	\$491	\$503	\$516
Cumul. Maint. Sinking Fund Balance	1000\$	\$323	\$653	\$992	\$1,340	\$1,697	\$2,062	\$2,435	\$2,816	\$3,204	\$3,600	\$4,003	\$4,413	\$4,830	\$5,254	\$5,685	\$6,123	\$6,568	\$7,020	\$7,479	\$7,945
<b>EBIDA</b>	1000\$	\$2,428	\$2,502	\$2,579	\$2,658	\$2,739	\$2,823	\$2,910	\$2,999	\$3,091	\$3,187	\$3,283	\$3,384	\$3,488	\$3,594	\$3,701	\$3,811	\$3,923	\$4,036	\$4,151	\$4,268
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$13,939	\$2,428	\$2,502	\$2,579	\$2,658	\$2,739	\$2,823	\$2,910	\$2,999	\$3,091	\$3,187	\$3,283	\$3,384	\$3,488	\$3,594	\$3,701	\$3,811	\$3,923	\$4,036	\$4,151	\$4,268
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119
Available Cash After All Loan Payments	1000\$	\$1,309	\$1,384	\$1,460	\$1,539	\$1,619	\$1,700	\$1,781	\$1,864	\$1,949	\$2,036	\$2,125	\$2,215	\$2,307	\$2,401	\$2,497	\$2,594	\$2,693	\$2,794	\$2,896	\$3,000
Cumul. Net Income After Loan Payments	1000\$	\$1,309	\$2,693	\$4,153	\$5,693	\$7,312	\$8,911	\$10,590	\$12,349	\$14,188	\$16,107	\$18,106	\$20,185	\$22,344	\$24,584	\$26,904	\$29,304	\$31,784	\$34,344	\$36,984	\$39,704
Principle Repayment Component	\$1,000	-\$422	-\$443	-\$465	-\$488	-\$512	-\$538	-\$565	-\$593	-\$623	-\$654	-\$687	-\$721	-\$757	-\$795	-\$835	-\$876	-\$920	-\$966	-\$1,015	-\$1,065
Principal Balance	\$1,000	\$13,518	\$13,075	\$12,610	\$12,122	\$11,610	\$11,072	\$10,507	\$9,914	\$9,291	\$8,637	\$7,950	\$7,229	\$6,472	\$5,677	\$4,843	\$3,966	\$3,046	\$2,080	\$1,065	\$0

## Detailed Figures & Tables: CHP Configurations AND Modified Steam Chiller Operation

**Table 5. Mercury 50: Monthly Energy Consumption & Costs Summary (Modified Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	3,506,704	314,380	915,541	\$287,796	\$180,029
February	3,114,218	280,248	1,069,390	\$265,534	\$161,623
March	3,316,725	301,119	1,524,251	\$307,439	\$173,347
April	3,108,375	284,330	1,728,977	\$301,007	\$164,364
May	3,133,948	288,360	1,835,701	\$379,308	\$163,578
June	2,945,550	272,964	2,598,809	\$431,952	\$155,445
July	2,974,954	277,262	3,039,049	\$450,814	\$159,236
August	2,992,437	278,482	2,770,463	\$470,183	\$159,441
September	2,958,308	273,855	1,994,218	\$410,085	\$154,489
October	3,238,262	295,642	1,542,646	\$326,763	\$170,057
November	3,249,169	294,158	1,297,600	\$267,411	\$170,130
December	3,488,697	313,123	922,112	\$285,624	\$178,200
<b>Grand Total</b>	<b>38,027,347</b>	<b>3,473,924</b>	<b>21,238,756</b>	<b>\$4,183,916</b>	<b>\$1,989,940</b>

**Table 6. Taurus 60: Monthly Energy Consumption & Costs Summary (Modified Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	4,252,106	473,521	276,324	\$263,084	\$204,742
February	3,776,190	422,110	331,358	\$239,151	\$188,006
March	4,021,744	453,546	533,466	\$270,002	\$210,784
April	3,769,106	428,259	644,958	\$265,731	\$199,640
May	3,800,114	434,329	1,097,691	\$328,800	\$214,086
June	3,571,671	411,140	1,902,157	\$380,948	\$206,449
July	3,607,324	417,613	2,196,646	\$397,633	\$212,417
August	3,628,524	419,451	2,123,894	\$414,639	\$214,986
September	3,587,139	412,481	1,380,129	\$358,284	\$206,291
October	3,926,602	445,297	736,592	\$289,091	\$207,729
November	3,939,827	443,062	384,407	\$252,301	\$185,240
December	4,230,271	471,627	336,375	\$265,311	\$198,512
<b>Grand Total</b>	<b>46,110,620</b>	<b>5,232,437</b>	<b>11,943,998</b>	<b>\$3,724,975</b>	<b>\$2,448,882</b>

**Table 7. Taurus 65: Monthly Energy Consumption & Costs Summary (Modified Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	4,770,887	503,945	97,169	\$261,716	\$206,110
February	4,236,907	449,231	127,277	\$235,497	\$191,660
March	4,512,419	482,687	219,638	\$259,126	\$221,660
April	4,228,958	455,775	298,797	\$251,791	\$213,580
May	4,263,749	462,235	687,274	\$300,595	\$242,291
June	4,007,434	437,556	1,450,733	\$349,632	\$237,764
July	4,047,438	444,445	1,685,978	\$365,668	\$244,382
August	4,071,224	446,401	1,681,331	\$380,657	\$248,968
September	4,024,790	438,983	981,330	\$327,879	\$236,696
October	4,405,669	473,907	385,743	\$272,954	\$223,866
November	4,420,508	471,529	103,228	\$244,023	\$193,518
December	4,746,388	501,930	145,590	\$263,515	\$200,309
<b>Grand Total</b>	<b>51,736,372</b>	<b>5,568,623</b>	<b>7,864,090</b>	<b>\$3,513,052</b>	<b>\$2,660,804</b>

**Table 8. Taurus 70: Monthly Energy Consumption & Costs Summary (Modified Steam Chiller Operation)**

Month	Monthly CHP Plant Electricity Output (kWh)	Monthly Fuel consumed (Therms)	Monthly Electricity Imports from the Grid (kWh)	Monthly utility Costs (\$)	Monthly Savings (\$)
January	5,951,369	610,818	24	\$305,904	\$161,922
February	5,285,264	544,501	2,006	\$272,525	\$154,632
March	5,628,948	585,052	11,496	\$293,453	\$187,333
April	5,275,349	552,433	19,402	\$277,769	\$187,602
May	5,318,749	560,263	134,677	\$294,851	\$248,035
June	4,999,012	530,350	572,657	\$315,162	\$272,234
July	5,048,914	538,700	695,296	\$327,292	\$282,758
August	5,078,586	541,071	762,508	\$337,919	\$291,706
September	5,020,663	532,080	268,745	\$300,923	\$263,652
October	5,495,785	574,411	62,074	\$294,748	\$202,072
November	5,514,295	571,528	258	\$285,785	\$151,756
December	5,920,809	608,376	656	\$304,351	\$159,472
<b>Grand Total</b>	<b>64,537,742</b>	<b>6,749,585</b>	<b>2,529,800</b>	<b>\$3,610,683</b>	<b>\$2,563,174</b>

Figure 11. Hourly Reduction in Electric Load (kW): Modified steam chiller operation - Taurus 65

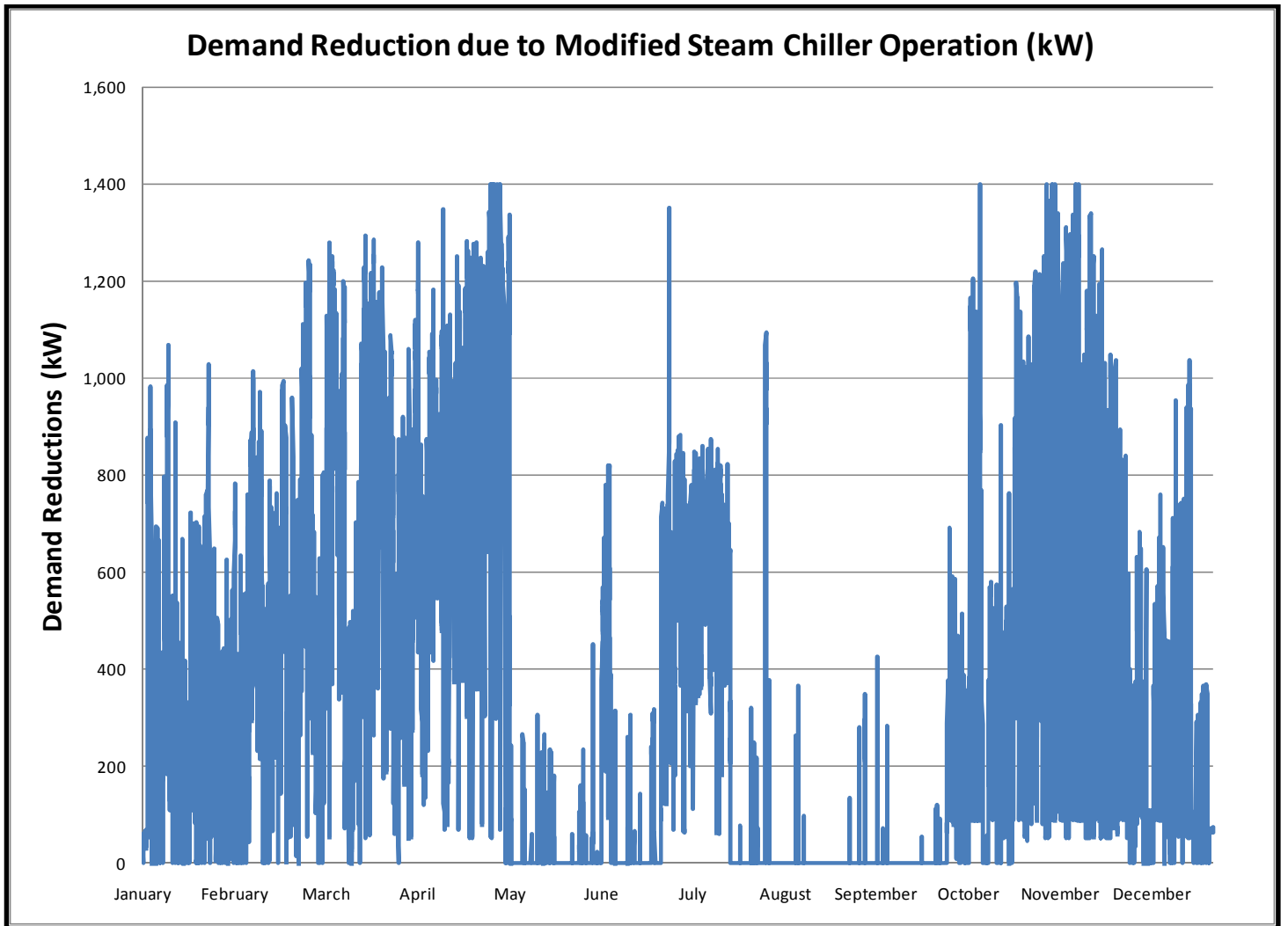


Figure 12. Internal Rate of Return Calculations:Mercury 50 (Modified Steam Chiller Operation)

Interest or Bond Rate		5.0%																			
First Cost of Plant (1000\$)		\$10,181																			
Avoided First Costs (1000\$)		-																			
Annual Power Generation		38,027	MWH																		
Projected Change in Electric Charges		3%																			
Projected Change in Fuel Charges		3%																			
Financing and Cash Flow Period		20	Years																		
Project:			VA Hospitals Dallas																		
Scenario:			Mercury 50 :CHP Plant																		
Steam Chiller Operation			Modified																		
IRR =			21.69%																		
Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$10,181																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$1,699	\$1,750	\$1,803	\$1,857	\$1,912	\$1,970	\$2,029	\$2,090	\$2,152	\$2,217	\$2,283	\$2,352	\$2,423	\$2,495	\$2,570	\$2,647	\$2,727	\$2,808	\$2,893	\$2,979	\$3,069
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$2,485	\$2,715	\$2,797	\$2,881	\$2,967	\$3,056	\$3,148	\$3,242	\$3,339	\$3,440	\$3,543	\$3,649	\$3,759	\$3,871	\$3,987	\$4,107	\$4,230	\$4,357	\$4,488	\$4,622	\$4,761
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$3,431	\$3,534	\$3,640	\$3,749	\$3,861	\$3,977	\$4,097	\$4,219	\$4,346	\$4,476	\$4,611	\$4,749	\$4,891	\$5,038	\$5,189	\$5,345	\$5,505	\$5,671	\$5,841	\$6,016
Change in Gas Cost	1000\$	-\$1,150	-\$1,184	-\$1,220	-\$1,256	-\$1,294	-\$1,333	-\$1,373	-\$1,414	-\$1,456	-\$1,500	-\$1,545	-\$1,592	-\$1,639	-\$1,688	-\$1,739	-\$1,791	-\$1,845	-\$1,900	-\$1,957	-\$2,016
Net Average Year Annual Savings	1000\$	\$2,281	\$2,349	\$2,420	\$2,493	\$2,567	\$2,644	\$2,724	\$2,805	\$2,890	\$2,976	\$3,066	\$3,157	\$3,252	\$3,350	\$3,450	\$3,554	\$3,660	\$3,770	\$3,883	\$4,000
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$380	\$390	\$400	\$410	\$420	\$430	\$441	\$452	\$463	\$475	\$487	\$499	\$511	\$524	\$537	\$551	\$565	\$579	\$593	\$608
Maintenance Cost of Generator System	1000\$	\$190	\$195	\$200	\$205	\$210	\$215	\$221	\$226	\$232	\$238	\$243	\$249	\$256	\$262	\$270	\$275	\$282	\$289	\$297	\$306
Cumul. Maint. Sinking Fund Balance	1000\$	\$190	\$385	\$585	\$790	\$0	\$215	\$436	\$662	\$893	\$0	\$243	\$493	\$749	\$1,011	\$0	\$275	\$558	\$847	\$1,143	\$0
<b>EBIDA</b>	1000\$	\$2,091	\$2,155	\$2,220	\$2,288	\$1,358	\$2,429	\$2,503	\$2,579	\$2,658	\$1,608	\$2,822	\$2,908	\$2,997	\$3,088	\$1,902	\$3,278	\$3,378	\$3,481	\$3,587	\$2,248
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$10,181	\$2,091	\$2,155	\$2,220	\$2,288	\$1,358	\$2,429	\$2,503	\$2,579	\$2,658	\$1,608	\$2,822	\$2,908	\$2,997	\$3,088	\$1,902	\$3,278	\$3,378	\$3,481	\$3,587	\$2,248
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817	-\$817
Available Cash After All Loan Payments	1000\$	\$1,274	\$1,338	\$1,403	\$1,471	\$1,541	\$1,612	\$1,686	\$1,762	\$1,841	\$791	\$2,005	\$2,091	\$2,180	\$2,271	\$1,085	\$2,461	\$2,561	\$2,664	\$2,770	\$1,431
Cumul. Net Income After Loan Payments	1000\$	\$1,274	\$2,612	\$4,015	\$5,486	\$6,027	\$7,639	\$9,325	\$11,088	\$12,929	\$13,720	\$15,725	\$17,816	\$19,996	\$22,267	\$23,352	\$25,814	\$28,375	\$31,039	\$33,808	\$35,240
Principle Repayment Component	1,000	-\$308	-\$323	-\$339	-\$356	-\$374	-\$393	-\$413	-\$433	-\$455	-\$478	-\$502	-\$527	-\$553	-\$581	-\$610	-\$640	-\$672	-\$706	-\$741	-\$778
Principal Balance	1,000	\$9,873	\$9,550	\$9,210	\$8,854	\$8,479	\$8,086	\$7,674	\$7,241	\$6,786	\$6,308	\$5,807	\$5,280	\$4,727	\$4,146	\$3,537	\$2,897	\$2,225	\$1,519	\$778	\$0

Figure 13. Internal Rate of Return Calculations:Taurus 60 (Modified Steam Chiller Operation)

Interest or Bond Rate		5.0%																			
First Cost of Plant (1000\$)		\$11,796																			
Avoided First Costs (1000\$)		-																			
Annual Power Generation		46,111	MWH																		
Projected Change in Electric Charges		3%																			
Projected Change in Fuel Charges		3%																			
Financing and Cash Flow Period		20	Years																		
Project:			VA Hospitals Dallas																		
Scenario:			Taurus 60 :CHP Plant																		
Steam Chiller Operation			Modified																		
IRR =			22.41%																		
Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$11,796																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$956	\$984	\$1,014	\$1,044	\$1,075	\$1,108	\$1,141	\$1,175	\$1,210	\$1,247	\$1,284	\$1,323	\$1,362	\$1,403	\$1,445	\$1,489	\$1,533	\$1,579	\$1,627	\$1,676	\$1,726
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$2,769	\$3,026	\$3,117	\$3,211	\$3,307	\$3,406	\$3,508	\$3,614	\$3,722	\$3,834	\$3,949	\$4,067	\$4,189	\$4,315	\$4,444	\$4,577	\$4,715	\$4,856	\$5,002	\$5,152	\$5,307
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$4,197	\$4,323	\$4,452	\$4,586	\$4,723	\$4,865	\$5,011	\$5,161	\$5,316	\$5,476	\$5,640	\$5,809	\$5,983	\$6,163	\$6,348	\$6,538	\$6,734	\$6,936	\$7,145	\$7,359
Change in Gas Cost	1000\$	-\$1,461	-\$1,505	-\$1,550	-\$1,596	-\$1,644	-\$1,693	-\$1,744	-\$1,797	-\$1,850	-\$1,906	-\$1,963	-\$2,022	-\$2,083	-\$2,145	-\$2,210	-\$2,276	-\$2,344	-\$2,414	-\$2,487	-\$2,561
Net Average Year Annual Savings	1000\$	\$2,736	\$2,818	\$2,903	\$2,990	\$3,079	\$3,172	\$3,267	\$3,365	\$3,466	\$3,570	\$3,677	\$3,787	\$3,901	\$4,018	\$4,138	\$4,262	\$4,390	\$4,522	\$4,658	\$4,797
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$461	\$473	\$484	\$497	\$509	\$522	\$535	\$548	\$562	\$576	\$590	\$605	\$620	\$636	\$652	\$668	\$685	\$702	\$719	\$737
Maintenance Cost of Generator System	1000\$	\$231	\$236	\$242	\$248	\$254	\$261	\$267	\$274	\$281	\$289	\$295	\$303	\$310	\$318	\$326	\$334	\$342	\$351	\$360	\$369
Cumul. Maint. Sinking Fund Balance	1000\$	\$231	\$467	\$709	\$957	\$0	\$261	\$528	\$802	\$1,083	\$0	\$295	\$598	\$908	\$1,226	\$0	\$334	\$676	\$1,027	\$1,387	\$0
<b>EBIDA</b>	1000\$	\$2,505	\$2,582	\$2,660	\$2,741	\$1,613	\$2,911	\$2,999	\$3,091	\$3,185	\$1,911	\$3,382	\$3,485	\$3,591	\$3,700	\$2,261	\$3,929	\$4,048	\$4,171	\$4,298	\$2,674
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$11,796	\$2,505	\$2,582	\$2,660	\$2,741	\$1,613	\$2,911	\$2,999	\$3,091	\$3,185	\$1,911	\$3,382	\$3,485	\$3,591	\$3,700	\$2,261	\$3,929	\$4,048	\$4,171	\$4,298	\$2,674
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947	-\$947
Available Cash After All Loan Payments	1000\$	\$1,559	\$1,635	\$1,714	\$1,795	\$1,879	\$1,964	\$2,053	\$2,144	\$2,238	\$964	\$2,435	\$2,538	\$2,644	\$2,753	\$1,315	\$2,982	\$3,102	\$3,225	\$3,352	\$1,727
Cumul. Net Income After Loan Payments	1000\$	\$1,559	\$3,194	\$4,908	\$6,702	\$7,369	\$9,333	\$11,386	\$13,530	\$15,768	\$16,733	\$19,168	\$21,706	\$24,350	\$27,103	\$28,418	\$31,400	\$34,502	\$37,726	\$41,078	\$42,805
Principle Repayment Component	1,000	-\$357	-\$375	-\$393	-\$413	-\$434	-\$455	-\$478	-\$502	-\$527	-\$553	-\$581	-\$610	-\$641	-\$673	-\$706	-\$742	-\$779	-\$818	-\$859	-\$901
Principal Balance	1,000	\$11,439	\$11,065	\$10,671	\$10,258	\$9,825	\$9,370	\$8,891	\$8,390	\$7,862	\$7,309	\$6,728	\$6,118	\$5,477	\$4,804	\$4,098	\$3,356	\$2,578	\$1,760	\$901	\$0

Figure 14. Internal Rate of Return Calculations:Taurus 65 (Modified Steam Chiller Operation)

Interest or Bond Rate		5.0%																			
First Cost of Plant (1000\$)		\$11,599																			
Avoided First Costs (1000\$)		-																			
Annual Power Generation		51,736	MWH																		
Projected Change in Electric Charges		3%																			
Projected Change in Fuel Charges		3%																			
Financing and Cash Flow Period		20	Years																		
Project:		VA Hospitals Dallas																			
Scenario:		Taurus 65 :CHP Plant																			
Steam Chiller Operation		Modified																			
IRR =		24.36%																			
Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$11,599																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$629	\$648	\$667	\$687	\$708	\$729	\$751	\$774	\$797	\$821	\$845	\$871	\$897	\$924	\$952	\$980	\$1,010	\$1,040	\$1,071	\$1,103	\$1,136
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$2,884	\$3,151	\$3,246	\$3,343	\$3,444	\$3,547	\$3,653	\$3,763	\$3,876	\$3,992	\$4,112	\$4,235	\$4,362	\$4,493	\$4,628	\$4,767	\$4,910	\$5,057	\$5,209	\$5,365	\$5,526
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$4,533	\$4,669	\$4,809	\$4,953	\$5,102	\$5,255	\$5,412	\$5,575	\$5,742	\$5,914	\$6,092	\$6,275	\$6,463	\$6,657	\$6,856	\$7,062	\$7,274	\$7,492	\$7,717	\$7,948
Change in Gas Cost	1000\$	-\$1,586	-\$1,633	-\$1,682	-\$1,733	-\$1,785	-\$1,838	-\$1,894	-\$1,950	-\$2,009	-\$2,069	-\$2,131	-\$2,195	-\$2,261	-\$2,329	-\$2,399	-\$2,471	-\$2,545	-\$2,621	-\$2,700	-\$2,781
Net Average Year Annual Savings	1000\$	\$2,947	\$3,035	\$3,126	\$3,220	\$3,317	\$3,416	\$3,519	\$3,624	\$3,733	\$3,845	\$3,961	\$4,079	\$4,202	\$4,328	\$4,458	\$4,591	\$4,729	\$4,871	\$5,017	\$5,168
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$517	\$530	\$544	\$557	\$571	\$585	\$600	\$615	\$630	\$646	\$662	\$679	\$696	\$713	\$731	\$749	\$768	\$787	\$807	\$827
Maintenance Cost of Generator System	1000\$	\$259	\$265	\$272	\$279	\$287	\$293	\$300	\$307	\$315	\$323	\$331	\$339	\$348	\$357	\$366	\$375	\$384	\$394	\$403	\$413
Cumul. Maint. Sinking Fund Balance	1000\$	\$259	\$524	\$796	\$1,074	\$1,357	\$1,645	\$1,938	\$2,236	\$2,539	\$2,847	\$3,160	\$3,478	\$3,801	\$4,129	\$4,462	\$4,800	\$5,143	\$5,491	\$5,844	\$6,202
<b>EBIDA</b>	1000\$	\$2,688	\$2,770	\$2,855	\$2,942	\$3,032	\$3,124	\$3,219	\$3,317	\$3,418	\$3,521	\$3,629	\$3,740	\$3,854	\$3,971	\$4,092	\$4,217	\$4,345	\$4,477	\$4,614	\$4,756
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$11,599	\$2,688	\$2,770	\$2,855	\$2,942	\$3,032	\$3,124	\$3,219	\$3,317	\$3,418	\$3,521	\$3,629	\$3,740	\$3,854	\$3,971	\$4,092	\$4,217	\$4,345	\$4,477	\$4,614	\$4,756
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931	-\$931
Available Cash After All Loan Payments	1000\$	\$1,758	\$1,840	\$1,924	\$2,011	\$2,101	\$2,193	\$2,288	\$2,386	\$2,487	\$2,590	\$2,696	\$2,805	\$2,917	\$3,032	\$3,150	\$3,271	\$3,395	\$3,522	\$3,652	\$3,784
Cumul. Net Income After Loan Payments	1000\$	\$1,758	\$3,597	\$5,521	\$7,532	\$9,629	\$11,812	\$14,081	\$16,436	\$18,877	\$21,404	\$24,017	\$26,716	\$29,501	\$32,372	\$35,329	\$38,372	\$41,501	\$44,715	\$48,014	\$51,400
Principle Repayment Component	1,000	-\$351	-\$368	-\$387	-\$406	-\$426	-\$448	-\$470	-\$494	-\$518	-\$544	-\$571	-\$600	-\$630	-\$661	-\$695	-\$729	-\$766	-\$804	-\$844	-\$886
Principal Balance	1,000	\$11,248	\$10,880	\$10,493	\$10,087	\$9,660	\$9,213	\$8,743	\$8,249	\$7,731	\$7,187	\$6,615	\$6,015	\$5,385	\$4,724	\$4,029	\$3,300	\$2,535	\$1,731	\$886	\$0

Figure 15. Internal Rate of Return Calculations:Taurus 70 (Modified Steam Chiller Operation)

Interest or Bond Rate		5.0%																			
First Cost of Plant (1000\$)		\$13,939																			
Avoided First Costs (1000\$)		-																			
Annual Power Generation		64,538	MWH																		
Projected Change in Electric Charges		3%																			
Projected Change in Fuel Charges		3%																			
Financing and Cash Flow Period		20	Years																		
Project:		VA Hospitals Dallas																			
Scenario:		Taurus 70 :CHP Plant																			
Steam Chiller Operation		Modified																			
IRR =		18.33%																			
Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<b>Net Installed Cost of Plant (1000\$)</b>	\$13,939																				
<b>Utility Projections</b>																					
Total Electric Cost w/o CHP	\$4,741	\$5,181	\$5,336	\$5,496	\$5,661	\$5,831	\$6,006	\$6,186	\$6,372	\$6,563	\$6,760	\$6,963	\$7,172	\$7,387	\$7,608	\$7,837	\$8,072	\$8,314	\$8,563	\$8,820	\$9,085
Total Electric Cost with CHP	\$202	\$208	\$215	\$221	\$228	\$235	\$242	\$249	\$256	\$264	\$272	\$280	\$289	\$297	\$306	\$315	\$325	\$335	\$345	\$355	\$366
Total Gas Cost w/o CHP	\$1,433	\$1,565	\$1,612	\$1,661	\$1,711	\$1,762	\$1,815	\$1,869	\$1,925	\$1,983	\$2,043	\$2,104	\$2,167	\$2,232	\$2,299	\$2,368	\$2,439	\$2,512	\$2,587	\$2,665	\$2,745
Total Gas Cost with CHP	\$3,408	\$3,724	\$3,836	\$3,951	\$4,070	\$4,192	\$4,318	\$4,447	\$4,580	\$4,718	\$4,859	\$5,005	\$5,155	\$5,310	\$5,469	\$5,633	\$5,802	\$5,976	\$6,156	\$6,340	\$6,531
<b>Gross Revenues for CHP Investment</b>																					
Change in Electric Cost	1000\$	\$4,972	\$5,122	\$5,275	\$5,433	\$5,596	\$5,764	\$5,937	\$6,115	\$6,299	\$6,488	\$6,683	\$6,883	\$7,089	\$7,302	\$7,521	\$7,747	\$7,979	\$8,219	\$8,465	\$8,719
Change in Gas Cost	1000\$	-\$2,159	-\$2,224	-\$2,290	-\$2,359	-\$2,430	-\$2,503	-\$2,578	-\$2,655	-\$2,735	-\$2,817	-\$2,901	-\$2,988	-\$3,078	-\$3,170	-\$3,265	-\$3,363	-\$3,464	-\$3,568	-\$3,675	-\$3,786
Net Average Year Annual Savings	1000\$	\$2,814	\$2,898	\$2,985	\$3,074	\$3,167	\$3,262	\$3,360	\$3,460	\$3,564	\$3,671	\$3,781	\$3,895	\$4,011	\$4,132	\$4,256	\$4,383	\$4,515	\$4,650	\$4,790	\$4,934
<b>Operating Costs</b>																					
Maintenance Allocation (@ \$10/MWH)	1000\$	\$645	\$662	\$678	\$695	\$712	\$730	\$748	\$767	\$786	\$806	\$826	\$847	\$868	\$890	\$912	\$935	\$958	\$982	\$1,007	\$1,032
Maintenance Cost of Generator System	1000\$	\$323	\$331	\$339	\$348	\$357	\$365	\$374	\$384	\$393	\$402	\$413	\$423	\$434	\$445	\$456	\$467	\$479	\$491	\$503	\$516
Cumul. Maint. Sinking Fund Balance	1000\$	\$323	\$653	\$992	\$1,340	\$1,697	\$2,062	\$2,436	\$2,819	\$3,211	\$3,612	\$4,022	\$4,441	\$4,869	\$5,306	\$5,752	\$6,207	\$6,671	\$7,144	\$7,626	\$8,117
<b>EBIDA</b>	1000\$	\$2,491	\$2,567	\$2,646	\$2,727	\$2,811	\$2,897	\$2,985	\$3,077	\$3,171	\$3,269	\$3,368	\$3,471	\$3,577	\$3,687	\$3,799	\$3,916	\$4,036	\$4,159	\$4,287	\$4,416
<b>Internal Rate of Return</b>																					
In/Outflows (\$1,000)	-\$13,939	\$2,491	\$2,567	\$2,646	\$2,727	\$2,811	\$2,897	\$2,985	\$3,077	\$3,171	\$3,269	\$3,368	\$3,471	\$3,577	\$3,687	\$3,799	\$3,916	\$4,036	\$4,159	\$4,287	\$4,416
<b>Financing Cash Flow</b>																					
Cost of Financing - Uniform Payments	1000\$	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119	-\$1,119
Available Cash After All Loan Payments	1000\$	\$1,372	\$1,449	\$1,527	\$1,608	\$1,691	\$1,778	\$1,867	\$1,958	\$2,052	\$2,149	\$2,250	\$2,353	\$2,459	\$2,568	\$2,679	\$2,792	\$2,907	\$3,024	\$3,143	\$3,264
Cumul. Net Income After Loan Payments	1000\$	\$1,372	\$2,821	\$4,348	\$5,957	\$7,648	\$9,421	\$11,276	\$13,213	\$15,232	\$17,333	\$19,516	\$21,781	\$24,128	\$26,557	\$29,068	\$31,661	\$34,336	\$37,093	\$39,933	\$42,856
Principle Repayment Component	1,000	-\$422	-\$443	-\$465	-\$488	-\$512	-\$538	-\$565	-\$593	-\$623	-\$654	-\$687	-\$721	-\$757	-\$795	-\$835	-\$876	-\$920	-\$966	-\$1,015	-\$1,065
Principal Balance	1,000	\$13,518	\$13,075	\$12,610	\$12,122	\$11,610	\$11,072	\$10,507	\$9,914	\$9,291	\$8,637	\$7,950	\$7,229	\$6,472	\$5,677	\$4,843	\$3,966	\$3,046	\$2,080	\$1,065	\$0

## Appendix C. Budgetary Quotes

The GC RAC obtained budgetary quotes from Solar Turbines. Detailed cost information and performance data are found in these quotes for the following equipment

- Mercury 50 turbine with HRSG (Natural Gas only)
- Taurus 60 turbine with HRSG ( Dual fuel)
- Taurus 65 turbine with HRSG (Natural Gas only)
- Taurus 70 turbine with HRSG ( Dual fuel)

**Solar Turbines Incorporated**  
**Budgetary Quotation for Page Southerland Page**

Inquiry # Dallas VA prepared on January 5, 2011

For more information contact:

Marco Perez, 713-825-5319, perez\_marco\_x@solarturbines.com

(Prices shown below quoted in US Dollars \$)

**This quote is provided for budgetary purposes only and does not represent a firm quote.**

**Gas Turbine Equipment**

(1) Gas Fuel MERCURY 50-6000R Turbine Generator Set.....	\$3,637,300
Commissioning Parts, Startup, and Site Testing.....	\$160,000

**Electrical Equipment**

Station Control System (SCS) (Monitor Only).....	\$233,700	
Power and Utility Breaker Control Options.....	Included in SCS	
Switchgear and MCC (design description below).....	\$298,900	
Switchgear, motor control center, auxiliary power transformer, and generator grounding resistor.		
Switchgear and MCC are shipped loose.		
Utility Tie-In.....	\$213,000	
Total for Electrical Equipment.....		\$745,600

**Mechanical Equipment**

Fuel Gas Compressor, 1 provided .....		\$471,600
1 Heat Recovery Steam Generator with ductburners.....	\$1,103,600	
HRSG Options.....	\$4,600	
Diverter Valve.....	\$186,500	
Diverter Valve Options.....	none selected	
Total for Heat Recovery Steam System.....		\$1,294,700
Gas Turbine Inlet Cooling.....		\$125,100

**Miscellaneous**

Construction Estimate.....		\$2,145,300
Project Management & Engineering.....		\$635,100
Shipping.....		\$133,400
Development Costs.....		\$0
Special or Avoided Capital Items.....		\$0
15% Balance of Plant Contingency.....		\$832,600

Total for BOP Equipment and Installation.....		\$6,383,400
-----------------------------------------------	--	-------------

<b>Grand Total for Turbomachinery and Balance of Plant.....</b>		<b>\$10,180,700</b>
-----------------------------------------------------------------	--	---------------------

Estimation of cost per ISO rating kilowatt for selected equipment.....	\$2,213	
------------------------------------------------------------------------	---------	--

ESA Cost per Month (Only Turbomachinery Covered).....	\$37,076	
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\*Duties and taxes not included in estimate.

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## **MERCURY 50-6000R Generator Set Package Features**

### **Engine:**

Single shaft turbine, designed for industrial use  
Axial compressor design  
Annular type combustor employing dry, low NOx technology

### **Basic Options:**

Fully enclosed, generator set package requiring 460V, 3-phase, 60 Hz AC power  
Rated Class I, Div II, Groups C,D per NEC  
120V, 1-phase, 50/60 Hz internal lighting and heater power  
Gas turbine engine in upward oriented air inlet, and upward oriented exhaust outlet  
1800 rpm; 60 Hz Gearbox  
Continuous Duty, Open Drip Proof generator rated for 13,800 VAC with Class F insulation, B rise

### **Included Package Features:**

Direct AC start motor system  
Duplex lube oil filter system  
Allen-Bradley based Turbotronics IV control system including:

- Ethernet network interface
- Touch Screen display with Engine Performance map
- Software for heat recovery interface (without diverter valve control)
- Software for CO<sub>2</sub> system "lock out" (maintenance access to enclosure)
- Backup Safety Shutdown System
- kW Control
- kVAR/Power Factor Control

### **Included Factory Testing/Customer Witness/Quality Control Documentation:**

Standard package dynamic testing  
Factory vibration testing  
Factory emissions testing per Solar's ES 9-97  
Observation on "Non-Interference" basis  
Quality Control documentation (Level 1)

### **Field-installed Ancillary Equipment (excludes ducting):**

Medium velocity, three-stage Camil-Farr air inlet filter  
Engine air inlet silencer  
Exhaust bellows (interface to waste heat recovery equipment)  
"Elbow" type enclosure inlet/exhaust ventilation system with silencer

### **Included "Off-Skid" Components/Systems:**

Remote desktop PC/monitor and Printer/Logger  
Gas fuel flow meter (for Gas-only and Dual Fuel configurations)  
AC motor-driven Liquid Fuel boost pump skid (for Liquid Fuel configurations)  
3-micron duplex filter/coalescer with auto drain (for Liquid Fuel configurations)  
CO<sub>2</sub> system cabinet  
Air/Oil lube oil cooler  
VRLA Batteries with 120V DC charging system (back-up post lube)  
Portable engine cleaning cart

### **Miscellaneous**

Short-term preservation for shipment  
Four (4) paper copies of Solar's Instruction, Operation and Maintenance manuals  
Four (4) CD-ROM copies of Solar's Instruction, Operation and Maintenance manuals  
UV Light and Gas Sensor test kit  
Internal equipment handling system  
Recuperator removal tool

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## Cogeneration Plant Estimated Performance Summary

Page Southerland Page  
Solar Turbines Incorporated  
January 5, 2011

Performance listed below is estimated, not guaranteed.

<b>Gas Turbine:</b>	
KW Gross Output @ ISO Conditions:	4,600 kW
Site Ambient Temperature for Performance Analysis:	80 °F
Site Elevation for Performance Analysis:	50 feet
Site Ambient Relative Humidity for Performance Analysis:	60 %
Turbine Inlet Pressure Loss:	4.0 "H <sub>2</sub> O
Turbine Outlet Pressure Loss:	7.0 "H <sub>2</sub> O
Turbine Fuel Consumption @ specified site conditions (LHV):	40.3 MMBtu/hr
KW Gross Output @ specified site conditions:	4,450 kW
Gas Compressor Power Consumption:	119 kW
Turbine Auxiliary Power Consumption:	40 kW
Total Auxiliary Power Consumption:	159 kW
Net Turbine Power Production:	4,292 kW
Black Start kW Requirement (Turbine Generator Set Only)	206 kW
<b>Boiler:</b>	
Condensate Return:	87 %
Condensate Temperature:	212 °F
Makeup Water Temperature:	50 °F
Process Steam Pressure:	150.0 psig
Process Steam Temperature:	366 °F
Steam Contributed by Gas Turbine:	13,745 lb/hr
Steam Contributed by Ductburners:	31,255 lb/hr
Ductburner Fuel Consumption (LHV):	32.1 MMBtu/hr
Deaerator Steam Consumption:	1,634 lb/hr
Boiler Steam Flow:	45,000 lb/hr
Steam Flow to Process:	45,000 lb/hr
<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	9,390 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,160 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	82.1 %

## Cogeneration Plant Estimated Performance Summary

Page Southerland Page  
Solar Turbines Incorporated  
January 5, 2011

Performance listed below is estimated, not guaranteed.

<b>Gas Turbine:</b>	
KW Gross Output @ ISO Conditions:	4,600 KW
Site Ambient Temperature for Performance Analysis:	80 °F
Site Elevation for Performance Analysis:	50 feet
Site Ambient Relative Humidity for Performance Analysis:	60 %
Turbine Inlet Pressure Loss:	4.0 "H <sub>2</sub> O
Turbine Outlet Pressure Loss:	7.0 "H <sub>2</sub> O
Turbine Fuel Consumption @ specified site conditions (LHV):	40.3 MMBtu/hr
KW Gross Output @ specified site conditions:	4,450 KW
Gas Compressor Power Consumption:	119 KW
Turbine Auxiliary Power Consumption:	40 KW
Total Auxiliary Power Consumption:	159 KW
Net Turbine Power Production:	4,292 KW
Black Start kW Requirement (Turbine Generator Set Only)	206 KW
<b>Boiler:</b>	
Condensate Return:	87 %
Condensate Temperature:	212 °F
Makeup Water Temperature:	50 °F
Process Steam Pressure:	150.0 psig
Process Steam Temperature:	366 °F
Steam Contributed by Gas Turbine:	13,745 lb/hr
Steam Contributed by Ductburners:	31,255 lb/hr
Ductburner Fuel Consumption (LHV):	32.1 MMBtu/hr
Deaerator Steam Consumption:	1,634 lb/hr
Boiler Steam Flow:	45,000 lb/hr
Steam Flow to Process:	43,366 lb/hr
<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	9,390 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,160 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	82.1 %

# Solar Turbines

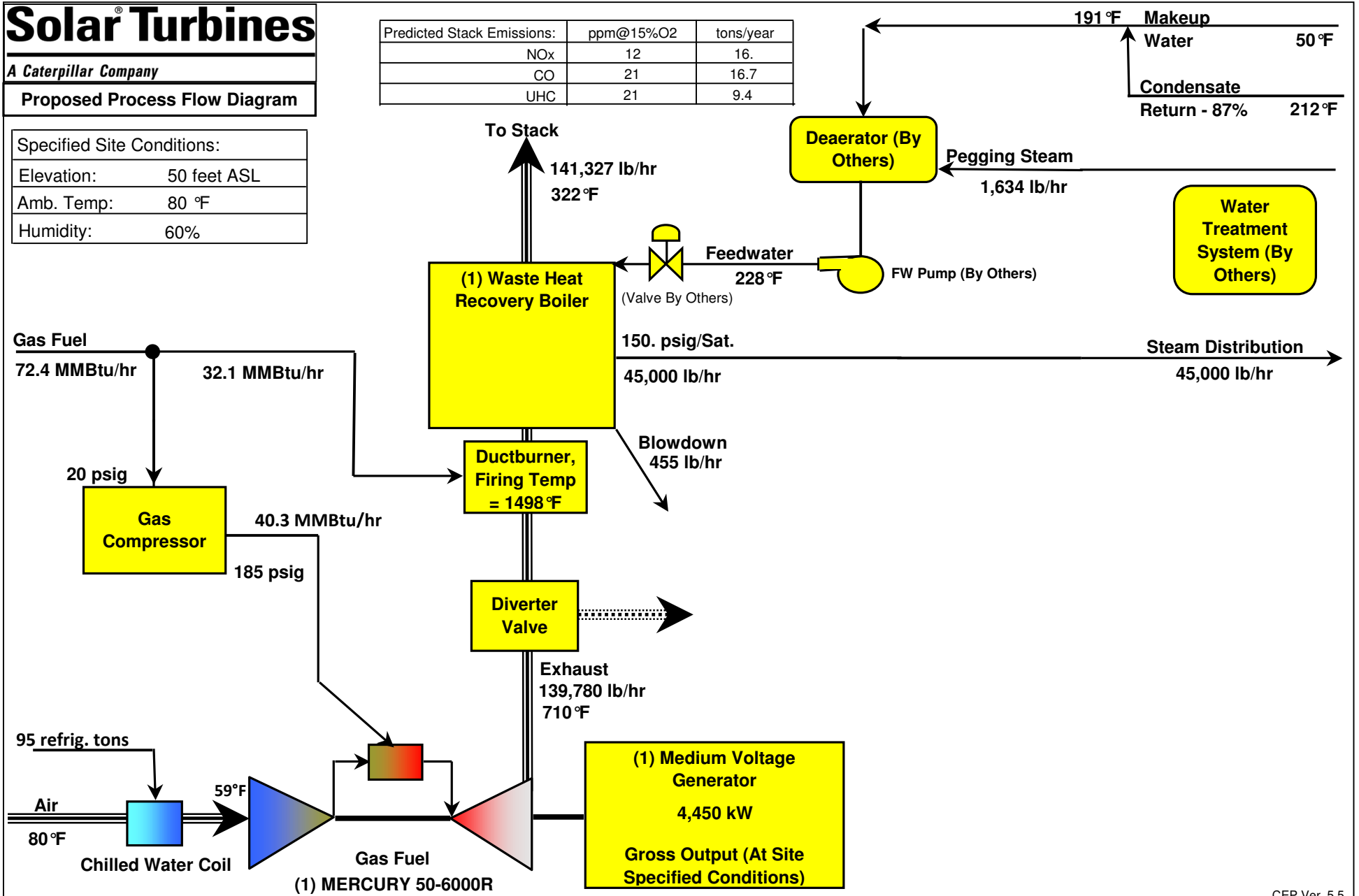
A Caterpillar Company  
**Proposed Process Flow Diagram**

Specified Site Conditions:

Elevation:	50 feet ASL
Amb. Temp:	80 °F
Humidity:	60%

Predicted Stack Emissions:

	ppm@15%O2	tons/year
NOx	12	16.
CO	21	16.7
UHC	21	9.4



System Efficiency = 82.1%  
 Fuel Flow(s) based on Lower Heating Value

Note: For Estimating Purposes only. For Guaranteed Performance, see your Solar Turbines Representative.

CEP Ver. 5.5

Page Southerland Page		
Ref. #	Dallas VA	1/5/2011
Designed by	Marco Perez	

## Off Design Performance Worksheet

### Page Southerland Page

Prepared by Marco Perez on January 5, 2011

**MERCURY 50-6000R**

**GSC STANDARD**

Gas

**CHP Off Design**

(Inlet Cooling in use in this column)

							Duct Burner On/Off	Off		
							# of Turbines in Service	1	(Inlet Cooling in use)	
Site Elevation:	50	feet						Boiler Steam Demand		lb/hr
Barometric Pressure:	29.86	"Hg						Unfired Steam Flow	13,745	lb/hr
Inlet Duct Loss:	4.0	"H2O						Firing Temperature	Off	°F
Exhaust Duct Loss:	7.0	"H2O						Duct Burner Fuel Flow	Off	MMBtu/hr
Ambient Temperature (T1):	80		20	40	59	80	100		°F	
Part Power ( kWe), % Load, or 0 for Max:	→ 0		0	0	0	0	0		kWe	
Engine Inlet Air Temperature (T1):	59		20	40	59	80	59		°F	
Nominal Output Power: (@terminals)	4,450		5,108	4,807	4,450	4,020	4,450		kWe	
Fuel Flow (LHV):	40.3		43.8	42.5	40.3	37.6	40.3		MMBtu/hr	
Inlet Air Flow:	137,825		147,551	144,302	137,825	130,569	137,825		lb/hr	
Exhaust Gas Temperature (T7):	710		664	690	710	730	710		°F	
Exhaust Gas Mass Flow:	139,780		149,678	146,367	139,780	132,393	139,780		lb/hr	
Exhaust Gas Volumetric Flow:	31,535		33,648	32,939	31,535	30,039	31,535		SCFM	
Nominal Thermal Efficiency: (@terminals)	37.7		39.8	38.6	37.7	36.5	37.7		%	
Nominal Heat Rate: (@terminals)	9,054		8,582	8,851	9,054	9,351	9,054		Btu/kWHR	
PCD Pressure:	123.9		133.4	130.3	123.9	116.4	123.9		psig	
Exhaust Heat (from T7 to 275 °F):	15.8		15.1	15.8	15.8	15.7	15.8		MMBtu/hr	
% Argon, wet:	0.9		0.9	0.9	0.9	0.9	0.9			
% CO <sub>2</sub> , wet:	2.5		2.5	2.5	2.5	2.4	2.5			
% H <sub>2</sub> O, wet:	5.6		5.0	5.2	5.6	6.5	5.6			
% N <sub>2</sub> , wet:	75.5		76.1	75.9	75.5	74.8	75.5			
% Oxygen, wet:	15.5		15.5	15.5	15.5	15.4	15.5			
							<b>Net CHP System Efficiency =</b>	<b>70.0</b>	% (LHV)	

# Estimated Power Island Emissions

## Page Southerland Page

Quoted using data available as of January 5, 2011

(1) Gas Fuel MERCURY 50-6000R with fired HRSG		Per Unit	Plant Total
Ambient Temperature	°F	80°F	
Fuel Type		Gas	
Assumed Fuel Sulphur Content	lb/MMBTU (HHV)	0.00	
Gas Turbine Exhaust Flow	lb/hr	139,780	139,780
Duct Burner Fuel Flow	lb/hr	1,547	1,547
Stack Exhaust Flow	lb/hr	141,327	141,327
FG Temperature Leaving Gas Turbine	°F	710	
FG Temperature Leaving Duct Burner	°F	1498	
FG Temperature At Stack	°F	322	
Heat Input to Gas Turbine	MMBtu/hr (LHV)	40.3	40.3
Heat Input from Duct Firing	MMBtu/hr (LHV)	32.1	32.1
Additive NOx from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive CO from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive UHC as CH4 from Duct Firing	lb/MMBTU (HHV)	0.045	
PM <sub>10</sub> /PM <sub>2.5</sub> Particulates from Gas Turbine	lb/MMBTU (HHV)	0.021	
Additive PM-10 Particulates from Duct Firing	lb/MMBTU (HHV)	0.021	
<b>Turbine Exhaust Gas Analysis</b>			
H <sub>2</sub> O	% vol	5.6%	
N <sub>2</sub>	% vol	75.5%	
CO <sub>2</sub>	% vol	2.5%	
O <sub>2</sub>	% vol	15.5%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Flue Gas Analysis After Duct Burner</b>			
H <sub>2</sub> O	% vol	9.1%	
N <sub>2</sub>	% vol	74.2%	
CO <sub>2</sub>	% vol	4.3%	
O <sub>2</sub>	% vol	11.5%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Gas Turbine Exhaust Emissions</b>			
NOx	ppm @ 15% O <sub>2</sub>	5	5
	lb/hr	0.8	0.8
CO	ppm @ 15% O <sub>2</sub>	10	10
	lb/hr	1.0	1.0
UHC	ppm @ 15% O <sub>2</sub>	10	10
	lb/hr	0.6	0.6
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	0.9	0.9
SO <sub>2</sub>	lb/hr	0.0	0.0

(1) Gas Fuel MERCURY 50-6000R with fired HRSG		Per Unit	Plant Total
<b>Total Emissions After Duct Burner</b>			
NOx	ppm @ 15% O2	12	12
	lb/hr	3.6	3.6
CO	ppm @ 15% O2	21	21
	lb/hr	3.8	3.8
UHC	ppm @ 15% O2	21	21
	lb/hr	2.2	2.2
PM <sub>10</sub>	lb/hr	1.7	1.7
SO <sub>2</sub>	lb/hr	0.0	0.0
<b>Exhaust Emissions At Stack</b>			
NOx	ppm @ 15% O2	12	12
	lb/MMBtu, HHV	0.046	
	lb/hr	3.6	3.6
	tons/year	16.0	16.0
CO	ppm @ 15% O2	21	21
	lb/MMBtu, HHV	0.048	
	lb/hr	3.8	3.8
	tons/year	16.7	16.7
UHC	ppm @ 15% O2	21	21
	lb/MMBtu, HHV	0.027	
	lb/hr	2.2	2.2
	tons/year	9.4	9.4
VOC	ppm @ 15% O2	4	4
	lb/MMBtu, HHV	0.005	
	lb/hr	0.2	0.2
	tons/year	0.9	0.9
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	1.7	1.7
	lb/MMBtu, HHV	0.021	
	tons/year	7.4	7.4
SO <sub>2</sub>	lb/hr	0.01	0.0
	lb/MMBtu, HHV	0.00014	
	tons/year	0.1	0.1
SCR Ammonia Slip	ppm @ 15% O2		N/A
SCR Reduction Efficiency	%		N/A
CO Catalyst Reduction Efficiency	%		N/A
UHC Catalyst Reduction Efficiency	%		N/A
Greenhouse Gas Emissions	lbs of CO <sub>2</sub> /MMBtu (HHV)	118	

### General Notes

SO<sub>2</sub> emissions depend upon the fuel's sulfur content. The SO<sub>2</sub> estimate is based upon the assumption of 100% conversion of fuel sulphur to SO<sub>2</sub>, using assumed values for various fuels that may not reflect actual fuel composition. Zero fuel bound nitrogen is assumed for gaseous fuels, less than 0.02% for liquid fuels. Actual emissions may be subject to site fuel characteristics. This document is for initial emissions estimates only. For air permit application emissions documentation, Solar can provide site-specific appropriate documentation.

### **Turbine Emissions Notes:**

Values given above are for 8760 hours/year operation.

The table below gives the load ranges to which the turbine emissions listed above apply.

Pollutant	Load Range
NOx	50 to 100%
CO	50 to 100%
UHC	50 to 100%

(1) Gas Fuel MERCURY 50-6000R with fired HRSG	Per Unit	Plant Total
-----------------------------------------------	----------	-------------

Fuels must comply with Solar specification ES 9-98.

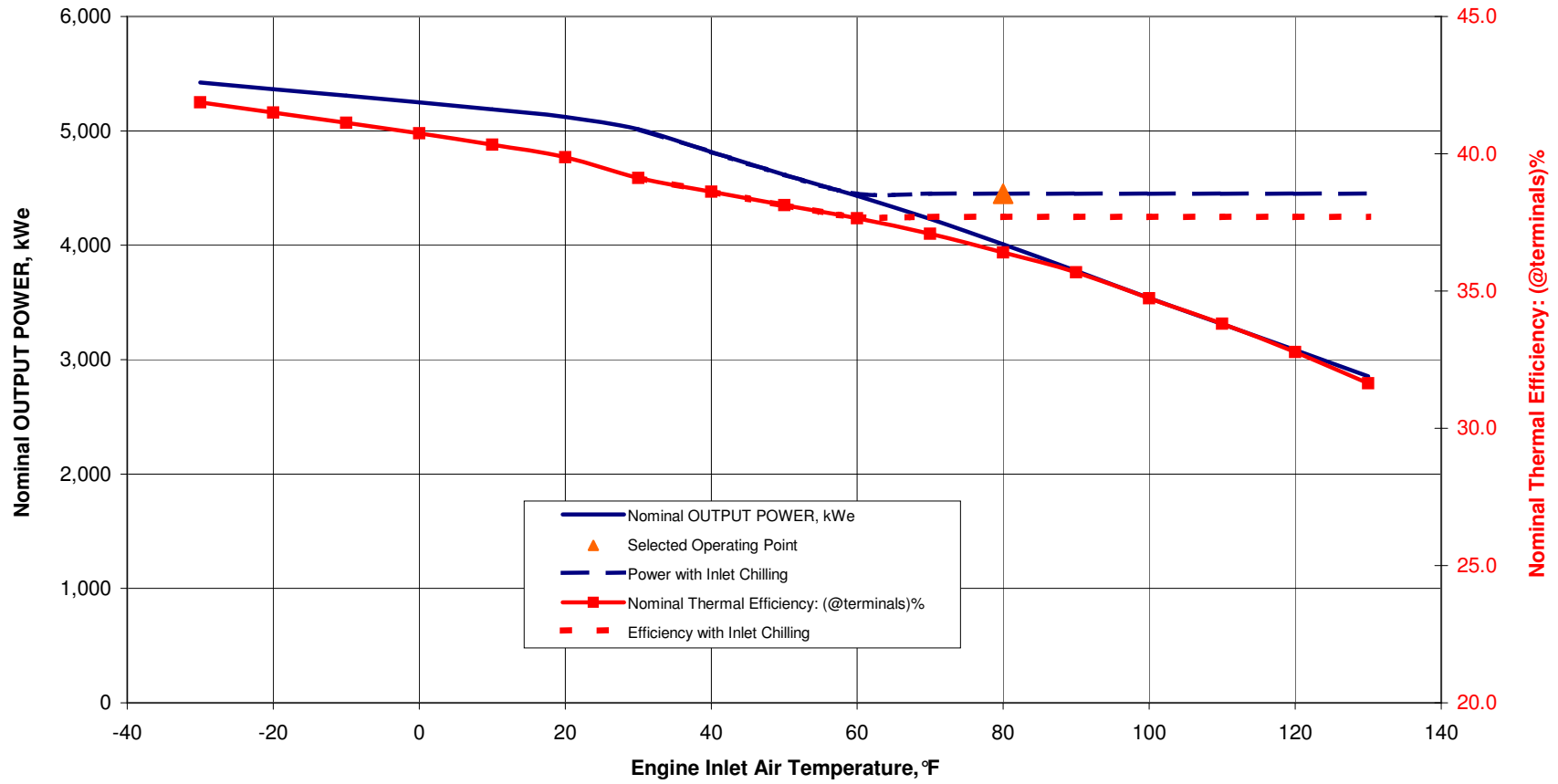
Values applicable for operation at ambient temperatures between 0 and 120°F.

For more information contact: Marco Perez, 713-825-5319, perez\_marco\_x@solarturbines.com

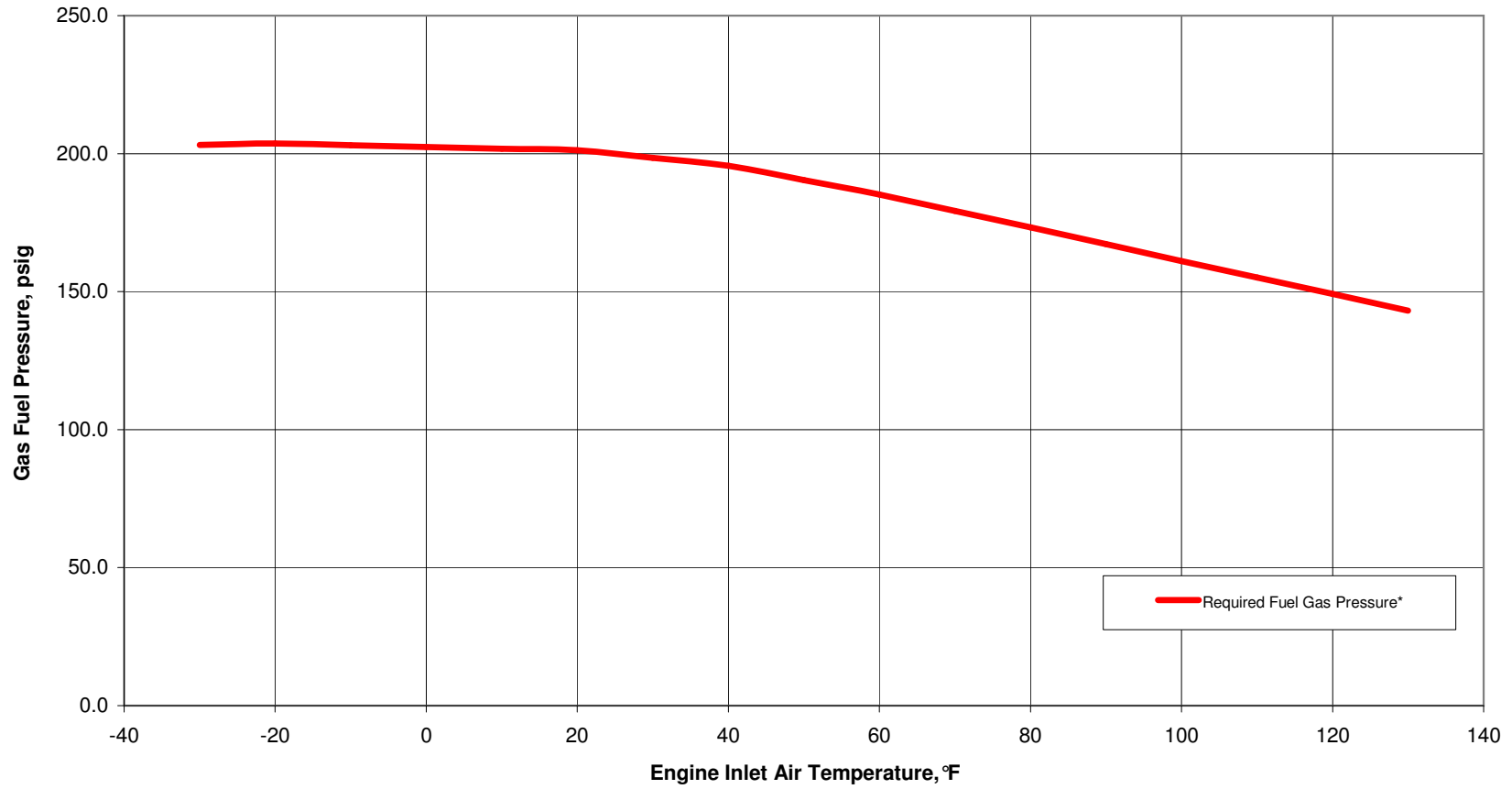
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CEP Ver. 5.5

MERCURY 50-6000R GSC STANDARD Std. Natural Gas Fuel



MERCURY 50-6000R GSC STANDARD Std. Natural Gas Fuel



**Solar Turbines Incorporated**  
**Budgetary Quotation for Page Southerland Page**

Inquiry # Dallas VA prepared on January 5, 2011

For more information contact:

Marco Perez, 713-825-5319, perez\_marco\_x@solarturbines.com

(Prices shown below quoted in US Dollars \$)

**This quote is provided for budgetary purposes only and does not represent a firm quote.**

**Gas Turbine Equipment**

(1) Dual Fuel TAURUS 60-7901S Turbine Generator Set.....	\$3,616,700
Commissioning Parts, Startup, and Site Testing.....	\$150,000

**Electrical Equipment**

Station Control System (SCS) (Monitor Only).....	\$247,300	
Power and Utility Breaker Control Options.....	Included in SCS	
Switchgear and MCC (design description below).....	\$296,300	
Switchgear, motor control center, auxiliary power transformer, and generator grounding resistor.		
Switchgear and MCC are shipped loose.		
Utility Tie-In.....	\$244,100	
Total for Electrical Equipment.....		\$787,700

**Mechanical Equipment**

Fuel Gas Compressor, 1 provided .....		\$653,800
1 Heat Recovery Steam Generator with ductburners.....	\$1,118,400	
HRSG Options.....	\$5,200	
Diverter Valve.....	\$206,700	
Diverter Valve Options.....	none selected	
Total for Heat Recovery Steam System.....		\$1,330,300
Emissions Control Equipment:(SCR and support equipment only).....		\$577,300
Continuous Emission Monitoring System, outdoor installation.....		\$86,300
Gas Turbine Inlet Cooling.....		\$233,500

**Miscellaneous**

Construction Estimate.....		\$2,455,100
Project Management & Engineering.....		\$704,400
Shipping.....		\$153,700
Development Costs.....		\$0
Special or Avoided Capital Items.....		\$0
15% Balance of Plant Contingency.....		\$1,047,300
Total for BOP Equipment and Installation.....		\$8,029,400
<b>Grand Total for Turbomachinery and Balance of Plant.....</b>		<b>\$11,796,100</b>
Estimation of cost per ISO rating kilowatt for selected equipment.....		\$2,080
ESA Cost per Month (Only Turbomachinery Covered).....		\$31,885

\*Duties and taxes not included in estimate.

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## **TAURUS 60-7901S Generator Set Package Features**

### **Engine:**

Single shaft turbine, designed for industrial use  
Axial compressor design  
Annular type combustor employing dry, low NOx technology

### **Basic Options:**

Fully enclosed, generator set package requiring 460V, 3-phase, 60 Hz AC power  
Rated Class I, Div II, Groups C,D per NEC  
120V, 1-phase, 50/60 Hz internal lighting and heater power  
Gas turbine engine in upward oriented air inlet, and axially oriented exhaust outlet  
1800 rpm; 60 Hz Gearbox  
Continuous Duty, Open Drip Proof generator rated for 13,800 VAC with Class F insulation, B rise

### **Included Package Features:**

Direct AC start motor system  
Duplex lube oil filter system  
Allen-Bradley based Turbotronics IV control system including:

- Ethernet network interface
- Touch Screen display with Engine Performance map
- Software for heat recovery interface (without diverter valve control)
- Software for CO<sub>2</sub> system "lock out" (maintenance access to enclosure)
- Backup Safety Shutdown System
- kW Control
- kVAR/Power Factor Control

### **Included Factory Testing/Customer Witness/Quality Control Documentation:**

Standard package dynamic testing  
Factory vibration testing  
Factory emissions testing per Solar's ES 9-97  
Observation on "Non-Interference" basis  
Quality Control documentation (Level 1)

### **Field-installed Ancillary Equipment (excludes ducting):**

Medium velocity, three-stage Camil-Farr air inlet filter  
Engine air inlet silencer  
Exhaust bellows (interface to waste heat recovery equipment)  
"Elbow" type enclosure inlet/exhaust ventilation system with silencer

### **Included "Off-Skid" Components/Systems:**

Remote desktop PC/monitor and Printer/Logger  
Gas fuel flow meter (for Gas-only and Dual Fuel configurations)  
AC motor-driven Liquid Fuel boost pump skid (for Liquid Fuel configurations)  
3-micron duplex filter/coalescer with auto drain (for Liquid Fuel configurations)  
CO<sub>2</sub> system cabinet  
Air/Oil lube oil cooler  
VRLA Batteries with 120V DC charging system (back-up post lube)  
Portable engine cleaning cart

### **Miscellaneous**

Short-term preservation for shipment  
Four (4) paper copies of Solar's Instruction, Operation and Maintenance manuals  
Four (4) CD-ROM copies of Solar's Instruction, Operation and Maintenance manuals  
UV Light and Gas Sensor test kit  
Internal equipment handling system

## Cogeneration Plant Estimated Performance Summary

Page Southerland Page  
Solar Turbines Incorporated  
January 5, 2011

Performance listed below is estimated, not guaranteed.

<b>Gas Turbine:</b>	
KW Gross Output @ ISO Conditions:	5,670 kW
Site Ambient Temperature for Performance Analysis:	80 °F
Site Elevation for Performance Analysis:	50 feet
Site Ambient Relative Humidity for Performance Analysis:	60 %
Turbine Inlet Pressure Loss:	4.0 "H <sub>2</sub> O
Turbine Outlet Pressure Loss:	13.0 "H <sub>2</sub> O
Turbine Fuel Consumption @ specified site conditions (LHV):	60.7 MMBtu/hr
KW Gross Output @ specified site conditions:	5,428 kW
Gas Compressor Power Consumption:	270 kW
Turbine Auxiliary Power Consumption:	15 kW
Total Auxiliary Power Consumption:	285 kW
Net Turbine Power Production:	5,143 kW
Black Start kW Requirement (Turbine Generator Set Only)	316 kW
<b>Boiler:</b>	
Condensate Return:	87 %
Condensate Temperature:	212 °F
Makeup Water Temperature:	50 °F
Process Steam Pressure:	150.0 psig
Process Steam Temperature:	366 °F
Steam Contributed by Gas Turbine:	29,783 lb/hr
Steam Contributed by Ductburners:	15,217 lb/hr
Ductburner Fuel Consumption (LHV):	15.9 MMBtu/hr
Deaerator Steam Consumption:	1,634 lb/hr
Boiler Steam Flow:	45,000 lb/hr
Steam Flow to Process:	45,000 lb/hr
<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	11,800 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,200 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	81.3 %

## Cogeneration Plant Estimated Performance Summary

Page Southerland Page  
Solar Turbines Incorporated  
January 5, 2011

Performance listed below is estimated, not guaranteed.

<b>Gas Turbine:</b>	
KW Gross Output @ ISO Conditions:	5,670 KW
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Site Ambient Relative Humidity for Performance Analysis:	60 %
Turbine Inlet Pressure Loss:	4.0 "H2O
Turbine Outlet Pressure Loss:	13.0 "H2O
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Deaerator Steam Consumption:	1,634 lb/hr
Boiler Steam Flow:	45,000 lb/hr
Steam Flow to Process:	43,366 lb/hr
<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	11,800 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,200 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	81.3 %

# Solar Turbines

A Caterpillar Company  
**Proposed Process Flow Diagram**

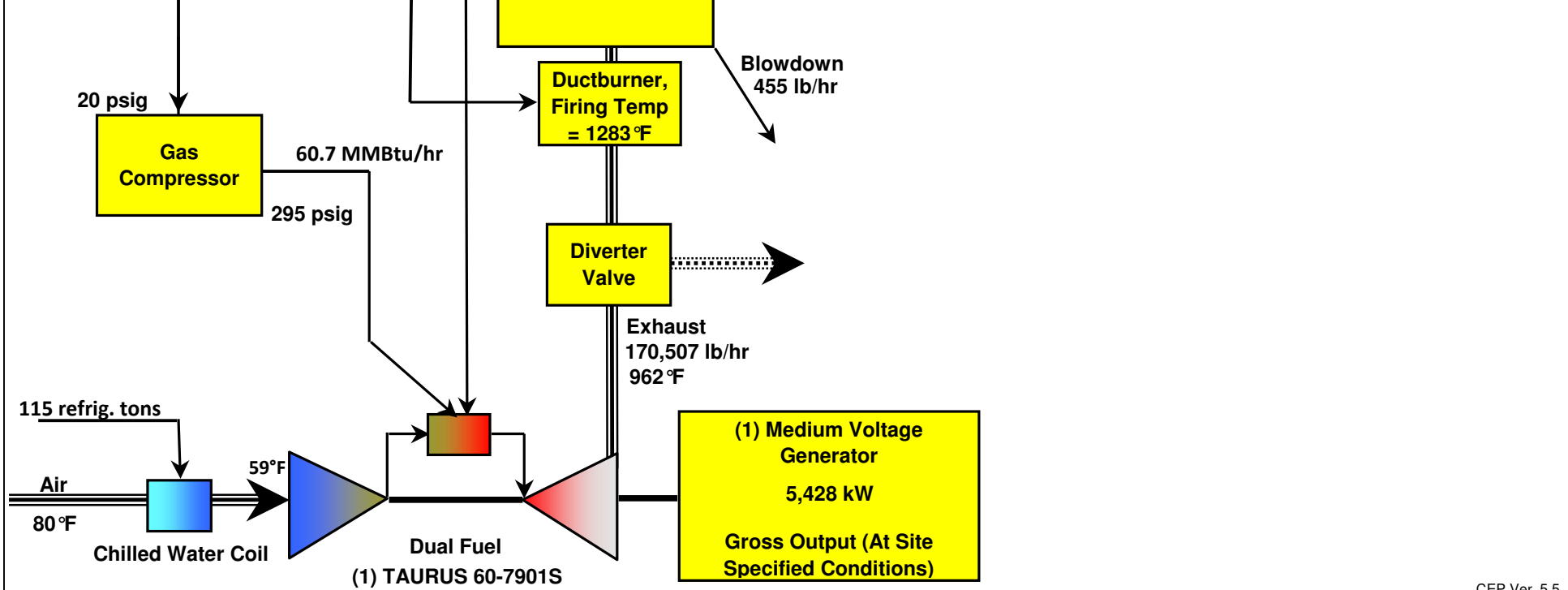
Specified Site Conditions:

Elevation:	50 feet ASL
Amb. Temp:	80 °F
Humidity:	60%

**Liquid Fuel**  
 Off

**Gas Fuel**  
 76.6 MMBtu/hr

Predicted Stack Emissions:	ppm@15%O2	tons/year
NOx	2	3.3
CO	47	38.3
UHC	27	12.6



System Efficiency = 81.3%  
 Fuel Flow(s) based on Lower Heating Value

Note: For Estimating Purposes only. For Guaranteed Performance, see your Solar Turbines Representative.

CEP Ver. 5.5

<b>Page Southerland Page</b>		
Ref. #	Dallas VA	1/5/2011
Designed by	Marco Perez	

## Off Design Performance Worksheet

### Page Southerland Page

Prepared by Marco Perez on January 5, 2011

**TAURUS 60-7901S**

**GSC STANDARD**

**Dual (Gas Performance)**

**CHP Off Design**

(Inlet Cooling in use in this column)

					Duct Burner On/Off	Off	
					# of Turbines in Service	1	(Inlet Cooling in use)
					Boiler Steam Demand		lb/hr
					Unfired Steam Flow	29,783	lb/hr
					Firing Temperature	Off	°F
					Duct Burner Fuel Flow	Off	MMBtu/hr
Site Elevation:	50						feet
Barometric Pressure:	29.86						"Hg
Inlet Duct Loss:	4.0						"H2O
Exhaust Duct Loss:	13.0						"H2O
Ambient Temperature (T1):	80	20	40	59	80	100	°F
Part Power ( kWe), % Load, or 0 for Max:	→ 0	0	0	0	0	0	kWe
Engine Inlet Air Temperature (T1):	59	20	40	59	80	59	°F
Nominal Output Power: (@terminals)	5,428	6,116	5,768	5,428	4,958	5,428	kWe
Fuel Flow (LHV):	60.7	66.4	63.5	60.7	57.2	60.7	MMBtu/hr
Inlet Air Flow:	167,562	177,739	173,121	167,562	159,293	167,562	lb/hr
Exhaust Gas Temperature (T7):	962	942	951	962	981	962	°F
Exhaust Gas Mass Flow:	170,507	180,962	176,203	170,507	162,067	170,507	lb/hr
Exhaust Gas Volumetric Flow:	38,662	40,875	39,842	38,662	36,998	38,662	SCFM
Nominal Thermal Efficiency: (@terminals)	30.5	31.4	31.0	30.5	29.6	30.5	%
Nominal Heat Rate: (@terminals)	11,180	10,861	11,013	11,180	11,530	11,180	Btu/kWHR
PCD Pressure:	160.8	171.3	166.5	160.8	152.4	160.8	psig
Exhaust Heat (from T7 to 275 °F):	30.5	31.4	31.	30.5	29.7	30.5	MMBtu/hr
% Argon, wet:	0.9	0.9	0.9	0.9	0.9	0.9	
% CO <sub>2</sub> , wet:	3.0	3.1	3.0	3.0	2.9	3.0	
% H <sub>2</sub> O, wet:	6.6	6.0	6.1	6.6	7.7	6.6	
% N <sub>2</sub> , wet:	75.2	75.7	75.6	75.2	74.2	75.2	
% Oxygen, wet:	14.4	14.3	14.4	14.4	14.2	14.4	
					<b>Net CHP System Efficiency =</b>	<b>77.7</b>	% (LHV)

## Estimated Power Island Emissions

### Page Southerland Page

Quoted using data available as of January 5, 2011

(1) Dual Fuel TAURUS 60-7901S with fired HRSG and SCR Emission Control System		Per Unit	Plant Total
Ambient Temperature	°F	80°F	
Fuel Type		Dual (Gas Performance)	
Assumed Fuel Sulphur Content	lb/MMBTU (HHV)	0.00	
Gas Turbine Exhaust Flow	lb/hr	170,507	170,507
Duct Burner Fuel Flow	lb/hr	768	768
Stack Exhaust Flow	lb/hr	171,274	171,274
FG Temperature Leaving Gas Turbine	°F	962	
FG Temperature Leaving Duct Burner	°F	1283	
FG Temperature At Stack	°F	290	
Heat Input to Gas Turbine	MMBtu/hr (LHV)	60.7	60.7
Heat Input from Duct Firing	MMBtu/hr (LHV)	15.9	15.9
Additive NOx from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive CO from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive UHC as CH4 from Duct Firing	lb/MMBTU (HHV)	0.045	
PM <sub>10</sub> /PM <sub>2.5</sub> Particulates from Gas Turbine	lb/MMBTU (HHV)	0.021	
Additive PM-10 Particulates from Duct Firing	lb/MMBTU (HHV)	0.021	
<b>Turbine Exhaust Gas Analysis</b>			
H <sub>2</sub> O	% vol	6.6%	
N <sub>2</sub>	% vol	75.2%	
CO <sub>2</sub>	% vol	3.0%	
O <sub>2</sub>	% vol	14.4%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Flue Gas Analysis After Duct Burner</b>			
H <sub>2</sub> O	% vol	8.0%	
N <sub>2</sub>	% vol	74.6%	
CO <sub>2</sub>	% vol	3.8%	
O <sub>2</sub>	% vol	12.7%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Gas Turbine Exhaust Emissions</b>			
NOx	ppm @ 15% O <sub>2</sub>	25	25
	lb/hr	6.0	6.0
CO	ppm @ 15% O <sub>2</sub>	50	50
	lb/hr	7.3	7.3
UHC	ppm @ 15% O <sub>2</sub>	25	25
	lb/hr	2.1	2.1
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	1.4	1.4
SO <sub>2</sub>	lb/hr	0.0	0.0

(1) Dual Fuel TAURUS 60-7901S with fired HRSG and SCR Emission Control System		Per Unit	Plant Total
<b>Total Emissions After Duct Burner</b>			
NOx	ppm @ 15% O2	24	24
	lb/hr	7.4	7.4
CO	ppm @ 15% O2	47	47
	lb/hr	8.7	8.7
UHC	ppm @ 15% O2	27	27
	lb/hr	2.9	2.9
PM <sub>10</sub>	lb/hr	1.8	1.8
SO <sub>2</sub>	lb/hr	0.0	0.0
<b>Exhaust Emissions At Stack</b>			
NOx	ppm @ 15% O2	2	2
	lb/MMBtu, HHV	0.009	
	lb/hr	0.7	0.7
	tons/year	3.3	3.3
CO	ppm @ 15% O2	47	47
	lb/MMBtu, HHV	0.103	
	lb/hr	8.7	8.7
	tons/year	38.3	38.3
UHC	ppm @ 15% O2	27	27
	lb/MMBtu, HHV	0.034	
	lb/hr	2.9	2.9
	tons/year	12.6	12.6
VOC	ppm @ 15% O2	5	5
	lb/MMBtu, HHV	0.007	
	lb/hr	0.3	0.3
	tons/year	1.3	1.3
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	1.8	1.8
	lb/MMBtu, HHV	0.021	
	tons/year	7.8	7.8
SO <sub>2</sub>	lb/hr	0.01	0.0
	lb/MMBtu, HHV	0.00014	
	tons/year	0.1	0.1
SCR Ammonia Slip	ppm @ 15% O2	5	
SCR Reduction Efficiency	%	90	
CO Catalyst Reduction Efficiency	%	N/A	
UHC Catalyst Reduction Efficiency	%	N/A	
Greenhouse Gas Emissions	lbs of CO2/MMBtu (HHV)	117	

**General Notes**

SO2 emissions depend upon the fuel's sulfur content. The SO2 estimate is based upon the assumption of 100% conversion of fuel sulphur to SO2, using assumed values for various fuels that may not reflect actual fuel composition. Zero fuel bound nitrogen is assumed for gaseous fuels, less than 0.02% for liquid fuels. Actual emissions may be subject to site fuel characteristics. This document is for initial emissions estimates only. For air permit application emissions documentation, Solar can provide site-specific appropriate documentation.

**Turbine Emissions Notes:**

Values given above are for 8760 hours/year operation.

The table below gives the load ranges to which the turbine emissions listed above apply.

Pollutant	Load Range
NOx	50 to 100%
CO	50 to 100%
UHC	50 to 100%

(1) Dual Fuel TAURUS 60-7901S with fired HRSG and SCR Emission Control System	<b>Per Unit</b>	<b>Plant Total</b>
-------------------------------------------------------------------------------	-----------------	--------------------

Fuels must comply with Solar specification ES 9-98.

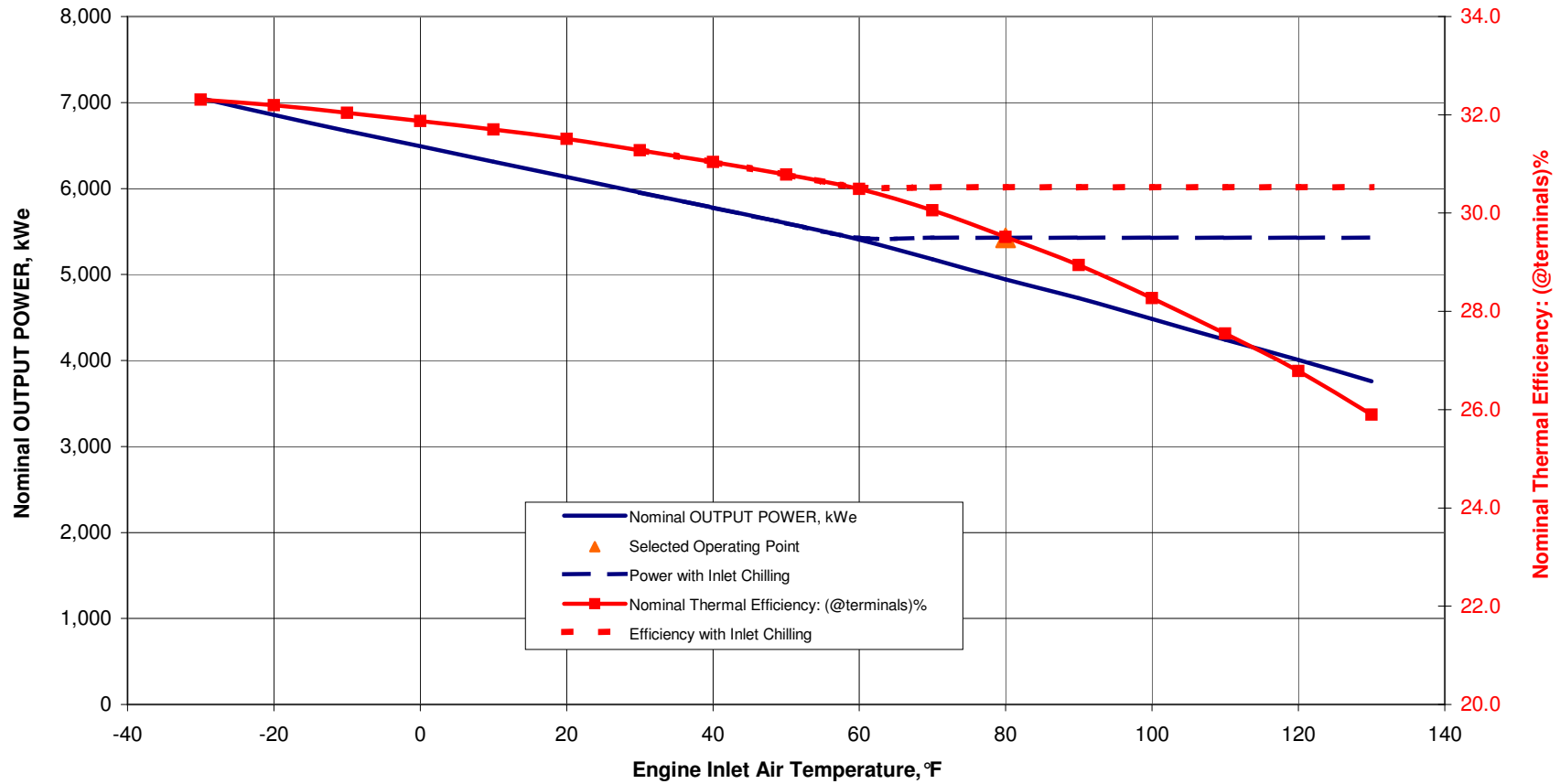
Values applicable for operation at ambient temperatures between 0 and 120°F.

For more information contact: Marco Perez, 713-825-5319, perez\_marco\_x@solarturbines.com

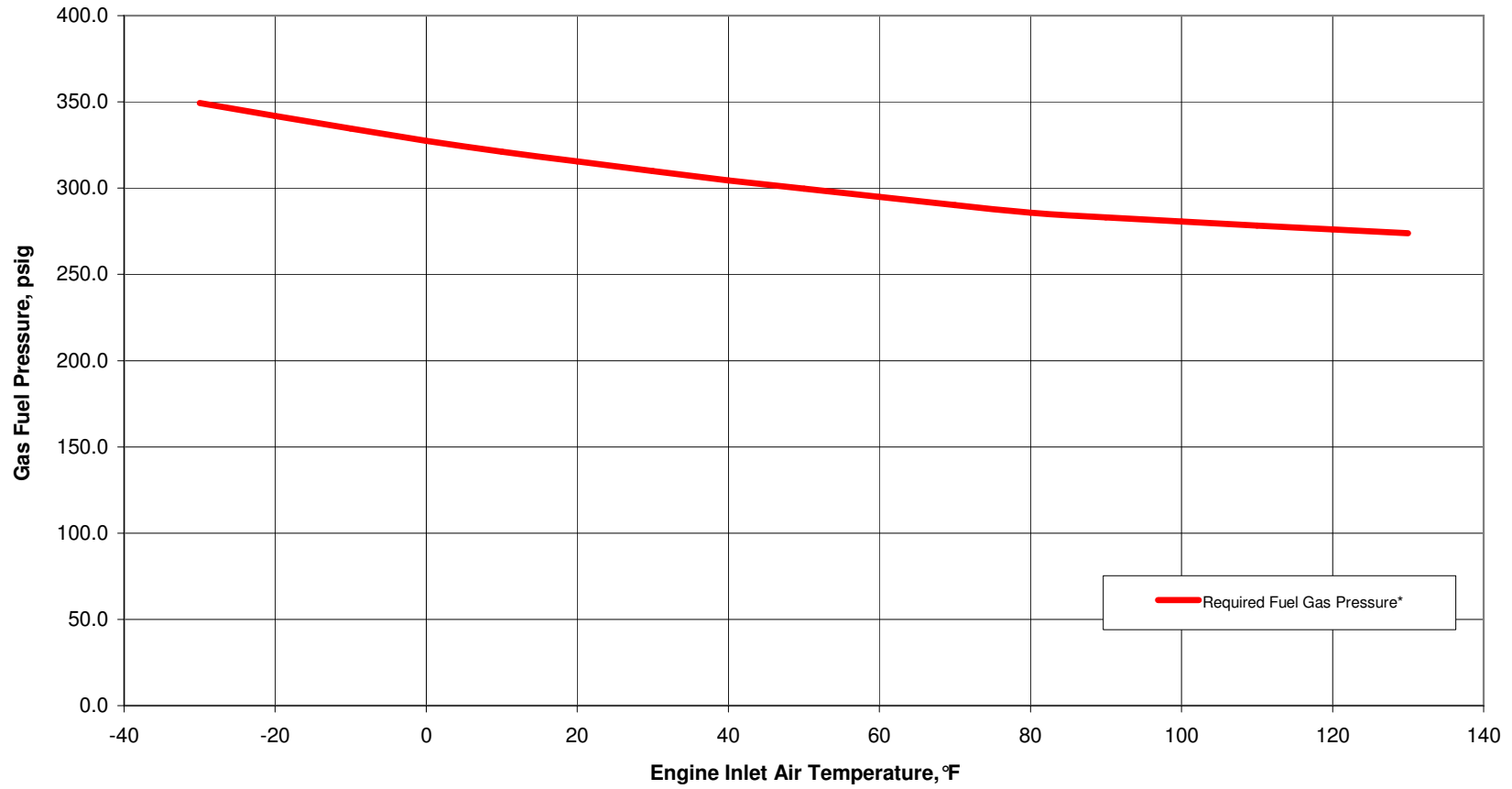
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CEP Ver. 5.5

TAURUS 60-7901S GSC STANDARD Std. Natural Gas Fuel



**TAURUS 60-7901S GSC STANDARD Std. Natural Gas Fuel**



**Solar Turbines Incorporated**  
**Budgetary Quotation for Page Southerland Page**

Inquiry # Dallas VA prepared on January 5, 2011

For more information contact:

Marco Perez, 713-825-5319, perez\_marco\_x@solarturbines.com

(Prices shown below quoted in US Dollars \$)

**This quote is provided for budgetary purposes only and does not represent a firm quote.**

**Gas Turbine Equipment**

(1) Gas Fuel TAURUS 65-8401S Turbine Generator Set.....	\$3,556,600
Commissioning Parts, Startup, and Site Testing.....	\$150,000

**Electrical Equipment**

Station Control System (SCS) (Monitor Only).....	\$240,500	
Power and Utility Breaker Control Options.....	Included in SCS	
Switchgear and MCC (design description below).....	\$296,300	
Switchgear, motor control center, auxiliary power transformer, and generator grounding resistor.		
Switchgear and MCC are shipped loose.		
Utility Tie-In.....	\$261,200	
Total for Electrical Equipment.....		\$798,000

**Mechanical Equipment**

Fuel Gas Compressor, 1 provided .....		\$615,700
1 Heat Recovery Steam Generator with ductburners.....	\$1,060,000	
HRSG Options.....	\$5,200	
Diverter Valve.....	\$206,700	
Diverter Valve Options.....	none selected	
Total for Heat Recovery Steam System.....		\$1,271,900
Emissions Control Equipment:(SCR and support equipment only).....		\$624,500
Continuous Emission Monitoring System, outdoor installation.....		\$86,300
Gas Turbine Inlet Cooling.....		\$226,600

**Miscellaneous**

Construction Estimate.....		\$2,408,400
Project Management & Engineering.....		\$679,900
Shipping.....		\$151,400
Development Costs.....		\$0
Special or Avoided Capital Items.....		\$0
15% Balance of Plant Contingency.....		\$1,029,400
Total for BOP Equipment and Installation.....		\$7,892,100
<b>Grand Total for Turbomachinery and Balance of Plant.....</b>		<b>\$11,598,700</b>
Estimation of cost per ISO rating kilowatt for selected equipment.....		\$1,843
ESA Cost per Month (Only Turbomachinery Covered).....		\$34,529

\*Duties and taxes not included in estimate.

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## **TAURUS 65-8401S Generator Set Package Features**

### **Engine:**

Single shaft turbine, designed for industrial use  
Axial compressor design  
Annular type combustor employing dry, low NOx technology

### **Basic Options:**

Fully enclosed, generator set package requiring 460V, 3-phase, 60 Hz AC power  
Rated Class I, Div II, Groups C,D per NEC  
120V, 1-phase, 50/60 Hz internal lighting and heater power  
Gas turbine engine in upward oriented air inlet, and axially oriented exhaust outlet  
1800 rpm; 60 Hz Gearbox  
Continuous Duty, Open Drip Proof generator rated for 13,800 VAC with Class F insulation, B rise

### **Included Package Features:**

Direct AC start motor system  
Duplex lube oil filter system  
Allen-Bradley based Turbotronics IV control system including:

- Ethernet network interface
- Touch Screen display with Engine Performance map
- Software for heat recovery interface (without diverter valve control)
- Software for CO<sub>2</sub> system "lock out" (maintenance access to enclosure)
- Backup Safety Shutdown System
- kW Control
- kVAR/Power Factor Control

### **Included Factory Testing/Customer Witness/Quality Control Documentation:**

Standard package dynamic testing  
Factory vibration testing  
Factory emissions testing per Solar's ES 9-97  
Observation on "Non-Interference" basis  
Quality Control documentation (Level 1)

### **Field-installed Ancillary Equipment (excludes ducting):**

Medium velocity, three-stage Camil-Farr air inlet filter  
Engine air inlet silencer  
Exhaust bellows (interface to waste heat recovery equipment)  
"Elbow" type enclosure inlet/exhaust ventilation system with silencer

### **Included "Off-Skid" Components/Systems:**

Remote desktop PC/monitor and Printer/Logger  
Gas fuel flow meter (for Gas-only and Dual Fuel configurations)  
AC motor-driven Liquid Fuel boost pump skid (for Liquid Fuel configurations)  
3-micron duplex filter/coalescer with auto drain (for Liquid Fuel configurations)  
CO<sub>2</sub> system cabinet  
Air/Oil lube oil cooler  
VRLA Batteries with 120V DC charging system (back-up post lube)  
Portable engine cleaning cart

### **Miscellaneous**

Short-term preservation for shipment  
Four (4) paper copies of Solar's Instruction, Operation and Maintenance manuals  
Four (4) CD-ROM copies of Solar's Instruction, Operation and Maintenance manuals  
UV Light and Gas Sensor test kit  
Internal equipment handling system

## Cogeneration Plant Estimated Performance Summary

Page Southerland Page  
Solar Turbines Incorporated  
January 5, 2011

Performance listed below is estimated, not guaranteed.

<b>Gas Turbine:</b>	
KW Gross Output @ ISO Conditions:	6,290 kW
Site Ambient Temperature for Performance Analysis:	80 °F
Site Elevation for Performance Analysis:	50 feet
Site Ambient Relative Humidity for Performance Analysis:	60 %
Turbine Inlet Pressure Loss:	4.0 "H <sub>2</sub> O
Turbine Outlet Pressure Loss:	13.0 "H <sub>2</sub> O
Turbine Fuel Consumption @ specified site conditions (LHV):	64.6 MMBtu/hr
KW Gross Output @ specified site conditions:	6,027 kW
Gas Compressor Power Consumption:	238 kW
Turbine Auxiliary Power Consumption:	10 kW
Total Auxiliary Power Consumption:	248 kW
Net Turbine Power Production:	5,779 kW
Black Start kW Requirement (Turbine Generator Set Only)	304 kW
<b>Boiler:</b>	
Condensate Return:	87 %
Condensate Temperature:	212 °F
Makeup Water Temperature:	50 °F
Process Steam Pressure:	150.0 psig
Process Steam Temperature:	366 °F
Steam Contributed by Gas Turbine:	32,438 lb/hr
Steam Contributed by Ductburners:	12,562 lb/hr
Ductburner Fuel Consumption (LHV):	13.5 MMBtu/hr
Deaerator Steam Consumption:	1,634 lb/hr
Boiler Steam Flow:	45,000 lb/hr
Steam Flow to Process:	45,000 lb/hr
<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	11,170 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,130 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	82.6 %

## Cogeneration Plant Estimated Performance Summary

Page Southerland Page  
Solar Turbines Incorporated  
January 5, 2011

Performance listed below is estimated, not guaranteed.

<b>Gas Turbine:</b>	
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Ductburner Fuel Consumption (LHV):	13.5 MMBtu/hr
Deaerator Steam Consumption:	1,634 lb/hr
Boiler Steam Flow:	45,000 lb/hr
Steam Flow to Process:	43,366 lb/hr
<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	11,170 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,130 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	82.6 %

# Solar Turbines

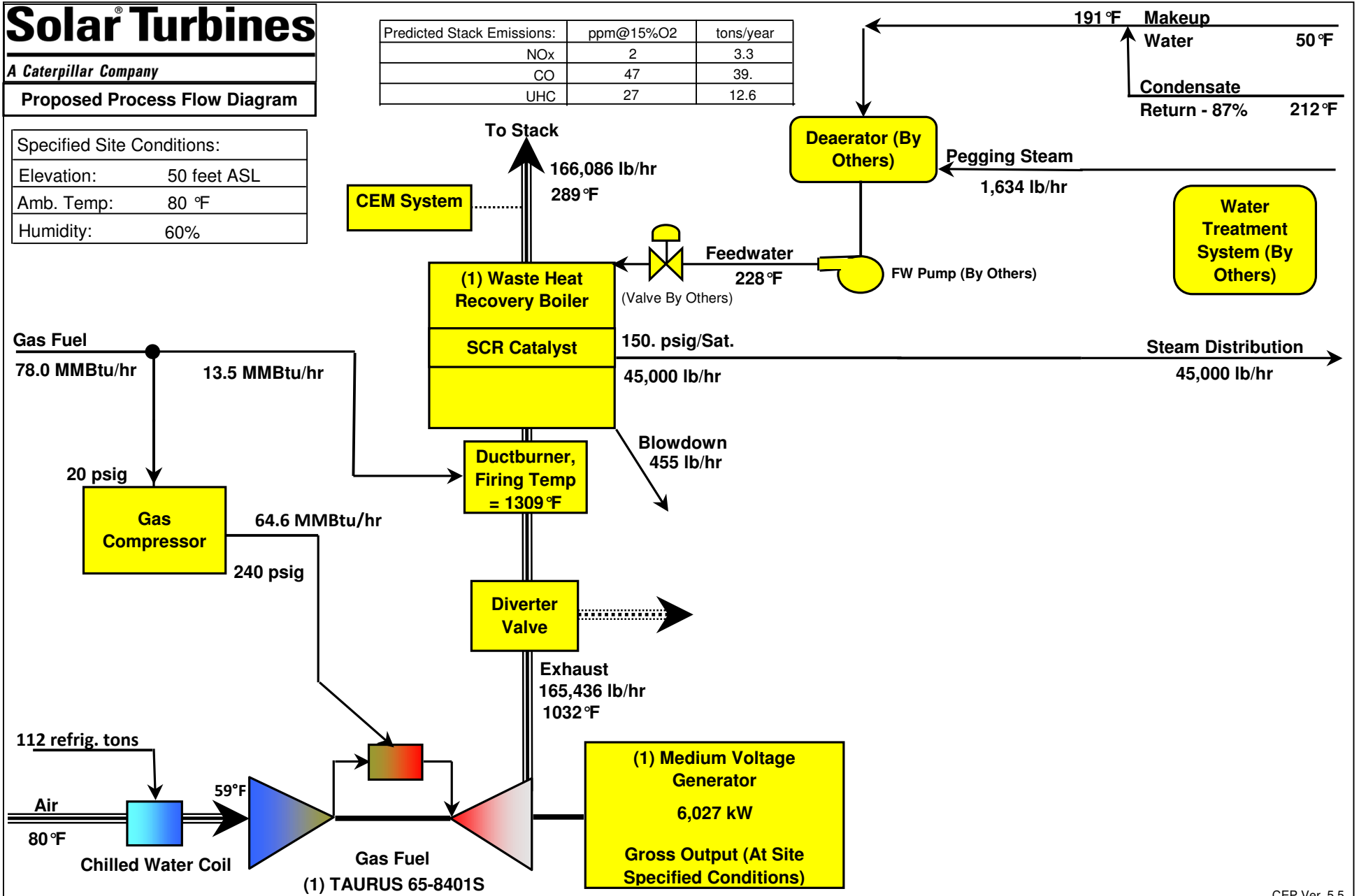
A Caterpillar Company  
**Proposed Process Flow Diagram**

Specified Site Conditions:

Elevation:	50 feet ASL
Amb. Temp:	80 °F
Humidity:	60%

Predicted Stack Emissions:

	ppm@15%O2	tons/year
NOx	2	3.3
CO	47	39.
UHC	27	12.6



System Efficiency = 82.6%  
 Fuel Flow(s) based on Lower Heating Value

Note: For Estimating Purposes only. For Guaranteed Performance, see your Solar Turbines Representative.

CEP Ver. 5.5

Page Southerland Page		
Ref. #	Dallas VA	1/5/2011
Designed by	Marco Perez	

## Off Design Performance Worksheet

### Page Southerland Page

Prepared by Marco Perez on January 5, 2011

**TAURUS 65-8401S**

**GSC STANDARD**

Gas

**CHP Off Design**

(Inlet Cooling in use in this column)

					Duct Burner On/Off	Off	
					# of Turbines in Service	1	(Inlet Cooling in use)
					Boiler Steam Demand		lb/hr
					Unfired Steam Flow	32,438	lb/hr
					Firing Temperature	Off	°F
					Duct Burner Fuel Flow	Off	MMBtu/hr
Site Elevation:	50						feet
Barometric Pressure:	29.86						"Hg
Inlet Duct Loss:	4.0						"H2O
Exhaust Duct Loss:	13.0						"H2O
Ambient Temperature (T1):	80	20	40	59	80	100	°F
Part Power ( kWe), % Load, or 0 for Max:	0	0	0	0	0	0	kWe
Engine Inlet Air Temperature (T1):	59	20	40	59	80	59	°F
Nominal Output Power: (@terminals)	6,027	7,056	6,538	6,027	5,436	6,027	kWe
Fuel Flow (LHV):	64.6	72.2	68.3	64.6	60.4	64.6	MMBtu/hr
Inlet Air Flow:	162,303	176,725	169,630	162,303	153,018	162,303	lb/hr
Exhaust Gas Temperature (T7):	1032	1004	1017	1032	1053	1032	°F
Exhaust Gas Mass Flow:	165,436	180,229	172,944	165,436	155,948	165,436	lb/hr
Exhaust Gas Volumetric Flow:	37,598	40,786	39,185	37,598	35,699	37,598	SCFM
Nominal Thermal Efficiency: (@terminals)	31.9	33.4	32.7	31.9	30.7	31.9	%
Nominal Heat Rate: (@terminals)	10,715	10,234	10,448	10,715	11,108	10,715	Btu/kWHR
PCD Pressure:	209.5	227.9	218.8	209.5	197.7	209.5	psig
Exhaust Heat (from T7 to 275 °F):	32.5	34.2	33.4	32.5	31.6	32.5	MMBtu/hr
% Argon, wet:	0.9	0.9	0.9	0.9	0.9	0.9	
% CO <sub>2</sub> , wet:	3.2	3.3	3.3	3.2	3.2	3.2	
% H <sub>2</sub> O, wet:	7.0	6.3	6.5	7.0	8.3	7.0	
% N <sub>2</sub> , wet:	75.0	75.6	75.4	75.0	74.0	75.0	
% Oxygen, wet:	13.8	13.8	13.9	13.8	13.7	13.8	
					<b>Net CHP System Efficiency =</b>	<b>80.5</b>	% (LHV)

## Estimated Power Island Emissions

### Page Southerland Page

Quoted using data available as of January 5, 2011

(1) Gas Fuel TAURUS 65-8401S with fired HRSG and SCR Emission Control System		Per Unit	Plant Total
Ambient Temperature	°F	80°F	
Fuel Type		Gas	
Assumed Fuel Sulphur Content	lb/MMBTU (HHV)	0.00	
Gas Turbine Exhaust Flow	lb/hr	165,436	165,436
Duct Burner Fuel Flow	lb/hr	650	650
Stack Exhaust Flow	lb/hr	166,086	166,086
FG Temperature Leaving Gas Turbine	°F	1032	
FG Temperature Leaving Duct Burner	°F	1309	
FG Temperature At Stack	°F	289	
Heat Input to Gas Turbine	MMBtu/hr (LHV)	64.6	64.6
Heat Input from Duct Firing	MMBtu/hr (LHV)	13.5	13.5
Additive NOx from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive CO from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive UHC as CH4 from Duct Firing	lb/MMBTU (HHV)	0.045	
PM <sub>10</sub> /PM <sub>2.5</sub> Particulates from Gas Turbine	lb/MMBTU (HHV)	0.021	
Additive PM-10 Particulates from Duct Firing	lb/MMBTU (HHV)	0.021	
<b>Turbine Exhaust Gas Analysis</b>			
H <sub>2</sub> O	% vol	7.0%	
N <sub>2</sub>	% vol	75.0%	
CO <sub>2</sub>	% vol	3.2%	
O <sub>2</sub>	% vol	13.8%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Flue Gas Analysis After Duct Burner</b>			
H <sub>2</sub> O	% vol	8.3%	
N <sub>2</sub>	% vol	74.5%	
CO <sub>2</sub>	% vol	3.9%	
O <sub>2</sub>	% vol	12.4%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Gas Turbine Exhaust Emissions</b>			
NOx	ppm @ 15% O <sub>2</sub>	25	25
	lb/hr	6.3	6.3
CO	ppm @ 15% O <sub>2</sub>	50	50
	lb/hr	7.7	7.7
UHC	ppm @ 15% O <sub>2</sub>	25	25
	lb/hr	2.2	2.2
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	1.5	1.5
SO <sub>2</sub>	lb/hr	0.0	0.0

(1) Gas Fuel TAURUS 65-8401S with fired HRSG and SCR Emission Control System		Per Unit	Plant Total
<b>Total Emissions After Duct Burner</b>			
NOx	ppm @ 15% O2	24	24
	lb/hr	7.5	7.5
CO	ppm @ 15% O2	47	47
	lb/hr	8.9	8.9
UHC	ppm @ 15% O2	27	27
	lb/hr	2.9	2.9
PM <sub>10</sub>	lb/hr	1.8	1.8
SO <sub>2</sub>	lb/hr	0.0	0.0
<b>Exhaust Emissions At Stack</b>			
NOx	ppm @ 15% O2	2	2
	lb/MMBtu, HHV	0.009	
	lb/hr	0.8	0.8
	tons/year	3.3	3.3
CO	ppm @ 15% O2	47	47
	lb/MMBtu, HHV	0.103	
	lb/hr	8.9	8.9
	tons/year	39.0	39.0
UHC	ppm @ 15% O2	27	27
	lb/MMBtu, HHV	0.033	
	lb/hr	2.9	2.9
	tons/year	12.6	12.6
VOC	ppm @ 15% O2	5	5
	lb/MMBtu, HHV	0.007	
	lb/hr	0.3	0.3
	tons/year	1.3	1.3
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	1.8	1.8
	lb/MMBtu, HHV	0.021	
	tons/year	7.9	7.9
SO <sub>2</sub>	lb/hr	0.01	0.0
	lb/MMBtu, HHV	0.00014	
	tons/year	0.1	0.1
SCR Ammonia Slip	ppm @ 15% O2	5	
SCR Reduction Efficiency	%	90	
CO Catalyst Reduction Efficiency	%	N/A	
UHC Catalyst Reduction Efficiency	%	N/A	
Greenhouse Gas Emissions	lbs of CO <sub>2</sub> /MMBtu (HHV)	116	

**General Notes**

SO2 emissions depend upon the fuel's sulfur content. The SO2 estimate is based upon the assumption of 100% conversion of fuel sulphur to SO2, using assumed values for various fuels that may not reflect actual fuel composition. Zero fuel bound nitrogen is assumed for gaseous fuels, less than 0.02% for liquid fuels. Actual emissions may be subject to site fuel characteristics. This document is for initial emissions estimates only. For air permit application emissions documentation, Solar can provide site-specific appropriate documentation.

**Turbine Emissions Notes:**

Values given above are for 8760 hours/year operation.

The table below gives the load ranges to which the turbine emissions listed above apply.

Pollutant	Load Range
NOx	50 to 100%
CO	50 to 100%
UHC	50 to 100%

(1) Gas Fuel TAURUS 65-8401S with fired HRSG and SCR Emission Control System	<b>Per Unit</b>	<b>Plant Total</b>
------------------------------------------------------------------------------	-----------------	--------------------

Fuels must comply with Solar specification ES 9-98.

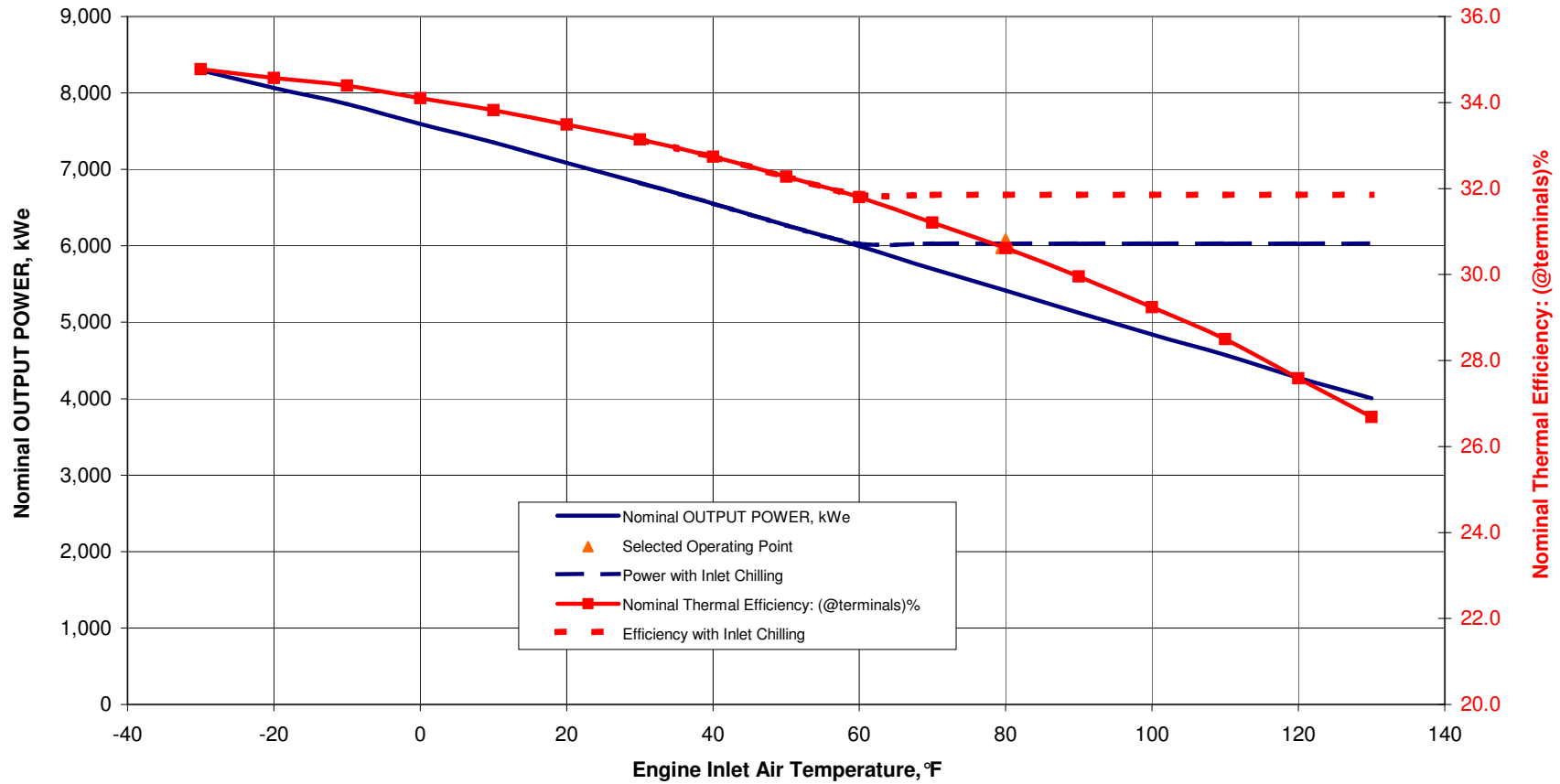
Values applicable for operation at ambient temperatures between 0 and 120°F.

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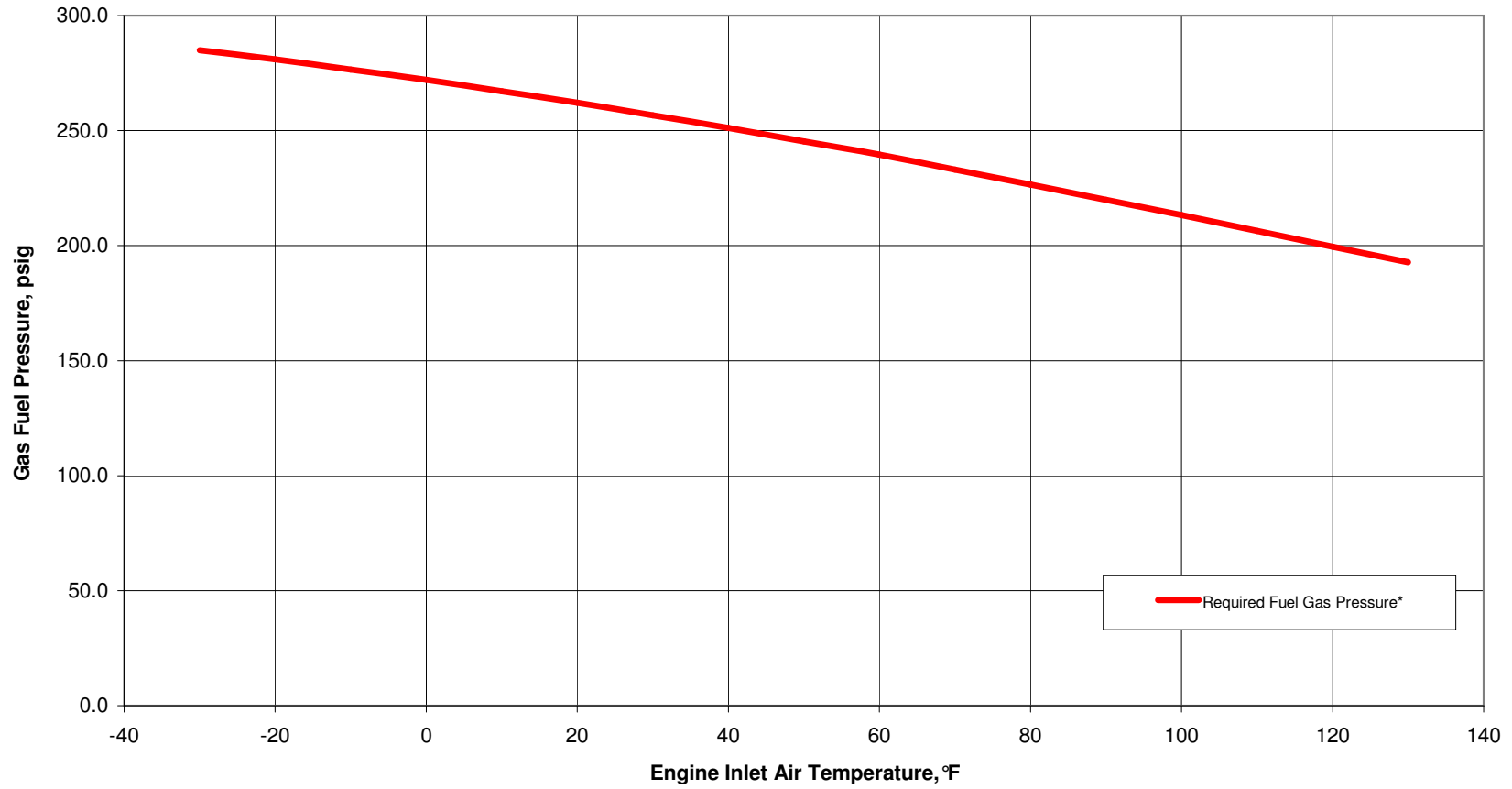
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TAURUS 65-8401S GSC STANDARD Std. Natural Gas Fuel



**TAURUS 65-8401S GSC STANDARD Std. Natural Gas Fuel**



**Solar Turbines Incorporated**  
**Budgetary Quotation for Page Southerland Page**

Inquiry # Dallas VA prepared on January 5, 2011

For more information contact:

Marco Perez, 713-825-5319, perez\_marco\_x@solarturbines.com

(Prices shown below quoted in US Dollars \$)

**This quote is provided for budgetary purposes only and does not represent a firm quote.**

**Gas Turbine Equipment**

(1) Dual Fuel TAURUS 70-10801S Axial Turbine Generator Set.....	\$4,572,600
Commissioning Parts, Startup, and Site Testing.....	\$150,000

**Electrical Equipment**

Station Control System (SCS) (Monitor Only).....	\$247,300	
Power and Utility Breaker Control Options.....	Included in SCS	
Switchgear and MCC (design description below).....	\$315,400	
Switchgear, motor control center, auxiliary power transformer, and generator grounding resistor.		
Switchgear and MCC are shipped loose.		
Utility Tie-In.....	\$304,500	
Total for Electrical Equipment.....		\$867,200

**Mechanical Equipment**

Fuel Gas Compressor, 1 provided .....		\$812,500
1 Heat Recovery Steam Generator with ductburners.....	\$1,131,200	
HRSG Options.....	\$6,400	
Diverter Valve.....	\$226,800	
Diverter Valve Options.....	none selected	
Total for Heat Recovery Steam System.....		\$1,364,400
Emissions Control Equipment:(SCR and support equipment only).....		\$717,600
Continuous Emission Monitoring System, outdoor installation.....		\$86,300
Gas Turbine Inlet Cooling.....		\$312,800

**Miscellaneous**

Construction Estimate.....		\$2,886,600
Project Management & Engineering.....		\$784,600
Shipping.....		\$182,600
Development Costs.....		\$0
Special or Avoided Capital Items.....		\$0
15% Balance of Plant Contingency.....		\$1,202,200
Total for BOP Equipment and Installation.....		\$9,216,800
<b>Grand Total for Turbomachinery and Balance of Plant.....</b>		<b>\$13,939,400</b>
Estimation of cost per ISO rating kilowatt for selected equipment.....		\$1,751
ESA Cost per Month (Only Turbomachinery Covered).....		\$41,151

\*Duties and taxes not included in estimate.

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## **TAURUS 70-10801S Axial Generator Set Package Features**

### **Engine:**

Single shaft turbine, designed for industrial use  
Axial compressor design  
Annular type combustor employing dry, low NOx technology

### **Basic Options:**

Fully enclosed, generator set package requiring 460V, 3-phase, 60 Hz AC power  
Rated Class I, Div II, Groups C,D per NEC  
120V, 1-phase, 50/60 Hz internal lighting and heater power  
Gas turbine engine in upward oriented air inlet, and axially oriented exhaust outlet  
1800 rpm; 60 Hz Gearbox  
Continuous Duty, Open Drip Proof generator rated for 13,800 VAC with Class F insulation, B rise

### **Included Package Features:**

Direct AC start motor system  
Duplex lube oil filter system  
Allen-Bradley based Turbotronics IV control system including:

- Ethernet network interface
- Touch Screen display with Engine Performance map
- Software for heat recovery interface (without diverter valve control)
- Software for CO<sub>2</sub> system "lock out" (maintenance access to enclosure)
- Backup Safety Shutdown System
- kW Control
- kVAR/Power Factor Control

### **Included Factory Testing/Customer Witness/Quality Control Documentation:**

Standard package dynamic testing  
Factory vibration testing  
Factory emissions testing per Solar's ES 9-97  
Observation on "Non-Interference" basis  
Quality Control documentation (Level 1)

### **Field-installed Ancillary Equipment (excludes ducting):**

Medium velocity, three-stage Camil-Farr air inlet filter  
Engine air inlet silencer  
Exhaust bellows (interface to waste heat recovery equipment)  
"Elbow" type enclosure inlet/exhaust ventilation system with silencer

### **Included "Off-Skid" Components/Systems:**

Remote desktop PC/monitor and Printer/Logger  
Gas fuel flow meter (for Gas-only and Dual Fuel configurations)  
AC motor-driven Liquid Fuel boost pump skid (for Liquid Fuel configurations)  
3-micron duplex filter/coalescer with auto drain (for Liquid Fuel configurations)  
CO<sub>2</sub> system cabinet  
Air/Oil lube oil cooler  
VRLA Batteries with 120V DC charging system (back-up post lube)  
Portable engine cleaning cart

### **Miscellaneous**

Short-term preservation for shipment  
Four (4) paper copies of Solar's Instruction, Operation and Maintenance manuals  
Four (4) CD-ROM copies of Solar's Instruction, Operation and Maintenance manuals  
UV Light and Gas Sensor test kit  
Internal equipment handling system

## Cogeneration Plant Estimated Performance Summary

Page Southerland Page  
Solar Turbines Incorporated  
January 5, 2011

Performance listed below is estimated, not guaranteed.

<b>Gas Turbine:</b>	
KW Gross Output @ ISO Conditions:	7,960 kW
Site Ambient Temperature for Performance Analysis:	80 °F
Site Elevation for Performance Analysis:	50 feet
Site Ambient Relative Humidity for Performance Analysis:	60 %
Turbine Inlet Pressure Loss:	4.0 "H <sub>2</sub> O
Turbine Outlet Pressure Loss:	13.0 "H <sub>2</sub> O
Turbine Fuel Consumption @ specified site conditions (LHV):	78.3 MMBtu/hr
KW Gross Output @ specified site conditions:	7,628 kW
Gas Compressor Power Consumption:	401 kW
Turbine Auxiliary Power Consumption:	22 kW
Total Auxiliary Power Consumption:	423 kW
Net Turbine Power Production:	7,205 kW
Black Start kW Requirement (Turbine Generator Set Only)	367 kW
<b>Boiler:</b>	
Condensate Return:	87 %
Condensate Temperature:	212 °F
Makeup Water Temperature:	50 °F
Process Steam Pressure:	150.0 psig
Process Steam Temperature:	366 °F
Steam Contributed by Gas Turbine:	36,377 lb/hr
Steam Contributed by Ductburners:	8,623 lb/hr
Ductburner Fuel Consumption (LHV):	9.9 MMBtu/hr
Deaerator Steam Consumption:	1,634 lb/hr
Boiler Steam Flow:	45,000 lb/hr
Steam Flow to Process:	45,000 lb/hr
<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	10,870 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,340 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	78.6 %

## Cogeneration Plant Estimated Performance Summary

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Solar Turbines Incorporated  
January 5, 2011

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Process Steam Pressure:	150.0 psig
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Steam Contributed by Gas Turbine:	36,377 lb/hr
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<b>Cycle Performance (lower heating value basis):</b>	
Net Turbine Heat Rate:	10,870 Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	4,340 Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	78.6 %

# Solar Turbines

A Caterpillar Company  
**Proposed Process Flow Diagram**

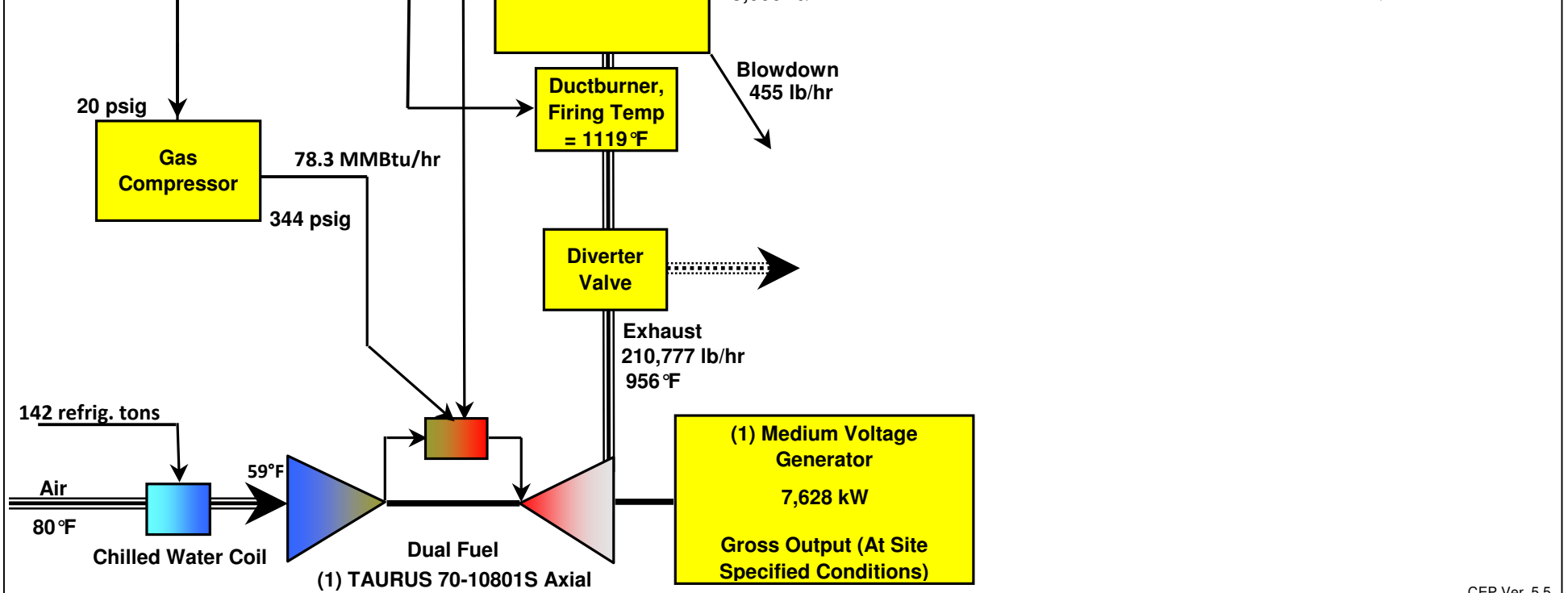
Specified Site Conditions:

Elevation:	50 feet ASL
Amb. Temp:	80 °F
Humidity:	60%

**Liquid Fuel**  
 Off

**Gas Fuel**  
 88.2 MMBtu/hr

Predicted Stack Emissions:	ppm@15%O2	tons/year
NOx	2	3.8
CO	48	45.1
UHC	26	13.9



System Efficiency = 78.6%  
 Fuel Flow(s) based on Lower Heating Value

Note: For Estimating Purposes only. For Guaranteed Performance, see your Solar Turbines Representative.

(1) Medium Voltage Generator  
 7,628 kW  
 Gross Output (At Site Specified Conditions)  
 ISO Rating - 7,960 kW

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Ref. #	Dallas VA	1/5/2011
Designed by	Marco Perez	

CEP Ver. 5.5

## Off Design Performance Worksheet

### Page Southerland Page

Prepared by Marco Perez on January 5, 2011

**TAURUS 70-10801S Axial**

**GSC STANDARD**

**Dual (Gas Performance)**

**CHP Off Design**

(Inlet Cooling in use in this column)

					Duct Burner On/Off	Off	
					# of Turbines in Service	1	(Inlet Cooling in use)
					Boiler Steam Demand		lb/hr
					Unfired Steam Flow	36,377	lb/hr
					Firing Temperature	Off	°F
					Duct Burner Fuel Flow	Off	MMBtu/hr
Site Elevation:	50						feet
Barometric Pressure:	29.86						"Hg
Inlet Duct Loss:	4.0						"H2O
Exhaust Duct Loss:	13.0						"H2O
Ambient Temperature (T1):	80	20	40	59	80	100	°F
Part Power ( kWe), % Load, or 0 for Max:	→ 0	0	0	0	0	0	kWe
Engine Inlet Air Temperature (T1):	59	20	40	59	80	59	°F
Nominal Output Power: (@terminals)	7,628	8,576	8,129	7,628	6,940	7,628	kWe
Fuel Flow (LHV):	78.3	86.5	82.5	78.3	73.2	78.3	MMBtu/hr
Inlet Air Flow:	206,976	221,467	214,777	206,976	195,172	206,976	lb/hr
Exhaust Gas Temperature (T7):	956	942	948	956	974	956	°F
Exhaust Gas Mass Flow:	210,777	225,663	218,779	210,777	198,722	210,777	lb/hr
Exhaust Gas Volumetric Flow:	47,844	51,019	49,518	47,844	45,423	47,844	SCFM
Nominal Thermal Efficiency: (@terminals)	33.2	33.9	33.6	33.2	32.4	33.2	%
Nominal Heat Rate: (@terminals)	10,271	10,083	10,146	10,271	10,543	10,271	Btu/kWHR
PCD Pressure:	238.9	256.4	248.3	238.9	224.8	238.9	psig
Exhaust Heat (from T7 to 275 °F):	37.3	39.1	38.3	37.3	36.1	37.3	MMBtu/hr
% Argon, wet:	0.9	0.9	0.9	0.9	0.9	0.9	
% CO <sub>2</sub> , wet:	3.1	3.2	3.2	3.1	3.0	3.1	
% H <sub>2</sub> O, wet:	6.8	6.1	6.3	6.8	8.0	6.8	
% N <sub>2</sub> , wet:	75.1	75.7	75.5	75.1	74.1	75.1	
% Oxygen, wet:	14.1	14.1	14.1	14.1	14.0	14.1	
					<b>Net CHP System Efficiency =</b>	77.6	% (LHV)

## Estimated Power Island Emissions

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Quoted using data available as of January 5, 2011

(1) Dual Fuel TAURUS 70-10801S Axial with fired HRSG and SCR Emission Control System		Per Unit	Plant Total
Ambient Temperature	°F	80°F	
Fuel Type		Dual (Gas Performance)	
Assumed Fuel Sulphur Content	lb/MMBTU (HHV)	0.00	
Gas Turbine Exhaust Flow	lb/hr	210,777	210,777
Duct Burner Fuel Flow	lb/hr	476	476
Stack Exhaust Flow	lb/hr	211,253	211,253
FG Temperature Leaving Gas Turbine	°F	956	
FG Temperature Leaving Duct Burner	°F	1119	
FG Temperature At Stack	°F	303	
Heat Input to Gas Turbine	MMBtu/hr (LHV)	78.3	78.3
Heat Input from Duct Firing	MMBtu/hr (LHV)	9.9	9.9
Additive NOx from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive CO from Duct Firing	lb/MMBTU (HHV)	0.080	
Additive UHC as CH4 from Duct Firing	lb/MMBTU (HHV)	0.045	
PM <sub>10</sub> /PM <sub>2.5</sub> Particulates from Gas Turbine	lb/MMBTU (HHV)	0.021	
Additive PM-10 Particulates from Duct Firing	lb/MMBTU (HHV)	0.021	
<b>Turbine Exhaust Gas Analysis</b>			
H <sub>2</sub> O	% vol	6.8%	
N <sub>2</sub>	% vol	75.1%	
CO <sub>2</sub>	% vol	3.1%	
O <sub>2</sub>	% vol	14.1%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Flue Gas Analysis After Duct Burner</b>			
H <sub>2</sub> O	% vol	7.5%	
N <sub>2</sub>	% vol	74.8%	
CO <sub>2</sub>	% vol	3.5%	
O <sub>2</sub>	% vol	13.3%	
SO <sub>2</sub>	% vol	0.0%	
Argon	% vol	0.9%	
<b>Gas Turbine Exhaust Emissions</b>			
NOx	ppm @ 15% O <sub>2</sub>	25	25
	lb/hr	7.7	7.7
CO	ppm @ 15% O <sub>2</sub>	50	50
	lb/hr	9.4	9.4
UHC	ppm @ 15% O <sub>2</sub>	25	25
	lb/hr	2.7	2.7
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	1.8	1.8
SO <sub>2</sub>	lb/hr	0.0	0.0

(1) Dual Fuel TAURUS 70-10801S Axial with fired HRSG and SCR Emission Control System		Per Unit	Plant Total
<b>Total Emissions After Duct Burner</b>			
NOx	ppm @ 15% O2	25	25
	lb/hr	8.6	8.6
CO	ppm @ 15% O2	48	48
	lb/hr	10.3	10.3
UHC	ppm @ 15% O2	26	26
	lb/hr	3.2	3.2
PM <sub>10</sub>	lb/hr	2.0	2.0
SO <sub>2</sub>	lb/hr	0.0	0.0
<b>Exhaust Emissions At Stack</b>			
NOx	ppm @ 15% O2	2	2
	lb/MMBtu, HHV	0.009	
	lb/hr	0.9	0.9
	tons/year	3.8	3.8
CO	ppm @ 15% O2	48	48
	lb/MMBtu, HHV	0.106	
	lb/hr	10.3	10.3
	tons/year	45.1	45.1
UHC	ppm @ 15% O2	26	26
	lb/MMBtu, HHV	0.033	
	lb/hr	3.2	3.2
	tons/year	13.9	13.9
VOC	ppm @ 15% O2	5	5
	lb/MMBtu, HHV	0.007	
	lb/hr	0.3	0.3
	tons/year	1.4	1.4
PM <sub>10</sub> /PM <sub>2.5</sub>	lb/hr	2.0	2.0
	lb/MMBtu, HHV	0.021	
	tons/year	9.0	9.0
SO <sub>2</sub>	lb/hr	0.01	0.0
	lb/MMBtu, HHV	0.00014	
	tons/year	0.1	0.1
SCR Ammonia Slip	ppm @ 15% O2	5	
SCR Reduction Efficiency	%	90	
CO Catalyst Reduction Efficiency	%	N/A	
UHC Catalyst Reduction Efficiency	%	N/A	
Greenhouse Gas Emissions	lbs of CO <sub>2</sub> /MMBtu (HHV)	117	

### General Notes

SO<sub>2</sub> emissions depend upon the fuel's sulfur content. The SO<sub>2</sub> estimate is based upon the assumption of 100% conversion of fuel sulphur to SO<sub>2</sub>, using assumed values for various fuels that may not reflect actual fuel composition. Zero fuel bound nitrogen is assumed for gaseous fuels, less than 0.02% for liquid fuels. Actual emissions may be subject to site fuel characteristics. This document is for initial emissions estimates only. For air permit application emissions documentation, Solar can provide site-specific appropriate documentation.

### **Turbine Emissions Notes:**

Values given above are for 8760 hours/year operation.

The table below gives the load ranges to which the turbine emissions listed above apply.

Pollutant	Load Range
NOx	50 to 100%
CO	50 to 100%
UHC	50 to 100%

(1) Dual Fuel TAURUS 70-10801S Axial with fired HRSG and SCR Emission Control System	<b>Per Unit</b>	<b>Plant Total</b>
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Fuels must comply with Solar specification ES 9-98.

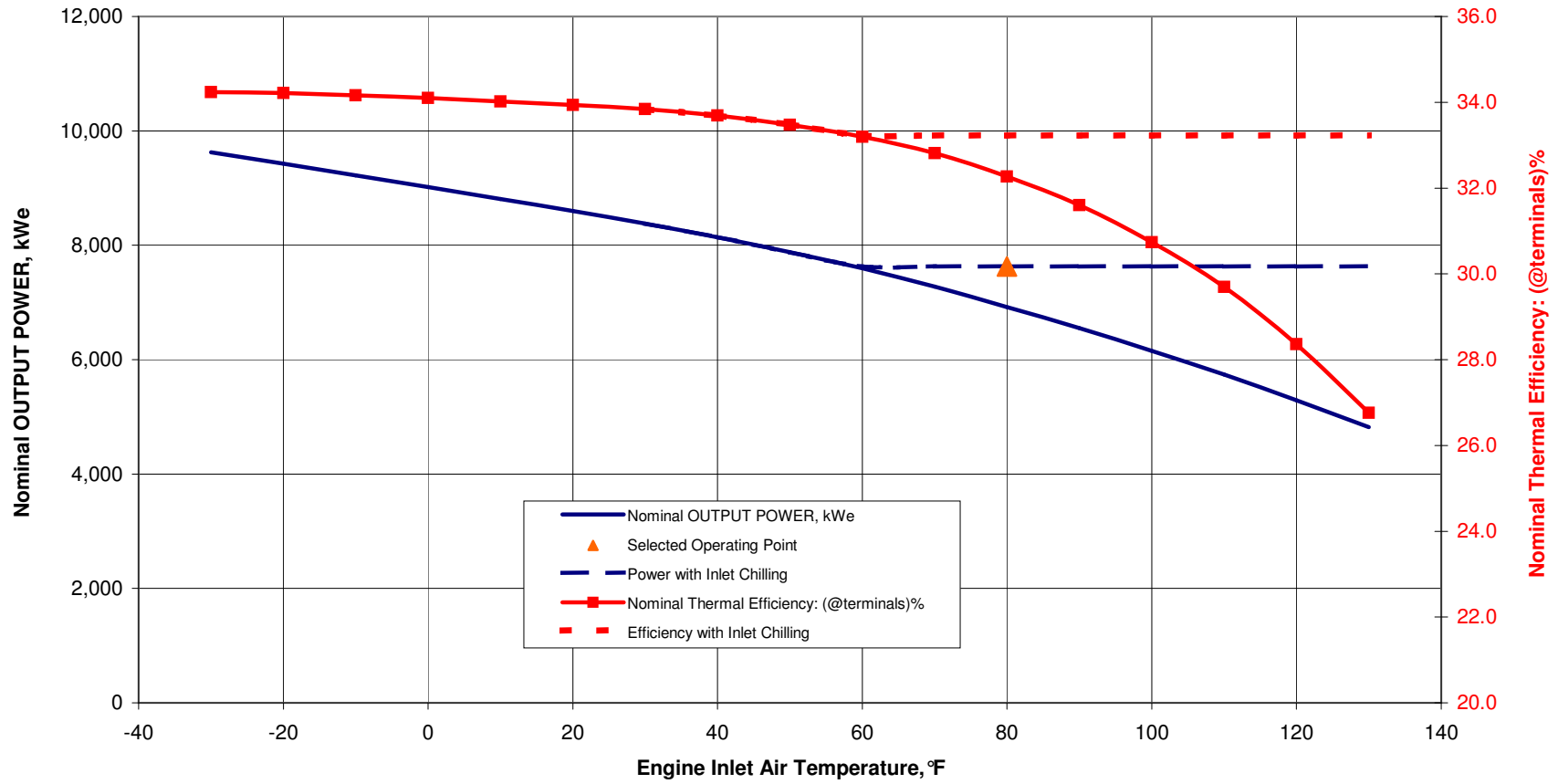
Values applicable for operation at ambient temperatures between 0 and 120°F.

For more information contact: Marco Perez, 713-825-5319, perez\_marco\_x@solarturbines.com

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TAURUS 70-10801S Axial GSC STANDARD Std. Natural Gas Fuel



**TAURUS 70-10801S Axial GSC STANDARD Std. Natural Gas Fuel**

