Texas State Capitol Complex:

Thermal Energy Storage &
Combined Heat and Power
Feasibility Study

Prepared for:

Texas Facilities Commission
Austin, TX 78705
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Executive Summary

The Texas Facilities Commission (TFC) had requested the US Department of Energy's Gulf Coast Clean Energy Application Center (GC RAC) to analyze the feasibility of a thermal energy storage tank (TES) and a combined heat and power (CHP) system to meet the electric loads for a select number of existing buildings and 1.3 million square feet of new construction office space at the State Capitol complex in Austin, Texas.

Based on discussions with TFC, the GC RAC gathered all the requisite data and modeled the hourly electric, chill water and heating hot water needs of the building stock. Subsequently, the installation of different sized TES tanks was analyzed in terms of impact on peak demand, capital costs, utility savings, simple payback and resultant Internal Rate of Return (IRR). The installation of a CHP system capable of serving all of the electric and heat loads, for each of the different sized tanks was then analyzed.

The impacts of the installation of TES tanks sized at 2.5, 4.5, 6.5, 8.5, 10.5 and 12.5 million gallons were analyzed. In addition to producing demand savings during the peak period, TES tanks can offset the capital required to replace aging chillers. Incremental capital costs ranged between **$1.1 – $11.5 million** resulting in a IRR ranging between **23.4% - 6.9%.** As the tank size increased (from 2.5-12.5 million gallons), the capital costs increased and a reduction in the IRR was observed.

A CHP system consisting of multiple natural gas turbines and an extraction steam turbine, capable of serving all the electricity needs for the building stock was analyzed. The system's operation was applied to the different hourly load profile scenarios (based onTES tank size). The analysis inculded a scenario under which no TES tank would be installed. Capital costs ranged between **$46.5 - $57.1 million**, resulting in annual savings of **$4.6 - $5.2 million** and IRR's ranging between **10.2% - 5.5%.** As the tank size increased (from 0-12.5 million gallons), the capital costs increased and a reduction in the IRR was observed.

The impact of the CHP system on the environment was also analyzed. Along with significant reductions in NO_x, SO_x, water and mercury, the installation of the CHP plant would result in a reduction of CO_2 by **50,496 tons/year**. This reduction would be equivalent to removing the carbon that would be either absorbed by **10,405 acres of forest** or emitted by **8,340 cars**.

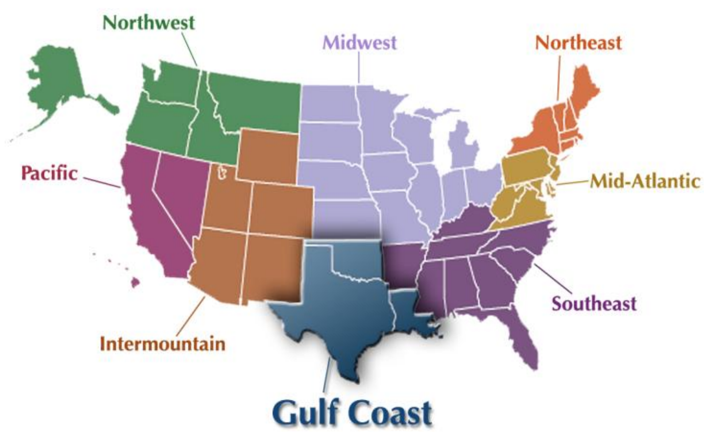
The summary of findings are bulleted below

- Simple Paybacks ranging from 9 -12 years
- Capital Investments ranging from $46 million - $57 million
- Annual Utility Savings ranging from $4.6 million – $5.2 million
- Internal Rates of return ranging from 5.5% - 10%

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 TFC 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 that 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.



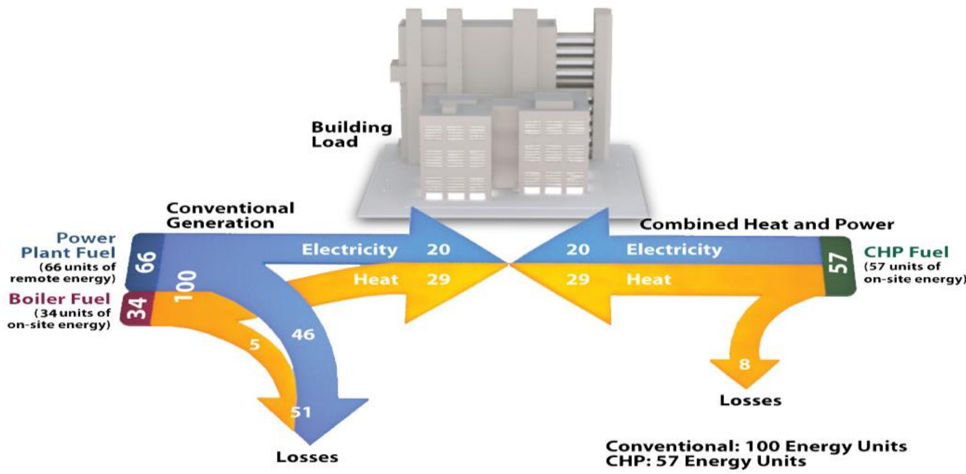
The goal of this CHP feasibility study is to establish whether CHP is technically and economically *viable.* The detailed analysis uses simulation software to determine building loads on an hour-by-hour basis. Detailed load information facilitates an in depth comparison of of the conventional separate 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. To accomplish the detailed analysis, the GC RAC engaged in the following:

- On-site meetings with TFC staff including limited walkthrough site-assessment
- Data collection including building envelope characteristics, age, area, hours of operation, type of HVAC systems, current energy consumption, utility rates and costs, and additional information related to energy supply and use
- Hour by hour building simulation using DOE software
- Calibration of baseline model to actual utility bills
- Hourly simulation of electric and thermal loads with and without CHP
- Examination of alternate CHP plant configurations
- Use of financial models to generate internal rate of return

This report documents the approach and results of a detailed CHP analysis undertaken by the GC RAC to assess the viability of implementing a Thermal Energy Storage tank and CHP at the Texas Capitol Complex in Austin, Texas. The analysis assumes that all of the existing and planned buildings are served by a single, interconnected district energy system providing chill water and steam throughout the campus.

Combined Heat and Power Overview

The combined heat and power (CHP) approach can provide chill water, steam, and electricity to the State Capitol Complex at a much higher energy efficiency than the present supply approach. In the current practice, electricity is purchased from Austin Energy, much of which is used in electric chiller to produce chill water to air condition the buildings. Steam is produced by combusting natural gas supplied by the General Land Office 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[1] 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. In cases where the on-site steam needs are less than that produced by the CHP system, which is the situation at the Texas State Capitol Complex, some of the steam from the CHP system must be redirected to another productive use. The most common alternate use is to make chill water by using the steam to drive a stream 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.

[1] 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.

Campus Profile

The Texas State Capitol Complex houses several state-owned buildings located in the central Austin business district. The campus houses the Texas Capitol building, government office buildings, the state library, a number of parking garages and surface packing lots. In addition to the existing building stock, TFC desired the analysis to include an addition of 1.3 million square feet of new construction comprising additional state office buildings. In order to facilitate the simulation, information with regards to the building envelope, age, area, hours of operation, type of HVAC systems was collected from the following sources

- Energy Systems Laboratory Group 1 & Group 2 report dated September 2, 2009
- Building Info Matrix – provided by TFC
- Utility Bills, Logs – provided by TFC

Table 1 summarizes the Buildings, adress and square feet included as part of the study.

Table 1. **Buildings included as part of the study**

Building ID	Building Name
ARC	Lorenzo De Zavala Archives & Library
CVC	Capitol Visitors Center
	Capitol
	Capitol Extension
DCG	Dewitt C. Greer
INS	Insurance Building
INX	Insurance Annex
JER	James E. Rudder Building
JHR	John H. Reagan Building
PDB	Price Daniel, Sr. Building
SCB	Supreme Court Building
SHB	Sam Houston Building
TCC	Tom C. Clark Building
TJR	Thomas Jefferson Rusk Building.
LBJ	Lyndon B. Johnson Building
REJ	Robert E. Johnson Building
SFA	Stephen F. Austin Building
THO	E. O. Thompson Building
WBT	William B. Travis Building
WPC	William P. Clements Building
New Off	Capitol Complex Expansion (1.3 million)

HVAC Systems

A Central Utility Plant housing both chillers and boilers provides chilled water and steam to several buildings at the Complex. There is a second chilled water plant located at the Stephen F. Austin Building which provides chilled water to SFA, LBJ and WBT. All remainder buildings have stand-alone chillers and boilers. Table 2 illustrates the chilled water source, heating source, air systems in each building. Table 3 illustrates the chiller tonnages in each of the plants. The CPP boilers provide steam for the heating needs to several buildings. However, during the months of June-September only ARC, CVC, PDB, SCB & TCC receive steam. The remainder buildings served by the CPP boilers have manual shut offs and do not receive steam during these peak summer months to minimize simultaneous heating and cooling.

Table 2. **HVAC Summary**

Bldg ID	Chill Water Source	Heat Source	Air Distribution System Type
ARC	CPP	CPP Boilers	Air Handler w/ VAVs
CVC	CPP	CPP Boilers	Multi Zone w/reheat
Cap	CPP	CPP Boilers	Multi Zone; Fan coils on G & 1st flr
Cap X	CPP	CPP Boilers	Air Handler w/ VAVs
DCG	CPP	CPP Boilers	Fan Coil Units
INS	CPP	CPP Boilers	Air Handler w/ VAVs
INX	CPP	CPP Boilers	Air Handler w/ VAVs
JER	CPP	CPP Boilers	Air Handler w/ VAVs
JHR	CPP	CPP Boilers	Air Handler w/ VAVs
LBJ	SFA Chillers	LBJ Boilers	Air Handler w/ VAVs
PDB	CPP	CPP Boilers	Air Handler w/ VAVs
REJ	REJ Chillers	REJ Boilers	Air Handler w/ VAVs
SCB	CPP	CPP Boilers	Air Handler w/ VAVs
SFA	SFA Chillers	SFA Boilers	Air Handler w/ VAVs
SHB	CPP	CPP Boilers	Air Handler w/ VAVs
TCC	CPP	CPP Boilers	Multi Zone AHUs
THO	THO Chillers	THO Boilers	Multi Zone AHUs
TJR	CPP	TJR Boilers	Air Handler w/ VAVs
WBT	SFA Chillers	SFA Boilers	Air Handler w/ VAVs
WPC	WPC Chillers	Electric	Air Handler w/ VAVs

Table 3. **Chiller Inventory**

Building	Manufacturer	Chiller Designation	Model Number	Serial Number	Tonnage	Install Date	Refrigerant
JER	Carrier	Chiller # 2 Back up only	30-11k-060-630	T-736788	75	1982	R22
WPC	Trane	Chiller # 1	CVHE-080F	L85D27519	800	1985	R11
WPC	Trane	Chiller # 2	CVHE-080F	L85D27520	800	1985	R11
WPC	York	Chiller # 3	YTD1E3C3CMFS	Decommissioned 1986	350	1985	R11
CPP	Trane	Chiller # 3	CVHE1250	L90C00828	1250	1990	123
CPP	Trane	Chiller # 4	CVHF1280	L94B01491	1280	1994	123
REJ	Trane	Chiller # 1	CVHFO55	L98D02613	550	1998	123
REJ	Trane	Chiller # 2	CVHFO55	L98D02622	550	1998	123
REJ	Trane	Chiller # 3	CVHF049	L03J06970	485	1998	123
REJ	Trane	Chiller # 4	RTWAO704X001C3DOW	U98DO9375	70	1998	R22
CPP	Trane	Chiller # 1	CVHF1470	L01K11227	1470	2001	123
SFA	Trane	Chiller # 2	CVHF1470	L03D04417	1470	2003	123
THO	Trane	Chiller # 1	RTWA1004XE01D3DOWFT	U03D09933	100	2003	R22
THO	Trane	Chiller # 2	RTWA1004XE01D3DOWFT	UO3D09934	100	2003	R22
SFA	Trane	Chiller # 1	CVHF1470	L09A06036	1470	2009	123
SFA	Trane	Chiller # 3	CVHF1470	L08M05710	1470	2009	123
CPP	Trane	Chiller # 2	CVHF1470	LI0E02655	1470	2010	123

Campus Energy Loads

Modeling

Subsequent to data collection, each building was modeled using Building Energy Analyzer™ Pro (BEA Pro). At the backbone of the software tool is a DOE-2.1e simulation engine which uses Typical Meteorological Year – data set 2 (TMY2) to simulate building loads. BEA Pro uses 8,760 hourly increments for modeling a year to mitigate the risks associated with simulation using longer time spans. Hourly heating coil load, cooling coil load, electric consumption and gas use modelled by BEA Pro are among the key outputs used in the load determination at the Capitol Complex. The electric consumption and gas use was compared primarily to actual utility bills. If utility bills were unavailable, then the model outputs were compared with load profiles determined by the Energy Systems Laboratory. In some cases, if no medium of comparison was available, then reasonable engineering checks were conducted (for e.g. comparison to the Commercial Buildings Energy Consumption Survey - CBECS data) to validate the model output.

Table 4 lists the error % in the model relative to actual annual electricity consumption for each of the modeled buildings. Since actual gas bills were unavailable on a building-by building basis, a similar comparison was not conducted for Gas usage. The net total gas use obtained by the adding the gas use of each of the modeled buildings served by the CPP was compared to the gas use at the CPP.

Table 4. **Error% - Modeled Electricity vs Actual Consumption**

Building ID	Error % -
ARC	-13%
Capitol, CVC and Extension	NA
DCG	NA
INS	-8%
INX	-3%
JER	-8%
JHR	3%
LBJ	-9%
PDB	-11%
REJ	-7%
SCB	-13%
SFA	-12%
SHB	-1%
TCC	0%
THO	-9%
TJR	-14%
WBT	7%
WPC	-7%
Capitol Campus Expansion	NA

Each Building was modeled and parameters such as lighting density, ventilation requirements, building envelope were used in the calibration process. Figure 1 & Figure 2 are *sample screenshots of the input screen* used in the modeling of SHB. Figure 3 - Figure 5 are *sample output screenshots* subsequent to the simulation for SHB, generated by BEA Pro.

Figure 1. *SHB Modeling – Input Screenshot 1*

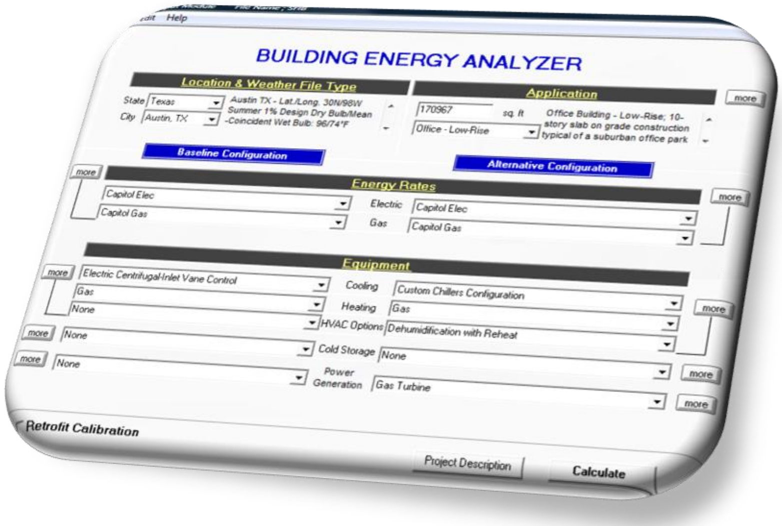


Figure 2. *SHB Modeling – Input Screenshot 2*

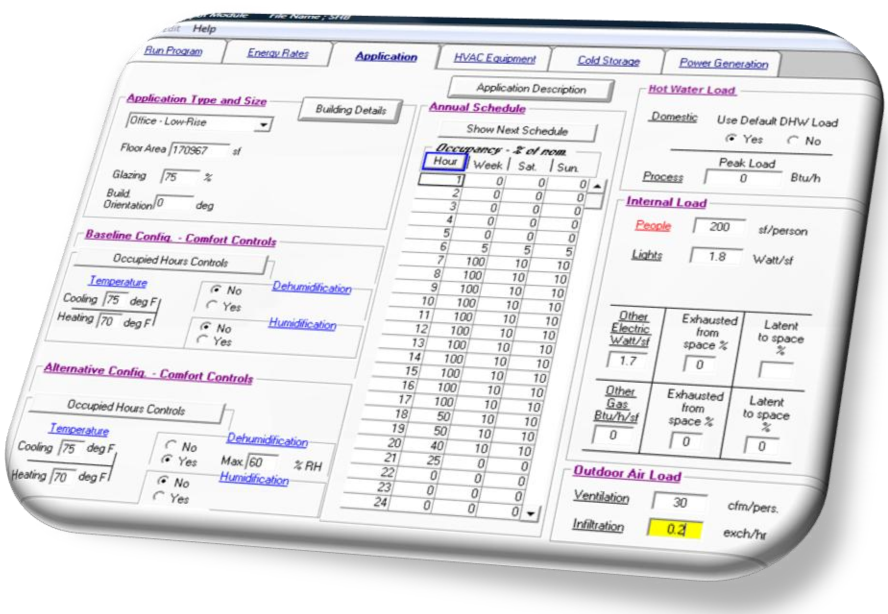


Figure 3. *SHB Modeling – Output Screenshot : Heating & Cooling Loads*

Building Energy Analyzer
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Cooling and Heating Coil Loads

Baseline System

Month	Cooling Sensible MMBtu	Cooling Latent MMBtu	Cooling Total MMBtu	Heating Sensible MMBtu	Heating Latent MMBtu	Heating Total MMBtu
JAN	280	0	280	460	0	460
FEB	340	0	340	417	0	417
MAR	585	0	585	233	0	233
APR	858	18	876	29	0	29
MAY	1,145	86	1,231	1	0	1
JUN	1,433	91	1,524	0	0	0
JUL	1,662	54	1,717	0	0	0
AUG	1,685	77	1,761	0	0	0
SEP	1,247	62	1,309	4	0	4
OCT	1,044	9	1,053	13	0	13
NOV	596	12	608	156	0	156
DEC	260	0	260	445	0	445
Total	11,136	409	11,545	1,758	0	1,758

Subreport:REP

Figure 4. *SHB Modeling – Output Screenshot : Electricity Consumption*

Building Energy Analyzer
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Electric Energy Consumption by End Use

Subreport:REPLONG.RPT

Baseline System

Month	Lights kWh	Misc. Equip. kWh	Space Cooling kWh	Pumps & Misc. kWh	Fans Vent. kWh	Space Heating kWh	Heat Reject. kWh	Refrig. kWh	Dom.Hot Water kWh	Total kWh
JAN	110,787	74,695	17,830	7,737	195,103	730	3,563	0	0	410,445
FEB	97,492	65,365	21,233	7,098	176,222	668	3,716	0	0	371,794
MAR	110,786	74,695	36,679	7,677	195,103	386	6,795	0	0	432,121
APR	106,355	71,585	54,395	7,347	188,810	81	9,567	0	0	438,140
MAY	110,786	74,695	74,839	7,573	195,103	2	12,694	0	0	475,692
JUN	106,355	71,585	90,289	7,521	188,810	0	14,222	0	0	478,782
JUL	107,832	72,283	101,241	7,796	195,103	0	15,820	0	0	500,075
AUG	113,741	77,107	103,604	7,839	195,103	0	15,901	0	0	513,295
SEP	100,446	66,760	78,106	7,407	188,810	14	12,638	0	0	454,181
OCT	110,787	74,695	64,582	7,655	195,103	39	10,817	0	0	463,678
NOV	103,401	69,173	38,063	7,431	188,810	333	6,932	0	0	414,143
DEC	104,878	69,870	17,076	7,738	195,103	718	3,657	0	0	399,040
Total	1,283,646	862,508	697,937	90,819	2,297,183	2,971	116,322	0	0	5,351,386

Figure 5. *SHB Modeling – Output Screenshot : Gas Consumption*

Building Energy Analyzer
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Gas Energy Consumption by End Use
Subreport:REPLONG.RPT

Baseline System

Month	Space Heating MMBtu	Space Cooling MMBtu	DHW & Process MMBtu	Misc. Domest. MMBtu	Supl. Heating MMBtu	Ext. Misc. MMBtu	Power Gen. MMBtu	Total MMBtu
JAN	893	0	24	0	0	0	0	918
FEB	810	0	22	0	0	0	0	832
MAR	451	0	25	0	0	0	0	476
APR	54	0	24	0	0	0	0	78
MAY	1	0	23	0	0	0	0	25
JUN	0	0	21	0	0	0	0	21
JUL	0	0	20	0	0	0	0	20
AUG	0	0	21	0	0	0	0	21
SEP	7	0	18	0	0	0	0	25
OCT	24	0	21	0	0	0	0	44
NOV	297	0	20	0	0	0	0	317
DEC	864	0	22	0	0	0	0	885
Total	3,401	0	260	0	0	0	0	3,661

LOAD AGGREGATION

Subsequent to the determination of hourly electric consumption, gas consumption, heating and cooling loads of each of the buildings and the new construction space, these values were aggregated for each of the 8,760 hours in order to determine the net total loads and consumption at the Capitol Complex. *Most of the data containing the hourly electric, chiller and heat loads for the individual buildings have been included in the report dated June 18, 2010 and related spreadsheets have subsequently been emailed to TFC. As a result, they are not presented in the current report.* Table 5 summarizes this aggregated electricity consumption, chilled water and heating loads at the Complex.

Table 5. **Aggregated Electric Consumption and Thermal Loads – Capitol Complex**

Month	Electricity Consumption (kWh)	Chiller Load (ton-hrs)	Heat Load (MMBtu)	Peak Electric Demand (kW)	Peak Chiller Demand (tons)	Peak Head Load (MMBtu/hr)
January	9,400,382	1,037,837	9,345	25,208	6,912	66
February	8,526,851	1,082,326	8,339	26,594	8,608	54
March	10,212,387	2,023,968	5,633	27,486	9,677	72
April	10,724,974	3,031,965	1,780	27,799	10,242	14
May	11,989,803	4,227,261	1,326	29,509	13,168	8
June	12,317,688	4,983,754	1,099	29,058	12,083	4
July	13,074,861	5,674,004	1,001	29,333	12,565	4
August	13,339,307	5,715,214	1,058	29,383	12,529	4
September	11,585,460	4,380,457	1,181	29,187	12,083	9
October	11,346,402	3,391,385	1,573	28,899	11,811	13
November	9,944,974	2,218,954	3,633	28,064	10,480	32
December	9,179,292	1,042,298	9,213	25,446	7,370	67
Totals	**131,642,381**	**38,809,424**	**45,180**	**29,509**	**13,168**	**72**

Thermal Energy Storage Analysis

Central Plant Integration

Due to a desire to serve the existing and new buildings from a single district energy system, integration of the existing central plants would provide an important initial backbone for future expansion. Based on feedback from TFC, the costs of these improvements are roughly 5 - 10 million dollars. Subsequent to discussions with TFC, these costs were considered independent and were not included, while analyzing the simple payback and IRR for the thermal energy storage tank.

Source of Savings – Thermal Energy Storage

The installation of the Thermal Energy Storage reduces demand charges during the peak period and helps avoid the purchase of aging chillers. Both these factors were considered as part of the analysis.

Electricity Rates

Austin Energy currently provides electrical service to the TFC under the State General Service – Demand (E14) rate. The analysis assumes that the installation of the TES could facilitate a shift to the Rider TOU – Thermal Energy Storage rate. Austin Energy has specified on peak and off peak periods and rates for the summer and winter months. Table 6 details the potential new rate structure, with the installation of the TES.

On-Peak: 4:00 p.m. to 8:00 p.m., Monday through Friday; May 1 through October 31.

Off-Peak: 8:00 p.m. to 4:00 p.m., Monday through Friday; all day Saturday, Sunday, Memorial Day, Independence Day, and Labor Day; May 1 through October 31. All day November 1 through April 30.

Table 6. **Austin Energy – Rate Structure**

	Winter Billing Months November through April	Summer Billing Months May through October
On-Peak	1.07 ¢ per kWh	1.07 ¢ per kWh
Off-Peak	1.07 ¢ per kWh	1.07 ¢ per kWh
Demand Rate (ELD)		
On-Peak	$10.94 per kW	$11.64 per kW
Off-Peak	$10.94 per kW	$0.00 per kW

Clauses

Summer Billed Demand: From May through October, the Summer Billed Demand shall be the highest fifteen-minute demand recorded during the on-peak period. The Summer Billed Demand shall not be less than 50% of the normal on-peak Summer Billed Demand. If more than 50% of the customer's load is attributable to cooling, the 50% floor will be waived.

Winter Billed Demand: From November through April, the Winter Billed Demand shall be the highest fifteen-minute demand recorded during the month, or 90% of the Summer Billed Demand set in the previous summer; whichever is less.

Thermal Storage Operation

Due to on-peak and off peak time-of-use rates for demand, charging and discharging strategy will hinge on reducing peak chilling demand coincident with Austin Energy's definition of peak and off-peak period. Additionally, in order to maximize the chiller tonnage that can be avoided for purchase, with the installation of the TES, care was taken to ensure that the TES charge operation co-incided with times when the building load was the least. This continuous time frame in summer for the charge cycle was observed to be between 11:00 PM and 6:00 AM. The charge and discharge cycles of the tank are shown in Table 7.

Table 7. **Thermal Storage Operation**

Tank Operation	Summer	Winter
Charge Cycle	11:00 PM to 6:00 AM, Monday through Friday; May 1 through October 31	9:00 PM to 6:00 AM, Monday through Sunday; November 1 through April 30
Discharge Cycle	4:00 PM to 8:00 PM, Monday through Friday; May 1 through October 31.	7:00 AM to 8:00 PM, Monday through Sunday; November 1 through April 30

Incentives – Thermal Energy Storage Tank

Austin Energy offers an incentive for the installation of a thermal energy storage tank. Table 8 details available incentives. Incentives for the TES were included as part of the analysis.

Table 8. **Austin Energy Rebate Schedule - TES**

Load Shifted	Rebate
1-100 kW	$300/kW
101-500 KW	$150/kW
>501 kW	$50/kW

Analysis

The study analyzed the installation of different TES tank sizes and its subsequent impacts. The resultant installation shifted hourly electric demands, thereby causing savings due to reduced peak demand charges and favorable off peak energy rates. Additionally, the installation of the TES could offset to an extent, the the purchase of additional chiller tonnages. The following assumptions were made

- The average efficiency of the existing chillers was 0.6 kW/ton. The tons of chilling saved during the peak period were translated to demand savings by multiplying by 0.6 kW. *Note that higher savings would be achievable if it were assumed that the existing chillers had a lower efficiency (>0.6 kw/ton).*
- Total as-built costs of new chillers would be $400/ton
- The Internal Rate of Return assumed the following
    - Marginal tax rate - 0%
    - Interest/Bond Rate - 5%
    - Projected escalation in Electric Charges - 3% annually
    - Financing & cash-flow period - 20 years

Avoided Chillers

Based on discussions with TFC, with regards to their chiller inventory, it was noted that certain chillers were nearing the end of their useful life and could potentially need replacement within the next few years. These chillers are listed in Table 9.

Table 9. **Chiller Inventory – Aging Chillers**

Building	Manufacturer	Chiller Designation	Model Number	Tonnage	Install Date	Refrigerant
JER	Carrier	Chiller # 2 Back up only	30-11k-060-630	75	1982	R22
WPC	Trane	Chiller # 1	CVHE-080F	800	1985	R11
WPC	Trane	Chiller # 2	CVHE-080F	800	1985	R11
WPC	York	Chiller # 3	YTD1E3C3CMFS	350	1985	R11
CPP	Trane	Chiller # 3	CVHE1250	1250	1990	123
CPP	Trane	Chiller # 4	CVHF1280	1280	1994	123

As per discussions with TFC, onsite chiller capacity of relatively new chillers totalled 9,200 tons. Capacity of the aging chillers listed in Table 9 totalled 4,555 tons. In addition to the chillers listed, the GC RAC assumes that roughly 3,000 tons of additional chiller capacity will be needed for the new construction office space. This results in a total tonnage (existing + new) of 16,755 tons. The installation of the TES can offset both the purchase of new chillers as well as the replacement of existing aging chillers. Equations below list the calculations for avoided chillers and the associated avoided costs with the installation of the TES. It has been assumed that 1 ton of chiller costs $400.

Avoided Chillers (tonnage) = 16,755 tons - Peak Electric Chiller Load for different TES tank size (tons) .

Avoided costs ($) = Avoided Chiller tonnage * $400.

It must be noted that, if the TES were not installed, chillers will have to be purchased for the new construction as well as to replace existing chillers that are aging. This situation has been considered the baseline and as a result does not have any savings associated with it.The installation of the TES would add additional costs, but also produce savings, while simultaneously offsetting the purchase of chillers. <u>As a result the financial analysis assumes the incremental benefits of the additional costs and compares these costs to the savings produced, while calculating the simple payback and IRR.</u>

Incremental Capital Costs ($) = TES Capital Costs ($) – Avoided Chiller Costs($)

Results

The Results of the Analysis are tabulated in Table 10 . Detailed hourly load profiles, resultant monthly demand charges and IRR calculations can be found in Appendix B.

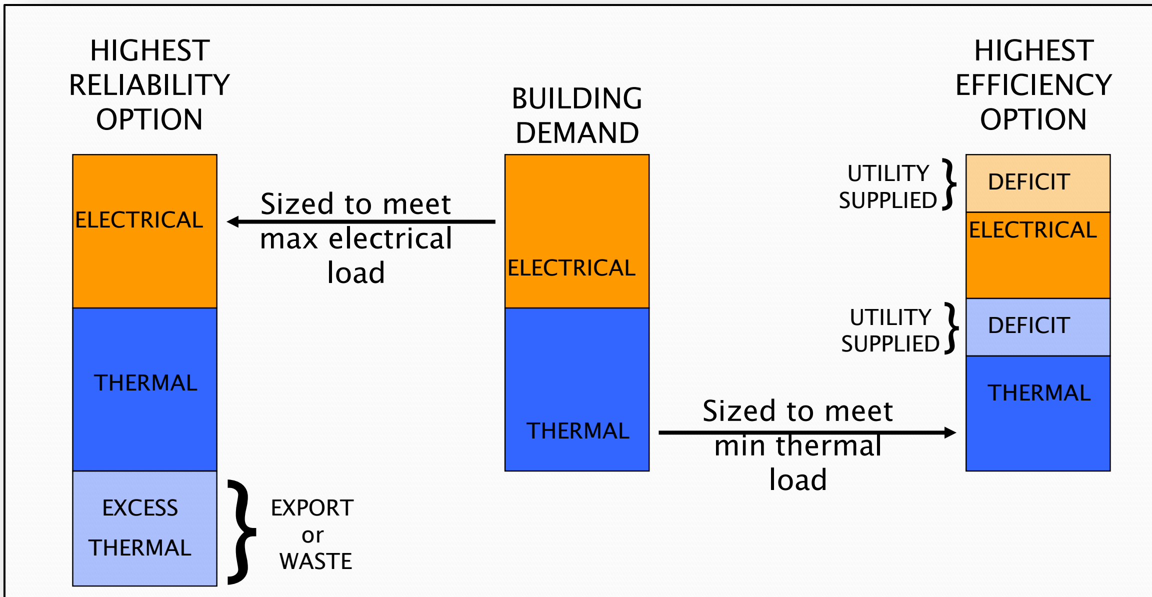
Table 10. **TES Analysis - Results**

TES Tank Size (In Million Gallons)	**2.5**	**4.5**	**6.5**	**8.5**	**10.5**	**12.5**
Electricity Costs due to Chiller - Existing ($)	$1,968,048	$1,968,048	$1,968,048	$1,968,048	$1,968,048	$1,968,048
Electricity Costs due to Chiller - with TES ($)	$1,760,080	$1,569,398	$1,366,957	$1,162,108	$1,140,189	$1,159,754
Max Chiller Tonnage - On Peak (tons)	9,545	8,150	7,115	6,080	5,045	4,010
Max Chiller Tonnage - Off Peak (tons)	12,335	12,335	13,075	15,493	16,870	16,870
Avoided Chiller Purchases (tons)	4,420	4,420	3,680	1,262	-115	-115
Avoided Chiller Costs ($)	$1,767,930	$1,767,930	$1,471,897	$504,999	-$45,813	-$45,813
TES Capital Costs ($)	$2,898,551	$4,956,522	$6,876,812	$8,500,000	$10,043,478	$11,503,623
Incremental Capital Costs ($)	$1,130,620	$3,188,591	$5,404,915	$7,995,001	$10,089,291	$11,549,436
Savings ($)	$207,969	$398,651	$601,092	$805,940	$827,860	$808,295
Simple Payback	5.44	8.00	8.99	9.92	12.19	14.29
Demand Shifted (kW)	2,174	3,913	5,652	7,391	7,901	7,901
Incentives ($50/kW)	$108,696	$195,652	$282,609	$369,565	$395,054	$395,054
Simple Payback with Incentives	4.91	7.51	8.52	9.46	11.71	13.80
Internal Rate of Return (with incentives)	23.4%	15.3%	13.3%	11.8%	8.9%	6.9%

CHP System Analysis

CHP design strategies differ based on several site-specific requirements. At the two extremes, systems can either be designed for the "highest reliability" – designed to meet peak electric load at the site or "highest efficiency" – designed to meet the minimum thermal loads. Most CHP systems are sized between the two scenarios. Figure 6 illustrates the two options, along with the associated electric and thermal flows.

Figure 6. *Typical CHP design strategies*



TFC requested the GC RAC to examine the highest reliability option as part of the study. As a result, the GC RAC has identified a viable CHP system for the Texas Capitol complex, such that the complex will potentially be independent of Austin Energy for its electricity needs.[2] The system was selected after consideration of a several alternative configurations. The selected option met general design goals expected to result in high technical and financial performance. The selected system is capable of serving the aggregated electricity, steam, and chilled water needs for all the buildings included as part of the study. *It is important to note that while the highest reliability option provides energy security and independence from the grid, the associated capital costs are higher and the corresponding IRR's are lower than that of the highest efficiency option.*

[2] While the selected CHP system meets generalized design goals and represents a viable system alternative, it may not be the most desirable or the most optimal solution for the TFC. A more in-depth study may be required to evaluate additional technologies and vendors who could provide a more optimal configuration or address other requirements/constraints of the state.

TES Operation – Revised

The analyses conducted for the TES and the subsequent charge/discharge cycles was primarily dictated by the peak period defined by Austin Energy's E16 time of use schedule. If a CHP Plant were to be installed, which will cater to all on-site electricity requirements, then the TES will be rescheduled to operate during "campus peak times" (M-F, 7:00 AM – 7:00 PM). Thus revised hourly electric and chiller loads, by the different sized TES tanks will be applied and used while analyzing the CHP system. Since the discharge and charge cycles will now be co-incident to the campus peak and off peak times, the costs of the avoided chillers (upto 6.5 million gallons), for lower capacity tanks will change in a way that will benefit TFC. While this is not true for higher capacity tanks, their installation reduces the peak demand to a higher degree, thereby having a potential to reduced the initial investment in the size of the CHP plant. Also important to note, that any savings that would occur by the shift in Austin Energy's schedules cannot be claimed while analyzing the CHP plant, since the plant will produce all the electricity needed for the campus. Table 11 lists the revised cost attributes for the different sized TES tanks.

Table 11. **Revised TES Analysis - Results**

TES TANK Size (million gallons)	2.5	4.5	6.5	8.5	10.5	12.5
TES Capital Costs ($)	$2,898,551	$4,956,522	$6,876,812	$8,500,000	$10,043,478	$11,503,623
Avoided Chiller Tonnage (tons)	4,676	3,359	2,041	724	-594	-1,911
Avoided Chiller Costs ($)	$1,870,580	$1,343,571	$816,562	$289,553	-$237,456	-$764,466
Net TES Capital Costs	$1,027,970	$3,612,951	$6,060,250	$8,210,447	$10,280,935	$12,268,089

Basis of Analysis

Without a TES, the peak load at the campus was determined to be approximately 29.5 MW. The campus' electric, steam and chiller loads exhibit strong variances due to their strong dependence on both seasonal and diurnal factors. Due to this extreme variability, it was discerned that "multiple smaller-sized prime-movers", will be a more optimal solution rather than "one or two big sized prime movers". Some of the advantages for this approach are operational flexibility, prevention of big prime-mover to operate at lower loads (more inefficient and unstable when operating at less than 50% loaded), ability for the system to meet loads when one or more turbines are down for maintenance and avoidance of potentially high standby charges from Austin Energy. The primary disadvantage would be more equipment & higher initial capital costs. The CHP system that was chosen would consist of multiple prime-movers, multiple heat recovery steam generators (HRSG) and an extraction steam turbines (condensing). The first preference will be given to the heat load at the campus. The steam generated by the HRSG will be diverted to the steam turbine, a portion of which will be extracted at 90 psig to serve the camputs heat load while producing some electricity. Steam that is not extracted for process needs will undergo full condensation to produce electricity in "combined-cycle" mode. The analysis initially assumed the installation of six Mercury 50's along with extraction steam turbines. Examination of the results, showed that prime-mover 6, ran between 200 to 1,000 hrs, depending on the size of the TES tank. An investment of 7.8 million dollars on relatively low run hours was considered imprudent and as a result, only 5 prime-movers were considered in the analyses, with requirements of the 6th prime-mover for the few "outlier hours", being supplemented by "boiler steam" to the steam turbine. These additional fuel costs were considered in the anaylsis.

The current Houston Ship Channel price was $4.14/MMBtu , transportation costs were assumed to be $0.9/MMBtu, resulting in a total gas cost of $5.00/MMBtu. Factoring an annual escalation of 3%, the gas price at the start of 2014 (assumption that it will take 3 years to build the CHP plant) would be roughly $5.50 /MMBtu. A similar escalation for electricity costs was included. Additionally, the calculations for the Internal Rate of Return assumed the following

- Marginal tax rate - 0%
- Interest/Bond Rate - 5%
- Projected escalation in Electric Charges - 3% annually
- Projected escalation in CHP fuel costs - 3% annually
- Financing & cash-flow period - 20 years

While these assumptions are simple, there is a potential to increase the IRR, if TFC 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.

CHP System Overview

A CHP system consisting of 5 Mercury turbines, five heat recovery steam generators and a Siemens steam turbine was analyzed. The product data from the manufacturer's cut-sheets is summarized in Table 12. Detailed specifications and budgetary quote for the equipment can be found in Appendix D.

Table 12. **Selected CHP System**

Solar Turbines – Mercury 50	
Rated Capacity (MW)	4.6 MW
Number of prime-movers	5
Fuel Input (therms)	405 therms
Steam Production (at 650 psig, 750 deg F)	8,405 lbs/hr
Siemens – SST 110	
Steam Turbine (kW)	5,300 – 8,500 kW (depending on TES)
Type	Twin-configuration

Results

The operation of the CHP system was analyzed against multiple baselines, each having different hourly electric and thermal load profiles caused due to the different tank sizes. Table 13 and Table 14 summarizes the results. Detailed hourly load profiles and IRR calculations are attached in the Appendix C. Detailed budgetary quotes representative of anticipated capital costs are attached along with Appendix D.

Table 13. **Plant Operation vs TES Tank Sizes**

Plant Operation vs. TES Tank Size	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
Peak Demand (kW)	29,509	28,673	28,004	27,335	26,667	25,998	25,329
Prime-Mover 1 - Average (kW)	4,404	4,437	4,438	4,439	4,440	4,441	4,442
Prime-Mover 2 - Average (kW)	3,818	3,861	3,896	3,910	3,929	3,945	3,963
Prime-Mover 3 - Average (kW)	2,659	2,748	2,841	2,929	2,978	3,022	3,045
Prime-Mover 4 - Average (kW)	1,512	1,481	1,458	1,464	1,502	1,527	1,545
Prime-Mover 5 - Average (kW)	737	716	706	690	669	637	610
Run-hrs for Prime - Mover 1	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Run-hrs for Prime - Mover 2	8,760	8,760	8,760	8,760	8,760	8,760	8,760
Run-hrs for Prime - Mover 3	6,562	6,847	7,073	7,319	7,460	7,538	7,565
Run-hrs for Prime - Mover 4	3,636	3,637	3,653	3,734	3,907	4,030	4,181
Run-hrs for Prime - Mover 5	1,796	1,784	1,809	1,811	1,787	1,760	1,767
Run hrs for Boiler Steam to produce kW	1,082	946	785	646	486	364	255
Steam Turbine - Average kW	2,257	2,211	2,161	2,120	2,088	2,067	2,054
Steam Turbine - max kW	8,555	8,475	7,990	7,327	6,664	6,002	5,339

Table 14. **Project Financials vs. TES tank size**

CHP Plant Financials vs. TES Tank Size	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
Total Gas Cost – Before CHP ($)	502,717	502,717	502,717	502,717	502,717	502,717	502,717
Total Electric – Before CHP ($)	10,015,714	9,903,725	9,816,307	9,730,492	9,645,845	9,562,657	9,480,743
Annual Utility Expenditures - Before CHP ($) [1]	$10,518,430	$10,406,442	$10,319,024	$10,233,209	$10,148,562	$10,065,373	$9,983,460
Annual Utility Expenditures - After CHP ($)	$5,329,619	$5,354,972	$5,371,274	$5,390,817	$5,411,475	$5,423,426	$5,430,808
Capital Costs ($)	$46,521,830	$47,509,636	$49,851,891	$51,967,871	$53,786,749	$55,525,917	$57,181,751
Savings ($)	$5,188,811	$5,051,469	$4,947,750	$4,842,392	$4,737,086	$4,641,948	$4,552,653
Simple Payback (yrs)	9.0	9.4	10.1	10.7	11.4	12.0	12.6
Internal Rate of Return (IRR)	10.18%	9.45%	8.48%	7.62%	6.87%	6.18%	5.56%

[1]Entails Gas Expenditures only, since electricity expenditures are $0 for the highest reliability option

The installation of the TES would reduce pre-CHP utility expenditures. Different tank sizes will result in different baseline expenditures. Table 15 summarizes the monthly baseline expenditures associated with the different sized TES tanks. Table 16 - Table 18 illustrates the monthly fuel use, costs and savings associated with the CHP plant when compared with the different tanks sizes. As can be seen from the tables, while the monthly fuel use is relatively constant, due to the fixed electricity needs of the campus, the monthly savings differ primarily due to reduced pre-CHP expenditures that is attributable to savings associated with the increasing TES tank sizes.

Table 15. **Monthly Expenditures/Baselines vs. TES tank size**

Monthly Fuel Use in MMBtu	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
January	$823,188	$814,050	$807,115	$800,857	$794,896	$789,132	$783,456
February	$785,944	$777,616	$771,441	$765,066	$758,307	$751,308	$744,274
March	$845,056	$836,229	$829,280	$822,701	$816,436	$810,511	$804,869
April	$830,772	$821,344	$813,803	$806,372	$798,858	$791,676	$784,578
May	$924,789	$915,057	$907,271	$899,485	$891,699	$884,090	$876,498
June	$932,432	$922,979	$915,417	$907,855	$900,293	$892,908	$885,555
July	$970,288	$960,275	$952,265	$944,255	$936,246	$928,236	$920,226
August	$983,988	$974,256	$966,470	$958,684	$950,898	$943,112	$935,340
September	$900,332	$890,879	$883,317	$875,756	$868,338	$860,963	$853,585
October	$890,085	$880,072	$872,062	$864,159	$856,305	$848,661	$841,476
November	$817,824	$808,782	$801,968	$795,483	$789,442	$783,617	$778,123
December	$813,732	$804,901	$798,615	$792,536	$786,843	$781,161	$775,482
Totals	**$10,518,430**	**$10,406,442**	**$10,319,024**	**$10,233,209**	**$10,148,562**	**$10,065,373**	**$9,983,460**

Table 16. **Monthly Fuel Use (MMBtu)– CHP plant vs. TES tank size**

Monthly Fuel Use in MMBtu	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
January	91,189	90,690	90,629	90,689	90,923	91,130	91,288
February	83,022	82,659	82,652	82,714	82,736	82,808	82,859
March	88,882	88,839	88,852	89,028	89,210	89,432	89,696
April	82,972	83,216	83,211	83,358	83,344	83,383	83,406
May	91,233	91,798	92,066	92,482	92,751	92,714	92,728
June	91,686	92,947	93,547	94,404	95,095	95,144	95,352
July	95,990	97,703	98,497	99,054	100,264	100,672	100,709
August	98,002	99,551	100,457	101,294	102,061	102,857	102,867
September	87,800	88,454	89,044	89,531	89,732	89,799	89,951
October	87,075	87,532	87,683	87,768	87,931	87,979	88,028
November	79,325	79,401	79,482	79,684	79,891	80,177	80,455
December	88,747	88,205	88,135	88,156	88,357	88,591	88,822
Totals	**1,065,924**	**1,070,994**	**1,074,255**	**1,078,163**	**1,082,295**	**1,084,685**	**1,086,162**

Table 17. **Monthly CHP fuel costs($) vs TES tank size**

Monthly CHP fuel costs ($)	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
January	$455,945	$453,448	$453,147	$453,447	$454,613	$455,649	$456,440
February	$415,112	$413,297	$413,258	$413,571	$413,682	$414,042	$414,293
March	$444,409	$444,195	$444,259	$445,142	$446,052	$447,158	$448,478
April	$414,860	$416,079	$416,056	$416,789	$416,718	$416,917	$417,030
May	$456,167	$458,992	$460,328	$462,410	$463,756	$463,569	$463,641
June	$458,428	$464,737	$467,736	$472,021	$475,476	$475,720	$476,761
July	$479,948	$488,513	$492,487	$495,269	$501,318	$503,358	$503,547
August	$490,010	$497,753	$502,287	$506,469	$510,305	$514,286	$514,335
September	$439,001	$442,268	$445,219	$447,654	$448,661	$448,995	$449,754
October	$435,377	$437,658	$438,415	$438,841	$439,657	$439,893	$440,142
November	$396,627	$397,006	$397,409	$398,422	$399,455	$400,887	$402,275
December	$443,735	$441,026	$440,673	$440,782	$441,783	$442,953	$444,111
Totals	**$5,329,619**	**$5,354,972**	**$5,371,274**	**$5,390,817**	**$5,411,475**	**$5,423,426**	**$5,430,808**

Table 18. **Monthly Savings ($) – CHP plant vs TES tank size**

Monthly Savings ($)	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
January	$367,243	$360,602	$353,968	$347,409	$340,283	$333,483	$327,016
February	$370,832	$364,319	$358,182	$351,495	$344,626	$337,266	$329,981
March	$400,647	$392,034	$385,021	$377,559	$370,383	$363,353	$356,391
April	$415,912	$405,265	$397,746	$389,583	$382,140	$374,759	$367,548
May	$468,622	$456,065	$446,943	$437,075	$427,943	$420,521	$412,856
June	$474,004	$458,243	$447,682	$435,834	$424,817	$417,188	$408,794
July	$490,340	$471,762	$459,778	$448,986	$434,928	$424,878	$416,678
August	$493,979	$476,503	$464,183	$452,215	$440,593	$428,826	$421,005
September	$461,331	$448,611	$438,099	$428,102	$419,678	$411,968	$403,831
October	$454,708	$442,414	$433,647	$425,318	$416,648	$408,768	$401,334
November	$421,197	$411,776	$404,559	$397,061	$389,987	$382,730	$375,848
December	$369,998	$363,875	$357,942	$351,754	$345,059	$338,208	$331,371
Totals	**$5,188,811**	**$5,051,469**	**$4,947,750**	**$4,842,392**	**$4,737,086**	**$4,641,948**	**$4,552,653**

Phasing

While performing the analyses, it was noticed that for small sized tanks, the savings of the TES was a small fraction in comparison to the savings achievable by the CHP plant. For tanks, sized greater than 6.5 million gallons, the associated savings was greater than 10%. These "savings" have been accounted in the form of reduced baseine-operating costs while analyzing the economics of the CHP system. (Refer Table 15). The GC RAC believes that claiming the fractional savings over a period of 0, 5 or 10 years (i.e. separate IRR calculations) has limited potential to have any significant impact on the presented results, given the current set of assumptions. The decision to install the CHP system simultaneously or within a few years has a minimal/negligible detrimental impact on the earlier investement(TES).

Special Comment

As is observed in the report, the higher capacity TES tanks have much higher paybacks/IRR than lower capacity tanks. Also, turbine inlet cooling can be used to maintain the nominal output of the gas turbines, as well as maximize the power output of the CHP plant. Potential exists to obtain better financial performance by implementing both large TES tanks and turbine inlet cooling. Such a strategy may downsize the initial investment in prime-movers, thereby making project economics, more favorable than the current results. Additionally, smaller sized CHP plants, while not providing energy independence from the grid, have lower capital costs, with potential simple paybacks in the 5-7 year range. These analyses are beyond the scope of the current report.

Environmental Analysis

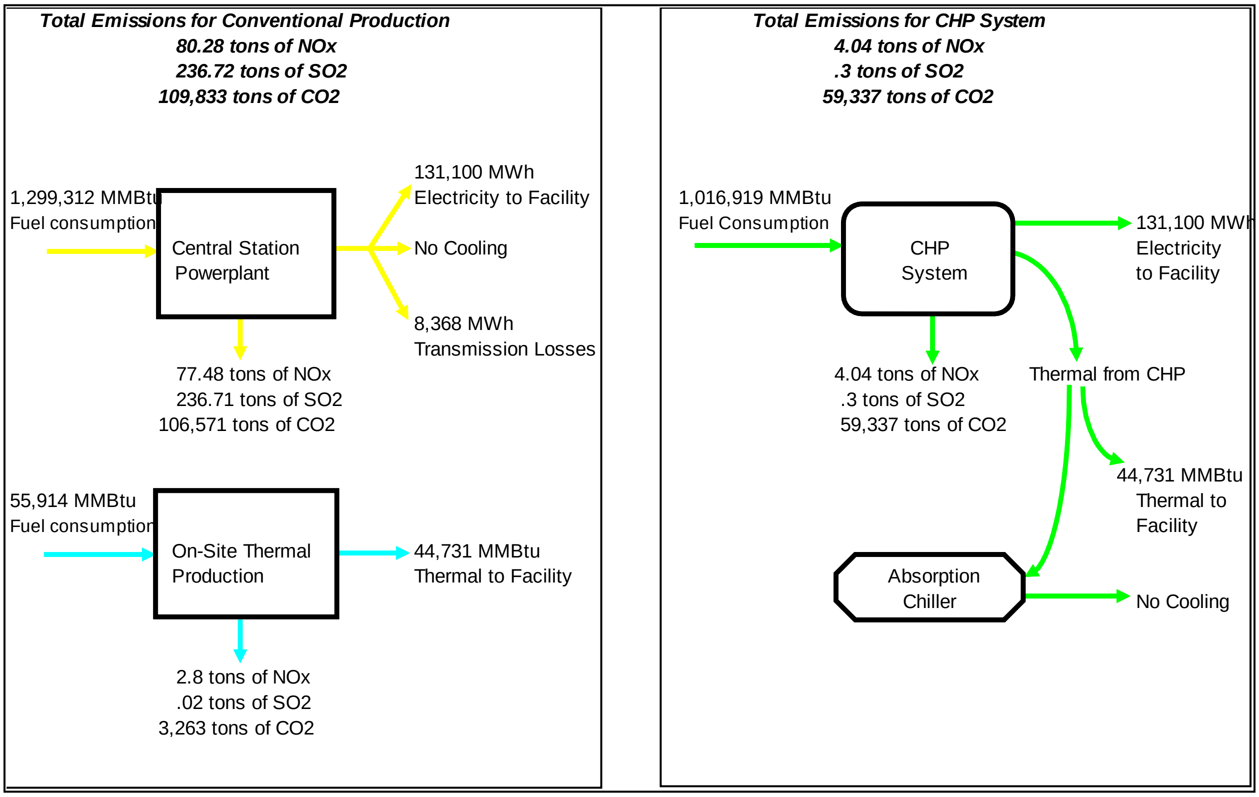
The CHP plant helps in reductions of major greenhouse gases. The Environmental Protection Agency's Emissions Calculator was used to analyze the reductions of NO_x, SO_x and CO_2.Table 19 quantifies these reductions.

Table 19. **Environmental Benefits : CHP System**

Annual Emissions Analysis	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions/Fuel Reduction	Percent Reduction
NOx (tons/year)	4.04	77.48	2.80	76.24	95%
SO2 (tons/year)	0.30	236.71	0.02	236.42	100%
CO2 (tons/year)	59,337	106,571	3,263	50,496	46%
Carbon (metric tons/year)	14,672	26,351	807	12,486	46%
Fuel Consumption (MMBtu/year)	1,016,919	1,299,312	55,914	338,308	25%
Acres of Forest Equivalent				10,405	
Number of Cars Removed				8,340	

Figure 7 compares the emissions between conventional grid/boiler utility model and combined heat and power.

Figure 7. *Emissions Comparison between Conventional Approach and CHP System*



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. Phase 1 TES Analyses : Load Profiles & IRR calculations

Documents Attached

Appendix C. Phase 2: CHP Analyses : Hourly Load Profiles and IRR Calculations

Documents Attached

Appendix D. Budgetary Quotes

Documents Attached

Appendix B. Phase 1 TES : Load Profiles & IRR calculations

Table 1 & Table 2 show the monthly peak demand due to the chiller load and the corresponding demand charges for the various different tank sizes. Figure 1 - Figure 12 show the hourly load profiles and the IRR calculations for each tank size in a sequential manner ranging from 2.5 million gallons to 12.5 million gallons.

Table 1. **Billed Peak Demand in kW due to chiller vs TES tank sizes**

Peak Demand due to the Chiller (kW)	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
January	4,147	3,371	2,750	2,024	459	0	0
February	5,165	4,388	3,589	2,024	459	0	0
March	5,806	5,030	3,589	2,024	459	0	0
April	6,145	5,154	3,589	2,024	459	0	0
May	7,901	5,727	3,988	2,249	510	0	0
June	7,250	5,076	3,336	1,597	0	0	0
July	7,539	5,365	3,626	1,887	148	0	0
August	7,517	5,343	3,604	1,865	126	0	0
September	7,250	5,076	3,337	1,598	0	0	0
October	7,086	4,913	3,173	1,434	0	0	0
November	6,288	5,154	3,589	2,024	459	0	0
December	4,422	3,646	3,025	2,024	459	0	0

Table 2. **Billed Peak Demand charges due to chiller vs TES tank sizes**

Demand Charges due to the Chiller ($)	NO - TES	2.5 Million Gallon TES	4.5 Million Gallon TES	6.5 Million Gallon TES	8.5 Million Gallon TES	10.5 Million Gallon TES	12.5 Million Gallon TES
January	$45,369	$36,875	$30,080	$22,143	$5,019	$0	$0
February	$56,500	$48,006	$39,266	$22,143	$5,019	$0	$0
March	$63,521	$55,027	$39,266	$22,143	$5,019	$0	$0
April	$67,227	$56,390	$39,266	$22,143	$5,019	$0	$0
May	$91,969	$66,664	$46,421	$26,177	$5,934	$0	$0
June	$84,384	$59,080	$38,837	$18,593	$0	$0	$0
July	$87,754	$62,449	$42,206	$21,962	$1,719	$0	$0
August	$87,502	$62,198	$41,955	$21,711	$1,468	$0	$0
September	$84,390	$59,085	$38,842	$18,598	$0	$0	$0
October	$82,486	$57,182	$36,938	$16,695	$0	$0	$0
November	$68,788	$56,390	$39,266	$22,143	$5,019	$0	$0
December	$48,377	$39,883	$33,088	$22,143	$5,019	$0	$0

Figure 1. *Hourly TES and Chiller Load Profile : __2.5 million gallons__*

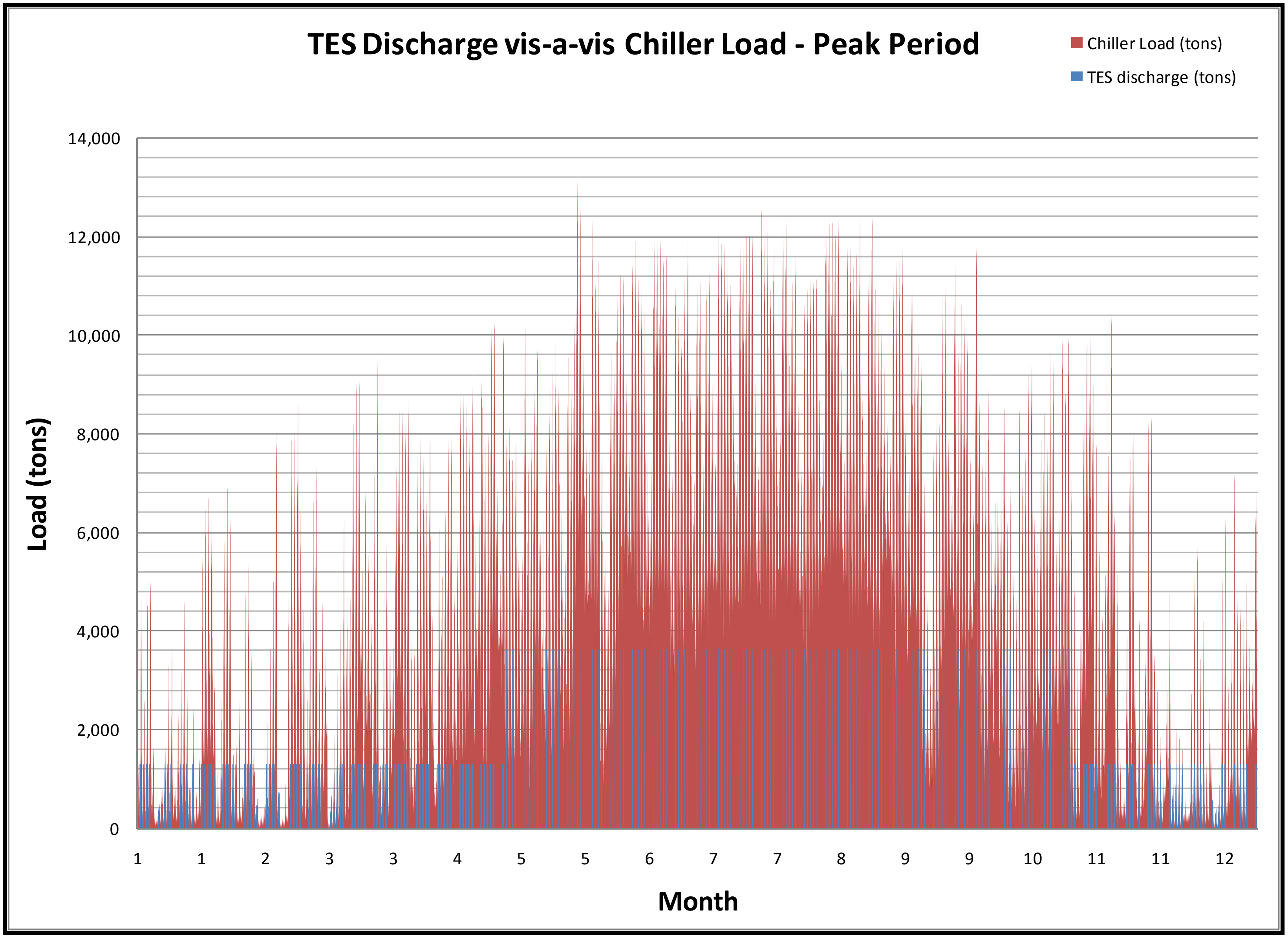


Figure 2. *Internal Rate of Return Calculations : 2.5 million gallon TES*

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**2,899**	
Avoided First Costs (1000$)	**1,768**	
Incentives (1000$)	**109**	
Projected Change in Electric Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project: Capitol Complex
Scenario: TES
Tank Size 2.5 million gallons
After Tax IRR = 23.40%

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Net Installed Cost of Plant (1000$)	$1,022																				
Utility Projections																					
Electric Costs w/o TES (Chiller only)	$1,968	$2,027	$2,088	$2,151	$2,215	$2,282	$2,350	$2,420	$2,493	$2,568	$2,645	$2,724	$2,806	$2,890	$2,977	$3,066	$3,158	$3,253	$3,350	$3,451	$3,555
Electric Cost with TES (Chiller Only)	$1,760	$1,813	$1,867	$1,923	$1,981	$2,040	$2,102	$2,165	$2,230	$2,297	$2,365	$2,436	$2,509	$2,585	$2,662	$2,742	$2,824	$2,909	$2,996	$3,086	$3,179
Gross Revenues for TES Investment																					
Net Average Year Annual Savings		$214	$221	$227	$234	$241	$248	$256	$263	$271	$279	$288	$297	$305	$315	$324	$334	$344	$354	$365	$376
In/Outflows ($1,000)	-$1,022	$214	$221	$227	$234	$241	$248	$256	$263	$271	$279	$288	$297	$305	$315	$324	$334	$344	$354	$365	$376
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82	-$82
Available Cash After All Loan Payments	1000$	$132	$139	$145	$152	$159	$166	$174	$181	$189	$197	$206	$215	$223	$233	$242	$252	$262	$272	$283	$294
Cumul. Net Income After Loan Payments		$132	$271	$416	$568	$727	$894	$1,067	$1,249	$1,438	$1,636	$1,842	$2,056	$2,279	$2,512	$2,754	$3,006	$3,267	$3,540	$3,822	$4,116
Principle Repayment Component	$1,000	-$31	-$32	-$34	-$36	-$38	-$39	-$41	-$43	-$46	-$48	-$50	-$53	-$56	-$58	-$61	-$64	-$67	-$71	-$74	-$78
Principal Balance	$1,000	$991	$959	$924	$889	$851	$812	$770	$727	$681	$633	$583	$530	$474	$416	$355	$291	$223	$152	$78	$0

Figure 3. *Hourly TES and Chiller Load Profile : **4.5 million gallons***

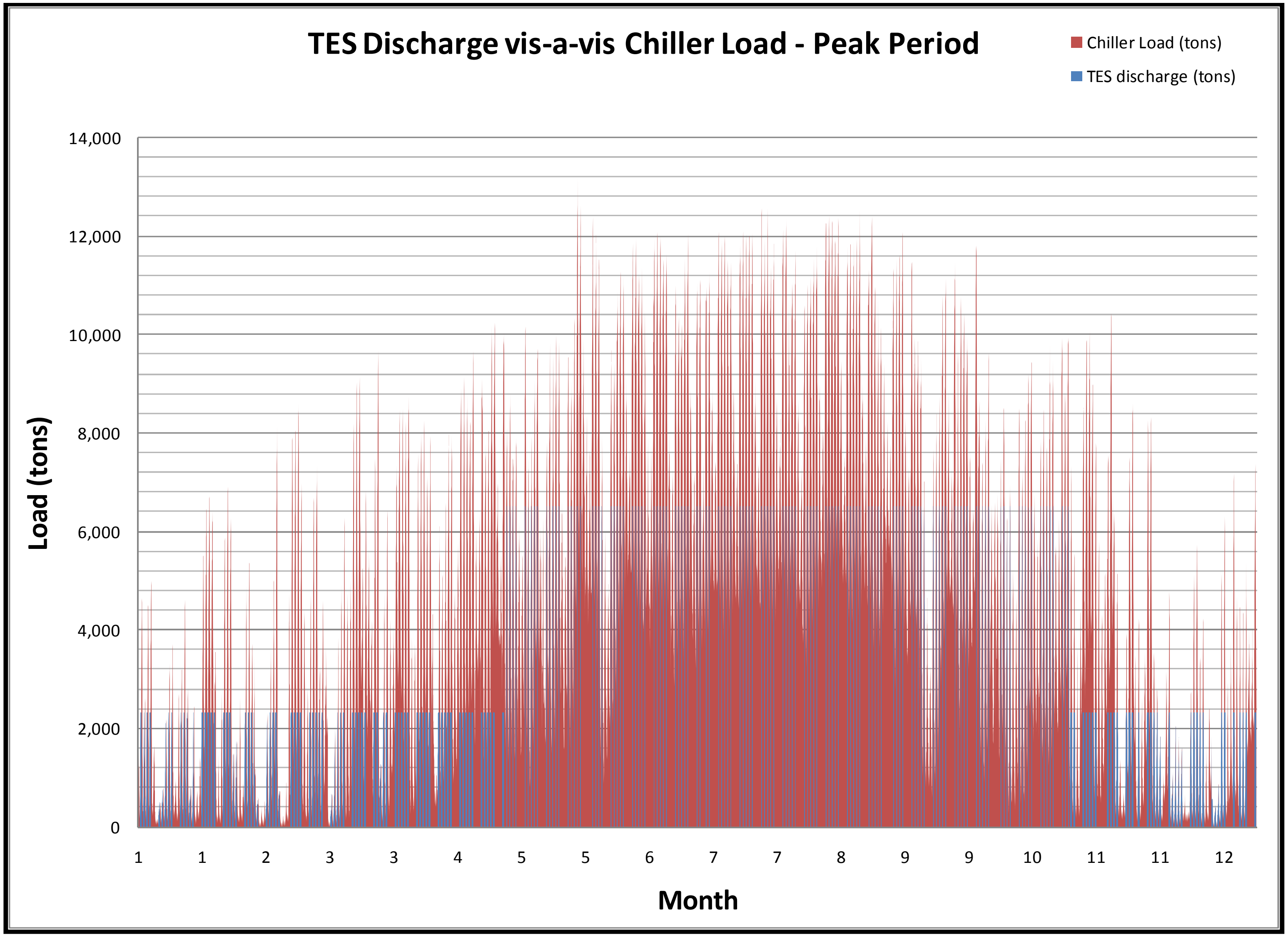


Figure 4. *Internal Rate of Return Calculations : 4.5 million gallon TES*

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**4,957**	
Avoided First Costs (1000$)	**1,768**	
Incentives (1000$)	**196**	
Projected Change in Electric Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project: Capitol Complex
Scenario: TES
Tank Size 4.5 million gallons
After Tax IRR = 15.28%

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Net Installed Cost of Plant (1000$)	$2,993																				
Utility Projections																					
Electric Costs w/o TES (Chiller only)	$1,968	$2,027	$2,088	$2,151	$2,215	$2,282	$2,350	$2,420	$2,493	$2,568	$2,645	$2,724	$2,806	$2,890	$2,977	$3,066	$3,158	$3,253	$3,350	$3,451	$3,555
Electric Cost with TES (Chiller Only)	$1,569	$1,616	$1,665	$1,715	$1,766	$1,819	$1,874	$1,930	$1,988	$2,048	$2,109	$2,172	$2,238	$2,305	$2,374	$2,445	$2,518	$2,594	$2,672	$2,752	$2,835
Gross Revenues for TES Investment																					
Net Average Year Annual Savings		$411	$423	$436	$449	$462	$476	$490	$505	$520	$536	$552	$568	$585	$603	$621	$640	$659	$679	$699	$720
In/Outflows ($1,000)	-$2,993	$411	$423	$436	$449	$462	$476	$490	$505	$520	$536	$552	$568	$585	$603	$621	$640	$659	$679	$699	$720
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240	-$240
Available Cash After All Loan Payments	1000$	$170	$183	$195	$209	$222	$236	$250	$265	$280	$296	$312	$328	$345	$363	$381	$400	$419	$439	$459	$480
Cumul. Net Income After Loan Payments		$170	$353	$549	$757	$979	$1,215	$1,465	$1,730	$2,010	$2,306	$2,617	$2,945	$3,291	$3,654	$4,034	$4,434	$4,853	$5,291	$5,750	$6,230
Principle Repayment Component	$1,000	-$91	-$95	-$100	-$105	-$110	-$116	-$121	-$127	-$134	-$140	-$147	-$155	-$163	-$171	-$179	-$188	-$198	-$207	-$218	-$229
Principal Balance	$1,000	$2,902	$2,807	$2,708	$2,603	$2,493	$2,377	$2,256	$2,129	$1,995	$1,854	$1,707	$1,552	$1,390	$1,219	$1,040	$852	$654	$447	$229	$0

Figure 5. *Hourly TES and Chiller Load Profile : __6.5 million gallons__*

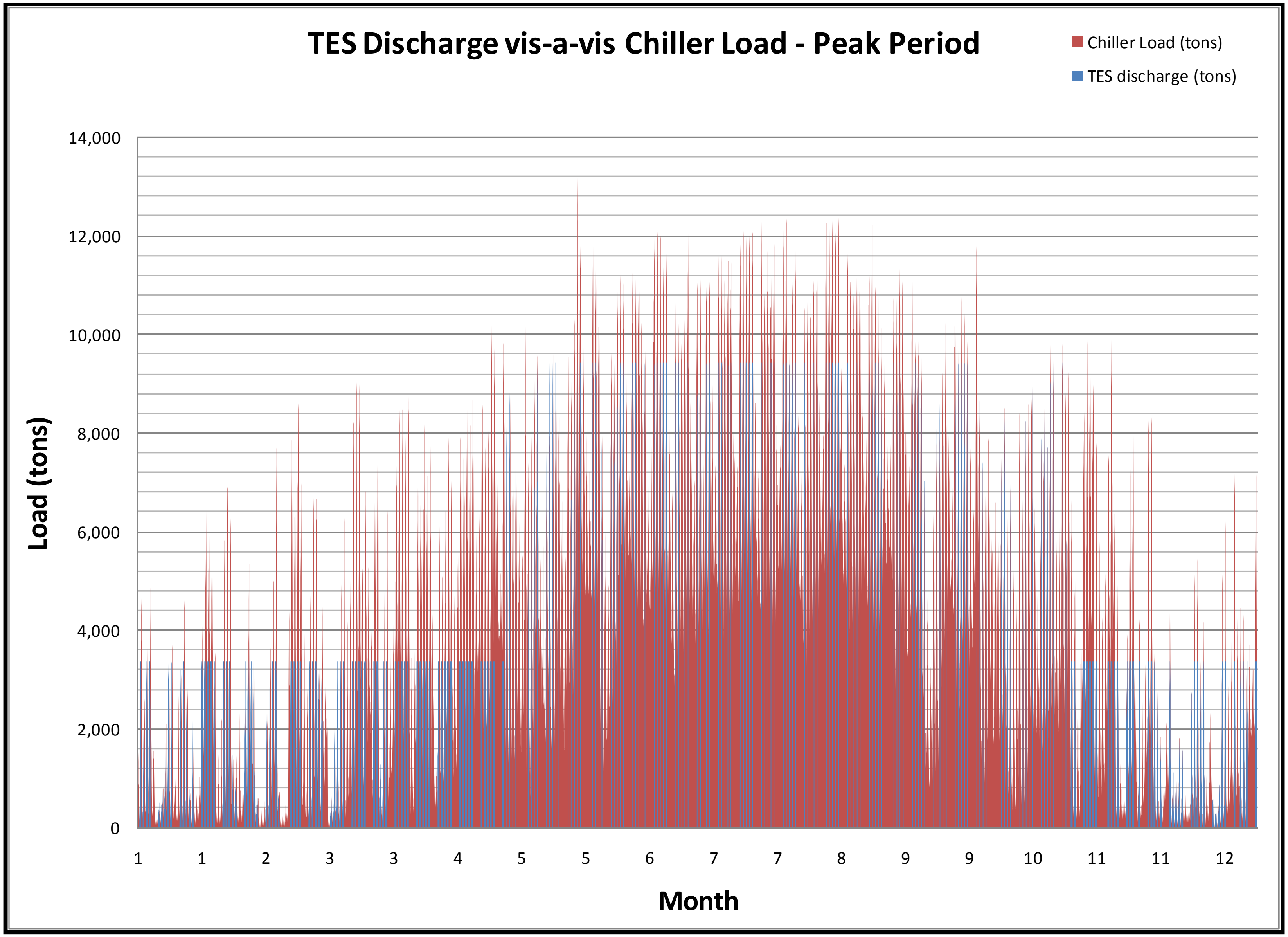


Figure 6. *Internal Rate of Return Calculations : 6.5 million gallon TES*

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**6,877**	
Avoided First Costs (1000$)	**1,472**	
Incentives (1000$)	**283**	
Projected Change in Electric Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project: Capitol Complex
Scenario: TES
Tank Size 6.5 million gallons
After Tax IRR = 13.29%

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Net Installed Cost of Plant (1000$)	$5,122																				
Utility Projections																					
Electric Costs w/o TES (Chiller only)	$1,968	$2,027	$2,088	$2,151	$2,215	$2,282	$2,350	$2,420	$2,493	$2,568	$2,645	$2,724	$2,806	$2,890	$2,977	$3,066	$3,158	$3,253	$3,350	$3,451	$3,555
Electric Cost with TES (Chiller Only)	$1,367	$1,408	$1,450	$1,494	$1,539	$1,585	$1,632	$1,681	$1,732	$1,784	$1,837	$1,892	$1,949	$2,007	$2,068	$2,130	$2,194	$2,259	$2,327	$2,397	$2,469
Gross Revenues for TES Investment																					
Net Average Year Annual Savings		$619	$638	$657	$677	$697	$718	$739	$761	$784	$808	$832	$857	$883	$909	$936	$965	$994	$1,023	$1,054	$1,086
In/Outflows ($1,000)	-$5,122	$619	$638	$657	$677	$697	$718	$739	$761	$784	$808	$832	$857	$883	$909	$936	$965	$994	$1,023	$1,054	$1,086
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411	-$411
Available Cash After All Loan Payments	1000$	$208	$227	$246	$266	$286	$307	$328	$350	$373	$397	$421	$446	$472	$498	$525	$554	$582	$612	$643	$675
Cumul. Net Income After Loan Payments		$208	$435	$681	$946	$1,232	$1,539	$1,867	$2,217	$2,591	$2,987	$3,408	$3,854	$4,326	$4,824	$5,350	$5,903	$6,486	$7,098	$7,741	$8,416
Principle Repayment Component	$1,000	-$155	-$163	-$171	-$179	-$188	-$198	-$208	-$218	-$229	-$240	-$252	-$265	-$278	-$292	-$307	-$322	-$338	-$355	-$373	-$391
Principal Balance	$1,000	$4,967	$4,805	$4,634	$4,455	$4,266	$4,069	$3,861	$3,643	$3,414	$3,174	$2,922	$2,657	$2,378	$2,086	$1,780	$1,457	$1,119	$764	$391	$0

Figure 7. *Hourly TES and Chiller Load Profile : __8.5 million gallons__*

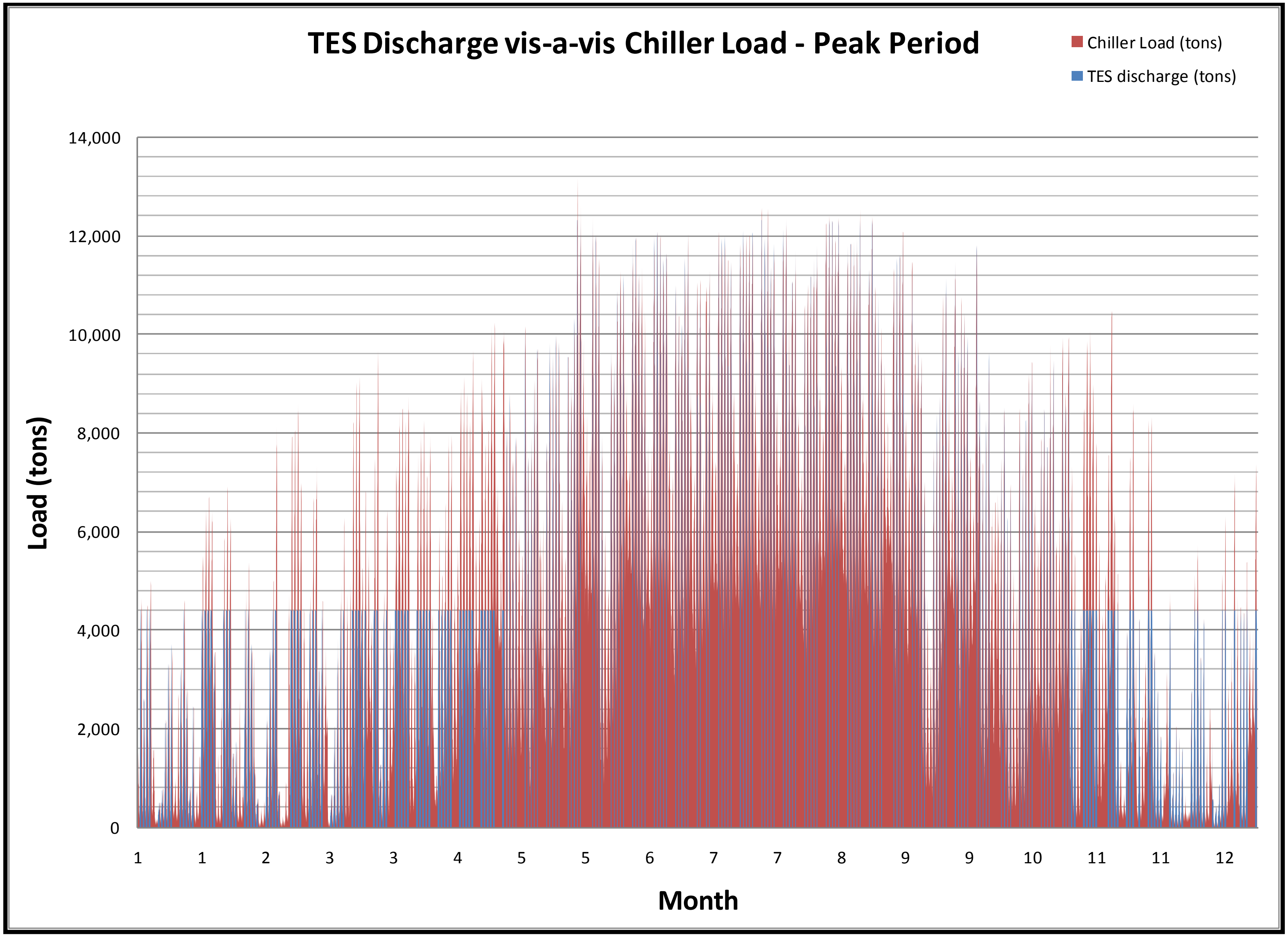


Figure 8. *Internal Rate of Return Calculations : 8.5 million gallon TES*

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**8,500**	
Avoided First Costs (1000$)	**505**	
Incentives (1000$)	**370**	
Projected Change in Electric Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project: Capitol Complex
Scenario: TES
Tank Size 8.5 million gallons
After Tax IRR = 11.76%

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Net Installed Cost of Plant (1000$)	$7,625																				
Utility Projections																					
Electric Costs w/o TES (Chiller only)	$1,968	$2,027	$2,088	$2,151	$2,215	$2,282	$2,350	$2,420	$2,493	$2,568	$2,645	$2,724	$2,806	$2,890	$2,977	$3,066	$3,158	$3,253	$3,350	$3,451	$3,555
Electric Cost with TES (Chiller Only)	$1,162	$1,197	$1,233	$1,270	$1,308	$1,347	$1,388	$1,429	$1,472	$1,516	$1,562	$1,609	$1,657	$1,707	$1,758	$1,811	$1,865	$1,921	$1,978	$2,038	$2,099
Gross Revenues for TES Investment																					
Net Average Year Annual Savings		$830	$855	$881	$907	$934	$962	$991	$1,021	$1,052	$1,083	$1,116	$1,149	$1,184	$1,219	$1,256	$1,293	$1,332	$1,372	$1,413	$1,456
In/Outflows ($1,000)	-$7,625	$830	$855	$881	$907	$934	$962	$991	$1,021	$1,052	$1,083	$1,116	$1,149	$1,184	$1,219	$1,256	$1,293	$1,332	$1,372	$1,413	$1,456
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612	-$612
Available Cash After All Loan Payments	1000$	$218	$243	$269	$295	$322	$350	$379	$409	$440	$471	$504	$537	$572	$607	$644	$681	$720	$760	$801	$844
Cumul. Net Income After Loan Payments		$218	$461	$730	$1,025	$1,348	$1,698	$2,078	$2,487	$2,926	$3,398	$3,901	$4,438	$5,010	$5,617	$6,261	$6,942	$7,663	$8,423	$9,224	$10,068
Principle Repayment Component	$1,000	-$231	-$242	-$254	-$267	-$280	-$294	-$309	-$324	-$341	-$358	-$376	-$394	-$414	-$435	-$457	-$479	-$503	-$529	-$555	-$583
Principal Balance	$1,000	$7,395	$7,153	$6,898	$6,631	$6,351	$6,057	$5,748	$5,423	$5,083	$4,725	$4,349	$3,955	$3,541	$3,106	$2,649	$2,170	$1,666	$1,138	$583	$0

Figure 9. *Hourly TES and Chiller Load Profile : **10.5 million gallons***

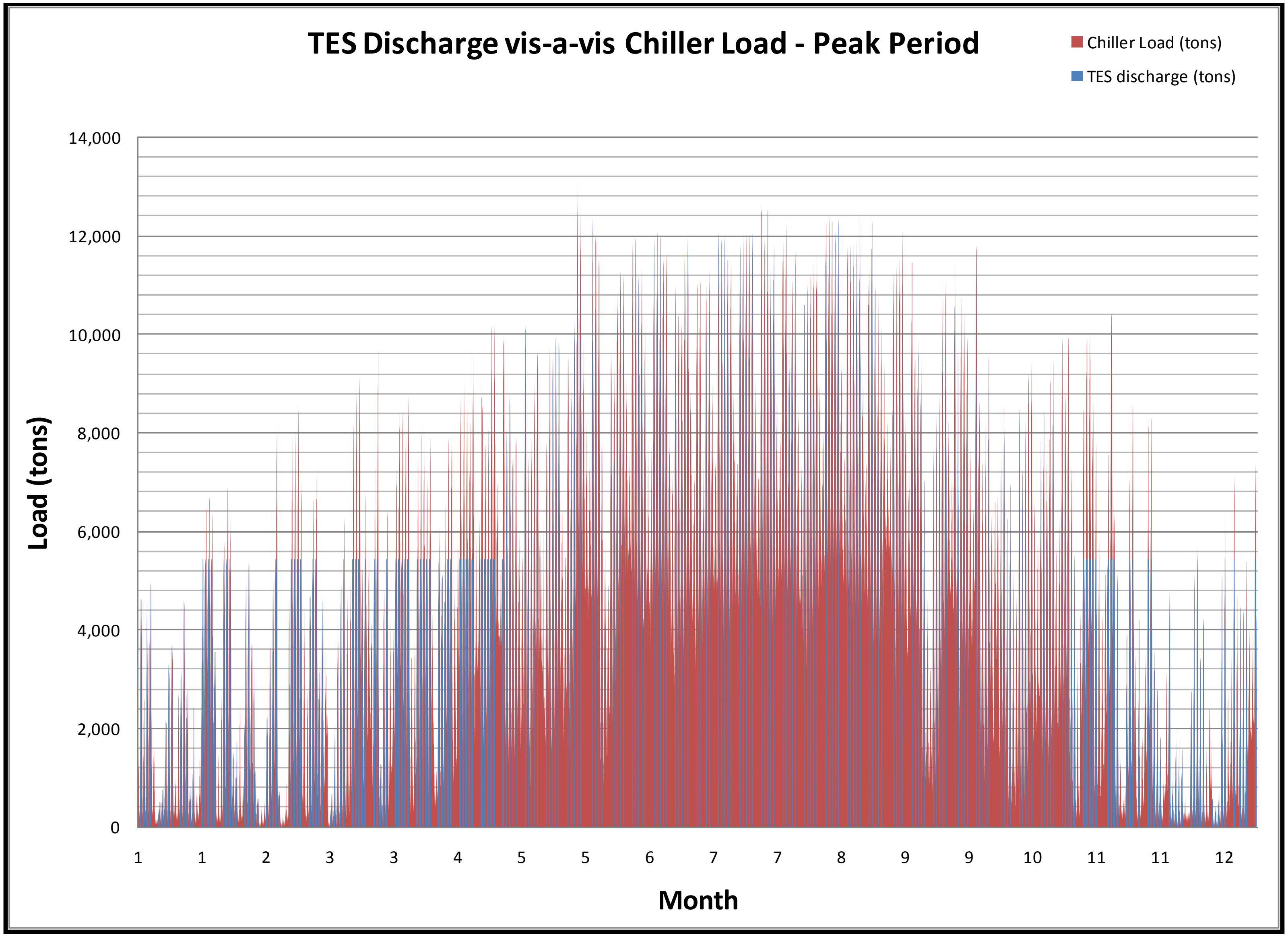


Figure 10. *Internal Rate of Return Calculations :* ***10.5 million gallon TES***

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**10,043**	
Avoided First Costs (1000$)	**(46)**	
Incentives (1000$)	**395**	
Projected Change in Electric Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project: Capitol Complex
Scenario: TES
Tank Size 10.5 million gallons
After Tax IRR = 8.92%

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Net Installed Cost of Plant (1000$)	$9,694																				
Utility Projections																					
Electric Costs w/o TES (Chiller only)	$1,968	$2,027	$2,088	$2,151	$2,215	$2,282	$2,350	$2,420	$2,493	$2,568	$2,645	$2,724	$2,806	$2,890	$2,977	$3,066	$3,158	$3,253	$3,350	$3,451	$3,555
Electric Cost with TES (Chiller Only)	$1,140	$1,174	$1,210	$1,246	$1,283	$1,322	$1,361	$1,402	$1,444	$1,488	$1,532	$1,578	$1,626	$1,674	$1,725	$1,776	$1,830	$1,885	$1,941	$1,999	$2,059
Gross Revenues for TES Investment																					
Net Average Year Annual Savings		$853	$878	$905	$932	$960	$989	$1,018	$1,049	$1,080	$1,113	$1,146	$1,180	$1,216	$1,252	$1,290	$1,328	$1,368	$1,409	$1,452	$1,495
In/Outflows ($1,000)	-$9,694	$853	$878	$905	$932	$960	$989	$1,018	$1,049	$1,080	$1,113	$1,146	$1,180	$1,216	$1,252	$1,290	$1,328	$1,368	$1,409	$1,452	$1,495
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778	-$778
Available Cash After All Loan Payments	1000$	$75	$100	$127	$154	$182	$211	$240	$271	$302	$335	$368	$402	$438	$474	$512	$551	$590	$631	$674	$717
Cumul. Net Income After Loan Payments		$75	$175	$302	$456	$638	$848	$1,089	$1,359	$1,662	$1,996	$2,364	$2,767	$3,205	$3,679	$4,191	$4,741	$5,332	$5,963	$6,637	$7,354
Principle Repayment Component	$1,000	-$293	-$308	-$323	-$339	-$356	-$374	-$393	-$413	-$433	-$455	-$478	-$501	-$527	-$553	-$580	-$609	-$640	-$672	-$706	-$741
Principal Balance	$1,000	$9,401	$9,093	$8,770	$8,431	$8,074	$7,700	$7,307	$6,895	$6,461	$6,007	$5,529	$5,028	$4,501	$3,948	$3,368	$2,758	$2,118	$1,446	$741	$0

Figure 11. *Hourly TES and Chiller Load Profile : **12.5 million gallons***

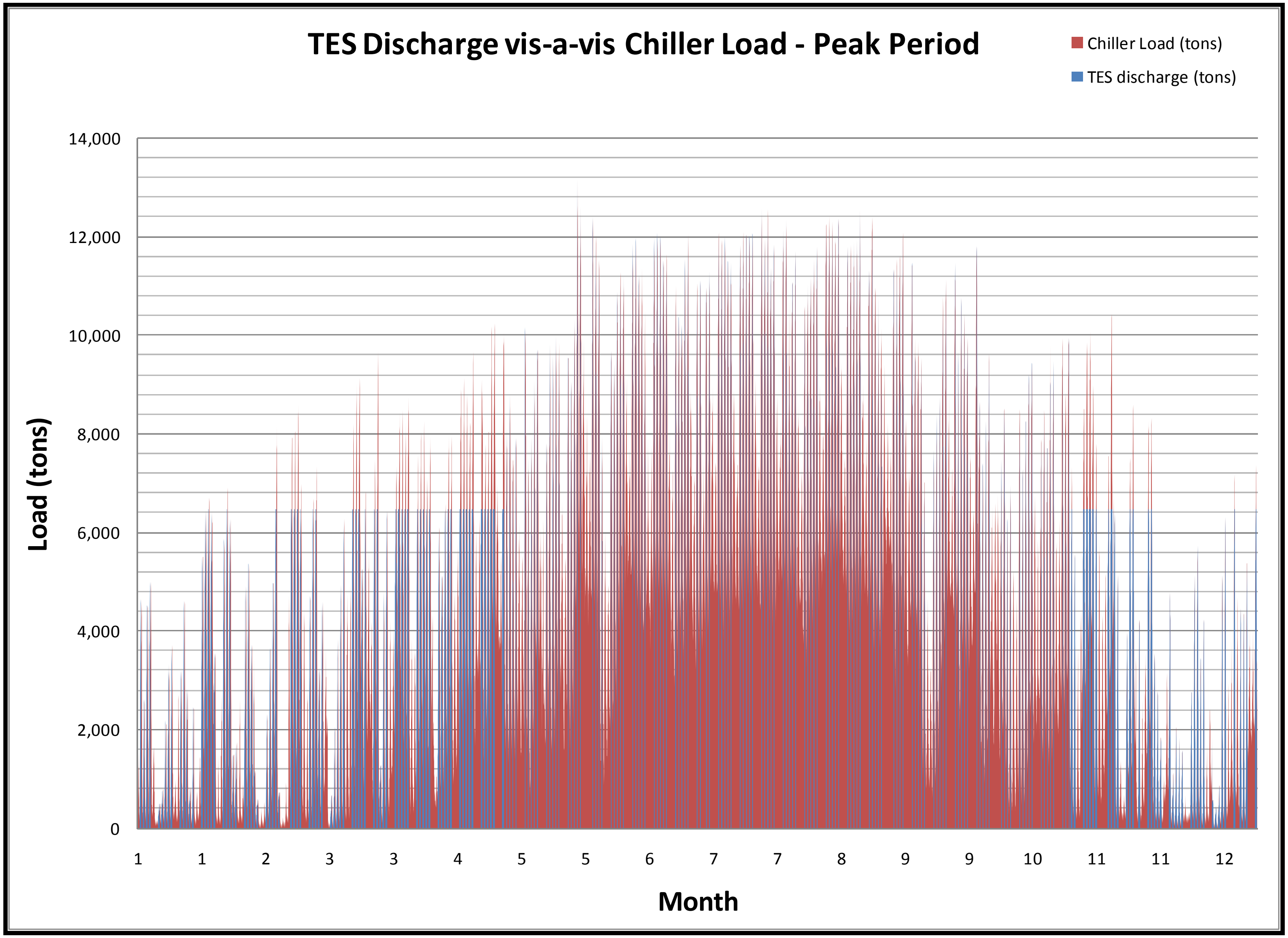


Figure 12. *Internal Rate of Return Calculations : 12.5 million gallon TES*

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**11,504**	
Avoided First Costs (1000$)	**(46)**	
Incentives (1000$)	**395**	
Projected Change in Electric Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project: Capitol Complex
Scenario: TES
Tank Size 12.5 million gallons
After Tax IRR = 6.94%

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Net Installed Cost of Plant (1000$)	$11,154																				
Utility Projections																					
Electric Costs w/o TES (Chiller only)	$1,968	$2,027	$2,088	$2,151	$2,215	$2,282	$2,350	$2,420	$2,493	$2,568	$2,645	$2,724	$2,806	$2,890	$2,977	$3,066	$3,158	$3,253	$3,350	$3,451	$3,555
Electric Cost with TES (Chiller Only)	$1,160	$1,195	$1,230	$1,267	$1,305	$1,344	$1,385	$1,426	$1,469	$1,513	$1,559	$1,605	$1,654	$1,703	$1,754	$1,807	$1,861	$1,917	$1,974	$2,034	$2,095
Gross Revenues for TES Investment																					
Net Average Year Annual Savings		$833	$858	$883	$910	$937	$965	$994	$1,024	$1,055	$1,086	$1,119	$1,152	$1,187	$1,223	$1,259	$1,297	$1,336	$1,376	$1,417	$1,460
In/Outflows ($1,000)	-$11,154	$833	$858	$883	$910	$937	$965	$994	$1,024	$1,055	$1,086	$1,119	$1,152	$1,187	$1,223	$1,259	$1,297	$1,336	$1,376	$1,417	$1,460
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895	-$895
Available Cash After All Loan Payments	1000$	-$63	-$38	-$12	$15	$42	$70	$99	$129	$160	$191	$224	$257	$292	$328	$364	$402	$441	$481	$522	$565
Cumul. Net Income After Loan Payments		-$63	-$100	-$112	-$97	-$55	$15	$114	$243	$402	$594	$817	$1,075	$1,367	$1,694	$2,059	$2,461	$2,902	$3,383	$3,905	$4,470
Principle Repayment Component	$1,000	-$337	-$354	-$372	-$391	-$410	-$431	-$452	-$475	-$498	-$523	-$549	-$577	-$606	-$636	-$668	-$701	-$736	-$773	-$812	-$852
Principal Balance	$1,000	$10,817	$10,463	$10,091	$9,700	$9,290	$8,860	$8,408	$7,933	$7,435	$6,911	$6,362	$5,785	$5,179	$4,543	$3,875	$3,174	$2,437	$1,664	$852	$0

Appendix C. Phase 2 CHP Analyses : Hourly Load Profiles and IRR Calculations

Figure 1 compares the Energy chargeable power (Btu/kWh) of the analyzed CHP plant and simple cycle centralized generation (part of the electric grid). Figure 2 compares the fuel chargeable to power ($/kWh) of the analyzed CHP plant to existing electricity purchases. Figure 3 depicts the hourly heat load that the CHP plant will have to serve. Figure 4 - Figure 10 depicts the hourly electric load profiles that the CHP plant will have to serve under different TES tank sizes. Figure 11 - Figure 14 illustrates the gas turbine kW and Steam Turbine kW for four of the scenarios a) No TES b) 4.5 million gallon TES tank c) 8.5 million gallon TES tank d) 12.5 million gallon TES tank. Figure 15 - Figure 21 illustrates the Internal Rate of Return Calculations associated with the CHP plant for different TES tank sizes.

Figure 1. *Energy Chargeable to Power - CHP Plant vs Conventional Generation*

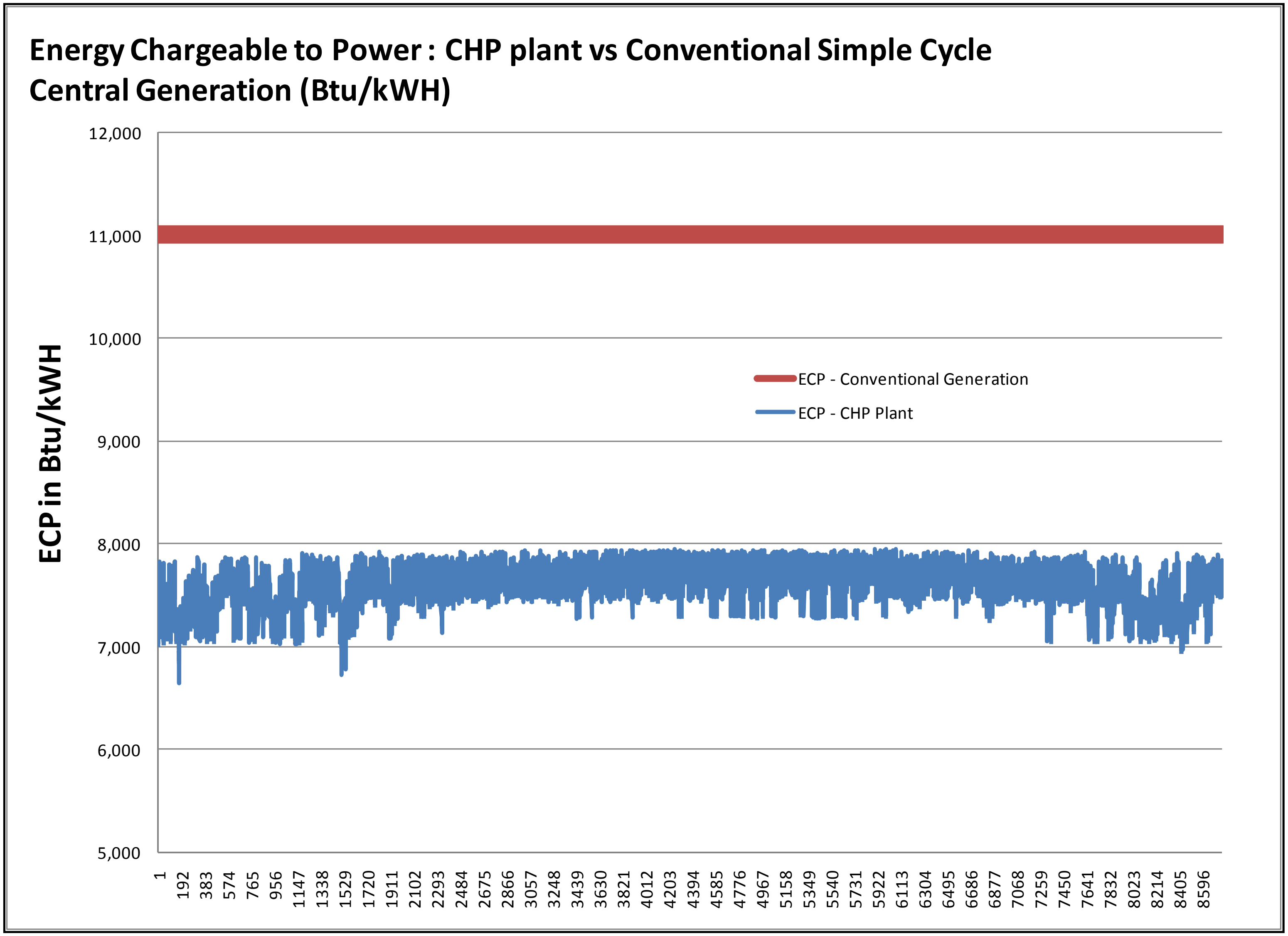


Figure 2. *Cost Chargeable to Power - CHP Plant vs Conventional Generation*

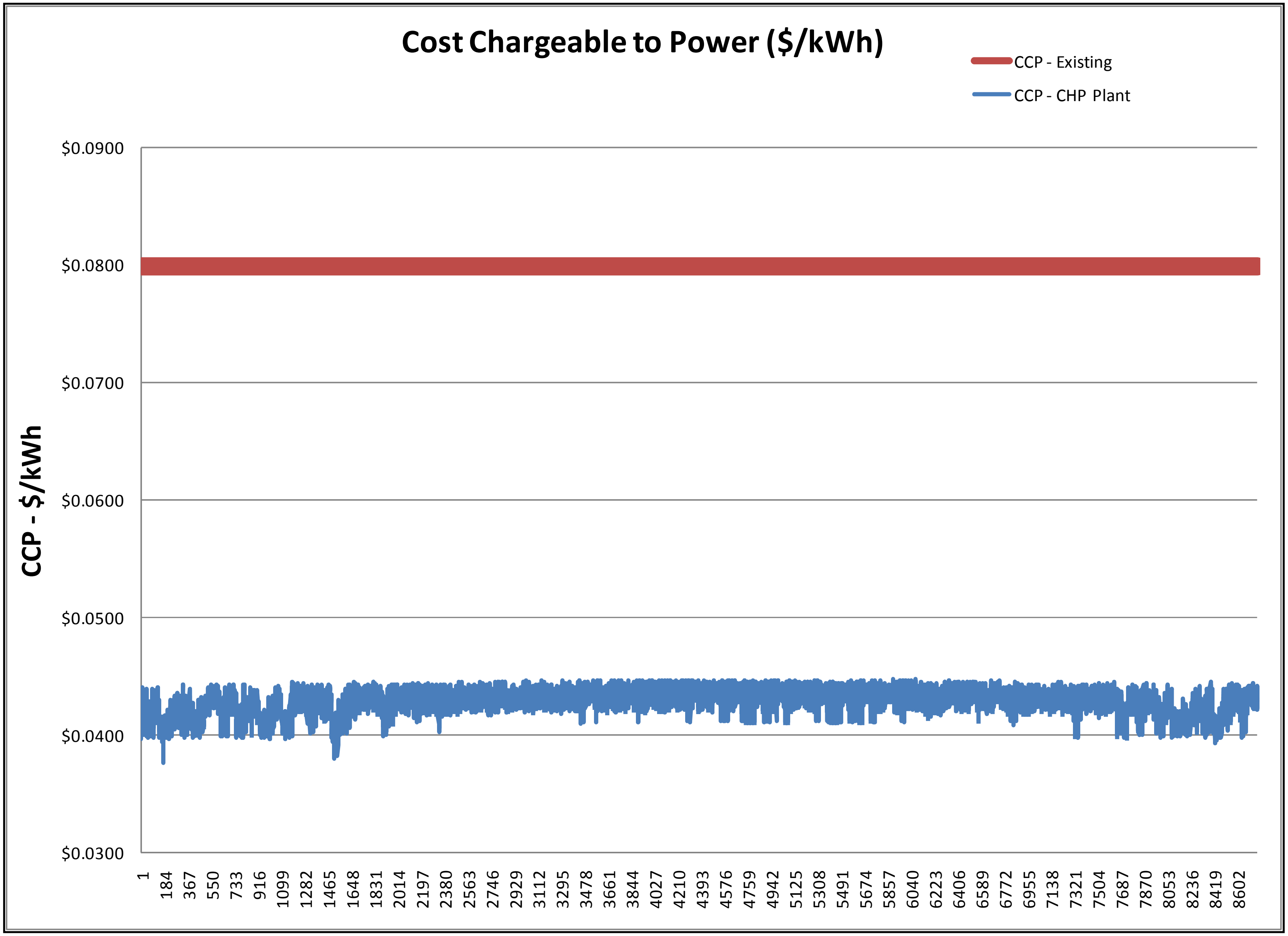


Figure 3. *Hourly Heat Load served by the CHP Plant*

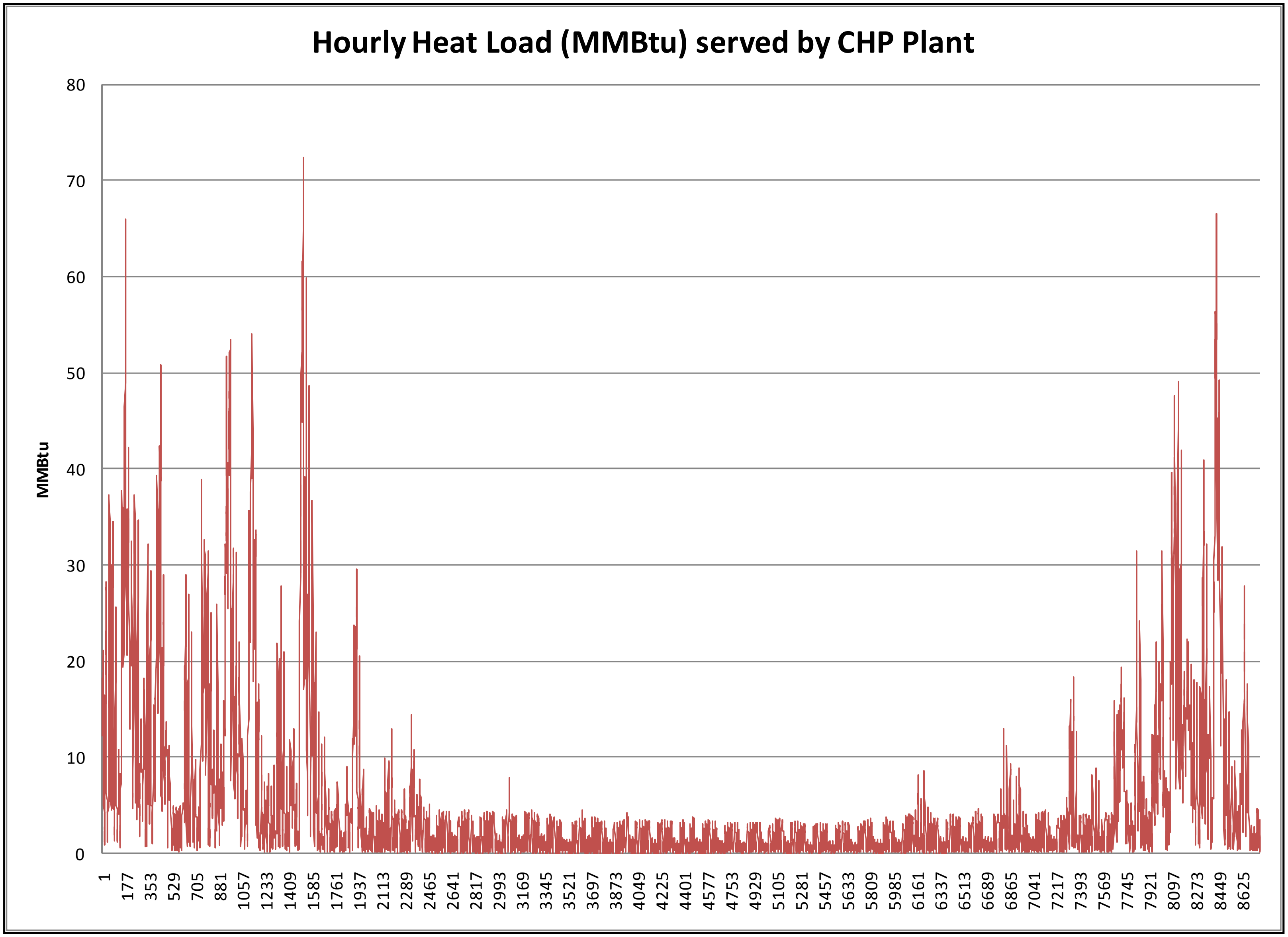


Figure 4. *Hourly Electric Load Profile served by CHP Plant: No TES tank*

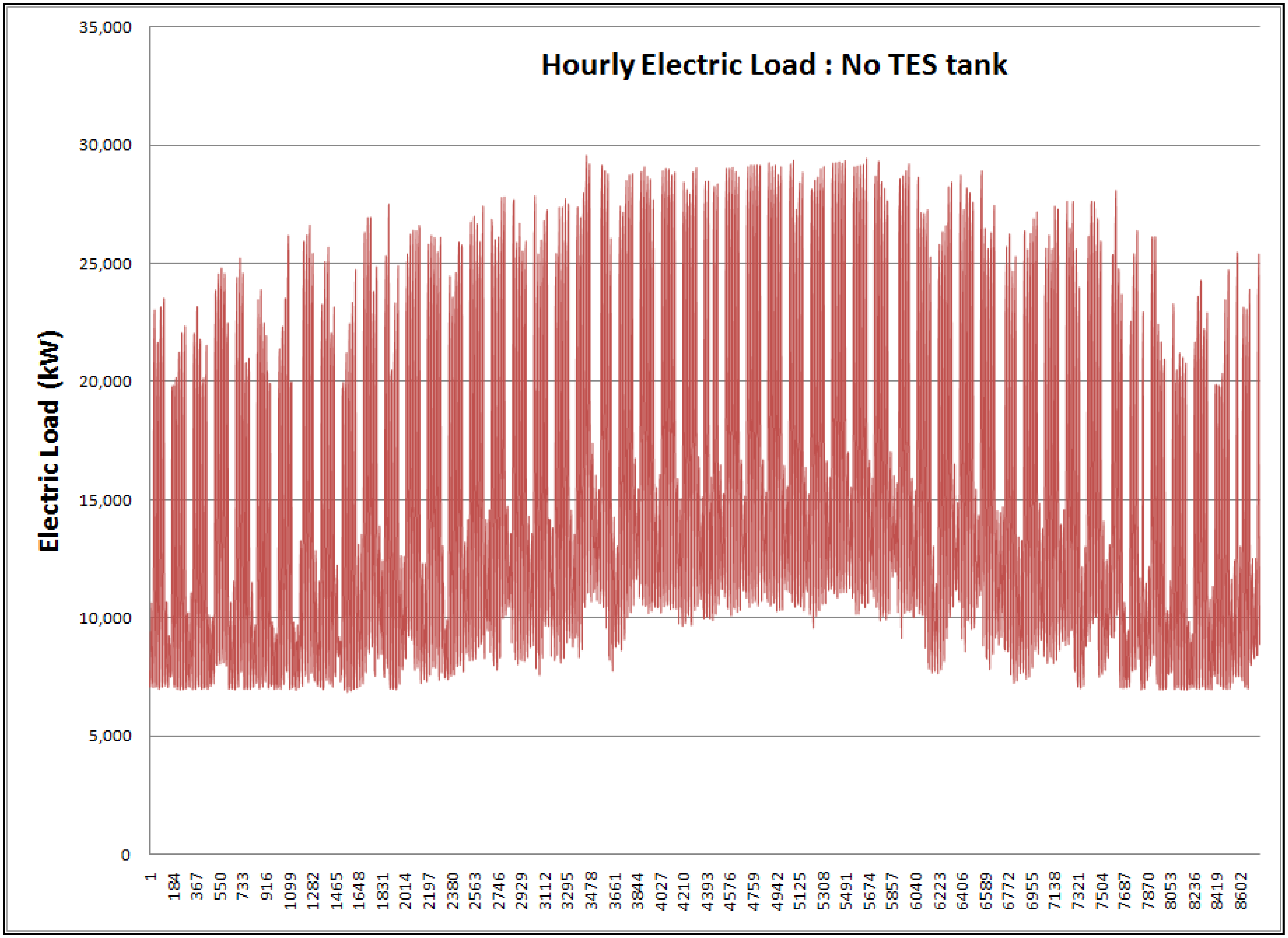


Figure 5. *Hourly Electric Load Profile served by CHP Plant:* ***2.5 million gallon TES tank***

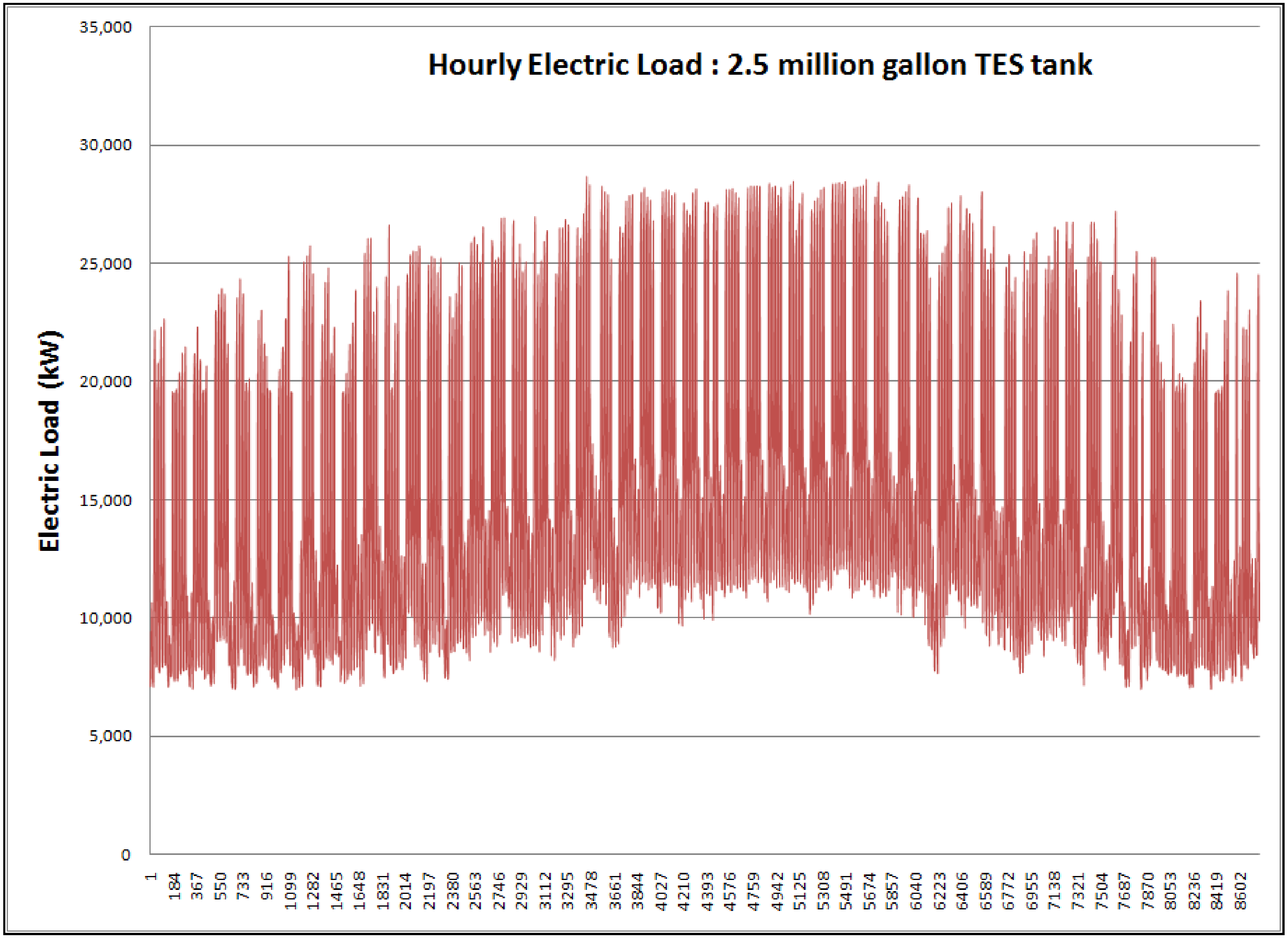


Figure 6. *Hourly Electric Load Profile served by CHP Plant: 4.5 million gallons TES tank*

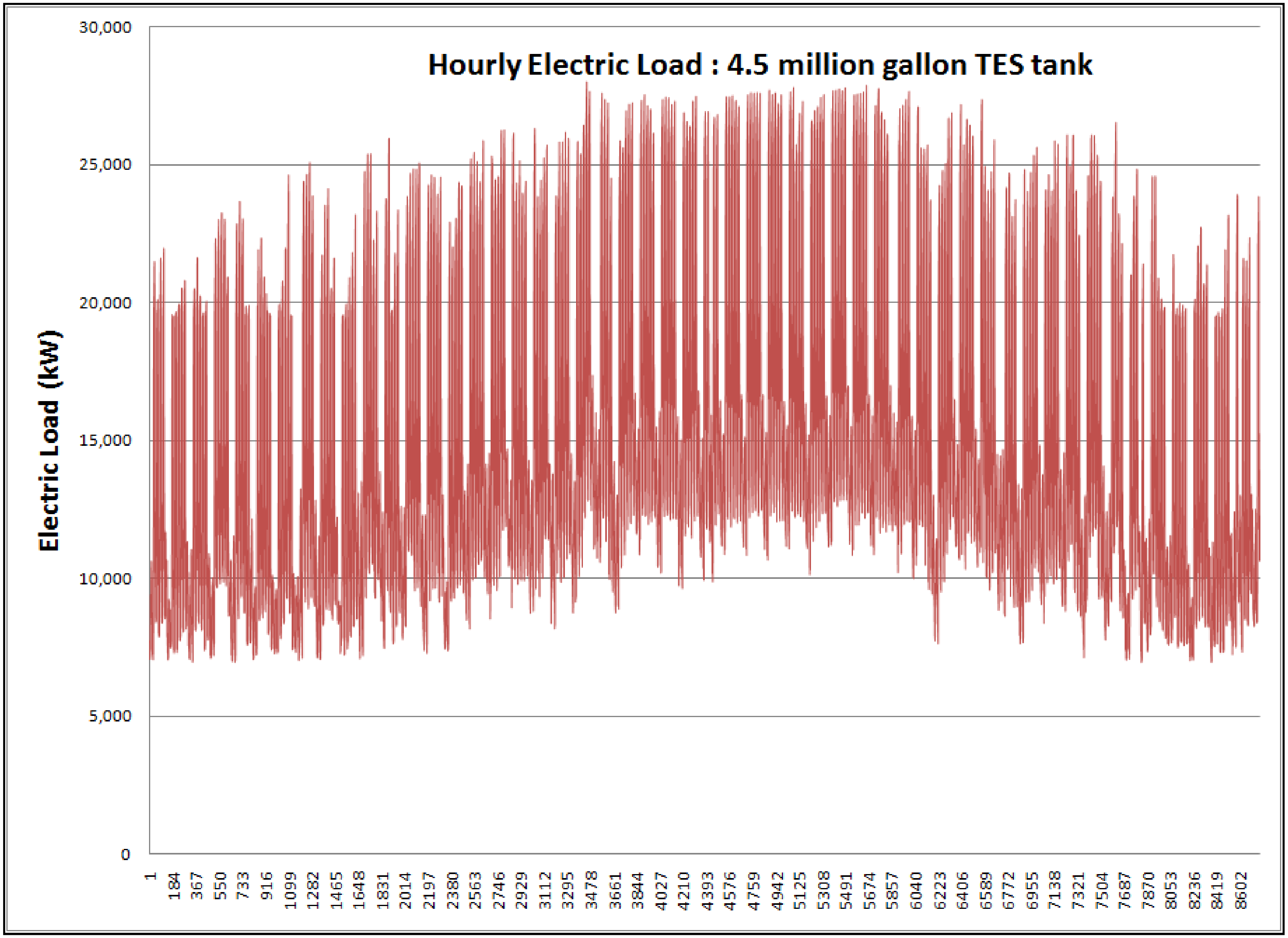


Figure 7. *Hourly Electric Load Profile served by CHP Plant:* ***6.5 million gallons TES tank***

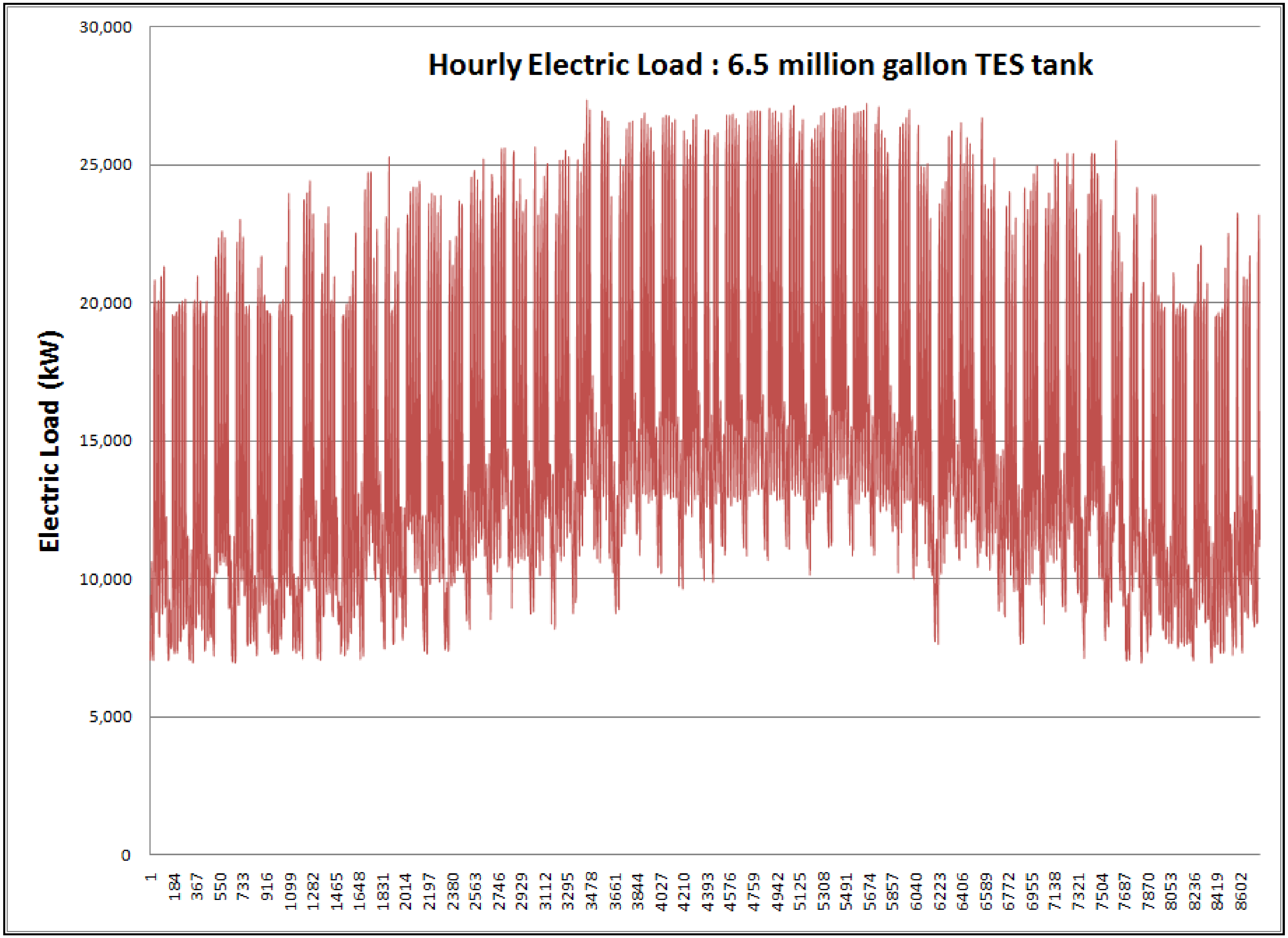


Figure 8. *Hourly Electric Load Profile served by CHP Plant: __8.5 million gallons TES tank__*

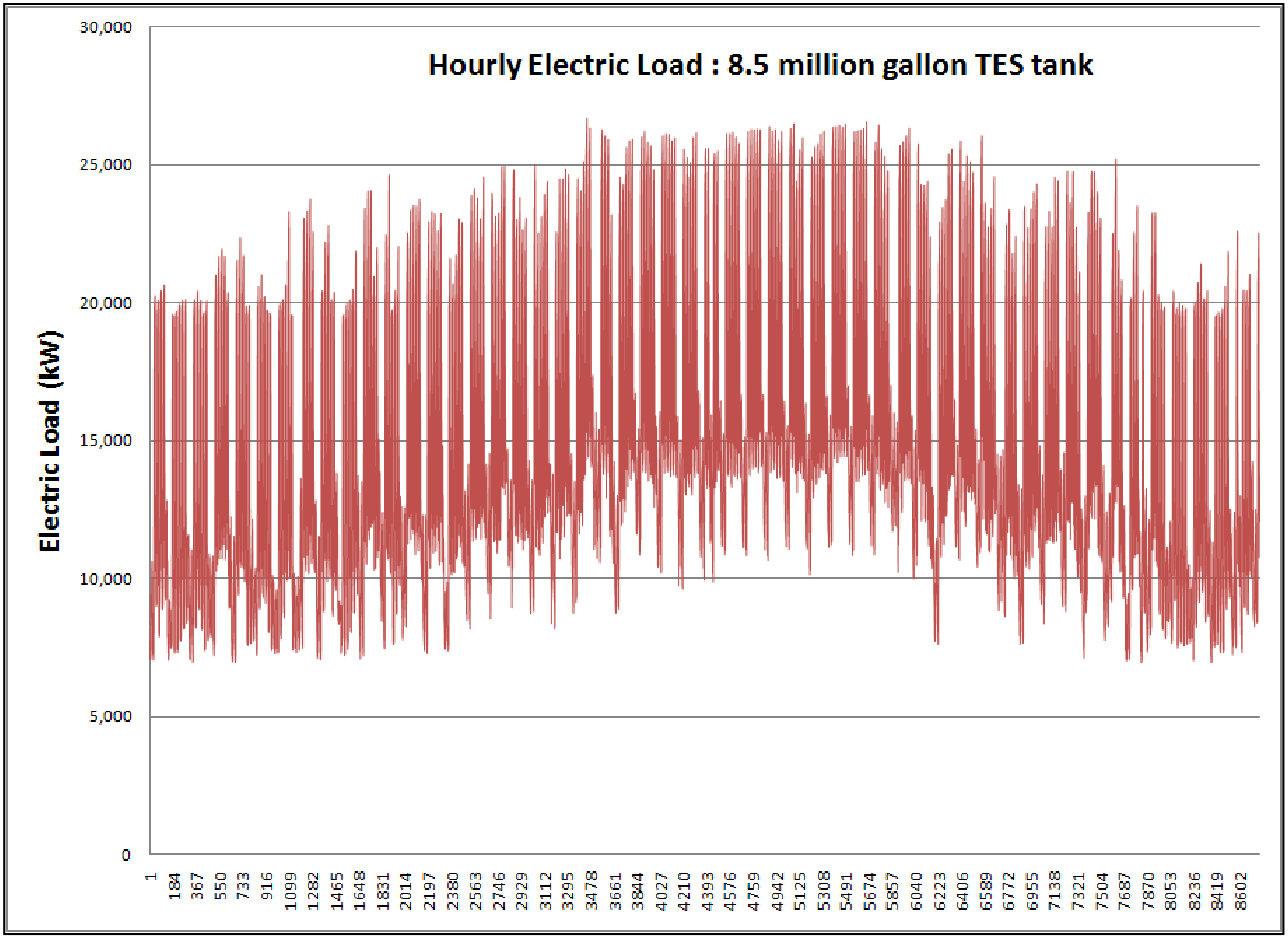


Figure 9. *Hourly Electric Load Profile served by CHP Plant:* ***<u>10.5 million gallons TES tank</u>***

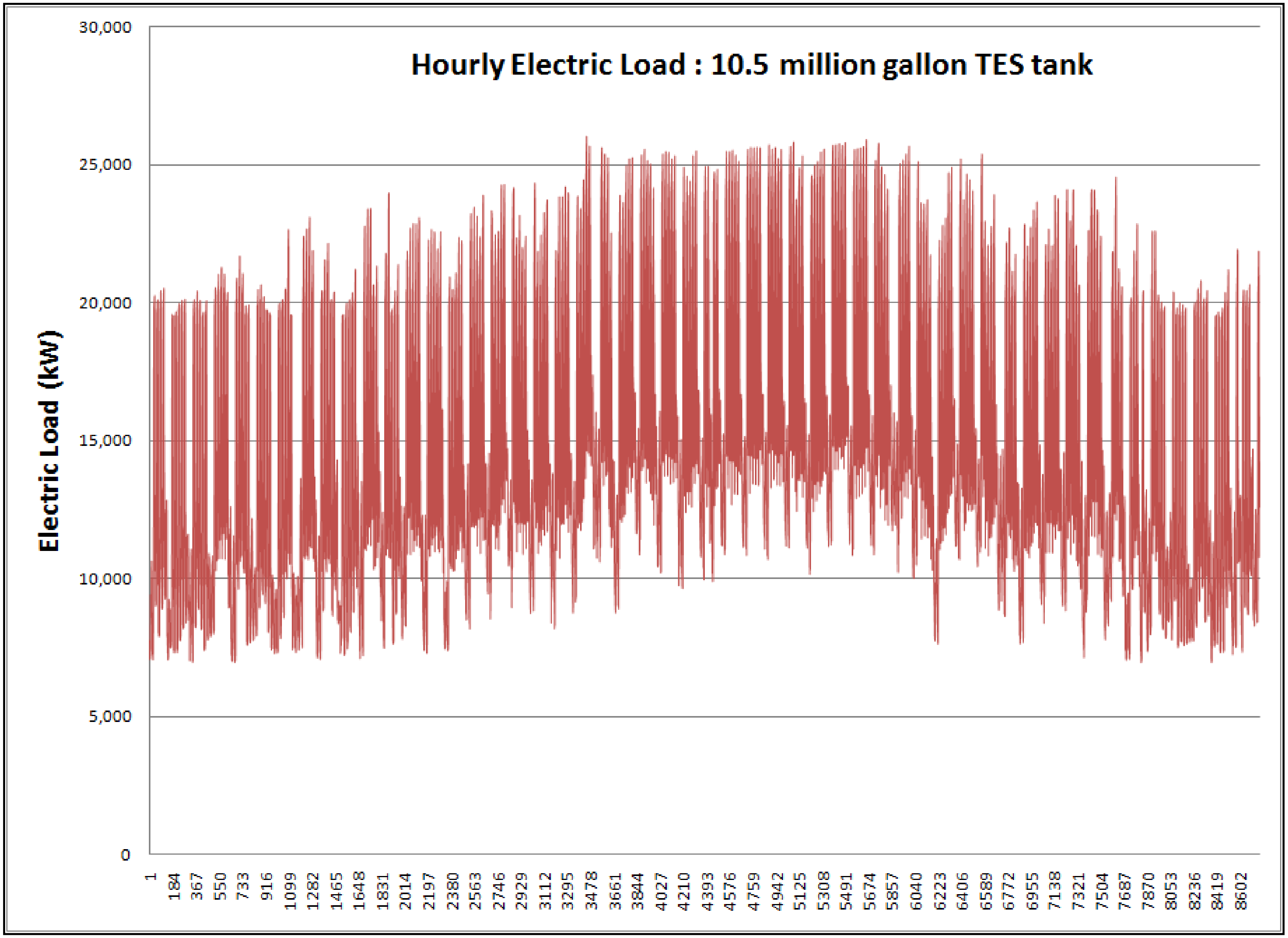


Figure 10. *Hourly Electric Load Profile served by CHP Plant:* ***12.5 million gallons TES tank***

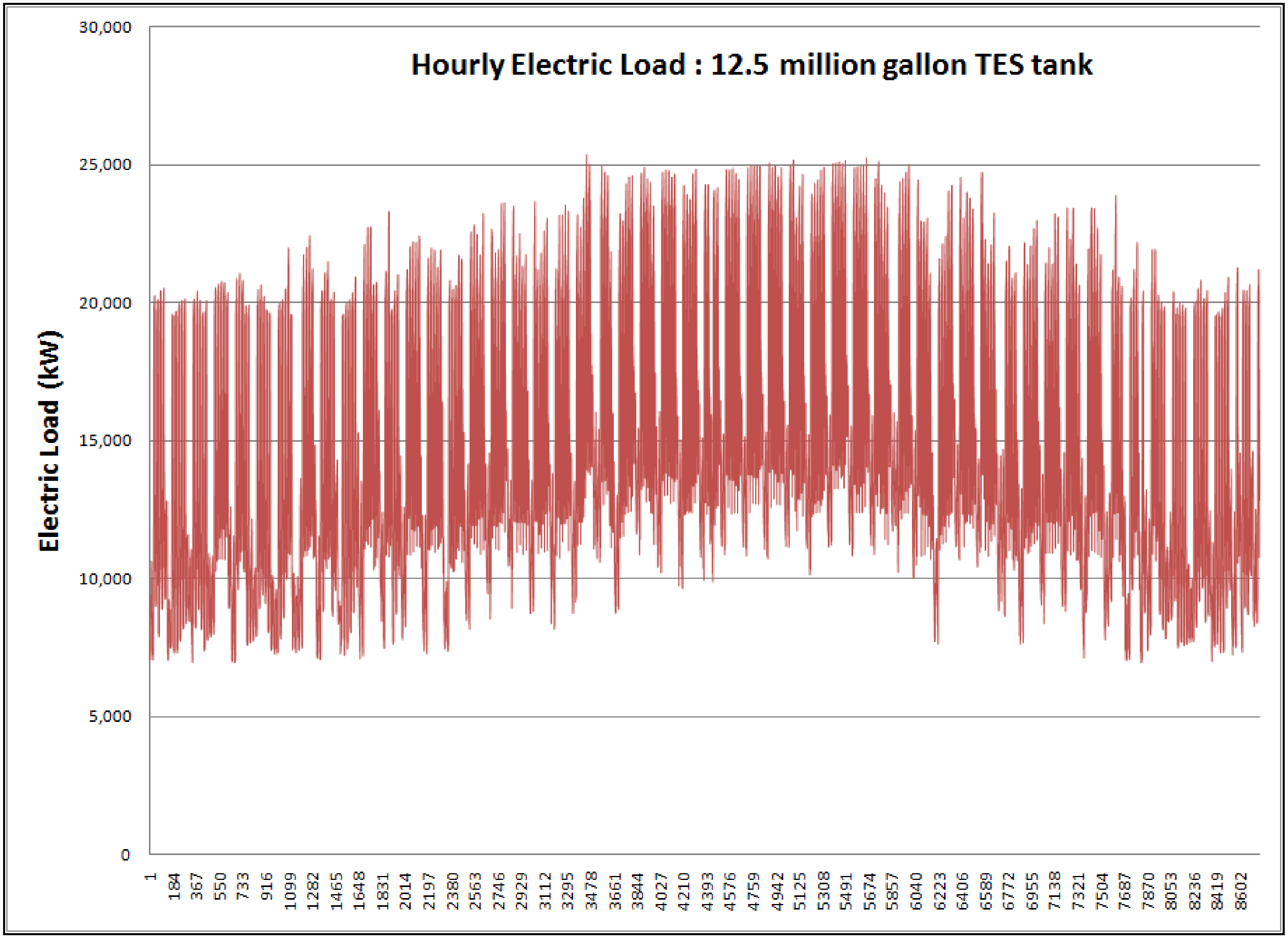


Figure 11. *Hourly Prime Mover kW and Steam Turbine kW: **No TES tank***

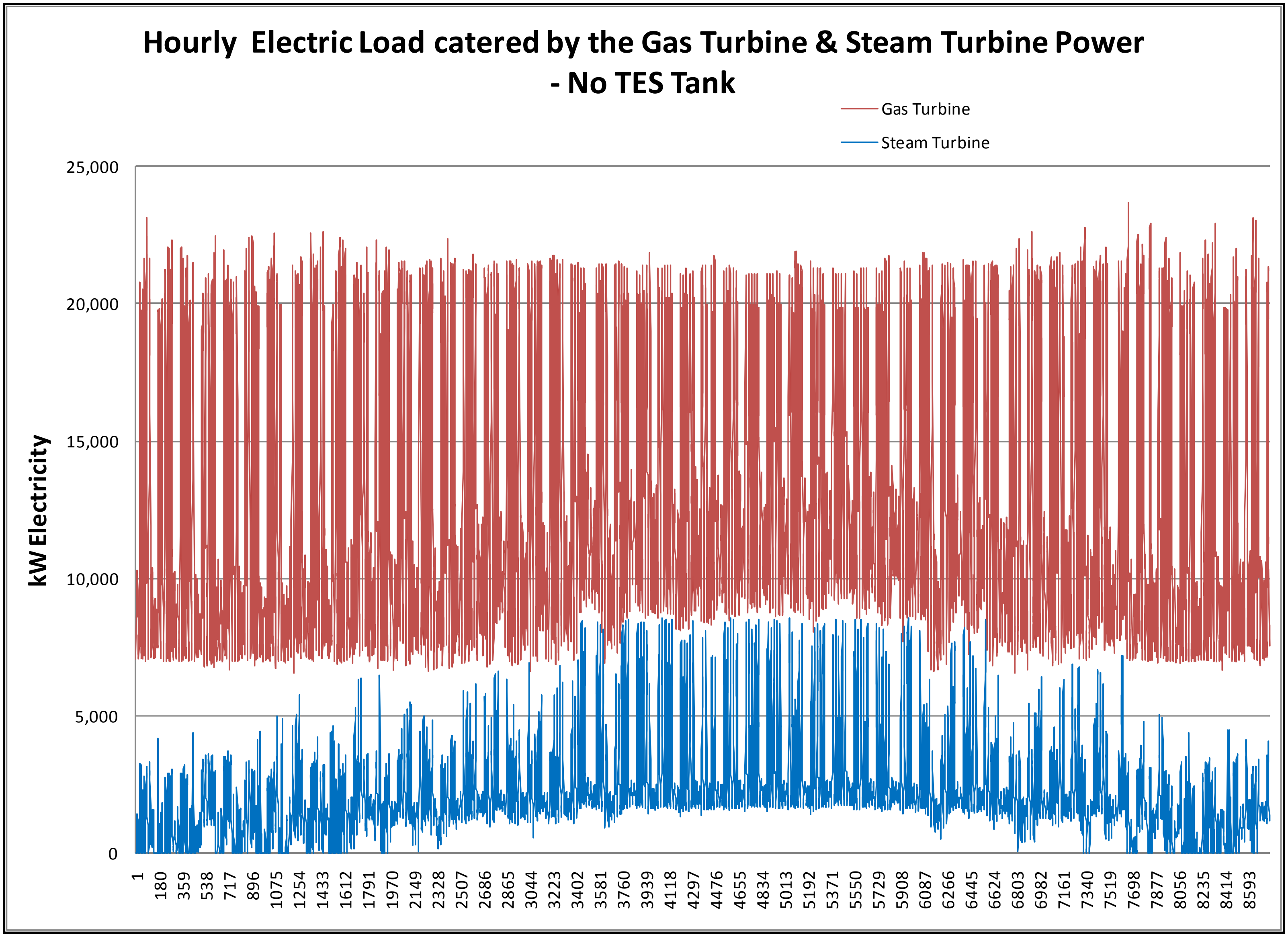


Figure 12. *Hourly Prime Mover kW and Steam Turbine kW:* ***4.5 million gallonTES tank***

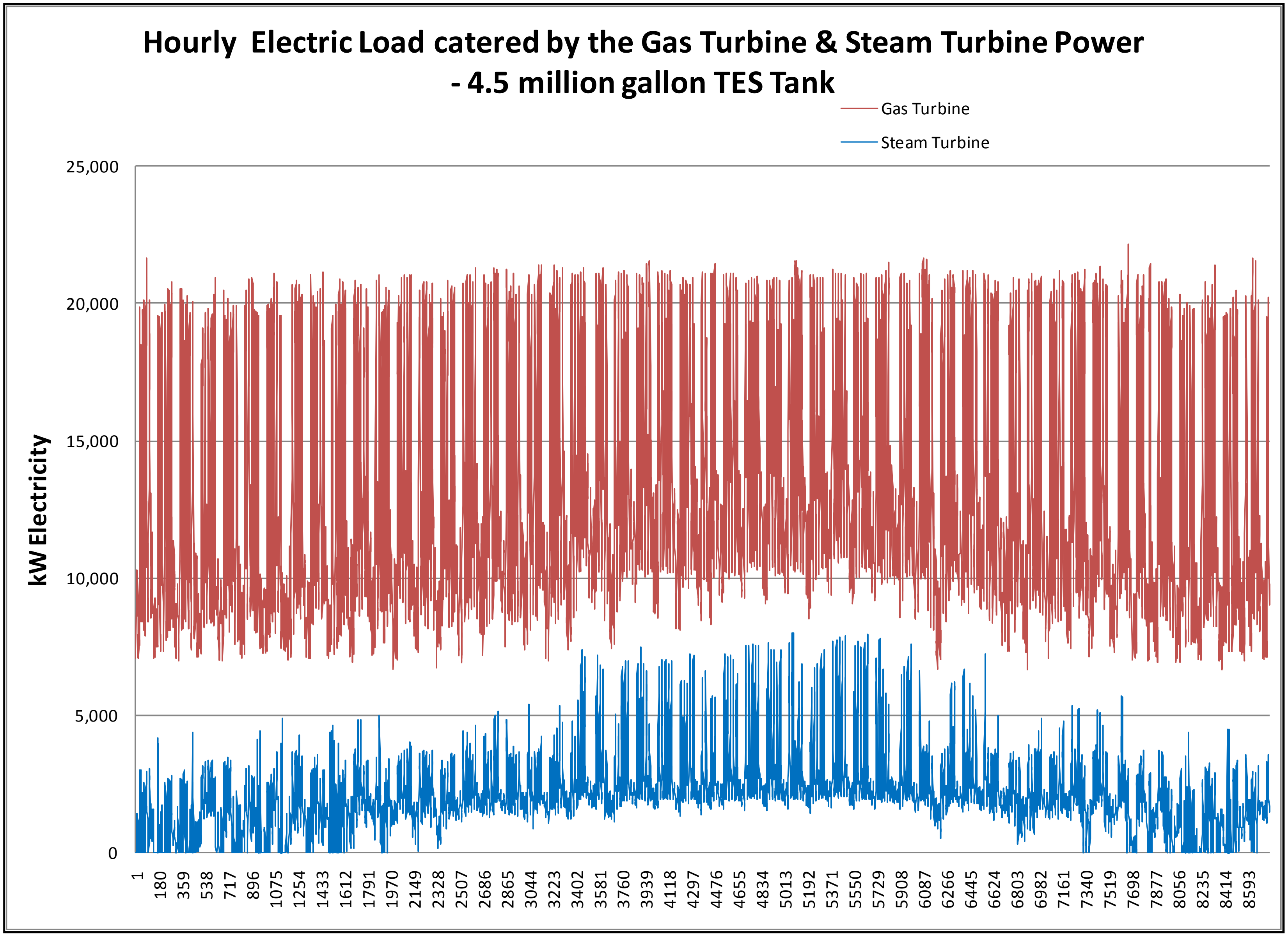


Figure 13. *Hourly Prime Mover kW and Steam Turbine kW:* ***8.5 million gallonTES tank***

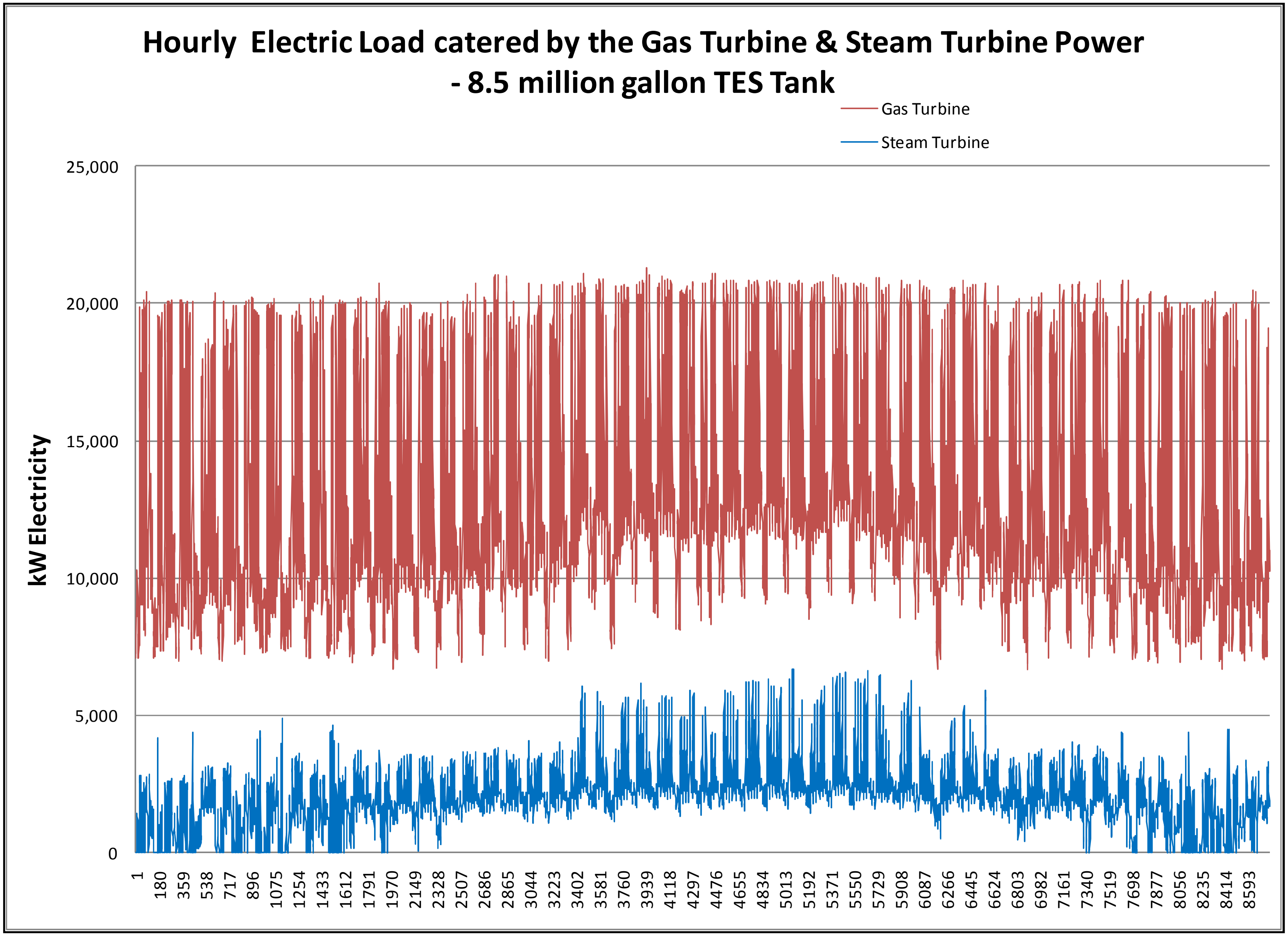


Figure 14. *Hourly Prime Mover kW and Steam Turbine kW:* ***12.5 million gallonTES tank***

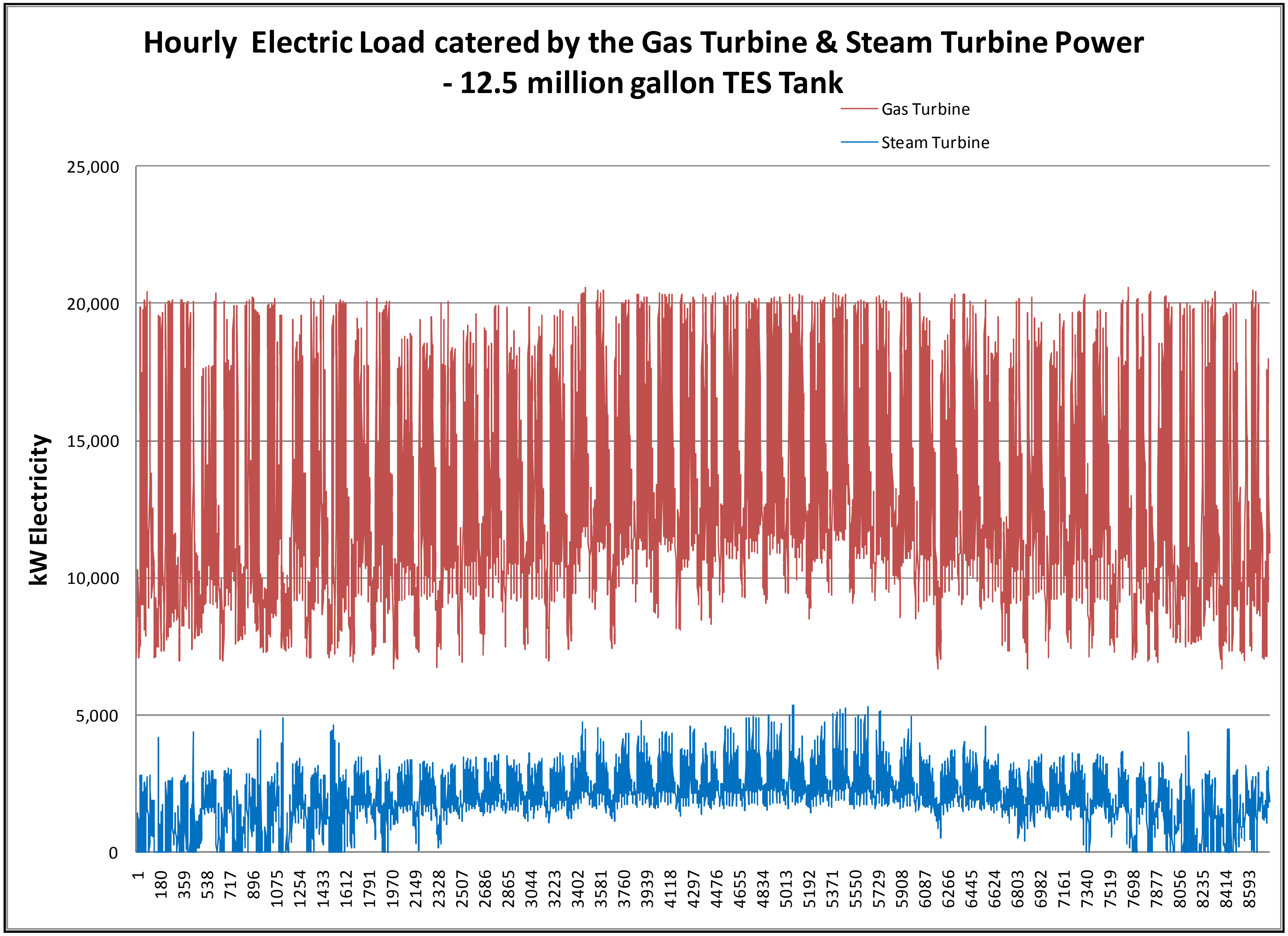


Figure 15. *Internal Rate of Return Calculations : CHP & No TES*

Interest or Bond Rate	5.0%		
First Cost of Plant (1000$)	$46,522		
Avoided First Costs (1000$)	-		
Annual Power Generation	131,642	MWH	
Projected Change in Electric Charges	3%		
Projected Change in Fuel Charges	3%		
Financing and Cash Flow Period	20	Years	

Project:	Capitol Complex
Scenario:	CHP & TES
TES Size	0.0 million gallons
IRR =	10.18%

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Net Installed Cost of Plant (1000$)	$46,522																				
Utility Projections																					
Total Electric Cost w/o CHP	$10,016	$10,944	$11,273	$11,611	$11,959	$12,318	$12,688	$13,068	$13,460	$13,864	$14,280	$14,708	$15,150	$15,604	$16,072	$16,554	$17,051	$17,563	$18,089	$18,632	$19,191
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$503	$549	$566	$583	$600	$618	$637	$656	$676	$696	$717	$738	$760	$783	$807	$831	$856	$882	$908	$935	$963
Total Gas Cost with CHP	$5,330	$5,824	$5,999	$6,178	$6,364	$6,555	$6,751	$6,954	$7,163	$7,377	$7,599	$7,827	$8,062	$8,303	$8,552	$8,809	$9,073	$9,346	$9,626	$9,915	$10,212
Gross Revenues for CHP Investment																					
Change in Electric Cost	1000$	$10,944	$11,273	$11,611	$11,959	$12,318	$12,688	$13,068	$13,460	$13,864	$14,280	$14,708	$15,150	$15,604	$16,072	$16,554	$17,051	$17,563	$18,089	$18,632	$19,191
Change in Gas Cost	1000$	-$5,274	-$5,433	-$5,596	-$5,764	-$5,936	-$6,115	-$6,298	-$6,487	-$6,682	-$6,882	-$7,088	-$7,301	-$7,520	-$7,746	-$7,978	-$8,217	-$8,464	-$8,718	-$8,979	-$9,249
Net Average Year Annual Savings	1000$	$5,670	$5,840	$6,015	$6,196	$6,382	$6,573	$6,770	$6,973	$7,183	$7,398	$7,620	$7,849	$8,084	$8,327	$8,576	$8,834	$9,099	$9,372	$9,653	$9,942
Operating Costs																					
Maintenance Allocation (@ $10/MWH)	1000$	$1,316	$1,349	$1,383	$1,418	$1,453	$1,489	$1,527	$1,565	$1,604	$1,644	$1,685	$1,727	$1,770	$1,815	$1,860	$1,907	$1,954	$2,003	$2,053	$2,105
Maintenance Cost of Generator System	1000$	$658	$675	$692	$709	$4,186	$745	$763	$782	$802	$4,736	$843	$864	$885	$907	$5,359	$953	$977	$1,002	$1,027	$6,063
Cumul. Maint. Sinking Fund Balance	1000$	$658	$1,333	$2,024	$2,733	$0	$745	$1,508	$2,290	$3,092	$0	$843	$1,706	$2,591	$3,499	$0	$953	$1,930	$2,932	$3,959	$0
EBIDA	**1000$**	**$5,012**	**$5,165**	**$5,324**	**$5,487**	**$2,195**	**$5,828**	**$6,007**	**$6,191**	**$6,381**	**$2,662**	**$6,777**	**$6,985**	**$7,199**	**$7,419**	**$3,217**	**$7,880**	**$8,121**	**$8,370**	**$8,626**	**$3,879**
Internal Rate of Return																					
In/Outflows ($1,000)	-$46,522	$5,012	$5,165	$5,324	$5,487	$2,195	$5,828	$6,007	$6,191	$6,381	$2,662	$6,777	$6,985	$7,199	$7,419	$3,217	$7,880	$8,121	$8,370	$8,626	$3,879
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733	-$3,733
Available Cash After All Loan Payments	1000$	$1,279	$1,432	$1,591	$1,754	-$1,538	$2,095	$2,274	$2,458	$2,648	-$1,071	$3,044	$3,252	$3,466	$3,686	-$516	$4,147	$4,388	$4,637	$4,893	$146
Cumul. Net Income After Loan Payments		$1,279	$2,711	$4,302	$6,056	$4,518	$6,613	$8,887	$11,345	$13,992	$12,921	$15,965	$19,217	$22,683	$26,369	$25,853	$30,001	$34,389	$39,026	$43,919	$44,066
Principle Repayment Component	$1,000	-$1,407	-$1,477	-$1,551	-$1,629	-$1,710	-$1,796	-$1,885	-$1,980	-$2,079	-$2,183	-$2,292	-$2,406	-$2,527	-$2,653	-$2,786	-$2,925	-$3,071	-$3,225	-$3,386	-$3,555
Principal Balance	$1,000	$45,115	$43,638	$42,086	$40,458	$38,748	$36,952	$35,067	$33,087	$31,008	$28,825	$26,534	$24,127	$21,601	$18,948	$16,162	$13,237	$10,166	$6,941	$3,555	$0

Figure 16. *Internal Rate of Return Calculations : CHP & 2.5 million gallon TES*

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**$47,510**	
Avoided First Costs (1000$)	**-**	
Annual Power Generation	**131,670**	**MWH**
Projected Change in Electric Charges	**3%**	
Projected Change in Fuel Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project:	Capitol Complex
Scenario:	CHP & TES
TES Size	2.5 million gallons
IRR =	**9.45%**

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Net Installed Cost of Plant (1000$)	$47,510																				
Utility Projections																					
Total Electric Cost w/o CHP	$9,904	$10,822	$11,147	$11,481	$11,826	$12,180	$12,546	$12,922	$13,310	$13,709	$14,120	$14,544	$14,980	$15,430	$15,893	$16,369	$16,860	$17,366	$17,887	$18,424	$18,977
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$503	$549	$566	$583	$600	$618	$637	$656	$676	$696	$717	$738	$760	$783	$807	$831	$856	$882	$908	$935	$963
Total Gas Cost with CHP	$5,355	$5,852	$6,027	$6,208	$6,394	$6,586	$6,784	$6,987	$7,197	$7,413	$7,635	$7,864	$8,100	$8,343	$8,593	$8,851	$9,116	$9,390	$9,672	$9,962	$10,261
Gross Revenues for CHP Investment																					
Change in Electric Cost	1000$	$10,822	$11,147	$11,481	$11,826	$12,180	$12,546	$12,922	$13,310	$13,709	$14,120	$14,544	$14,980	$15,430	$15,893	$16,369	$16,860	$17,366	$17,887	$18,424	$18,977
Change in Gas Cost	1000$	-$5,302	-$5,461	-$5,625	-$5,794	-$5,968	-$6,147	-$6,331	-$6,521	-$6,717	-$6,918	-$7,126	-$7,339	-$7,560	-$7,786	-$8,020	-$8,261	-$8,508	-$8,764	-$9,027	-$9,297
Net Average Year Annual Savings	1000$	$5,520	$5,685	$5,856	$6,032	$6,213	$6,399	$6,591	$6,789	$6,992	$7,202	$7,418	$7,641	$7,870	$8,106	$8,349	$8,600	$8,858	$9,124	$9,397	$9,679
Operating Costs																					
Maintenance Allocation (@ $10/MWH)	1000$	$1,317	$1,350	$1,383	$1,418	$1,453	$1,490	$1,527	$1,565	$1,604	$1,644	$1,685	$1,728	$1,771	$1,815	$1,860	$1,907	$1,955	$2,004	$2,054	$2,105
Maintenance Cost of Generator System	1000$	$658	$675	$692	$709	$4,187	$745	$763	$783	$802	$4,737	$843	$864	$885	$908	$5,360	$953	$977	$1,002	$1,027	$6,064
Cumul. Maint. Sinking Fund Balance	1000$	$658	$1,333	$2,025	$2,734	$0	$745	$1,508	$2,291	$3,093	$0	$843	$1,707	$2,592	$3,499	$0	$953	$1,931	$2,933	$3,959	$0
EBIDA	**1000$**	**$4,862**	**$5,011**	**$5,164**	**$5,323**	**$2,025**	**$5,654**	**$5,828**	**$6,006**	**$6,190**	**$2,465**	**$6,576**	**$6,777**	**$6,985**	**$7,199**	**$2,989**	**$7,646**	**$7,880**	**$8,122**	**$8,370**	**$3,615**
Internal Rate of Return																					
In/Outflows ($1,000)	-$47,510	$4,862	$5,011	$5,164	$5,323	$2,025	$5,654	$5,828	$6,006	$6,190	$2,465	$6,576	$6,777	$6,985	$7,199	$2,989	$7,646	$7,880	$8,122	$8,370	$3,615
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812	-$3,812
Available Cash After All Loan Payments	1000$	$1,049	$1,198	$1,352	$1,510	-$1,787	$1,842	$2,015	$2,194	$2,378	-$1,348	$2,763	$2,965	$3,172	$3,386	-$823	$3,834	$4,068	$4,309	$4,558	-$197
Cumul. Net Income After Loan Payments		$1,049	$2,248	$3,600	$5,110	$3,323	$5,165	$7,180	$9,374	$11,752	$10,405	$13,168	$16,133	$19,305	$22,691	$21,868	$25,702	$29,771	$34,080	$38,638	$38,441
Principle Repayment Component	$1,000	-$1,437	-$1,509	-$1,584	-$1,663	-$1,746	-$1,834	-$1,925	-$2,022	-$2,123	-$2,229	-$2,340	-$2,457	-$2,580	-$2,709	-$2,845	-$2,987	-$3,136	-$3,293	-$3,458	-$3,631
Principal Balance	$1,000	$46,073	$44,564	$42,980	$41,317	$39,570	$37,737	$35,811	$33,789	$31,667	$29,438	$27,097	$24,640	$22,059	$19,350	$16,505	$13,518	$10,382	$7,089	$3,631	$0

Figure 17. *Internal Rate of Return Calculations : **CHP & 4.5 million gallon TES***

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**$49,852**	
Avoided First Costs (1000$)	**-**	
Annual Power Generation	**131,738**	**MWH**
Projected Change in Electric Charges	**3%**	
Projected Change in Fuel Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project:	Capitol Complex	
Scenario:	CHP & TES	
TES Size	4.5	million gallons
	IRR =	**8.48%**

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021
Net Installed Cost of Plant (1000$)	$49,852								
Utility Projections									
Total Electric Cost w/o CHP	$9,816	$10,727	$11,048	$11,380	$11,721	$12,073	$12,435	$12,808	$13,192
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$503	$549	$566	$583	$600	$618	$637	$656	$676
Total Gas Cost with CHP	$5,371	$5,869	$6,045	$6,227	$6,414	$6,606	$6,804	$7,008	$7,219
Gross Revenues for CHP Investment									
Change in Electric Cost	1000$	$10,727	$11,048	$11,380	$11,721	$12,073	$12,435	$12,808	$13,192
Change in Gas Cost	1000$	-$5,320	-$5,480	-$5,644	-$5,813	-$5,988	-$6,167	-$6,352	-$6,543
Net Average Year Annual Savings	1000$	$5,407	$5,569	$5,736	$5,908	$6,085	$6,268	$6,456	$6,649
Operating Costs									
Maintenance Allocation (@ $10/MWH)	1000$	$1,317	$1,350	$1,384	$1,419	$1,454	$1,490	$1,528	$1,566
Maintenance Cost of Generator System	1000$	$659	$675	$692	$709	$4,189	$745	$764	$783
Cumul. Maint. Sinking Fund Balance	1000$	$659	$1,334	$2,026	$2,735	$0	$745	$1,509	$2,292
EBIDA	**1000$**	**$4,748**	**$4,894**	**$5,044**	**$5,199**	**$1,896**	**$5,522**	**$5,692**	**$5,866**
Internal Rate of Return									
In/Outflows ($1,000)	-$49,852	$4,748	$4,894	$5,044	$5,199	$1,896	$5,522	$5,692	$5,866
Financing Cash Flow									
Cost of Financing - Uniform Payments	1000$	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000
Available Cash After All Loan Payments	1000$	$748	$893	$1,044	$1,198	-$2,104	$1,522	$1,692	$1,866
Cumul. Net Income After Loan Payments		$748	$1,641	$2,684	$3,883	$1,778	$3,300	$4,992	$6,858
Principle Repayment Component	$1,000	-$1,508	-$1,583	-$1,662	-$1,745	-$1,833	-$1,924	-$2,020	-$2,121
Principal Balance	$1,000	$48,344	$46,761	$45,099	$43,354	$41,521	$39,597	$37,577	$35,455

Year	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Net Installed Cost of Plant (1000$)												
Utility Projections												
Total Electric Cost w/o CHP	$13,588	$13,996	$14,416	$14,848	$15,293	$15,752	$16,225	$16,712	$17,213	$17,729	$18,261	$18,809
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$696	$717	$738	$760	$783	$807	$831	$856	$882	$908	$935	$963
Total Gas Cost with CHP	$7,435	$7,658	$7,888	$8,125	$8,368	$8,619	$8,878	$9,144	$9,419	$9,701	$9,992	$10,292
Gross Revenues for CHP Investment												
Change in Electric Cost	$13,588	$13,996	$14,416	$14,848	$15,293	$15,752	$16,225	$16,712	$17,213	$17,729	$18,261	$18,809
Change in Gas Cost	-$6,739	-$6,941	-$7,150	-$7,364	-$7,585	-$7,813	-$8,047	-$8,288	-$8,537	-$8,793	-$9,057	-$9,329
Net Average Year Annual Savings	$6,849	$7,054	$7,266	$7,484	$7,708	$7,940	$8,178	$8,423	$8,676	$8,936	$9,204	$9,480
Operating Costs												
Maintenance Allocation (@ $10/MWH)	$1,605	$1,645	$1,686	$1,729	$1,772	$1,816	$1,861	$1,908	$1,956	$2,005	$2,055	$2,106
Maintenance Cost of Generator System	$803	$4,740	$843	$864	$886	$908	$5,363	$954	$978	$1,002	$1,027	$6,067
Cumul. Maint. Sinking Fund Balance	$3,095	$0	$843	$1,707	$2,593	$3,501	$0	$954	$1,932	$2,934	$3,961	$0
EBIDA	**$6,046**	**$2,314**	**$6,423**	**$6,620**	**$6,823**	**$7,032**	**$2,815**	**$7,469**	**$7,698**	**$7,934**	**$8,177**	**$3,413**
Internal Rate of Return												
In/Outflows ($1,000)	$6,046	$2,314	$6,423	$6,620	$6,823	$7,032	$2,815	$7,469	$7,698	$7,934	$8,177	$3,413
Financing Cash Flow												
Cost of Financing - Uniform Payments	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000	-$4,000
Available Cash After All Loan Payments	$2,046	-$1,686	$2,423	$2,619	$2,822	$3,031	-$1,185	$3,469	$3,698	$3,934	$4,177	-$587
Cumul. Net Income After Loan Payments	$8,904	$7,218	$9,641	$12,260	$15,083	$18,114	$16,929	$20,398	$24,096	$28,030	$32,206	$31,619
Principle Repayment Component	-$2,227	-$2,339	-$2,456	-$2,579	-$2,708	-$2,843	-$2,985	-$3,134	-$3,291	-$3,456	-$3,628	-$3,810
Principal Balance	$33,228	$30,889	$28,433	$25,854	$23,147	$20,304	$17,319	$14,185	$10,894	$7,438	$3,810	$0

Figure 18. *Internal Rate of Return Calculations :* ***CHP & 6.5 million gallon TES***

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**$51,968**	
Avoided First Costs (1000$)	**-**	
Annual Power Generation	**131,839**	**MWH**
Projected Change in Electric Charges	**3%**	
Projected Change in Fuel Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project:	Capitol Complex	
Scenario:	CHP & TES	
TES Size	6.5	million gallons
IRR =	**7.62%**	

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Net Installed Cost of Plant (1000$)	$51,968																				
Utility Projections																					
Total Electric Cost w/o CHP	$9,730	$10,633	$10,952	$11,280	$11,619	$11,967	$12,326	$12,696	$13,077	$13,469	$13,873	$14,290	$14,718	$15,160	$15,615	$16,083	$16,566	$17,062	$17,574	$18,102	$18,645
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$503	$549	$566	$583	$600	$618	$637	$656	$676	$696	$717	$738	$760	$783	$807	$831	$856	$882	$908	$935	$963
Total Gas Cost with CHP	$5,391	$5,891	$6,067	$6,249	$6,437	$6,630	$6,829	$7,034	$7,245	$7,462	$7,686	$7,917	$8,154	$8,399	$8,651	$8,910	$9,178	$9,453	$9,736	$10,029	$10,329
Gross Revenues for CHP Investment																					
Change in Electric Cost	1000$	$10,633	$10,952	$11,280	$11,619	$11,967	$12,326	$12,696	$13,077	$13,469	$13,873	$14,290	$14,718	$15,160	$15,615	$16,083	$16,566	$17,062	$17,574	$18,102	$18,645
Change in Gas Cost	1000$	-$5,341	-$5,502	-$5,667	-$5,837	-$6,012	-$6,192	-$6,378	-$6,569	-$6,766	-$6,969	-$7,178	-$7,394	-$7,616	-$7,844	-$8,079	-$8,322	-$8,571	-$8,828	-$9,093	-$9,366
Net Average Year Annual Savings	1000$	$5,291	$5,450	$5,614	$5,782	$5,956	$6,134	$6,318	$6,508	$6,703	$6,904	$7,111	$7,325	$7,544	$7,771	$8,004	$8,244	$8,491	$8,746	$9,008	$9,279
Operating Costs																					
Maintenance Allocation (@ $10/MWH)	1000$	$1,318	$1,351	$1,385	$1,420	$1,455	$1,492	$1,529	$1,567	$1,606	$1,646	$1,688	$1,730	$1,773	$1,817	$1,863	$1,909	$1,957	$2,006	$2,056	$2,108
Maintenance Cost of Generator System	1000$	$659	$676	$693	$710	$4,193	$746	$764	$784	$803	$4,744	$844	$865	$887	$909	$5,367	$955	$979	$1,003	$1,028	$6,072
Cumul. Maint. Sinking Fund Balance	1000$	$659	$1,335	$2,027	$2,737	$0	$746	$1,510	$2,294	$3,097	$0	$844	$1,709	$2,595	$3,504	$0	$955	$1,933	$2,936	$3,964	$0
EBIDA	**1000$**	**$4,632**	**$4,774**	**$4,921**	**$5,072**	**$1,763**	**$5,388**	**$5,554**	**$5,724**	**$5,900**	**$2,161**	**$6,267**	**$6,460**	**$6,658**	**$6,862**	**$2,637**	**$7,289**	**$7,513**	**$7,743**	**$7,980**	**$3,206**
Internal Rate of Return																					
In/Outflows ($1,000)	-$51,968	$4,632	$4,774	$4,921	$5,072	$1,763	$5,388	$5,554	$5,724	$5,900	$2,161	$6,267	$6,460	$6,658	$6,862	$2,637	$7,289	$7,513	$7,743	$7,980	$3,206
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170	-$4,170
Available Cash After All Loan Payments	1000$	$462	$604	$751	$902	-$2,407	$1,218	$1,384	$1,554	$1,730	-$2,009	$2,097	$2,290	$2,488	$2,692	-$1,533	$3,119	$3,343	$3,573	$3,810	-$964
Cumul. Net Income After Loan Payments		$462	$1,067	$1,818	$2,720	$313	$1,531	$2,915	$4,469	$6,199	$4,189	$6,287	$8,576	$11,064	$13,756	$12,223	$15,342	$18,684	$22,257	$26,067	$25,104
Principle Repayment Component	$1,000	-$1,572	-$1,650	-$1,733	-$1,819	-$1,910	-$2,006	-$2,106	-$2,211	-$2,322	-$2,438	-$2,560	-$2,688	-$2,822	-$2,964	-$3,112	-$3,267	-$3,431	-$3,602	-$3,782	-$3,971
Principal Balance	$1,000	$50,396	$48,746	$47,013	$45,194	$43,284	$41,278	$39,172	$36,960	$34,638	$32,200	$29,640	$26,952	$24,129	$21,166	$18,054	$14,787	$11,356	$7,754	$3,971	$0

Figure 19. *Internal Rate of Return Calculations :* ***CHP & 8.5 million gallon TES***

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**$53,787**	
Avoided First Costs (1000$)	**-**	
Annual Power Generation	**131,966**	**MWH**
Projected Change in Electric Charges	**3%**	
Projected Change in Fuel Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project:	Capitol Complex
Scenario:	CHP & TES
TES Size	8.5 million gallons
IRR =	**6.87%**

Year	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Net Installed Cost of Plant (1000$)	$53,787																				
Utility Projections																					
Total Electric Cost w/o CHP	$9,646	$10,540	$10,856	$11,182	$11,518	$11,863	$12,219	$12,586	$12,963	$13,352	$13,753	$14,165	$14,590	$15,028	$15,479	$15,943	$16,421	$16,914	$17,421	$17,944	$18,482
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$503	$549	$566	$583	$600	$618	$637	$656	$676	$696	$717	$738	$760	$783	$807	$831	$856	$882	$908	$935	$963
Total Gas Cost with CHP	$5,411	$5,913	$6,091	$6,273	$6,462	$6,655	$6,855	$7,061	$7,273	$7,491	$7,715	$7,947	$8,185	$8,431	$8,684	$8,944	$9,213	$9,489	$9,774	$10,067	$10,369
Gross Revenues for CHP Investment																					
Change in Electric Cost	1000$	$10,540	$10,856	$11,182	$11,518	$11,863	$12,219	$12,586	$12,963	$13,352	$13,753	$14,165	$14,590	$15,028	$15,479	$15,943	$16,421	$16,914	$17,421	$17,944	$18,482
Change in Gas Cost	1000$	-$5,364	-$5,525	-$5,691	-$5,861	-$6,037	-$6,218	-$6,405	-$6,597	-$6,795	-$6,999	-$7,209	-$7,425	-$7,648	-$7,877	-$8,113	-$8,357	-$8,608	-$8,866	-$9,132	-$9,406
Net Average Year Annual Savings	1000$	$5,176	$5,332	$5,492	$5,656	$5,826	$6,001	$6,181	$6,366	$6,557	$6,754	$6,957	$7,165	$7,380	$7,602	$7,830	$8,065	$8,307	$8,556	$8,812	$9,077
Operating Costs																					
Maintenance Allocation (@ $10/MWH)	1000$	$1,320	$1,353	$1,386	$1,421	$1,457	$1,493	$1,530	$1,569	$1,608	$1,648	$1,689	$1,732	$1,775	$1,819	$1,865	$1,911	$1,959	$2,008	$2,058	$2,110
Maintenance Cost of Generator System	1000$	$660	$676	$693	$711	$4,197	$747	$765	$784	$804	$4,748	$845	$866	$887	$910	$5,372	$956	$980	$1,004	$1,029	$6,078
Cumul. Maint. Sinking Fund Balance	1000$	$660	$1,336	$2,029	$2,740	$0	$747	$1,512	$2,296	$3,100	$0	$845	$1,710	$2,598	$3,507	$0	$956	$1,935	$2,939	$3,968	$0
EBIDA	**1000$**	**$4,517**	**$4,655**	**$4,798**	**$4,946**	**$1,629**	**$5,254**	**$5,416**	**$5,582**	**$5,753**	**$2,006**	**$6,112**	**$6,300**	**$6,493**	**$6,692**	**$2,458**	**$7,109**	**$7,327**	**$7,552**	**$7,783**	**$2,999**
Internal Rate of Return																					
In/Outflows ($1,000)	-$53,787	$4,517	$4,655	$4,798	$4,946	$1,629	$5,254	$5,416	$5,582	$5,753	$2,006	$6,112	$6,300	$6,493	$6,692	$2,458	$7,109	$7,327	$7,552	$7,783	$2,999
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316	-$4,316
Available Cash After All Loan Payments	1000$	$201	$339	$482	$630	-$2,687	$938	$1,100	$1,266	$1,437	-$2,310	$1,796	$1,984	$2,177	$2,376	-$1,858	$2,793	$3,011	$3,236	$3,467	-$1,317
Cumul. Net Income After Loan Payments		$201	$540	$1,022	$1,652	-$1,035	-$96	$1,003	$2,269	$3,707	$1,396	$3,192	$5,176	$7,353	$9,729	$7,871	$10,663	$13,674	$16,910	$20,377	$19,060
Principle Repayment Component	$1,000	-$1,627	-$1,708	-$1,793	-$1,883	-$1,977	-$2,076	-$2,180	-$2,289	-$2,403	-$2,523	-$2,650	-$2,782	-$2,921	-$3,067	-$3,221	-$3,382	-$3,551	-$3,728	-$3,915	-$4,110
Principal Balance	$1,000	$52,160	$50,452	$48,659	$46,776	$44,798	$42,722	$40,543	$38,254	$35,850	$33,327	$30,677	$27,895	$24,974	$21,907	$18,686	$15,304	$11,754	$8,025	$4,110	$0

Figure 20. *Internal Rate of Return Calculations : <u>CHP & 10.5 million gallon TES</u>*

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**$55,526**	
Avoided First Costs (1000$)	**-**	
Annual Power Generation	**132,123**	**MWH**
Projected Change in Electric Charges	**3%**	
Projected Change in Fuel Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project:	Capitol Complex	
Scenario:	CHP & TES	
TES Size	10.5	million gallons
IRR =	**6.18%**	

Year	2010	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
<u>Net Installed Cost of Plant (1000$)</u>	$55,526																				
<u>Utility Projections</u>																					
Total Electric Cost w/o CHP	$9,563	$10,449	$10,763	$11,086	$11,418	$11,761	$12,114	$12,477	$12,851	$13,237	$13,634	$14,043	$14,464	$14,898	$15,345	$15,806	$16,280	$16,768	$17,271	$17,789	$18,323
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$503	$549	$566	$583	$600	$618	$637	$656	$676	$696	$717	$738	$760	$783	$807	$831	$856	$882	$908	$935	$963
Total Gas Cost with CHP	$5,423	$5,926	$6,104	$6,287	$6,476	$6,670	$6,870	$7,076	$7,289	$7,507	$7,733	$7,964	$8,203	$8,450	$8,703	$8,964	$9,233	$9,510	$9,795	$10,089	$10,392
<u>Gross Revenues for CHP Investment</u>																					
Change in Electric Cost	1000$	$10,449	$10,763	$11,086	$11,418	$11,761	$12,114	$12,477	$12,851	$13,237	$13,634	$14,043	$14,464	$14,898	$15,345	$15,806	$16,280	$16,768	$17,271	$17,789	$18,323
Change in Gas Cost	1000$	-$5,377	-$5,538	-$5,704	-$5,876	-$6,052	-$6,233	-$6,420	-$6,613	-$6,811	-$7,016	-$7,226	-$7,443	-$7,666	-$7,896	-$8,133	-$8,377	-$8,628	-$8,887	-$9,154	-$9,429
Net Average Year Annual Savings	1000$	$5,072	$5,225	$5,381	$5,543	$5,709	$5,880	$6,057	$6,238	$6,426	$6,618	$6,817	$7,021	$7,232	$7,449	$7,672	$7,903	$8,140	$8,384	$8,635	$8,894
<u>Operating Costs</u>																					
Maintenance Allocation (@ $10/MWH)	1000$	$1,321	$1,354	$1,388	$1,423	$1,458	$1,495	$1,532	$1,571	$1,610	$1,650	$1,691	$1,734	$1,777	$1,821	$1,867	$1,914	$1,961	$2,010	$2,061	$2,112
Maintenance Cost of Generator System	1000$	$661	$677	$694	$711	$4,202	$747	$766	$785	$805	$4,754	$846	$867	$888	$911	$5,378	$957	$981	$1,005	$1,030	$6,085
Cumul. Maint. Sinking Fund Balance	1000$	$661	$1,338	$2,032	$2,743	$0	$747	$1,514	$2,299	$3,104	$0	$846	$1,712	$2,601	$3,512	$0	$957	$1,937	$2,943	$3,973	$0
<u>EBIDA</u>	**1000$**	**$4,412**	**$4,547**	**$4,687**	**$4,831**	**$1,507**	**$5,133**	**$5,291**	**$5,453**	**$5,621**	**$1,865**	**$5,971**	**$6,155**	**$6,344**	**$6,538**	**$2,294**	**$6,946**	**$7,159**	**$7,379**	**$7,605**	**$2,809**
<u>Internal Rate of Return</u>																					
In/Outflows ($1,000)	-$55,526	$4,412	$4,547	$4,687	$4,831	$1,507	$5,133	$5,291	$5,453	$5,621	$1,865	$5,971	$6,155	$6,344	$6,538	$2,294	$6,946	$7,159	$7,379	$7,605	$2,809
<u>Financing Cash Flow</u>																					
Cost of Financing - Uniform Payments	1000$	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456	-$4,456
Available Cash After All Loan Payments	1000$	-$44	$92	$232	$376	-$2,948	$677	$835	$998	$1,165	-$2,591	$1,516	$1,699	$1,888	$2,083	-$2,162	$2,490	$2,703	$2,923	$3,150	-$1,646
Cumul. Net Income After Loan Payments		-$44	$48	$280	$656	-$2,293	-$1,615	-$780	$217	$1,382	-$1,209	$307	$2,006	$3,894	$5,977	$3,815	$6,306	$9,009	$11,932	$15,082	$13,436
Principle Repayment Component	$1,000	-$1,679	-$1,763	-$1,851	-$1,944	-$2,041	-$2,143	-$2,250	-$2,363	-$2,481	-$2,605	-$2,735	-$2,872	-$3,016	-$3,166	-$3,325	-$3,491	-$3,666	-$3,849	-$4,041	-$4,243
Principal Balance	$1,000	$53,847	$52,083	$50,232	$48,288	$46,247	$44,104	$41,853	$39,491	$37,010	$34,405	$31,669	$28,797	$25,781	$22,615	$19,290	$15,799	$12,134	$8,285	$4,243	$0

Figure 21. *Internal Rate of Return Calculations : **CHP & 12.5 million gallon TES***

Interest or Bond Rate	**5.0%**	
First Cost of Plant (1000$)	**$57,182**	
Avoided First Costs (1000$)	**-**	
Annual Power Generation	**132,300**	**MWH**
Projected Change in Electric Charges	**3%**	
Projected Change in Fuel Charges	**3%**	
Financing and Cash Flow Period	**20**	**Years**

Project:	Capitol Complex	
Scenario:	CHP & TES	
TES Size	12.5	million gallons
IRR =	**5.56%**	

Year	**2010**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
Net Installed Cost of Plant (1000$)	$57,182																				
Utility Projections																					
Total Electric Cost w/o CHP	$9,481	$10,360	$10,671	$10,991	$11,321	$11,660	$12,010	$12,370	$12,741	$13,124	$13,517	$13,923	$14,340	$14,771	$15,214	$15,670	$16,140	$16,625	$17,123	$17,637	$18,166
Total Electric Cost with CHP	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Total Gas Cost w/o CHP	$503	$549	$566	$583	$600	$618	$637	$656	$676	$696	$717	$738	$760	$783	$807	$831	$856	$882	$908	$935	$963
Total Gas Cost with CHP	$5,431	$5,934	$6,112	$6,296	$6,485	$6,679	$6,880	$7,086	$7,299	$7,518	$7,743	$7,975	$8,215	$8,461	$8,715	$8,976	$9,246	$9,523	$9,809	$10,103	$10,406
Gross Revenues for CHP Investment																					
Change in Electric Cost	1000$	$10,360	$10,671	$10,991	$11,321	$11,660	$12,010	$12,370	$12,741	$13,124	$13,517	$13,923	$14,340	$14,771	$15,214	$15,670	$16,140	$16,625	$17,123	$17,637	$18,166
Change in Gas Cost	1000$	-$5,385	-$5,547	-$5,713	-$5,884	-$6,061	-$6,243	-$6,430	-$6,623	-$6,822	-$7,026	-$7,237	-$7,454	-$7,678	-$7,908	-$8,145	-$8,390	-$8,641	-$8,901	-$9,168	-$9,443
Net Average Year Annual Savings	1000$	$4,975	$5,124	$5,278	$5,436	$5,599	$5,767	$5,940	$6,118	$6,302	$6,491	$6,686	$6,886	$7,093	$7,306	$7,525	$7,751	$7,983	$8,223	$8,469	$8,723
Operating Costs																					
Maintenance Allocation (@ $10/MWH)	1000$	$1,323	$1,356	$1,390	$1,425	$1,460	$1,497	$1,534	$1,573	$1,612	$1,652	$1,694	$1,736	$1,779	$1,824	$1,869	$1,916	$1,964	$2,013	$2,063	$2,115
Maintenance Cost of Generator System	1000$	$661	$678	$695	$712	$4,207	$748	$767	$786	$806	$4,760	$847	$868	$890	$912	$5,386	$958	$982	$1,007	$1,032	$6,093
Cumul. Maint. Sinking Fund Balance	1000$	$661	$1,340	$2,035	$2,747	$0	$748	$1,516	$2,302	$3,108	$0	$847	$1,715	$2,604	$3,516	$0	$958	$1,940	$2,947	$3,978	$0
EBIDA	**1000$**	**$4,313**	**$4,446**	**$4,583**	**$4,724**	**$1,392**	**$5,019**	**$5,173**	**$5,332**	**$5,496**	**$1,731**	**$5,839**	**$6,018**	**$6,203**	**$6,394**	**$2,139**	**$6,793**	**$7,001**	**$7,216**	**$7,438**	**$2,630**
Internal Rate of Return																					
In/Outflows ($1,000)	-$57,182	$4,313	$4,446	$4,583	$4,724	$1,392	$5,019	$5,173	$5,332	$5,496	$1,731	$5,839	$6,018	$6,203	$6,394	$2,139	$6,793	$7,001	$7,216	$7,438	$2,630
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588	-$4,588
Available Cash After All Loan Payments	1000$	-$275	-$142	-$6	$135	-$3,196	$430	$585	$744	$908	-$2,858	$1,251	$1,430	$1,615	$1,805	-$2,449	$2,204	$2,413	$2,628	$2,849	-$1,958
Cumul. Net Income After Loan Payments		-$275	-$418	-$423	-$288	-$3,484	-$3,054	-$2,469	-$1,726	-$818	-$3,676	-$2,425	-$995	$620	$2,425	-$24	$2,180	$4,593	$7,220	$10,070	$8,111
Principle Repayment Component	$1,000	-$1,729	-$1,816	-$1,907	-$2,002	-$2,102	-$2,207	-$2,317	-$2,433	-$2,555	-$2,683	-$2,817	-$2,958	-$3,106	-$3,261	-$3,424	-$3,595	-$3,775	-$3,964	-$4,162	-$4,370
Principal Balance	$1,000	$55,452	$53,637	$51,730	$49,728	$47,626	$45,419	$43,102	$40,668	$38,113	$35,430	$32,614	$29,656	$26,550	$23,289	$19,865	$16,270	$12,495	$8,532	$4,370	$0

Solar Turbines Incorporated

Budgetary Quotation for 5 Mercury 50s

Inquiry # TBD prepared on December 2, 2010

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		
(5) Gas Fuel MERCURY 50-6000R Turbine Generator Sets……		$17,980,700
Commissioning Parts, Startup, and Site Testing……		$460,000
Electrical Equipment		
Station Control System (SCS) (Monitor Only)……	$374,600	
Power and Utility Breaker Control Options……	Included in SCS	
Switchgear and MCC (design description below)……	$1,494,600	
Switchgear, motor control center, auxiliary power transformer, and generator grounding resistor.		
Switchgear and MCC are shipped loose.		
Utility Tie-In……	$243,300	
Total for Electrical Equipment……		$2,112,500
Mechanical Equipment		
Fuel Gas Compressors, 5 provided ……		$2,481,800
Fuel Gas Filter/Separator……		$343,500
5 Heat Recovery Steam Generators ……	$5,887,600	
HRSG Options……	none selected	
Total for Heat Recovery Steam System……		$5,887,600
Miscellaneous		
Construction Estimate……		$9,030,100
Project Management & Engineering……		$2,007,700
Shipping……		$592,800
Development Costs……		$0
Special or Avoided Capital Items……		$0
6% Balance of Plant Contingency……		$1,347,400
Total for BOP Equipment and Installation……		$23,803,400
Grand Total for Turbomachinery and Balance of Plant……		**$42,244,100**
Estimation of cost per ISO rating kilowatt for selected equipment……		$1,836
ESA Cost per Month (Only Turbomachinery Covered)……		$185,380

*Duties and taxes not included in estimate.

CEP Ver. 5.5

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 CO2 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_2 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

Cogeneration Plant Estimated Performance Summary

5 Mercury 50s

Solar Turbines Incorporated

December 2, 2010

Performance listed below is estimated, not guaranteed.

Gas Turbines:		
KW Gross Output @ ISO Conditions:	23,000	kW
Site Ambient Temperature for Performance Analysis:	75	°F
Site Elevation for Performance Analysis:	0	feet
Site Ambient Relative Humidity for Performance Analysis:	60	%
Turbine Inlet Pressure Loss:	4.0	"H2O
Turbine Outlet Pressure Loss:	10.0	"H2O
Turbine Fuel Consumption @ specified site conditions (LHV):	191.6	MMBtu/hr
KW Gross Output @ specified site conditions:	20,560	kW
Gas Compressor Power Consumption:	753	KW
Turbine Auxiliary Power Consumption:	200	kW
Total Auxiliary Power Consumption:	953	kW
Net Turbine Power Production:	19,607	kW
Black Start kW Requirement (Turbine Generator Set Only)	206	kW

Boilers:		
Condensate Return:	60	%
Condensate Temperature:	212	°F
Makeup Water Temperature:	70	°F
Process Steam Pressure:	650.0	psig
Process Steam Temperature:	750	°F
Steam Contributed by Gas Turbines:	42,026	lb/hr
Steam Contributed by Ductburners:	0	lb/hr
Ductburner Fuel Consumption (LHV):	6.6	MMBtu/hr
Deaerator Steam Consumption:	2,875	lb/hr
Boiler Steam Flow:	42,026	lb/hr
Steam Flow to Process:	42,026	lb/hr

Cycle Performance (lower heating value basis)**:**		
Net Turbine Heat Rate:	9,770	Btu/kWHR
Gross Plant Heat Rate (Process steam or Tons converted to equivalent KW):	5,820	Btu/kWHR
Overall Cycle Thermal Efficiency (LHV):	58.6	%

Caterpillar Confidential: Green

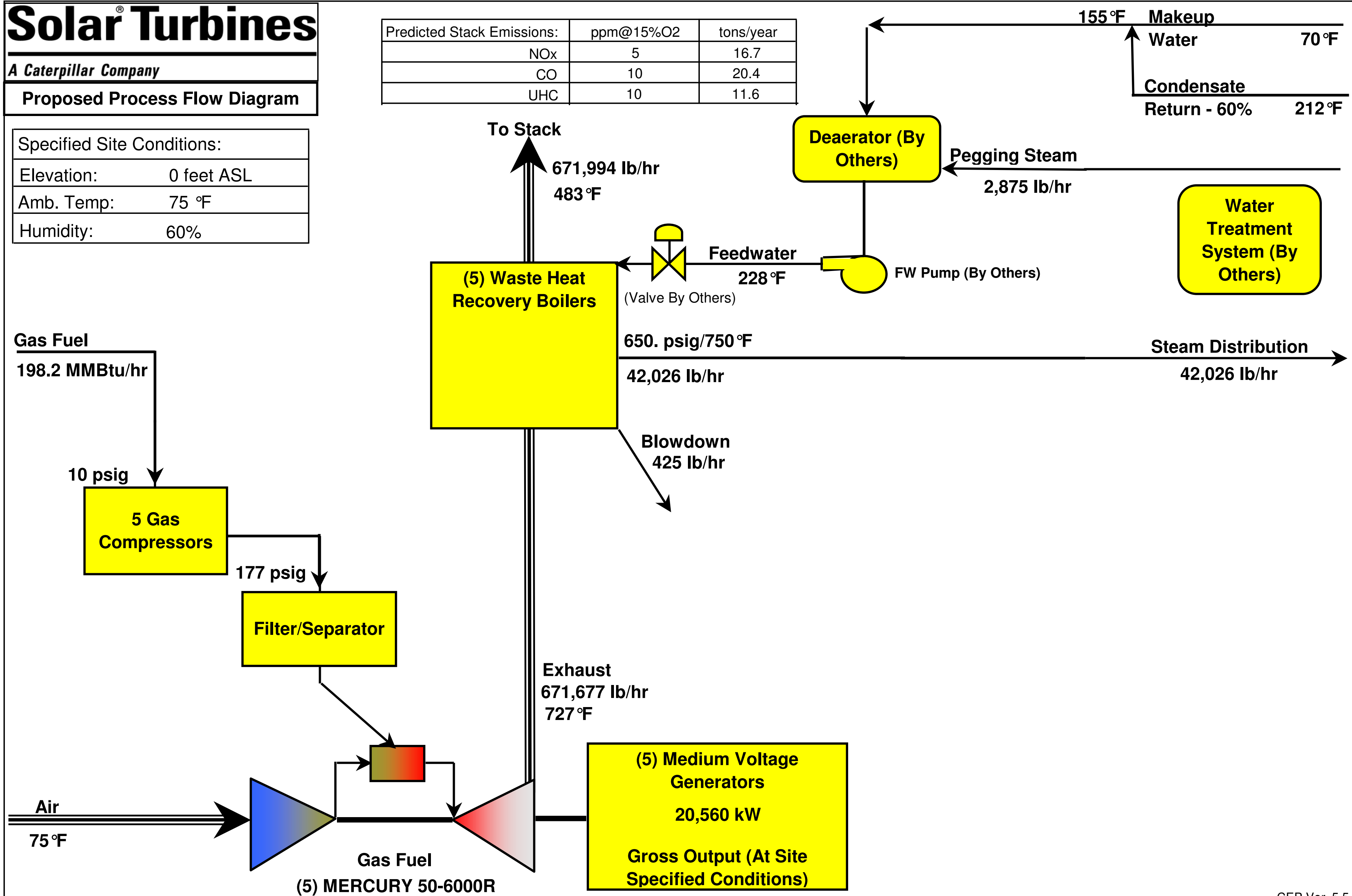
CEP Ver. 5.5

Solar Turbines
A Caterpillar Company

Proposed Process Flow Diagram

Predicted Stack Emissions:	ppm@15%O2	tons/year
NOx	5	16.7
CO	10	20.4
UHC	10	11.6

Specified Site Conditions:	
Elevation:	0 feet ASL
Amb. Temp:	75 °F
Humidity:	60%



ISO Rating - 23,000 kW

System Efficiency = 58.6%

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

5 Mercury 50s		
Ref. #	TBD	12/2/2010
Designed by	Marco Perez	

Off Design Performance Worksheet

5 Mercury 50s

Prepared by Marco Perez on December 2, 2010

MERCURY 50-6000R

GSC STANDARD

Gas

CHP Off Design

Duct Burner On/Off	Off
# of Turbines in Service	1
Boiler Steam Demand		lb/hr
Unfired Steam Flow	8,528	lb/hr
Firing Temperature	Off	°F
Duct Burner Fuel Flow	Off	MMBtu/hr

Site Elevation:	0	feet					
Barometric Pressure:	29.92	"Hg					
Inlet Duct Loss:	4.0	"H2O					
Exhaust Duct Loss:	10.0	"H2O					
Ambient Temperature (T1):	75	10	30	59	70	90	°F
Part Power (kWe), % Load, or 0 for Max:	→	0	0	0	0	0	kWe
Engine Inlet Air Temperature (T1):	75	10	30	59	70	90	°F
Nominal Output Power: (@terminals)	4,112	5,158	4,987	4,435	4,221	3,780	kWe
Fuel Flow (LHV):	38.3	44.0	43.8	40.4	39.0	36.2	MMBtu/hr
Inlet Air Flow:	132,476	147,853	147,794	138,083	134,187	127,135	lb/hr
Exhaust Gas Temperature (T7):	727	651	681	711	723	738	°F
Exhaust Gas Mass Flow:	134,335	149,987	149,921	140,042	136,079	128,892	lb/hr
Exhaust Gas Volumetric Flow:	30,372	33,642	33,656	31,536	30,722	29,310	SCFM
Nominal Thermal Efficiency: (@terminals)	36.6	40.0	38.8	37.5	36.9	35.6	%
Nominal Heat Rate: (@terminals)	9,321	8,527	8,790	9,102	9,241	9,578	Btu/kWHR
PCD Pressure:	118.4	133.7	133.7	124.1	120.2	112.6	psig
Exhaust Heat (from T7 to 275°F):	15.8	14.7	15.8	15.9	15.8	15.5	MMBtu/hr
% Argon, wet:	0.9	0.9	0.9	0.9	0.9	0.9	
% CO_2, wet:	2.4	2.5	2.5	2.5	2.4	2.4	
% H_2O, wet:	6.3	4.9	5.1	5.6	6.0	7.2	
% N_2, wet:	75.0	76.1	76.0	75.5	75.2	74.2	
% Oxygen, wet:	15.4	15.5	15.5	15.5	15.5	15.3	
			Net CHP System Efficiency =			61.6	% (LHV)

Estimated Power Island Emissions

5 Mercury 50s

Quoted using data available as of December 2, 2010

(5) Gas Fuel MERCURY 50-6000R with HRSGs		**Per Unit**	**Plant Total**
Ambient Temperature	°F	75°F	
Fuel Type		Gas	
Assumed Fuel Sulphur Content	lb/MMBTU (HHV)	0.00	
Gas Turbine Exhaust Flow	lb/hr	134,335	671,677
Duct Burner Fuel Flow	lb/hr	63	317
Stack Exhaust Flow	lb/hr	134,399	671,994
FG Temperature Leaving Gas Turbine	°F	727	
FG Temperature Leaving Duct Burner	°F	763	
FG Temperature At Stack	°F	483	
Heat Input to Gas Turbine	MMBtu/hr (LHV)	38.3	191.6
Heat Input from Duct Firing	MMBtu/hr (LHV)	1.3	6.6
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	
$PM_{10}/PM_{2.5}$ Particulates from Gas Turbine	lb/MMBTU (HHV)	0.021	
Additive PM-10 Particulates from Duct Firing	lb/MMBTU (HHV)	0.021	
Turbine Exhaust Gas Analysis			
H_2O	% vol	6.3%	
N_2	% vol	75.0%	
CO_2	% vol	2.4%	
O_2	% vol	15.4%	
SO_2	% vol	0.0%	
Argon	% vol	0.9%	
Gas Turbine Exhaust Emissions			
NOx	ppm @ 15% O2	5	5
	lb/hr	0.8	3.8
CO	ppm @ 15% O2	10	10
	lb/hr	0.9	4.7
UHC	ppm @ 15% O2	10	10
	lb/hr	0.5	2.7
$PM_{10}/PM_{2.5}$	lb/hr	0.9	4.4
SO_2	lb/hr	0.0	0.0

(5) Gas Fuel MERCURY 50-6000R with HRSGs		Per Unit	Plant Total
Exhaust Emissions At Stack			
NOx	ppm @ 15% O2	5	5
	lb/MMBtu, HHV	0.018	
	lb/hr	0.8	3.8
	tons/year	3.3	16.7
CO	ppm @ 15% O2	10	10
	lb/MMBtu, HHV	0.022	
	lb/hr	0.9	4.7
	tons/year	4.1	20.4
UHC	ppm @ 15% O2	10	10
	lb/MMBtu, HHV	0.013	
	lb/hr	0.5	2.7
	tons/year	2.3	11.6
VOC	ppm @ 15% O2	2	2
	lb/MMBtu, HHV	0.003	
	lb/hr	0.1	0.3
	tons/year	0.2	1.2
$PM_{10}/PM_{2.5}$	lb/hr	0.9	4.4
	lb/MMBtu, HHV	0.021	
	tons/year	3.9	19.5
SO_2	lb/hr	0.01	0.0
	lb/MMBtu, HHV	0.00014	
	tons/year	0.0	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 CO2/MMBtu (HHV)	114	

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.

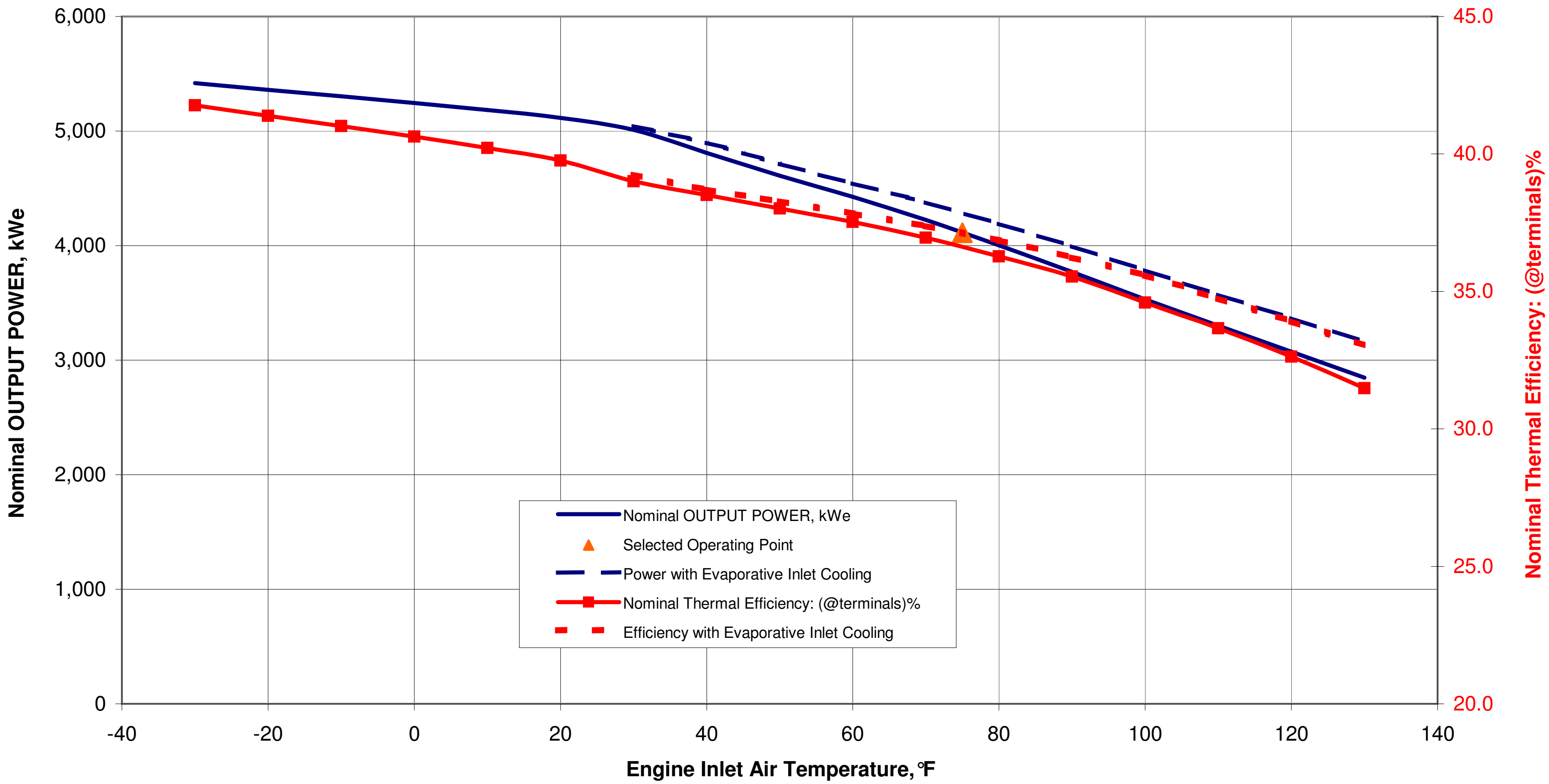
Pollutant	Load Range
NOx	50 to 100%
CO	50 to 100%
UHC	50 to 100%

Fuels must comply with Solar specification ES 9-98.

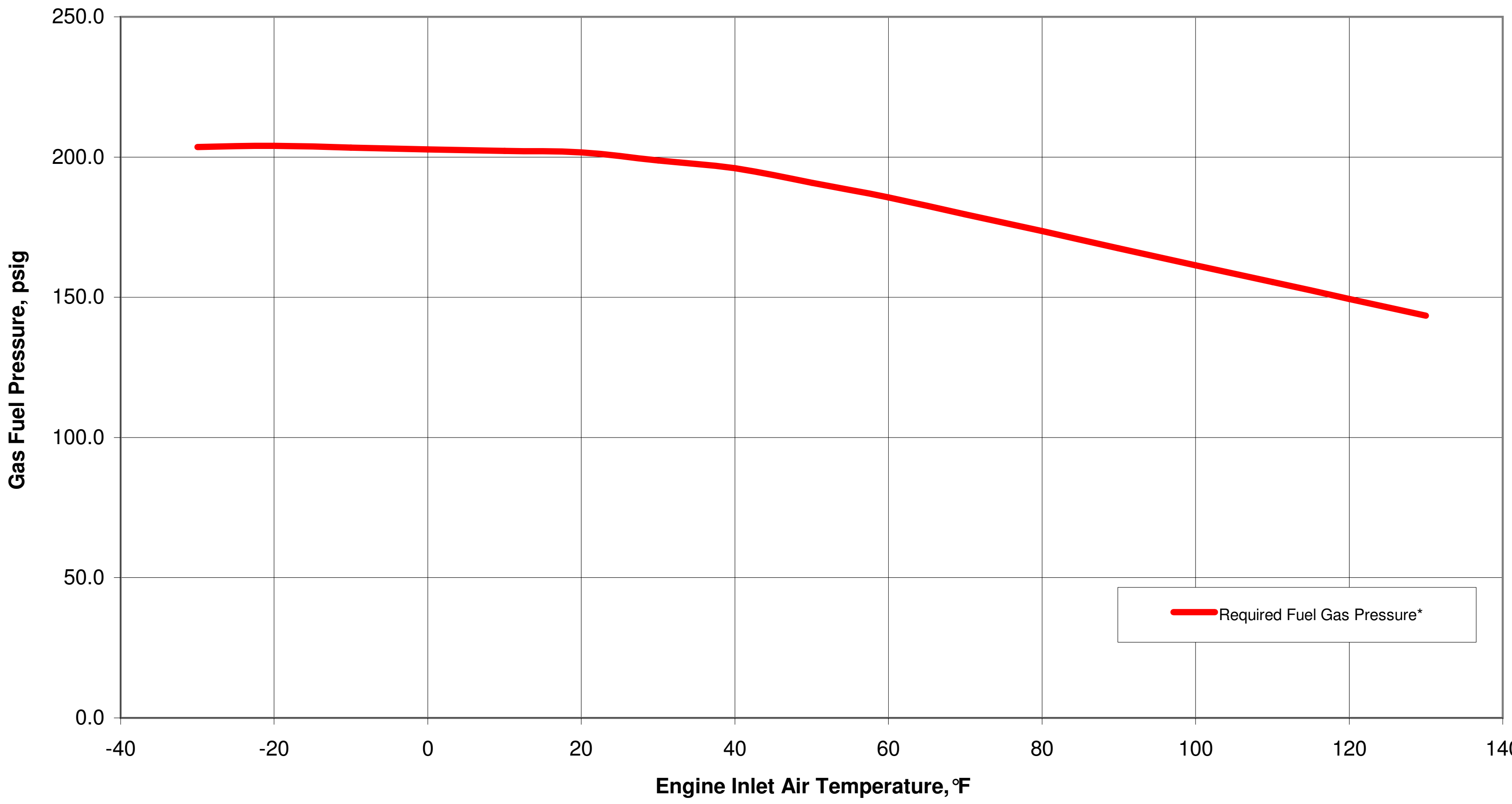
Values applicable for operation at ambient temperatures between 0 and 120℉.

For more information contact: Marco Perez, 713-825-5319, perez_marco_x@solarturbines.com

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



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



SIEMENS

Siemens Turbomachinery Equipment GmbH,
Postfach 17 28, D-67207 Frankenthal

Krishnan Umamaheswar, LEED AP, CEM, CDSM
U.S. DOE Gulf Coast Clean Energy Application Center
Research Scientist, Houston Advanced Research Center (HARC)
4800 Research Forest Drive
The Woodlands, Texas 77381

Budget-Offer 118224-1A

Date	15.12.10
Contact	Joseph C. Gelineau
Telephone	+1 (281) 856 4514
Telefax	+1 (281) 856 4499
E-Mail	joseph.gelineau@siemens.com
Mobile	407 619 7783

Reference: Austin Tech

Dear Krishnan,

We thank you for your enquiry for the a.m. project. Please find below a **non-binding budget offer** based on our "Siemens Energy Inc. Selling Policy 1000, dtd 1 May, 2005 ".

If we can be of any further assistance, please do not hesitate to contact us.

Kind regards,

Joseph C. Gelineau
Siemens Energy Inc.

Since November 2006 KK&K is part of Siemens, integrated into the Division Oil & Gas within the Sector Energy

1.1 Scope of supply

SIEMENS TURBINE SST-110 (former TWIN CA56)

This turbine type comprises two separate steam cases connected to one integral, single stage, two pinion parallel shaft gearbox with central bull wheel at the gear exit.

Both turbine rotors are made of a customized turbine wheel, positively located by a Hirth-toothed coupling and clamped in position by a profiled tension bolt, and a shaft. A controlled extraction of process steam between the HP-part and the LP-part is possible without additional cost.

1.1.1 Steam part A

Turbine casing
The casing is supported from the bearing casing via a centerring which permits radial movement freely under the influence of temperature. The vertical split allows easy access to the turbine wheel.

1.1.1.1.1 **Turbine wheel**
Radial flown (Ø455mm Curtis wheel) and mounted to the shaft in overhung design.

Inlet valve
Is a quick-acting trip valve.

1.1.2 Steam part B

Turbine casing
The casing is supported from the bearing casing via a centerring which permits radial movement freely under the influence of temperature. The vertical split allows easy access to the turbine wheel.

1.1.2.1.1 **Turbine wheel**
Axial flown and mounted to the shaft in overhung design. The blades are milled of the solid disk (Ø600mm).

Inlet valve
Hydraulically-actuated combined governing and quick-acting trip valve

1.1.3 GEARBOX

The integrally gearbox is designed and manufactured in SIEMENS workshop acc. to DIN 3990 with gear of single helical gearing type. The hydrodynamic sleeve bearings are forced-oil lubricated. Ground gearing, combined with contact pattern adjustment during assembly, guarantees extremely low vibration levels and low noise. The gearbox housing (material GG25) is horizontally split and allows easy inspection of gears and bearings.
The 2 turbine wheels are mounted onto the pinion shafts by a self-centering Hirth-toothed coupling.

1.1.3.17 Resistance thermometer PT 100 on each gearbox bearing insert, wired to a junction box fitted on the base frame

1.1.4 **OIL SUPPLY SYSTEM**

STE provides the complete lubrication and control oil supply. Designed acc. to Siemens standards it is integrated in the turbine base frame and comprises essentially:

Oil reservoir in carbon steel which allows an oil retention time of more then 3 min

Hydraulic rack with pressure/temperature gauges, overflow valves etc.

Sight glass for oil level indication

Single oil cooler for fresh water (design, manufacturing and testing in accordance to the relevant DIN standards and AD-Merkblätter)

Duplex oil filter (filter mesh 25 µm) with changeover valve and visual fouling indicator

Oilpiping up- and downstream of oil filter in carbon steel

Mechanically driven main oil pump (integrated into gearbox / shaft driven / 100% flow)

Auxilliary oil pump (1 pc. / 100% flow) with electric motor connected to 460 V / 60 Hz / 3 phase

1.1.5 **BASEFRAME**

Below the turbine/gear the oilreservoir is designed as a baseframe for mounting on customer's foundation

1.1.6 **TURBINE CONTROL**

1.1.6.1 **Turbine governor**

The turbine is equipped with an electronically governor (SIEMENS SC900), which is keeping the speed or frequency of the driven equipment constant. The compact design enables mounting in a standard 19“ rack.

Technical details:
- Protection class IP00
- NEMA class D
- Supply voltage 24V DC
- Profibus DP interface
- binary + analogue I/O

1.1.6.3 **Over speed protection**

The separate trip device is protecting against over speed independent from the regulation, by means of a separate speed pickup.

Budget-Offer 118224-1A

Testing of the complete tripping line is possible without interruption of operation.

Conditions for trip:
- overspeed
- excess acceleration over a limit
- incomming emergency shut-off signal
- trip condition on speed governor

1.1.11 **COUPLING**

Flexible coupling between gearbox and driven equipment including guard.
Designed according to torsional analysis.

1.1.12 **COATING / PRESERVATION / PACKAGING**

1.1.12.1 **Prime coat**

Surface preparation acc. DIN EN ISO 12944-4.
parts < 140°C: TEKNODUR PRIMER 3422; dry layer > 80µm
parts > 140°C: LUBERPOX special zinc dust paint IGO1.751
Colour RAL 7001 (silver grey); dry layer > 50µm

1.1.12.2 **Top coating**

Dry layer thickness (incl. prime coat) > 150µm
parts < 140°C: TEKNODUR 9204, RAL 5002 (ultramarine blue)

1.1.12.3 **Preservation**

Appropriate for short time storage of 6 months between delivery and erection, in light industrial atmosphere, indoor.
Outside under roof, a duration of more than 2 months should not be exceeded.

1.1.13 **STANDARD ACCESSORIES**

1.1.13.1 Conical steam strainer for installation in the live steam pipe (supplied loose)

ACCESSORIES

1.2.1 SYNCHRONOUS GENERATOR

of self-exciting, self-regulation, brushless configuration. It is a salient pole type with fully interconnected damper bars (for stable parallel operation, transient performance, load imbalance or any other load variations encountered), three phase exciter armature and rotating diodes. An electronic voltage regulator regulates the excitation of the exciter.

Rated power		8100 kVA
Rated power factor		0.8
Rated voltage		13.8 kV
Rated frequency		60 Hz
Rated speed		1800 rpm
Connection		Star + N
Efficiency	4/4 load	96.8 %
	3/4 load	96.5 %
	2/4 load	95.5 %
	1/4 load	92.3 %
Mounting		IM B3
Enclosure		IP44 R
Cooling		IC31 - Self cooled, with flanges in fresh air and exhaust air for ventilation ducts
Bearings		Sleeve bearing
Lubrication		Pressure oil lubrication
Ambient temperature		40°C
Insulation class		F, temperature rise acc to class F
Altitude		up to 1000m above sea level

All generators are equipped with thermal protection: 6xPT100 sensors in the stator winding, 1xPT100 per bearing in the bearings, anti-condensation heater and (water cooled types) leakage detection device.

1.2.2 LOCAL PANEL

with following features:

- Speed indicator
- Switch for "Electric oil pump ON/OFF"
- Switch for "Turbine START/STOP"
- Switch for "Triptest"
- Button for "Emergency Stop"
- Signal lamp "Turbine ready"

1.2.3 CONTROL / PROTECTION PANEL

Design: metal enclosed cubicle, for floor mounting with front doors (RITTAL TS8) Protection IP42 acc. EN 60 529, Indoor use (up to +40°C, 70% humidity) The entire switchboard is ready assembled wired and tested for connection at

site.
H*D: 2000*600 mm; Assumed Width: 3 Fields*800mm;
Plinth and cable entry as you like.

OP: Operator panel SIMATIC MP277 (10 inch) with TFT colour display and touch operation for control and visualization tasks.

Control: Turbine speed/Frequency
Inlet-, extraction- or exhaust pressure (on demand)
Power limiter (on demand)

Mains- and generator-protection: The mains- and generator protection is incl. all necessary components acc. to the VDEW ("Verein deutscher Elektrizitätswerke" = association of German electric utilities) standards. A voltage vector surge supervision is foreseen. With medium voltage applications an earthfault relay and with sizes >1200 kW a differential protection relay is applied.

Control circuits: generator anti-condensation heater
Electrical oil pump
If applicable: Oilheating, Air-Oilcooler, Noise hood,….

Monitoring: Temperatures acc. Interlocking scheme
Pressures acc. Interlocking scheme.

Communication: PROFIBUS DP-Interface as slave for client's distributed control system (DCS). Other interface on demand.

Synchronising: LED synchroscope with synchronizing check relay.

PLC unit: PLC unit SIEMENS S7-300 for applications in the upper performance range with medium quantity framework and I/O interface.

Additional equipment: Instrument, displays,…

Control voltage: control battery 24V lead acid type, maintenance free, capacity 60Ah

Teleservice: To help you on request we need telephone connection, which you can connect on demand.

Field cabeling: Cabeling between turbine and control panel is to be done by customer. Wiring diagram/plan is included in scope.

1.2.4 **Automatic drain valves**
for inlet- and exhauststeam (supplied loose)

1.2.5 Intermediate piping between HP-part and LP-part (loose supply)

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1.2.6 Cyclone-type steam separator for installation in the live steam pipe (supplied loose).

Operating points SST-110 (former TWIN CA56)

for driving a: Generator

	1	2	3	4	5
	Main datas	Extr.		Main datas	Extr.
Turbine part A					
Inlet pressure	650 psig	650 psig		45.80 bar(a)	45.80 bar(a)
Inlet temperature	750 °F	750 °F		399 °C	399 °C
Exhaust pressure	95 psig	95 psig		7.55 bar(a)	7.55 bar(a)
Exhaust temperature	435 °F	435 °F		224 °C	224 °C
Enthalpy	2,893 kJ/kg	2,892 kJ/kg		2,893 kJ/kg	2,892 kJ/kg
Turbine speed	14,294 rpm	14,294 rpm		14,294 rpm	14,294 rpm
Mass flow	85,500 lb/hr	85,500 lb/hr		38,790 kg/h	38,790 kg/h
Turbine part B					
Inlet pressure	93.5 psig	93.5 psig		7.45 bar(a)	7.45 bar(a)
Inlet temperature	435 °F	435 °F		224 °C	224 °C
Exhaust pressure	8.7 psia	8.7 psia		0.60 bar(a)	0.60 bar(a)
Exhaust temperature	186.8 °F	212 °F		86 °C	100 °C
Enthalpy	2,569 kJ/kg	2,680 kJ/kg		2,569 kJ/kg	2,680 kJ/kg
Turbine speed	11,571 rpm	11,571 rpm		11,571 rpm	11,571 rpm
Mass flow	85,500 lb/hr	43,475 lb/hr		38,790 kg/h	19,720 kg/h
Performance					
Outlet speed	1,800 rpm	1,800 rpm		1,800 rpm	1,800 rpm
Output at coupling	6,630 kW	4,391 kW		6,630 kW	4,391 kW
Power at terminals	6,410 kW	4,245 kW		6,410 kW	4,245 kW

Dimensions

	Turbine part A - casing		Turbine part B - casing	
Inlet flange ANSI	DN 6	PN 900	DN 12	PN 400
Exhaust flange ANSI	DN 14	PN 150	DN 24	PN 150

Sound pressure level

Octave/LP(A)	31.5 Hz	0.0 dB(A)
	63 Hz	47.5 dB(A)
	125 Hz	60.6 dB(A)
	250 Hz	73.5 dB(A)
	500 Hz	75.8 dB(A)
	1000 Hz	79.0 dB(A)
	2000 Hz	80.3 dB(A)
	4000 Hz	80.0 dB(A)
	8000 Hz	78.0 dB(A)
	16000 Hz	0.0 dB(A)
Total level		86.1 dB(A)

Measuring surface factor 15dB
measured at 1m distance from the surface; tolerance +3 dB(A); turbine without driven machine or separate gear

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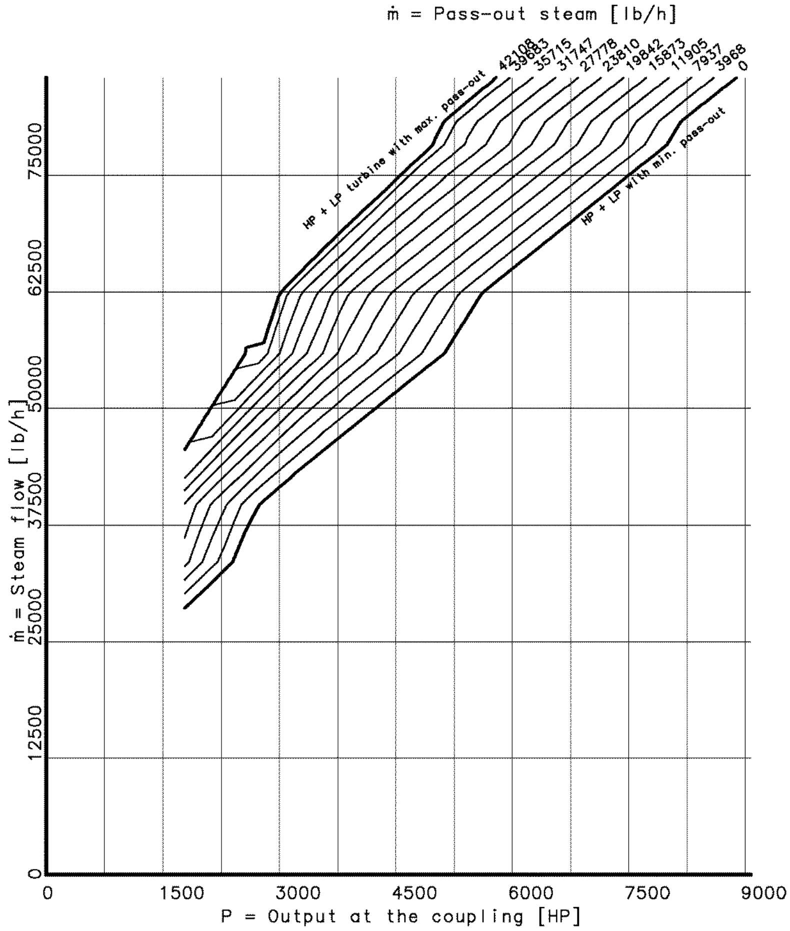
DAMPFENTNAHMEDIAGRAMM
STEAM PASS-OUT DIAGRAM

Kunde Client		Nummer Number	118224 /118224
Projekt Project	Austin Tech	Maschinen-Typ Machine-Type	SST-110(CFR5 AFA6 GT6)



Max. Abdampftemperatur Max. Exhaust steam temp.	694.8 / 651.2 deg F		14:37:36
Frischdampfdruck Live steam press.	664.24/ 108.05PSI	Abdampfdruck Exhaust steam pressure	109.50 / 8.702 PSI
Frischdampftemperatur Live steam temperature	750.2 deg F	Betriebsdrehzahl Operating speed	1800 rpm

Druckangaben in PSI sind Absolutdruecke

Pressure indications in PSI are absolute values

Datum Date 14-DEC-10	Name Drawn by ZIP	Gepr. Checked by	Norm Checked by
Zeichnungsnummer Drawing number			
Blatt Sheet	von of	Blatt Sheets	

Siemens Turbomachinery Equipment GmbH

1.3.2.1 **Mechanical test run at SIEMENS workshop**

Before leaving the workshop, each turbine undergoes a mechanical no-load test run.
There the order related controller setup is done and recorded. Also the function of the oil system, over speed protection mechanisms, the emergency stop and further systems is examined.

After reaching the equilibrium the turbine is operated 1 hour with rated speed. At the end of this continuous test further data, like temperatures and vibrations, are recorded.

1.3.2.2 **DELIVERY**

FOB acc. Incoterms (2000). The scope of supply will be packed and transported to the named location. The exact date will be announced in a advise of readiness for dispatch.

1.3.2.3 **Packing**

Plastic foil and wooden case acc. to Siemens' standard for transportation with higher demands.

1.3.3 **DOCUMENTATION**

The following documents are in our scope of supply:

- P&I diagram	12 weeksafter order date
- Installation drawing	12 weeksafter order date
- Interlocking diagram	12 weeksafter order date
- Operation manual 1x paper / 1x electronic Language: English	...after order date
- Steam flow / performance diagram	4 weeksafter order date
- Steam quality requirements	4 weeksafter order date
- Installation guidelines	4 weeksafter order date
- Operation chart for erection and start-up	
- Operating data sheet	6 weeksafter order date
- Flange connection sizes	6 weeksafter order date
- Test run description	6 weeksafter order date
- Quality assurance plan	12 weeksafter order date

Required steam quality for turbine operation

Conductivity at 25°C in the condensed sample measured according to highly acidic cation exchanger and CO2 removal	< 0,2 µS/cm in continuous Operation (cont. operation)	
- Silica (SiO_2)	< 0,02 mg/kg	during cont. operation
- Total Iron (Fe)	< 0,02 mg/kg	during cont. operation
- Sodium + Potassium (Na + K)	< 0,01 mg/kg	during cont. operation
- Copper (Cu)	< 0,003 mg/kg	during cont. operation
- Oxygen (O_2)	< 0,02 mg/kg	during cont. operation
- Chloride (Cl^-)	< 0,01 mg/kg	during cont. operation
- pH Value	9,2 - 9,6	during cont. operation

The steam quality must be absolutely dry under any circumstances (x=1 in the h-s-diagram), which means that an effective drop and dirt separator (i.e. a cyclone) should be installed into the live steam pipework.
Allowance must be made for non-steady state operating condition such as the start-up of the boiler.
If an effective drop and dirt separator is not installed at site or the installation becomes non-functional, any liability claim for corrosion-erosion damage to the turbine is inadmissible.
All other chemical elements or compounds in steam are not permissible.

Relevant Codes and Standards

DIN (German Industrial Norm), EN (European Norm), ISO (International Organization for Standards), VDI (Association of German Engineers), IEC (International Electro-technical Commission), VDE (Association of German Electrical Engineers)

- DIN 4312 (Construction of Steam Turbines)
- DIN 3960, 3961/62, 3990 (for Gearing)
- DIN 1943 (Acceptance Test of Steam Turbines)
- DIN EN 563 (Safety of machinery – Temperatures of touchable surfaces)
- DIN ISO 1940 (Mechanical vibration – Balance quality requirements of rigid rotors)
- DIN ISO 10816 (Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts)
- VDI 2059 (Shaft vibrations of turbosets)
- AD-Merkblätter (calculation, manufacturing rules and testing of pressure parts)
- ANSI / AGMA 2101 - C95 (Fundamental rating factors and calculation methods for involute spur and helical gear teeth)
- NEMA SM 23 (National Electric Manufacturers Association, Steam turbines for mechanical drive service)

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The following materials and services are not included (unless otherwise stipulated)

- Any pipe work or valves outwith the respective turbine terminal flanges, check valves, non-return valves, compensators or insulation
- Cooling water supply or return pipe work, including valves, for the oil cooler
- Safety relief valves in the steam pipe work
- Calculation or design of the foundation
- Excavation, civil or joinery work
- Building, lubricating, cleaning materials or fuel
- First fill of lubricating oil
- Provision of any measures for absorbing substances hazardous to waters
- Installation or commissioning of the plant, as well as steam costs for the trial run (see erection quotation)
- Lifting gear, erection scaffolding, means of transport or consumables (water, air, electricity) needed for installation
- Any costs for official material-, inspection- or acceptance-tests, including preparation for acceptance tests, insofar as these are not specified
- Electrical interconnecting cabling or devices.
- Provision of any qualified/ specialist support personnel (e.g. bricklayer, electrician or similar craftsmen) for the specified duration and in the number required for the erection.
- The support personnel should follow the instructions of the erection supervisor.
- SIEMENS accepts no responsibility or liability for the support personnel
- Design of any civil works involving excavation, building/ structures, concrete or scaffolding including the supply of any construction materials therefore
- Provision of any heating, lighting, power supplies or water including any supplies necessary to the installation or for the subsequent operation
- Protection of the erection parts and material against damage or injury of any kind
- Provision of any materials or preparations of any kind needed for the completion of the testing which may be otherwise contractually required

Budget-Offer 118224-1A

PRICING:

Qty.	Description	Pos.	Price
1	Siemens Steam Turbine SST-110 (former TWIN CA56)	1.1	Incl.
1	TWIN Gearbox	1.1.3	incl.
1	Oil supply unit	1.1.4	incl.
1	mechanical main oil pump	1.1.4.4	incl.
1	auxilliary oil pump with electric motor	1.1.4.5	incl.
1	Electronical governor SC900	1.1.6.1	incl.
1	Overspeed trip device	1.1.6.3	incl.
1	Flexible coupling	1.1.11	incl.
1	Synchronous-Generator 8100 kVA, 13.8 kV, 60 Hz, IP44 R, Sleeve bearing	1.2.1	incl.
1	Local panel	1.2.2	incl.
1	Control-/Protection Panel (incl. PLC Siemens S7, mains- / generator-protection, synchronizing unit)	1.2.3	incl.
1	Automatic drain valves for inlet- and exhaust steam (supplied loose)	1.2.4	incl.

Total budgetary lump sum price(U.S. Dollars) $ 2,376,000.00

Incoterms (2000): FCA Bremerhaven, Germany (INCOTERMS 2000)

Ready for delivery: 10 months

Payment: to be clarified

Warranty 12 months from start-up,
latest 18 months from readiness for dispatch

Limits of supply:
Flanges of turbine, Top of foundations, Terminal boxes of turbine auxiliary equipment

Not included are:
First fill of oil, foundations, cabling between turbo generator and board or other connections, interface installation to other supervision units

Remarks:
The a.m. delivery time is preliminary. The final delivery time will be scheduled during the negotiation.
The a.m. price is net, excluding VAT or similar turnover tax.

Precedence of Conditions:

Budget-Offer 118224-1A

This offer is based on the “Siemens Energy Inc. Selling Policy 1000, dtd 1 May,2005” copy provided.

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VALIDITY

This present quotation is a budgetary quotation only and is as such without engagement and subject to change without prior notice. All provisions are subject to negotiation and final approval by Seller. As a result we also don't provide for any validity in our bid, as it isn't firm anyway.

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Pre-Designed Steam Turbines

Mechanical drives and turbogenerators from 45 kW up to 10 MW

Power Generation Oil & Gas and Industrial Applications

SIEMENS

Experience You Can Trust

Tandem turbogenerator delivering an electrical output of 4,000 kW in a co-generation facility

Industrial applications served by Siemens Pre-designed Steam Turbines from 45 kW up to 10 MW	Waste disposal	Biomass	Co-generation	Gas expansion	Waste heat utilization	Mechanical power supply	ORC / Geothermics
Chemicals	■		■	■	■	■	
Petrochemicals /Refinery			■	■	■	■	
Power supply		■	■	■	■	■	■
Waste disposal	■						
Metallurgy / Steel			■	■	■	■	
Wood processing		■					■
Papermaking			■	■			
IPP / Contracting	■	■	■	■	■		■
Equipment fabrication	■	■	■	■	■	■	■
Driven machines						■	
Sugar industry			■			■	
Palm oil industry	■	■	■			■	
Textile industry			■	■			
Foodstuffs processing			■		■		
Marine / Offshore					■		
Gas industry			■	■			

Examples

Pre-designed Steam Turbines: System Solutions

Do you require process heat in the form of steam for your manufacturing operation? Or would you like to tap the energy potential of available waste heat flows? For such requirements, we can provide the following:

- Turbine components matched to your specific needs and expectations
- Many years of experience in advising customers and implementing complete turbine installations, e.g., for co-generation, waste disposal or waste heat utilization applications

Your benefit: Proven and cost-efficient turbine solutions that will reduce your electricity bill dramatically while enabling you to obtain process steam.

The high quality of our turbine technology, and the trust placed in us by our satisfied clientele, have been demonstrated in a diverse range of applications.

We are committed to providing our customers with comprehensive advice and support in all project phases.

The following examples from our services portfolio attest to this ambition:

- Advice to match your requirements on machine design and possibilities for integrating our steam turbines into your application environment
- Determination of space needs before the start of fabrication
- Installation and commissioning carried out exclusively by experienced specialists
- Personnel training in turbine operation and maintenance
- Storage and shipping logistics geared to ensure rapid availability and fast spare part supplies
- Assistance in the form of economically priced status analyses throughout the equipment's service life

Complete turbine installations – the easy way to superior cost efficiency

At your request, we can supply your steam turbine with all requisite ancillary equipment such as

- Transmission(s)
- Driven machinery (pump, compressor, generator)
- Condenser
- Monitoring and control systems

Having determined the right turbine size on the basis of your requirements, we can design and build the entire turbine installation right down to its handover, ready for service. All equipment characteristics will conform to DIN 4312 and meet key specifications of API 611/612.

We can also take care of issues such as a torsion analysis of the overall system, foundation ratings, and support with the integration of turbine controllers into an overall process management system

Steam turbine AFA 4 G5a as a gas expansion turbine in a German electricity supplier's plant

Arguments in Favour of our Steam Turbines

Steam turbine TWIN-AFA 66 turbogenerator in a co-generation plant delivering an electrical output of 3.7 MW

- Low investment cost
- Optimized price/performance ratio
- Highest availability and minimal maintenance needs thanks to straightforward, time-tested design
- Very good part-load performance and broad load range due to nozzle group control
- Fast start-up capability from cold to fully operable state
- High degree of automation
- Outstanding user friendliness and ease of operation
- Low space requirement
- Minimum foundation needs
- Service life in excess of 25 years
- Fast, economically priced siemens-service

Siemens Pre-designed Steam Turbines Technology Realizes Savings Potentials:

EUR 100,000 p.a.* through steam expansion

E.g. Food processing operation

Use of reducer stations to expand steam from the medium-pressure saturated state to 3-bar and 6-bar mains system level.

Our solution with turbogenerator set

Turbogenerators were arranged in parallel with the reducer stations. Expanding steam in these turbines produces an additional 500 kW of electrical power by co-generation.

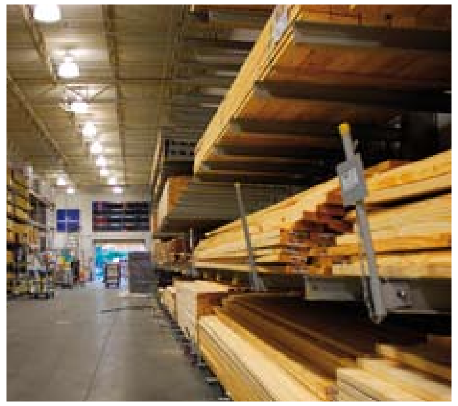
EUR 960,000 p.a.* through power generation

E.g. Wood processing plant

Generation of process steam for impregnation, heating and drying - with supply of power into the public grid.

Additional gains with two turbogenerators

Two turbogenerators delivering 2.4 MW were installed, both supplying power into the public grid. Thanks to automatically actuated nozzle group valves, these units achieve high efficiencies even in part-load operation.



EUR 450,000 p.a.* through waste heat utilization

E.g. Glassmaking

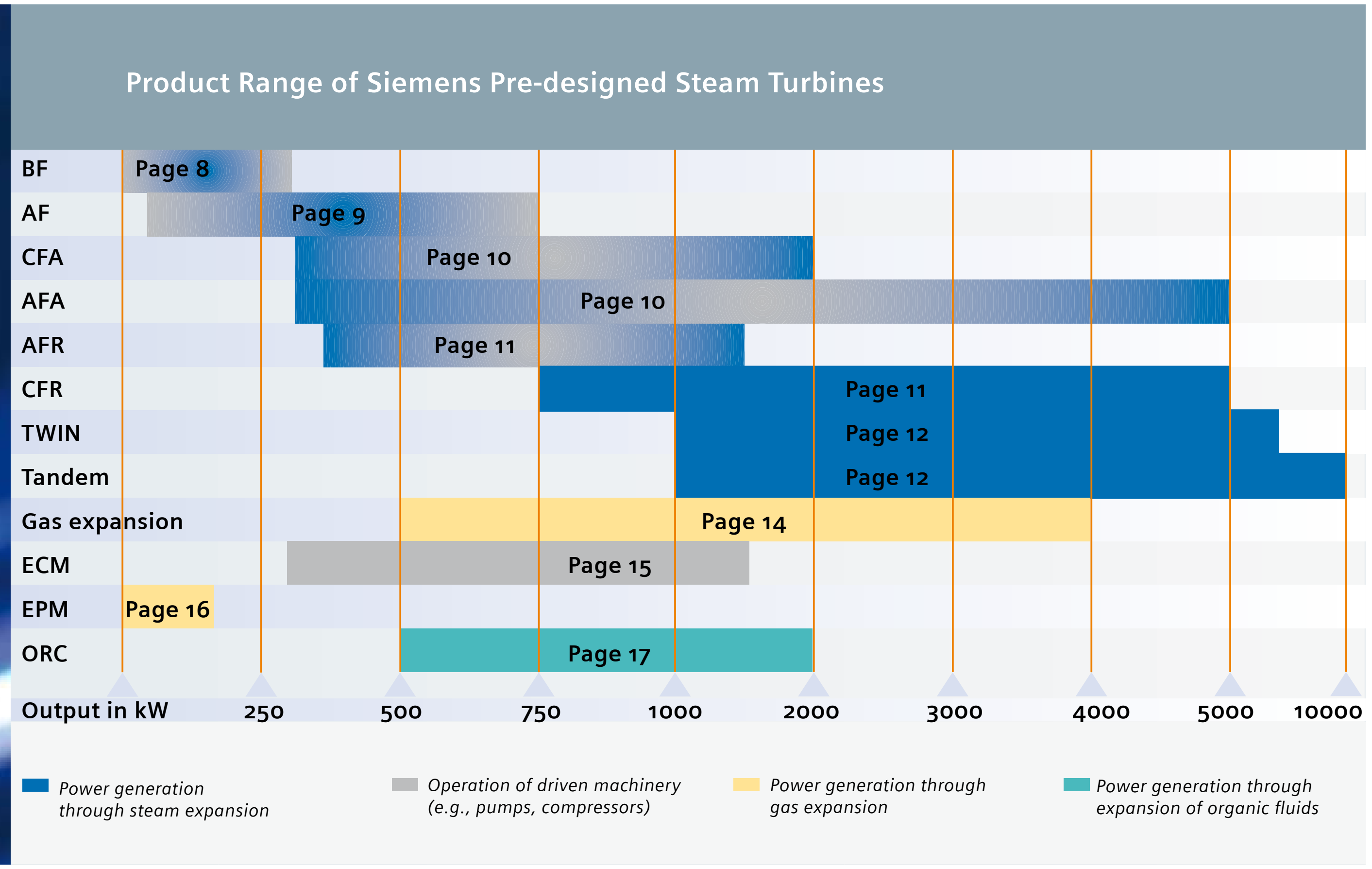
Large amounts of high-temperature waste heat are available from the heated glass tank

Combination solution with waste heat boiler and a Siemens steam turbine

A waste heat boiler supplies high-pressure steam to a 1.6-MW turbine.
At 8,000 operating hours per year, electricity costs are reduced by EUR 1.0 million!
The costs of this combination solution were recovered within 2 years.

** Actual savings may vary depending on specific equipment characteristics.*

Siemens Pre-designed Steam Turbine Technology



Characteristic data and ranges of our turbines:
Live steam temperature (dry, saturated): up to 530 °C
Power range: 45 kW up to 10 MW
Outlet steam pressure: 0.08 to 29 bar abs.
Live steam pressure: 3 - 131 bar abs.
Speed: 500 - 23000 r.p.m.

Thanks to our unrivalled technological expertise, our steam turbines are noted for an array of outstanding features:

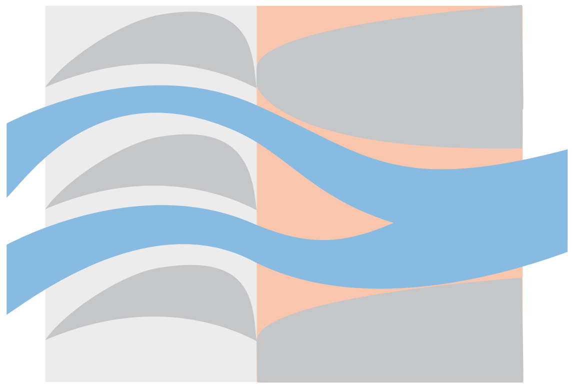
- Custom turbine design based on modular flexibility
- High energy efficiency through innovative multi-stage technology, high volume flows and small enthalphy differentials
- Broad output range
- Simple and rugged, long-life design

Operating principle of Siemens Pre-designed steam turbines

The turbines operate on the impulse principle. The incoming steam is expanded in the nozzles, resulting in a conversion of thermal energy into kinetic energy. The latter is in turn transformed into mechanical energy as the steam flow is deflected by the impeller blades.
From the impeller, energy is passed to the driven machine or generator via a gear transmission unit and coupling.

Quick start capability

The special configuration of the runner bearings permits an extremely fast start-up from cold to full operating r.p.m. As a result, our turbines are suitable for both continuous service and frequent start-up/shutdown cycles. The start-up time is limited by the mass moment of inertia of co-rotating parts and/or by the boiler's operating characteristics. A high degree of operating safety and ease of maintenance reduce operating costs substantially.



Turbine shaft and impeller

The turbine shaft with its impeller consists of one integral forging. Each of these components is subjected to 100% testing using ultrasound and magnetic particle methods to demonstrate its freedom from flaws.
As a general rule, the turbine shaft and impeller operate rotodynamically between the first and second natural bending frequency. The unit runs very smoothly thanks to its dynamic self-centering action in this range.
The rotor can be mounted in small-diameter bearings so that lower peripheral speeds benefit the turbine's service life.

Siemens Pre-designed Steam Turbines: Our Series

BF

BF – standby turbine with quick-start capability for up to 300 kW

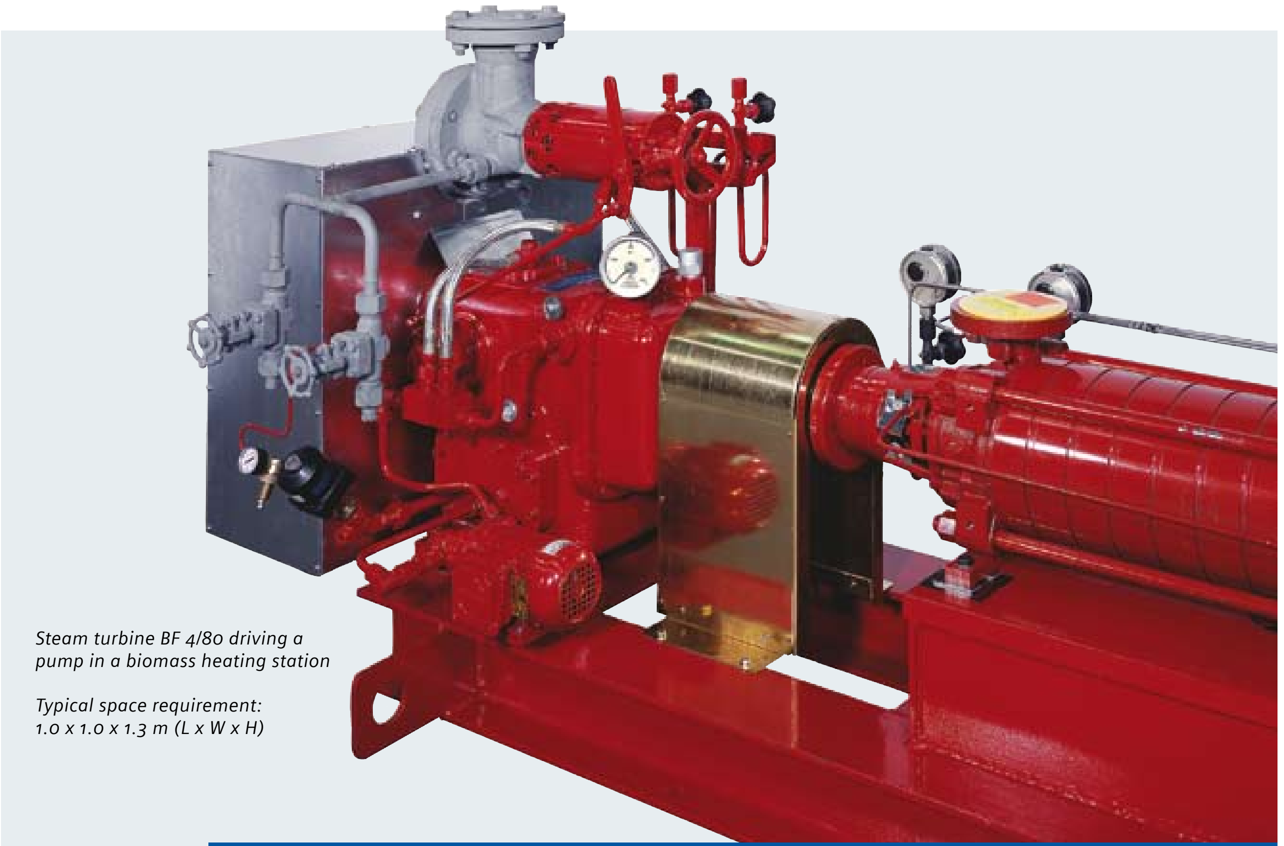
BF turbines are single-stage, direct drive, back-pressure steam turbines in which the flow passes axially through the blading.
The impeller, nozzle system and shaft gland seal are easy to reach.
Similarly, all transmission components are readily accessible for maintenance.

This BF series steam turbines come with an all-hydraulic speed governor as standard. A mechanical trip device protects the turbine against overspeeds.

All pressure-loaded parts are extensively tested, and each turbine is subjected to a trial run before delivery.

BF turbines are typically used as a stand-by unit, e.g., for feedwater supply in power stations.

- Frequent start-up and shutdown
- Quick-start capability
- Straightforward, low-maintenance design
- Horizontal installation
- Vertical installation is supported by Type 3.5 units
- Single-ring turbine rotor
- Axial through-flow
- Direct drive or equipped with transmission



Steam turbine BF 4/80 driving a pump in a biomass heating station

Typical space requirement: 1.0 x 1.0 x 1.3 m (L x W x H)

Design size	BF 3.5	BF 4/80	BF 4/125
Output [kW]	45	250	300
Speed [r.p.m.]	4500	4500	4500
Live steam pressure [bar abs.]	101	46	26
Live steam temperature [°C]	500	500	430
Outlet steam pressure [bar abs.]	1-8	1-11	1-11

All data represent characteristic (maximum) values

AF

AF – standby turbine with quick-start capability for up to 750 kW

AF turbines are single-stage back-pressure steam turbines in which the flow passes axially through the blading. The impeller, nozzle system and shaft gland seal are easy to reach. Similarly, all transmission components are readily accessible for maintenance.

This AF 4 steam turbines come with a torsion bar speed governor as standard. Other governor systems can also be connected. A bolt-type trip device protects the turbine against overspeeds.

All pressure-loaded parts are extensively tested, and each turbine is subjected to a trial run before delivery.

AF turbines are used e.g. as a power source for pumps or fans.

- Frequent start-up and shutdown
- Quick-start capability
- Straightforward, low-maintenance design
- Horizontal installation
- Single-ring turbine rotor
- Axial through-flow
- Integral transmission for optimum load matching

Steam turbine AF 4 Gs driving a pump

Typical space requirement: 1.2 x 1.5 x 1.3 m (L x W x H)

Design size	AF 3,5 Gs	AF 4 Gs
Output [kW]	300	750
Speed [r.p.m.]	11000	10500
Live steam pressure [bar abs.]	101	101
Live steam temperature [°C]	500	500
Outlet steam pressure [bar abs.]	1-17	1-17

All data represent characteristic (maximum) values

Siemens Pre-designed Steam Turbines: Our Series

AFA, CFA

CFA – the solution for high-pressure steam expansion applications

AFA and CFA series turbines stand out by their rugged design and renowned reliability even under the most severe operating conditions.

AFA and CFA machines are ideal for saturated steam service. Their suitability for use as condensation or back-pressure turbines in combination with diverse transmission types opens up a broad application range.

- Curtis rotor (CFA) or axial wheel (AFA) made from solid material
- Direct-drive type or with integral single-stage spur gear unit
- Compact design
- High mechanical efficiency due to
  - Low number of bearing
  - Optimized runner diameter
  - Fitted blade height
- Automatic nozzle group control
- Quick start without turbine preheating
- Suitable for driving mechanical equipment or generators

Steam turbine CFR 3.5 G3a driving a pump set in a wood processing plant in Argentina (application: waste heat utilization)

Typical space requirement: 2.7 x 2.2 x 2.1 m (L x W x H)

Design size	AFA 3.5	AFA 4	AFA 6	CFA 4
Output [kW]	600	2200	6000	1600
Speed [r.p.m.]	13600	18000	11400	10500
Live steam pressure [bar abs.]	101	131	41	41
Live steam temperature [°C]	500	530	450	450
Outlet steam pressure [bar abs.]	1-17	0,08-25	0,08-11	1-17

All data represent characteristic (maximum) values

AFR, CFR

The optimum solution for back-pressure turbines up to 6 MW

Our AFR and CFR series combine all design features and advantages of the AFA and CFA lines.

- Radial Curtis rotor (CFR) or radial impulse wheel (AFR), both milled
- Direct-drive type or with integral single-stage spur gear unit
- Compact, space-saving design
- High mechanical efficiency due to low number of bearings
- Quick start without turbine preheating
- Automatic nozzle group control

Steam turbine CFR 5 G5a driving a generator in a wood processing plant.

Typical space requirement: 3.4 x 3.0 x 2.5 m (L x W x H)

Design size	AFR 3	CFR 3	CFR 5
Output [kW]	1500	2500	6000
Speed [r.p.m.]	24900	24900	16000
Live steam pressure [bar abs.]	65	65	65
Live steam temperature [°C]	480	480	480
Outlet steam pressure [bar abs.]	1-17	1-17	1-11

All data represent characteristic (maximum) values

Siemens Pre-designed Steam Turbines: Our Variants

TWIN

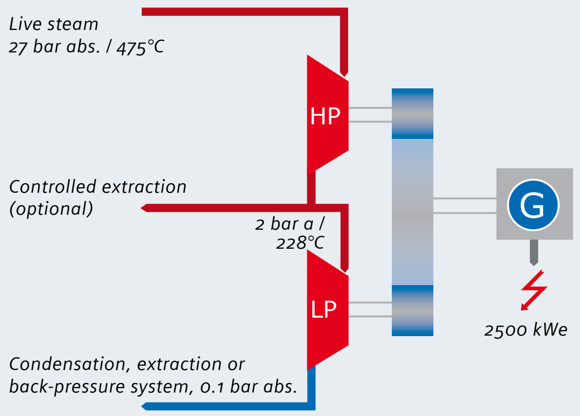
Multi-stage version for enhanced flexibility

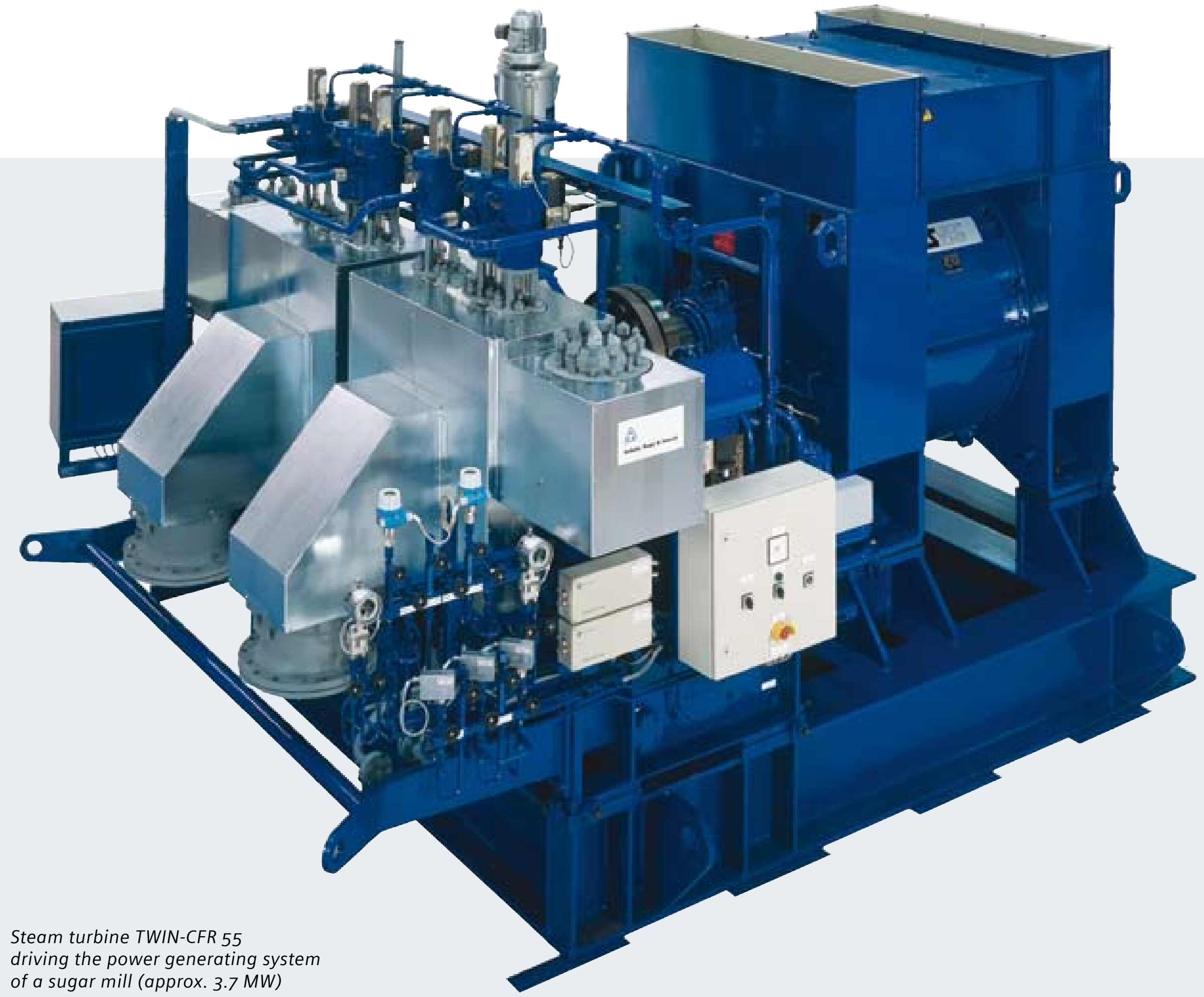
Our multi-stage TWIN versions are noted for their particular cost efficiency and high performance. Proven turbine technology is enhanced by adding a second steam section. Thanks to the integral transmission, the compact design of each machine is preserved.

TWIN versions allow you to reduce high heat gradients while providing a controlled extraction capability. It is also possible to run the two turbines on different steam supplies.

The versatility of our turbine range can be further increased through a combination of tandem and TWIN versions. Such turbine configurations provide a pressure-controlled supply for up to three steam systems.

Configuration example:





Steam turbine TWIN-CFR 55 driving the power generating system of a sugar mill (approx. 3.7 MW)

Typical space requirement: 3.6 x 2.4 x 2.8 m (L x W x H)

TANDEM

The universal combination for superior output

This turbine concept permits a quick, low-cost and space-saving expansion of each unit. Tandem is the two-in-one solution!

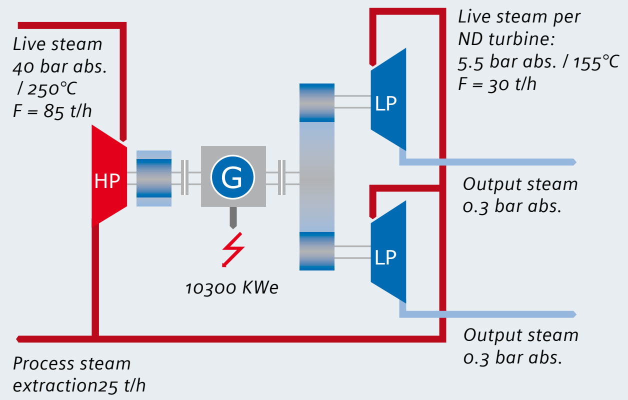
In this machine configuration, output is increased by simply adding a second turbine. The generator has two shaft ends and is placed between the low-pressure and high-pressure turbines. Electrical output can thus be boosted to as much as 10 MW.

An additional benefit of this tandem combination is that a controlled extraction feature, as required in co-generation heating plants, can be provided between the low-pressure and high-pressure units without additional cost.

At the customer's request we will design for a subsequent expansion already in the project phase even if only one turbine-generator set is initially installed.

- Reduction of high thermal gradients with good efficiency
- Pressure controlled supply for up to three steam systems
- Machines can be optionally supplied with an individual de-coupling capability for a flexible response to the customer's specific operating needs
- High flexibility through combination of individual steam turbine series

Configuration example:



Tandem system comprising one TWIN-AFA 66 and one AFA 6 G6a in a biomass heating plant

Typical space requirement: 9.0 x 4.0 x 3.8 m (L x W x H)

Siemens Pre-designed Steam Turbines: Our Variants

GET

Gas expansion with power generation up to 4 MW

Our gas expansion turbines are modified KK&K steam turbines from our standard range. Equipped with special gas seals and made of cold-tough materials where appropriate, these units are suitable for virtually all gases and temperature ranges. One typical application is the expansion of natural gas at transfer stations.

- Low specific price for minimum payback periods
- High availability due to straightforward technology
- Good efficiency even in part-load mode
- Low maintenance cost
- Simple, low-cost conversion to different gas pressures and volume flows
- Suitable for cold generation applications

The expansion of natural gas in conjunction with electric power generation is an ecologically and economically beneficial solution delivering electricity at low cost.

Steam turbine CFR 3 G5a designed as a gas expansion unit for a natural gas transfer station.

Typical space requirement: equivalent to our other steam turbine series

Design size	AFA	CFR
Output [kW]	4,000	4,000
Inlet gas pressure (abs.) [bar]	130	65
Inlet gas temperature [°C]	300	300
Outlet gas pressure (abs.) [bar]	26	20
Outlet gas temperature [°C]	-40	-40
Gas throughput [Nm³/h]	140,000	70,000

All data represent characteristic (maximum) values

EPM

Expansion Power Module

Gas expansion turbine for electric power generation

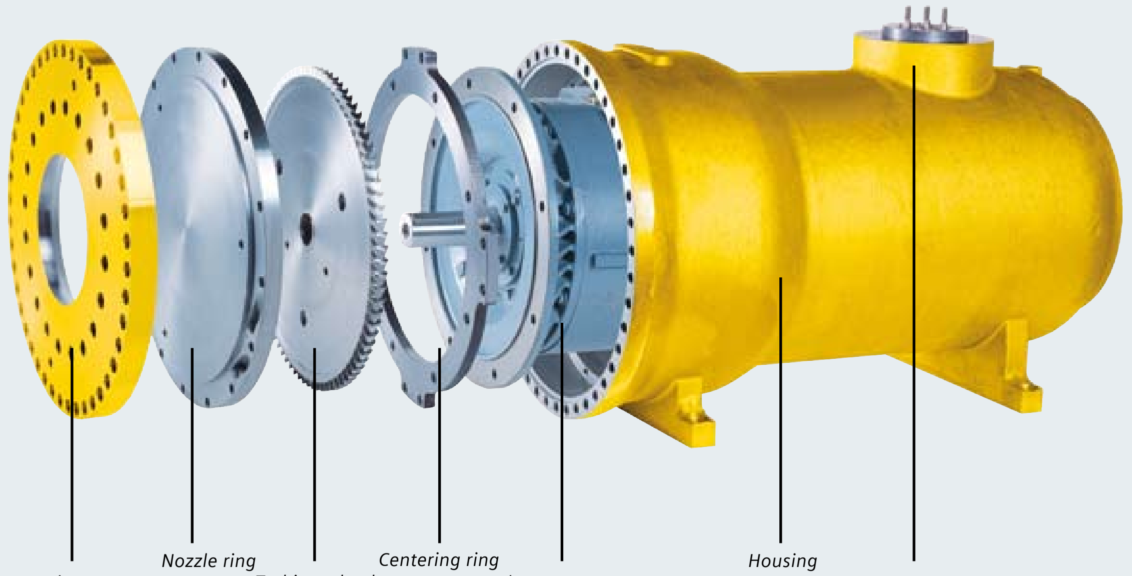
Expansion Power Modules (EPM) are compact turbogenerators designed to expand natural gas at gas pressure regulating stations. With an EPM system, electrical energy is produced instead of merely destroying the pressure difference in a reducing valve. At gas flow rates up to 15000 m³/h and gas pressures up to 70 bar, it is possible to achieve generator outputs of 110 kW while obtaining outlet pressures of between 1.1 and 25 bars.

The waste heat from the generator, which is fitted directly into the gas pipeline, simultaneously serves to heat the natural gas, thus reducing the energy requirement for preheating. Related to the additional energy input, EPM gas expansion turbines achieve electrical efficiencies up to 98.8%.

The benefits of their modular design, based on the use of standard components, are obvious:

- Low investment cost
- Retrofittable in existing installations
- Simple but highly power-efficient design (up to 110 kWe)
- Low maintenance needs and high availability
- Short payback periods even for small reducing stations
- Equipment technology provided by our partner companies

Typical space requirement: 1.2 x 0.8 x 0.9 m (L x W x H)



Siemens Pre-designed Steam Turbines: Our Variants

ECM

Expansion Compression Module

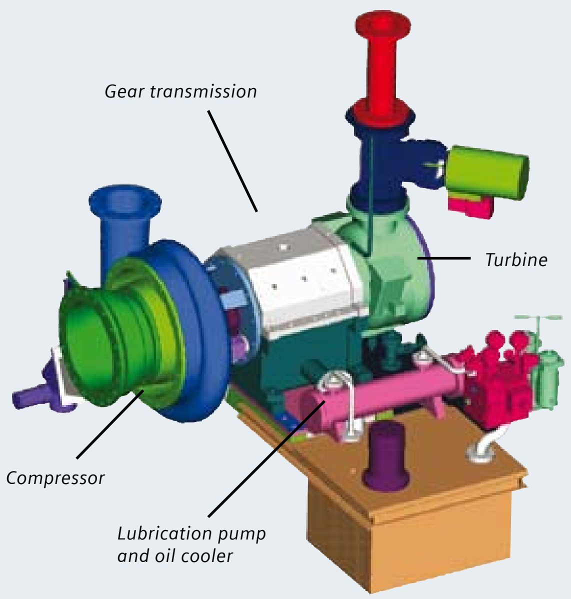
Directly coupled compressor-turbine combination for power inputs up to 1500 kW

Each Expansion Compression Module (ECM) is a unitized combination of a compressor and a steam turbine mounted on a single shaft without any intermediate coupling. Each module comes with all mechanical and electrical control components.

Modules are built from standard pre-designed steam turbine and compressor assemblies.

The units are supplied rated for specific application requirements and are ready for connection.

ECM
Typical space requirement: 2.2 x 2.0 x 2.6 m (L x W x H)



Expanded compressor & turbine combination options

Apart from ECMs we can supply a variety of integral compressor/turbine sets comprising compressors sourced from a member of our group and a driving turbine from our range.

Steam turbine AFA 6 Da driving a compressor for a refinery in Abu Dhabi

ORC

Organic Rancine Cycle

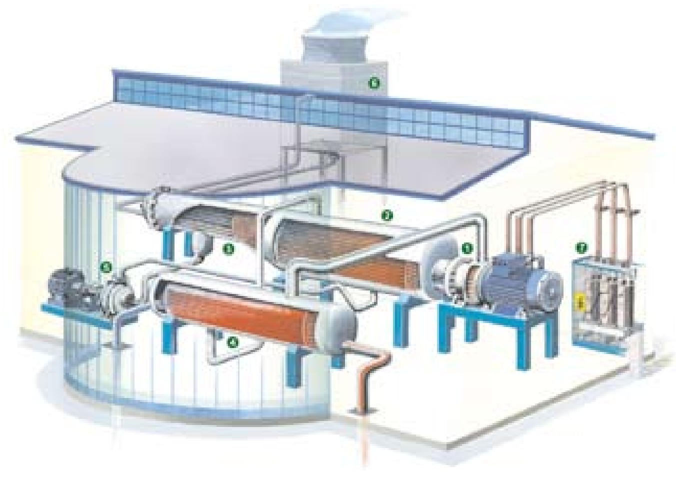
For applications involving the generation of electricity from renewable energies, e.g. geothermal systems in which heat is available at a low temperature level, we supply turbine technology that is based on steam power processes but relies on the use of organic operating media, i.e., the so-called organic rancine cycle (ORC).

In an ORC power system, a low-boiling organic operating medium circulates instead of water and ensures a maximum energy output at temperatures from 100°C upwards and pressures of less than 20 bar.

Our ORC turbines deliver electrical outputs of up to 1.5 MW and provide the same benefits as steam process systems (CRC).

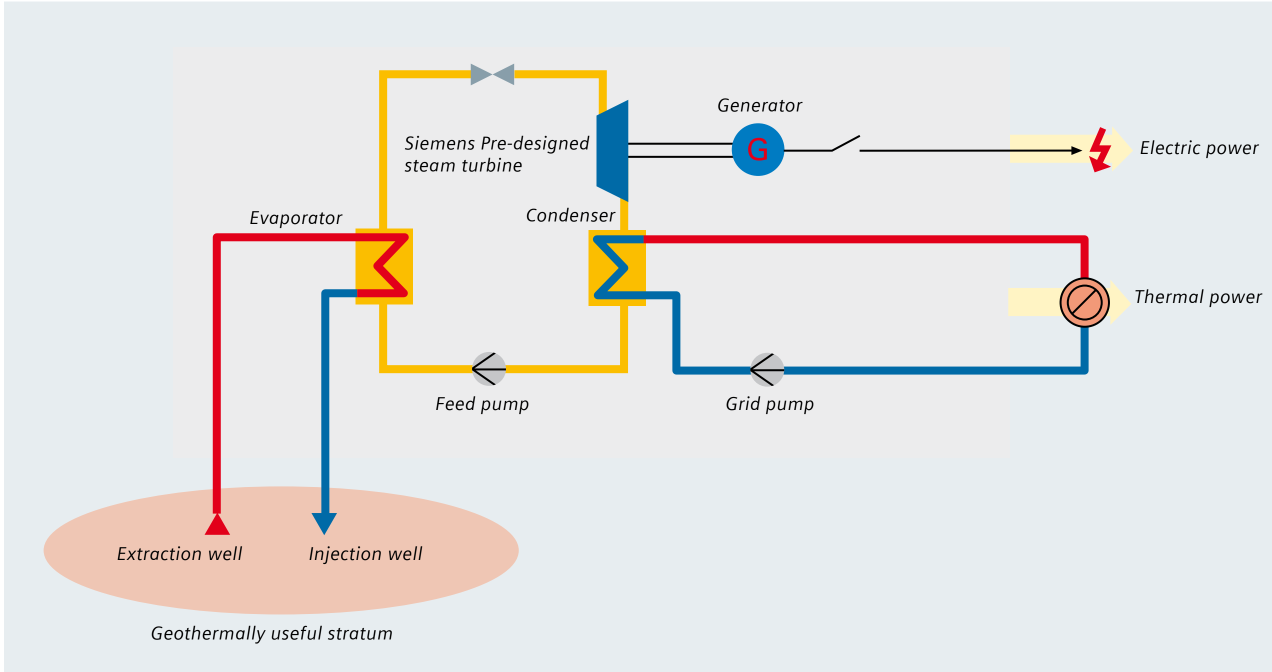
- Simple technology involving low piping and equipment pressure ratings
- Easy-to-automate process sequences
- High efficiency
- Reduced investment and operating costs
- Low maintenance and servicing requirements

We supply solutions for this application type in cooperation with our partner company, GMK of Rostock/Germany.



1 Turbine with generator		Power data in kW	
2 Recuperator		Evaporator	9,700
3 Condenser		Preheater	4,700
4 Evaporator and preheater		Recuperator	2,800
5 Cooling tower		Condenser	12,500
6 Grid coupling		Generator	1,900

ORC application: geothermal plant



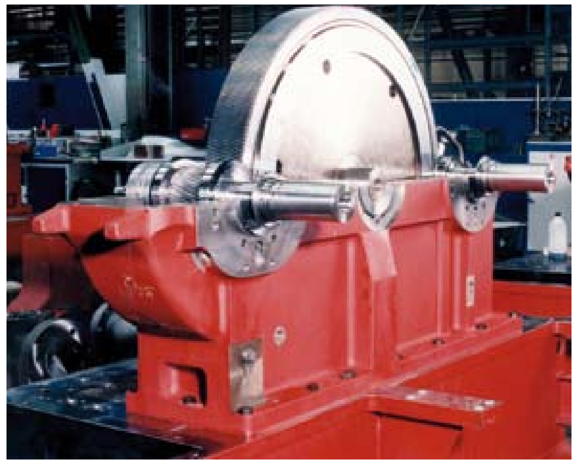
Gears and Electronics

Siemens Pre-designed Steam Turbines: Spur Gear Transmissions

We have accumulated many decades of experience in the fabrication of turbomachinery and transmissions. Over 12,000 transmissions built in-house by us have been delivered to satisfied customers to date.

Our single-stage spur gear units are capable of transmitting as much as 5 MW of power. Due to their rugged design, our transmissions can handle rotational speeds of up to 30,000 r.p.m. on the pinion shaft (depending on type) and are available with transmission ratios up to 1:17. Ground teeth, in conjunction with a correction of tooth contact surfaces during assembly, ensure maximum operating smoothness and very low noise output in service. Their high mechanical precision and maintenance-free sliding bearings allow these gear units to operate in both the subcritical and overcritical range.

- High flexibility despite modular standardization
- Matched turbine and transmission technology based on our system competence
- Independence from external transmission vendors thanks to in-house fabrication
- Adaptability to diverse turbine speeds ensures high efficiency
- Transmission design and rating conforms to DIN 3990 and is based on calculations performed by our own engineers
- High manufacturing precision for maximum service life
- Worldwide customer support



Model	G2a	G3a	G4a	G5a	G6a	TWIN
Centre distance	225	321	399	544	630	1088-1154
Rotational speed (wheel shaft, max.) [r.p.m.]	10,000	5,000	4,000	3,600	3,600	3,000
Rotational speed (pinion, max.) [r.p.m.]	30,000	30,000	30,000	30,000	30,000	30,000
Transmission ratio	1.6-6.8	1.6-10.0	1.6-12.8	1.6-14.9	1.6-17.7	1.6-14.9
Power rating (max.) [kW]	2,000	2,000	2,500	3,000	4,000	5,000
Weight [kg]	1,100	1,350	1,700	2,500	3,000	2,750
Length [mm]	1,020	1,170	1,345	1,620	1,790	1,900
Width (not including coupling stubs) [mm]	650	650	650	650	650	650
Height [mm]	955	925	1,000	1,145	1,240	1,145

Measuring – Control – Instrumentation
Our expertise for our steam turbines

Advanced electronic equipment contributes greatly to the performance of our turbine systems. We supply high-precision turbine control and monitoring technology. At the customer's request, we will advise on interfacing with overall process management systems or can supply the entire turbine visualization system.

The above-mentioned services are based on DIN, EN, VDE and VDEW codes and standards. Planning and implementation will be handled in accordance with our proprietary electrical engineering guidelines, taking existing customer specifications and national regulations into account.

Our range of electrical engineering products:

Terminal boxes, designed as
- Field interface boxes, mounted on equipment for termination of actuators and sensors

Local control panels/consoles for
- Operation/MMI
- Control
- Monitoring
- Signal transfer and bus interfacing

Switchgear cabinets/panels for
- Operating and indicating functions
- Closed/open-loop control (PLC)
- Measuring and monitoring
- Electrical protection of turbogenerators
- Turbogenerator synchronization
- Mains and generator circuit breakers for low and medium-voltage applications up to 12 kV
- Control and power supply for auxiliary drives
- Available in-house engineering
- Bus interfacing
- Remote maintenance

Operating and visualization stations

Manufacturing Cells

Advanced Production Technology with Quality Assurance

Our steam turbines are produced by the most advanced manufacturing technology in terms of both the equipment pool employed and the logistical control of all production workflows.

Component assembly or individual fabrication steps are performed or implemented in individual production cells operating on their own account.

The responsibility for organizing the specific process - e.g., planning, control, programming, resource management, manufacturing, testing and conveying - resides with the staff of each cell, whose key tasks specifically include quality control and time scheduling.

Given the high proportion of turbine components manufactured in-house, Siemens Pre-designed steam turbines achieve unsurpassed levels of quality and reliability.

Within this structure, optimized material flows and production workflows have given rise to the following key benefits:

- High content of „in-house" manufactured components in every product
- Competitive price levels through domestic production („made in Germany")
- Continuous expansion of know-how
- Maximum schedule reliability
- No dependence on external suppliers

Our advanced, quality-focused production approach finds its outward expression in clean-cut and functionally structured manufacturing areas incorporating neatly arranged storage facilities for parts, jigs and fixtures.

Our overall concept and ongoing effort to ensure unsurpassed manufacturing precision is further supported by

- preventive equipment maintenance
- coordinated repair strategies

Quality, Service and Contacts

Siemens Customer Support – Worldwide Reliability

Certified Quality and Safety – for Every Machine

Our DIN EN ISO 9001 certified quality management system, backed up by a KTA 1401 qualification certificate, attests to our high quality standards for its products and services.

Quality assurance and test/inspection processes

Methods employed for quality assurance include the following:

- Dimensional testing (3D measurement, shape and position measurement, surface roughness measurement)
- Electrical and mechanical run-out determination
- Leak and pressure tests
- Testing of mechanical properties
- Material identity tests, chemical analysis, X-ray inspection, ultrasonic testing, surface crack tests (magnetic and by dye-penetration method)

Mechanical test run during final inspection

Each fully assembled unit must pass a no-load mechanical test run at full r.p.m.

The customer benefits through reduced on-site commissioning times.

Labour safety and environmental protection

We address health and labour safety as well as environmental impact issues with the same meticulous care as product quality. This commitment has won us SCC certification.

Each turbine or installation enjoys full global support based on our comprehensive range of after-sales services:

- Fast spare part supplies
- Repairs and overhauls
- Conversion and upgrading projects
- Maintenance and on-site erection
- Malfunction and vibration analysis

The reliability of this service derives from the following factors:

- Support and execution by our own technicians
- As-built documentation of all turbine installations
- Advanced electronic aids and measuring technology
- Extensive know-how based on in-house fabrication
- Certified quality assurance

KK&K steam turbines:

Since November 2006 KK&K is part of Siemens, integrated into the division Oil&Gas and Industrial Applications.

Furthermore for the Customer support of our KK&K-machines the experienced experts are still available.

Individual agreements assure you of continuous maintenance support that will safeguard the longevity of your turbine equipment.

It may also be worth mentioning that we keep spare parts available for more than 30 years after the delivery of your machine.

Contact new units:

You can reach us during business hours
Mon. - Fri. from 7:00 a.m. till 5:00 p.m.

Siemens Turbomachinery
Equipment GmbH
Pre-designed Steam Turbines
Hessheimer Strasse 2
67227 Frankenthal
Germany

Phone +49 6233 85-2291
Fax +49 6233 85-2660

E-mail: turbines@agkkk.de

Contact also our website:
www.siemens.com/agkkk

Contact service:

You can reach us during business hours
Mon. - Fri. from 7:00 a.m. till 5:00 p.m.

On-site installation:
Phone +49 6233 85-2314
Fax +49 6233 85-2758

Customer support, after-sales service, spare parts store:
Phone +49 6233 85-2418
Fax +49 6233 85-2720

E-mail: turbines@agkkk.de

Service Helpdesk (24 hours/day):
+49 171 518 2610

Attachment 2

Siemens Energy, Inc.
10730 Telge Road
Houston, Texas 77095-5002

Selling Policy 1000

(For Sales in United States, Except Louisiana)

May 1, 2005

These Terms and Conditions Govern The Sale of Equipment and Services

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The terms and conditions set forth in the Siemens Energy, Inc. ("Siemens") proposal and in this Selling Policy 1000 are the terms and conditions governing the Siemens proposal and any Agreement between the parties for the Equipment and/or Services covered by such proposal. Each proposal is valid for sixty (60) days from the date of the proposal unless extended or withdrawn in writing by Siemens. The issuance of a Purchaser purchase order or any other reasonable manner of acceptance by Purchaser communicated to Siemens during such validity period will form an Agreement based upon the terms and conditions of the Siemens proposal and this Selling Policy 1000.

1. Definitions
Whenever used in this document with initial capitalization, the following definitions shall be applicable:

A. "Agreement" or "Contract" means the Siemens proposal, this Selling Policy 1000, Purchaser's purchase order, as accepted by Siemens, (excluding any preprinted terms and conditions on said purchase order and in any attachments to or Purchaser documents referenced in said purchase order) and any other document set forth in the Siemens proposal; or an integrated agreement signed by Siemens and Purchaser; for the Equipment, and/or Services.

B. "Field Installation Services" means the installation by Siemens of Purchaser's Material at the Site.

C. "Field Repair and Modernization Services" means the repair, modification or modernization work, or some or all of them, performed by Siemens on Purchaser's Material at the Site and for certain activities at a repair facility selected by Siemens.

D. "Equipment" means equipment, components, parts, materials and Software provided by Siemens pursuant to the Agreement.

E. "Maintenance Services" means the disassembly, inspection and reassembly of Purchaser's Material at the Site.

F. "Party" means individually either Siemens or Purchaser.

G. "Parties" means collectively both Siemens and Purchaser.

H. "Purchaser" means the entity purchasing Equipment, or Services or both, as well as any other owners of the facility where the Equipment or Purchaser's Material is or will be installed.

I. "Purchaser's Material" means the equipment, materials, components and items of any kind owned by Purchaser or any other owner of the Site for which Services are to be provided or are provided under the Agreement.

J. "Services" means Shop Repair and Modernization Services, Field Installation Services, Field Repair and Modernization Services, Maintenance Services, and Technical Services; or some or all of them provided by Siemens pursuant to the Agreement.

K. "Services on Third Party Parts" means Services in connection with the installation of Third Party Parts.

L. "Shop Repair and Modernization Services" means work performed by Siemens on Purchaser's Material at a Siemens manufacturing plant, a Siemens repair facility or another suitable facility selected by Siemens.

M. "Siemens" means Siemens and its affiliated companies and their subsidiaries, successors and assigns.

N. "Site" means the Purchaser's facility where the Equipment or Purchaser's Material is or will be installed.

O. "Special Services" means the performance by a Siemens field service representative of diagnostic and operational troubleshooting on Purchaser's Material, both on line and off line. This work may be conducted on Site or by telecommunication.

P. "Software" means instructions in machine readable form, other than source code, and associated documentation delivered by Siemens to Purchaser in chip, disk and/or tape format.

Q. "Supplier" means any subcontractor or supplier of any tier who supplies goods and services to Siemens in connection with the obligations of Siemens under the Agreement.

R. "Technical Field Assistance" means the advice and consultation given to Purchaser's personnel by a field service representative of Siemens with respect to:

(1) installation, inspection, repair and/or maintenance activities performed by others at the Site, and

(2) any Siemens recommended quality assurance procedures for activities performed at the Site.

Technical Field Assistance does not include management, supervision or regulation of Purchaser's personnel, agents or contractors.

S. "Technical Services" means (i) Technical Field Assistance; (ii) Special Services; (iii) inspection of equipment which has been disassembled by Purchaser or others; (iv) technical evaluation of inspections performed by Siemens, Purchaser or others; (v) technical information provided by Siemens, including data interpretation and reports; (vi) inspections, technical evaluation of inspections, technical analysis of materials and technical recommendations related to Shop Repair and Modernization Services; (vii) advice and consultation given to Purchaser's personnel at the Site or at a Siemens facility by a Siemens engineer or technician; and/or (viii) advice and guidance given to Purchaser by Siemens field engineer(s) regarding methods and procedures for installation, maintenance and/or calibration of the Equipment or Purchaser's Material.

T. "Third Party Parts" means parts, components, equipment or materials provided by Purchaser under the Agreement which were not manufactured or supplied by Siemens or the predecessors of Siemens or which were originally supplied by Siemens or the predecessors of Siemens and subsequently repaired, serviced or otherwise modified or altered by any party not affiliated with Siemens or with a predecessor of Siemens.

2. Scope

Siemens will furnish to Purchaser Equipment, and/or Services as specified in and pursuant to the Agreement.

3. Price Policy

For an Agreement for Equipment supply only, unless otherwise stated in the Siemens proposal, the price does not include disassembly and reassembly of Equipment at the Site.

Prices are firm for (i) Equipment with a scheduled shipment date of 60 weeks or less from the date of the Agreement and (ii) Services which are scheduled to be performed within 60 weeks or less from the date of the Agreement.

For (i) Equipment with a scheduled shipment date in excess of 60 weeks and (ii) Services scheduled to be completed beyond 60 weeks from the date of the Agreement, the prices are subject to adjustment upward or downward for changes in the specified labor and material indexes in accordance with the provisions of the applicable Siemens Price Adjustment Policy.

4. Terms of Payment

A. Unless otherwise specified, Siemens shall issue invoices in accordance with the schedule set forth in the Siemens proposal. If an invoice schedule is not set forth in the Siemens proposal, Siemens shall issue invoices as the work is completed, but no more often than monthly. In any event, all invoices shall be paid within thirty (30) days after the date of the invoice.

B. In any instance where Purchaser is unable to return components to Siemens for fitting or for coordination with other assemblies by the specific date agreed to in the Agreement, Siemens reserves the right to invoice Purchaser for work performed to date and either ship the components to Purchaser in their existing state or hold the components in storage at Purchaser's risk and expense. That portion of the work which is to be performed by Siemens at a later date will be performed as a Purchaser requested change under Article 18, Changes.

C. If shipments are delayed by Purchaser, affected payments shall become due based on the date Siemens is prepared to make shipment.

D. Any past due payments shall, without prejudice to the right of Siemens to payment when due, bear interest at a floating rate equivalent to one-twelfth (1/12) of the per annum prime rate charged by Chase Manhattan Bank, New York, New York, U.S.A., as such prime rate is published on the first banking day following the date payment is due, plus an additional one-half of one percent (0.5%), payable each month or portion thereof that payment is delayed. If payments are not made when due Siemens, upon fifteen (15) days written notice, may, at its option, (i) terminate this Agreement (which termination shall be treated as a termination pursuant to Article 11, Termination) or (ii) suspend all further work hereunder. Resumption of work thereafter is contingent upon correction of the payments deficiency by Purchaser. The schedule for the resumed work will be established by Siemens based on its then current work load and the availability of other resources. All Siemens expenses associated with any such suspension shall be for the account of Purchaser.

E. If there exists a good faith dispute over the amounts to be paid, Purchaser shall pay the undisputed amount. The disputed portion may be held in abeyance until resolution of the dispute with that portion, together with the interest charge specified in Paragraph D above, due thirty (30) days after said resolution.

F. Unless otherwise set forth in the Siemens proposal, if shipment (from the manufacturing plant or repair facility where the work is performed) and/or Delivery of an item of the Equipment or completion of the Services is delayed for causes which are within the reasonable control of Siemens, issuance of the invoice covering the final 5% payment for the work will be deferred for twice the number of months by which shipment/Delivery of such item of the Equipment or completion of such Services is delayed; provided, however, that such deferral of the final invoice shall only be applicable if the delay in shipment and/or Delivery of the Equipment or the delay in completion of the Services has actually delayed the Purchaser's project for which the Equipment and/or Services were purchased.

G. THE REMEDIES OF PURCHASER SET FORTH ABOVE AND/OR IN THE SIEMENS PROPOSAL FOR DELAY IN SHIPMENT/DELIVERY OR COMPLETION OF SERVICES CAUSED BY SIEMENS ARE PURCHASER'S SOLE AND EXCLUSIVE REMEDIES AND NO OTHER REMEDIES OF ANY KIND WHATSOEVER SHALL APPLY. Deferral of the issuance of the final 5% invoice as set forth above and/or provision of the remedy set forth in the Siemens proposal shall constitute complete fulfillment of all liabilities of Siemens to Purchaser for delay in shipment/Delivery of Equipment or completion of Services whether based in contract, in tort (including negligence and strict liability), or any other theory of recovery.

5. Delivery, Title and Risk of Loss or Damage

A. Unless otherwise stated in the Siemens proposal, Delivery of each component of Equipment shall be made Ex Works at the manufacturing plant. Subject to the provisions of Paragraph B below, legal and equitable title and risk of loss or damage to each such component of the Equipment shall pass from Siemens to Purchaser upon Delivery.

B. Title to and right of possession of any Software licensed hereunder, without legal process, shall remain with Siemens or its licensor, except that Purchaser shall have the right of possession and use of the Software provided hereunder for the terms of the corresponding license provided herein, so long as no breach of this Agreement has been made by Purchaser and all payments due Siemens have been paid. Nothing in this Agreement shall be construed as giving Purchaser any right to sell, assign, lease or in any other manner transfer or encumber Siemens' or its licensor's ownership of the Software, or as limiting Siemens or its licensor from using and licensing the Software to any third party.

C. Purchaser's Material sent to Siemens for Shop Repair and Modernization Services or Purchaser's Material or Equipment being returned pursuant to the provisions of the Warranty or Patents Articles of the Agreement will be delivered by Purchaser at its expense to the repair or manufacturing plant designated by Siemens where the work is to be performed. Title to such Equipment or Purchaser's Material will remain at all times with Purchaser. Risk of loss or damage to such Equipment or Purchaser's Material will transfer to Siemens upon its arrival on board the carrier at the repair or manufacturing plant and will transfer back to Purchaser upon its delivery to the carrier at the repair or manufacturing plant for return to Purchaser after the work is performed. Delivery of Purchaser's Material shall be made when the item is placed on board carrier at the repair or manufacturing plant after the work is performed. When repair work is performed by Siemens at the Site, title and risk of loss or damage to the Equipment, to Purchaser's Material and to other property shall remain at all times with Purchaser. Title to any defective or nonconforming components of the Equipment that are replaced by Siemens, as part of its warranty obligations shall, at Siemens' option, revert back to Siemens upon completion of the replacement, with a deemed value of zero.

D. Risk of loss of or damage to Purchaser's Material or other property located at the Site shall remain with Purchaser at all times during the performance of work hereunder. If Purchaser procures or has procured property damage insurance applicable to occurrences at the Site, Purchaser shall obtain a waiver by the insurers of all subrogation rights against Siemens and its Suppliers.

6. Transportation

A. Transportation and Storage

When items of Equipment are ready for shipment or Shop Repair and Modernization Services are completed on Purchaser's Material, Siemens will notify Purchaser to arrange for shipment. If Siemens has agreed in the Siemens proposal to transport Equipment, when items of Equipment are ready for shipment or Shop Repair and Modernization Services are completed on Purchaser's Material, Siemens will (i) in the absence of shipping instructions inform Purchaser of pending shipment and Purchaser will thereafter promptly give shipping instructions to Siemens (ii) determine the method of transportation and the routing of the shipment and (iii) ship the Equipment or Purchaser's Material freight prepaid and included in the price by Normal Carriage:

(1) to Purchaser's designated destination when shipped by highway transport, or

(2) to the nearest suitable rail siding to Purchaser's designated destination when shipped by rail transport.

In the event that Purchaser fails to provide Siemens with timely shipping instructions, Siemens will ship the Equipment or Purchaser's Material by Normal Carriage to Purchaser or to a suitable storage location selected by Siemens.

If the Equipment and/or Purchaser's Material is to be placed into storage in accordance with the above, delivery of the Equipment or Purchaser's Material shall be deemed to have occurred for all purposes under the Agreement, including any payment due upon Delivery, at the time the Equipment or Purchaser's Material is placed on board carrier for shipment to the storage location. If the Equipment and/or Purchaser's Material is to be stored in the facility where manufactured, or where Shop Repair and Modernization Services are performed, delivery shall be deemed to have occurred when the Equipment and/or Purchaser's Material is placed into the storage location at such facility.

In the event of storage pursuant to the preceding Paragraph, all expenses thereby incurred by Siemens, such as preparation for and placement into storage, handling, freight, storage, inspection, preservation, taxes and insurance, shall be payable by Purchaser upon receipt of an invoice(s) from Siemens When conditions permit and upon payment to Siemens of any additional amounts due hereunder, Purchaser shall arrange, at its expense, for removing the Equipment and/or Purchaser's Material from storage.

B. Normal Carriage
When Siemens is providing the transportation of the Equipment and/or Purchaser's Material, Siemens shall make every reasonable effort to ship by highway transport unless rail transport is required. Normal Carriage means carriage either by highway transport (provided this does not necessitate use of specialized riggers trailers) or by rail transport, on normal routing from the repair facility or manufacturing plant to (i) Purchaser's designated destination when shipped by highway transport or (ii) the nearest accessible suitable rail siding to Purchaser's designated destination when shipped by rail transport or (iii) the port of export selected by Siemens if shipped by water transport outside of the United States.

C. Special Transportation and Services

Purchaser agrees to pay or to reimburse any transportation charges in excess of regular charges for Normal Carriage, including, but not limited to, excess charges for special routing, special trains, specialized riggers trailers, lighterage, barging and air transport.

Purchaser also agrees to pay or to reimburse any cost incurred or charge resulting from special services performed in connection with the transportation of the Equipment or Purchaser's Material, including, but not limited to, the construction and repair of transportation and handling facilities, bridges and roadways, of whatever kind and wherever located.

7. Warranty

A. Equipment Warranty and Exclusive Remedy (excluding Software)
Siemens warrants that each component of the Equipment (excluding Software and consumables) furnished to Purchaser, including any part repaired or replaced by Siemens during the Equipment Warranty Period, will be free of defects in design, workmanship and materials until the earlier of eighteen (18) months after the Delivery of such component of the Equipment or one (1) year from the date of first use of the item of Equipment (the "Equipment Warranty Period").

If during the Equipment Warranty Period Siemens is promptly notified in writing that the Equipment or any component thereof fails to conform to the Equipment Warranty, Siemens will at its option and expense correct such nonconformity by repair or replacement.

B. Software Warranty and Exclusive Remedy
If Equipment includes Software, Siemens also warrants that the Software will be free of errors which materially affect its utility until the earlier of eighteen (18) months after the Delivery of such Software or one (1) year from the date of first use of the Software (the "Software Warranty Period"). If during the Software Warranty Period, Siemens is promptly notified in writing that the Software fails to conform to its warranty, Siemens will at its option and expense correct the nonconformity by correction in the medium originally supplied or by providing a procedure to Purchaser for correction of the nonconformity. Third party Software shall be warranted on a pass through basis in the same manner and for the same period and extent provided to Siemens by the entity which supplied said third party software.

C. Field Installation Services, Field Repair and Modernization Services, Maintenance Services, and/or Shop Repair and Modernization Services Warranty and Exclusive Remedy
Siemens warrants that the work performed by Siemens on Purchaser's Material, including any materials (excluding consumables) supplied by Siemens in connection therewith (hereinafter in this Paragraph C referred to as the "Work"), will be free of defects in design, workmanship and materials until the earlier of fifteen (15) months after the completion of

such services or one (1) year from the date of first use of Purchaser's Material (the "Field and Shop Repair and Modernization Services Warranty Period").

If during the Field and Shop Repair and Modernization Services Warranty Period, Siemens is promptly notified in writing that the Work or any part thereof fails to conform to the Field Installation Services, Field Repair and Modernization Services, Maintenance Services, and/or Shop Repair and Modernization Services Warranty, Siemens will at its option and expense correct such nonconformity by repair, replacement or reperformance of the defective portion of the Work. If repair, replacement or reperformance is impracticable, Siemens will refund the amount of the compensation paid to Siemens for such nonconforming portion of the Work.

D. Technical Services Warranty and Exclusive Remedy
Siemens warrants for each item of Technical Services that (i) the advice, recommendations and performance of its personnel will reflect competent professional knowledge and judgment and (ii) the technical information, reports and analyses transmitted by Siemens in connection therewith will reflect competent professional knowledge and judgment, beginning with the start of the item of Technical Services and ending one (1) year after completion of said item of Technical Services by Siemens (the "Technical Services Warranty Period").

If during the Technical Services Warranty Period, Siemens is promptly notified in writing that any portion of the Technical Services fails to conform to the Technical Services Warranty, Siemens will promptly reperform such nonconforming portion of the Technical Services. If reperformance is impracticable Siemens will refund the amount of the compensation paid to Siemens for such nonconforming portion of the Technical Services.

E. Title
Siemens warrants that the Equipment, upon Delivery, shall not be subject to any encumbrances, liens, security interests, or other defects in title. In the event of any failure to conform to this warranty, Siemens, upon prompt written notice of such failure, shall defend the title to the Equipment.

F. Performance Guarantee(s) and Exclusive Remedy
There are no performance guarantees of the Equipment and/or Services unless specifically set forth in the Siemens proposal. In the event any performance guarantees are provided in the Siemens proposal, Purchaser's sole and exclusive remedy and Siemens' sole and exclusive liability for any failure of the Equipment and/or Services to comply with such performance guarantees under any theory of recovery shall be the liquidated damages specified in such Siemens proposal up to the limit specified therein, which liquidated damages shall only be paid on a "no harm, no foul" basis. The Parties agree that such liquidated are a reasonable determination of the damages that Purchaser would incur as a result of the failure of the Equipment and/or Services to meet the Performance Guarantees and do not constitute a penalty.

G. Warranty Conditions
The warranties and remedies set forth in this Article are conditioned upon:

(1) Purchaser's receipt, handling, storage, installation, testing, operation and maintenance, including tasks incident thereto, of the Equipment and/or Purchaser's Material in accordance with the recommendations of Siemens to the extent applicable or, in the absence of such recommendations or to the extent not applicable, in accordance with the generally accepted practices of the industry. In addition, such Equipment and Purchaser's Material shall not have been operated in excess of limitations specified in writing by Siemens and not have been subjected to accident, alteration, abuse or misuse; and

(2) For all warranty work, where disassembly, removal, replacement and reinstallation of Equipment, materials, structures or Purchaser's Material was not part of the Siemens scope of work under the Agreement; Purchaser providing, without cost to Siemens, access to the nonconformity by disassembling, removing, replacing and reinstalling any Equipment, materials, structures or Purchaser's Material to the extent necessary to permit Siemens to perform its warranty obligations.

(3) All warranty work being performed on a single-shift straight-time basis, Monday through Friday. In the event Purchaser requests correction of warranty items on an overtime or multiple shift schedule, the premium portion of such overtime or multiple shift shall be to Purchaser's account.

(4) Purchaser, without cost to Siemens, making its Site facilities and personnel (to the extent consistent with personnel job classifications) available to assist Siemens in the performance of its warranty obligations.

(5) the Purchaser, with respect to Paragraph 4 above, reimbursing Siemens for all costs incurred in the transportation of personnel and defective, repaired or replacement parts to and from the Site.

H. Additional Conditions Applicable to the Sale of Monitoring Devices
Monitoring devices supplied by Siemens pursuant to the Agreement, such as but not limited to, monitors for generator condition and for steam chemistry, are intended to enhance the availability and reliability of the equipment. These moni-

tors normally represent state-of-the-art technology which enables users to better diagnose and control conditions within a turbine generator. While such monitors follow conditions and trends within the equipment and thereby permit earlier detection of harmful conditions, Siemens does not warrant or represent that the use of such monitors will prevent failure or detect all harmful conditions in a turbine generator and Purchaser acknowledges the same.

I. Additional Conditions Applicable to Diagnostic and Non-Destructive Examination and Testing
Diagnostic and non-destructive examination and testing techniques employed by Siemens represent the current Siemens techniques for detecting defects in (including indications of cracking) and evaluation of the condition of Purchaser's Material. However even these current techniques, when performed according to the standards detailed above in this Article, may not detect all of the defects in Purchaser's Material (including indications of cracking) and such failure shall not constitute a breach by Siemens of its warranty obligations. Purchaser acknowledges that Siemens will not be responsible for the consequences of undetected defects including undetected cracks.

J. Additional Conditions Applicable to Technical Field Assistance
Where Siemens furnishes Technical Field Assistance under the Agreement, Purchaser is responsible for (i) the supervision, management, regulation, arbitration and determination of the number of its personnel, agents, or contractors and their work and (ii) the planning, scheduling, management and progress of the work. Unless expressly agreed to in writing by Siemens, under no circumstances shall Siemens provide or be obligated to provide Technical Field Assistance directly or indirectly to any competitor of Siemens or their employees, representatives, or consultants.

K. Purchaser Supplied Third Party Parts and Materials
Purchaser assumes the entire liability and risk arising out of or resulting from Third Party Parts and Services on Third Party Parts. The warranties and remedies set forth herein do not apply to any Third Party Parts or Services on Third Party Parts, and SIEMENS DISCLAIMS ANY AND ALL WARRANTIES AND REMEDIES, WHETHER STATUTORY, EXPRESS OR IMPLIED, FOR OR WITH RESPECT TO THIRD PARTY PARTS OR SERVICES ON THIRD PARTY PARTS.

L. Exclusivity of Warranties, Performance Guarantees and Remedies.
THE WARRANTIES AND PERFORMANCE GUARANTEES SET FORTH IN THIS ARTICLE ARE EXCLUSIVE AND ARE IN LIEU OF ALL OTHER WARRANTIES AND PERFORMANCE GUARANTEES, WHETHER STATUTORY, EXPRESS, OR IMPLIED (INCLUDING ALL WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND ALL WARRANTIES ARISING FROM COURSE OF DEALING OR USAGE OF TRADE). Correction of nonconformities in the manner and for the period of time provided above constitute Siemens' sole and exclusive liability and Purchaser's sole and exclusive remedy for defective or nonconforming Equipment and/or Services whether claims of the Purchaser are based in contract, in tort (including negligence and strict liability), or any other theory of recovery.

8. Taxes
The price paid or to be paid to Siemens under the Agreement does not include any federal (other than federal and state income taxes imposed on Siemens), state, or local property, license, privilege, sales, use, excise, value added, gross receipts, or similar taxes now or hereafter applicable to, measured by, or imposed upon or with respect to the transaction, the Equipment and Purchaser's Material, its or their sale, their value or their use, or any Services performed in connection therewith. Purchaser agrees to pay or reimburse Siemens for any such taxes which Siemens or its Suppliers are required to pay.

9. Additional Conditions Applicable to Nuclear Installations
In the event the Services or the Equipment provided under the Agreement are to be performed or utilized at or in any manner in connection with a nuclear installation, the following conditions shall apply:

A. Purchaser Insurance
(1) If Purchaser procures property damage insurance applicable to occurrences at the Site and third party non-nuclear liability insurance, or either of such types of insurance, such insurance will name Siemens and its Suppliers as additional insureds.

(2) Purchaser shall have at its own cost, prior to the arrival of nuclear fuel at the Site, secured and shall thereafter maintain in force protection against liability arising out of or resulting from a nuclear incident (as defined in the Atomic Energy Act of 1954, as amended) as required by the Nuclear Regulatory Commission; provided, however, that if the nuclear liability protection system in effect on the date of the Agreement expires or is repealed, changed, or modified, Purchaser will, without cost to Siemens, maintain liability protection through government indemnity, limitation of liability, and/or liability insurance which will not result in a material impairment of the protection afforded Siemens and its Suppliers by such nuclear liability protection system which is in effect as of the date of the Agreement, taking into account the availability of insurance, customary practice in the industry for plants of similar size and character, and other relevant factors in light of then existing conditions. In any event, the protection provided pursuant to this Article shall remain in effect until the decommissioning of the nuclear plant.

B. Waivers by Purchaser
Neither Siemens nor its Suppliers shall be liable for any loss of, damage to, or loss of use of property or equipment wherever located, arising out of or resulting from a "Nuclear Incident." Purchaser waives and will require its insurers to waive all rights of recovery against Siemens and its Suppliers on account of any such loss, damage, or loss of use. All such waivers shall be in a form acceptable to Siemens.

In the event Purchaser recovers damages from a third party based on losses at the Site resulting from the hazardous properties of source, special nuclear or byproduct material (as defined in the Atomic Energy Act of 1954, as amended), Purchaser shall indemnify Siemens and its Suppliers against claims by such third party which are based on Purchaser's recovery of such damages. In addition, Purchaser waives and will require its insurers to waive all rights of recovery against Siemens and its Suppliers, for any and all costs or expenses arising out of or in connection with the investigation and settlement of claims or the defense of suits for damage resulting from the nuclear energy hazard.

C. Third Party Property Protection
Purchaser will indemnify Siemens and its Suppliers for any liability arising out of loss of or damage to property at the Site which arises out of a "nuclear incident". In addition, Purchaser shall obtain for the benefit of Siemens and its Suppliers, protection against liability for, arising out of, or resulting from damage to any property or equipment located at the Site which is used or intended for use by Purchaser in connection with the operation of the nuclear power plant (including but not limited to fuel) and which is owned by parties other than Purchaser.

D. Decontamination
Purchaser shall, without cost to Siemens, perform any required decontamination and health physics to the extent necessary for Siemens to perform its contractual obligations. This includes decontamination of any Siemens equipment or tools used in the performance thereof. Purchaser shall provide documentation demonstrating that components or parts being returned to Siemens meet the requirements designated for unrestricted release as set forth in 10CFR20.

10. Force Majeure

A. Siemens will not be liable for failure to perform or delay in performance of any obligation resulting from or contributed to by any cause beyond the reasonable control of Siemens or its Suppliers or from any act of God; act of civil or military authority; act of war whether declared or undeclared; act (including delay, failure to act or priority) of any governmental authority or Purchaser; act of terrorism; civil disturbance, rebellion, insurrection, riot or sabotage; fire, inclement weather conditions, earthquake, flood or natural disaster; strike, work stoppage or other labor difficulty; embargo, epidemic or quarantine; railroad car, fuel or energy shortage; major equipment breakdown; delay or accident in shipping or transportation; or failure or delay beyond its reasonable control in obtaining necessary manufacturing facilities, labor, or materials from usual sources.

B. In the event of a delay in performance excusable under this Article, the date of Delivery or time for performance of the work will be extended by a period of time reasonably necessary to overcome the effect of such delay, and Purchaser will reimburse Siemens for its additional costs and expenses resulting from the delay.

11. Termination

A. Purchaser may terminate the Agreement for convenience upon thirty (30) days prior written notice to Siemens and payment of reasonable and proper termination charges. Should the work be delayed for a period in excess of six (6) months for any reason attributable to Purchaser and/or force majeure, or should any payment from Purchaser be thirty (30) days or more past due, at the option of Siemens, the Agreement may be deemed to have been terminated by Purchaser. Termination charges in either event will be the applicable Termination Fee from the Termination Fee Schedule set forth in the Siemens proposal. The Parties agree that such Termination Fees are a reasonable determination of the damages that Siemens would incur as a result of such termination and do not constitute a penalty. In the absence of a Termination Fee Schedule, the termination charges shall be calculated based upon the portion of the purchase price for the work performed, man hours expended and materials acquired at as the date of termination plus the expenses associated with the termination, including, but not limited to, any additional expense incurred by reason of termination or cancellation of agreements between Siemens and its Suppliers, and any applicable cost allocated in contemplation of performance. Siemens will make every reasonable effort to minimize such termination charges. All termination charges shall be due and payable thirty (30) days from the date of the Siemens invoice.

B. Purchaser may terminate the Agreement for cause in the event of (i) an act of insolvency or bankruptcy by Siemens or (ii) a material breach of the Agreement by Siemens which Siemens fails to commence to cure within thirty (30) days after notice thereof from Purchaser and fails to diligently pursue thereafter. In such event, Siemens will reimburse Purchaser for its reasonable and verifiable costs to complete the Services or obtain replacement Equipment up to twenty percent (20%) of the total price paid to Siemens under the Agreement.

C. In the event of any breach of the Agreement by Purchaser, Siemens shall be entitled to an extension of time to the extent necessitated by the breach and to reimbursement for all costs and expenses incurred by Siemens as a result of such breach. Siemens may terminate the Agreement for cause in the event of (i) an act of insolvency or bankruptcy by Purchaser or (ii) a material breach of the Agreement by Purchaser which Purchaser fails to commence to cure within thirty (30) days after notice thereof from Siemens and fails to diligently pursue thereafter. In such event, Purchaser shall pay Siemens the applicable Termination Fee set forth in the Termination Fee Schedule plus all costs and expenses incurred as a result such breach and termination. In the absence of a Termination Fee Schedule, the termination charges shall be calculated based upon the portion of the purchase price for the work performed, man hours expended and materials acquired at as the date of termination plus the expenses associated with the breach and termination, including, but not limited to, any additional expense incurred by reason of termination or cancellation of agreements between Siemens and its Suppliers, and any applicable cost allocated in contemplation of performance.

12. Intellectual Property Infringement

A. Siemens will, at its own expense, defend or at its option settle any suit or proceeding brought against Purchaser so far as based on an allegation that any Services on Purchaser's Material or the Equipment (including parts thereof), or use thereof for their intended purpose, constitutes an infringement of any United States patent or copyright or misappropriation of a trade secret, if Siemens is notified promptly in writing and given authority, information, and assistance in a timely manner for the defense of said suit or proceeding. Siemens will pay the damages and costs awarded in any suit or proceeding so defended. Siemens will not be responsible for any settlement of such suit or proceeding made without its prior written consent. In case the Services on Purchaser's Material or the Equipment, or any part thereof, as a result of any suit or proceeding so defended is held to constitute infringement of any such United States patent, copyright or trade secret, or its use by Purchaser is enjoined, Siemens will, at its option and its own expense, either: (a) procure for Purchaser the right to continue using said Equipment and/or Purchaser's Material; (b) replace it with substantially equivalent non-infringing equipment; or (c) modify it so it becomes non-infringing.

B. Siemens will have no duty or obligation to Purchaser under this Article to the extent that the Services on Purchaser's Material or Equipment is (a) supplied according to Purchaser's design or instructions wherein compliance therewith has caused Siemens to deviate from its normal course of performance, (b) modified by Purchaser or its contractors after delivery, or (c) combined by Purchaser or its contractors with items not furnished hereunder and by reason of said design, instruction, modification, or combination a suit is brought against Purchaser. In addition, if by reason of such design, instruction, modification or combination, a suit or proceeding is brought against Siemens, Purchaser shall protect Siemens in the same manner and to the same extent that Siemens has agreed to protect Purchaser under the provisions of Paragraph A above.

C. THIS ARTICLE IS AN EXCLUSIVE STATEMENT OF ALL THE DUTIES OF THE PARTIES RELATING TO PATENTS, COPYRIGHTS OR TRADE SECRETS AND DIRECT OR CONTRIBUTORY INFRINGEMENT THEREOF AND OF ALL THE REMEDIES OF PURCHASER RELATING TO ANY CLAIMS, SUITS, OR PROCEEDINGS INVOLVING PATENTS, COPYRIGHTS OR TRADE SECRETS. Compliance with this Article as provided herein shall constitute fulfillment of all liabilities of the parties under the Agreement with respect to patents, copyrights or trade secrets.

13. Confidential Information

A. Siemens may have a proprietary interest in information that may be furnished pursuant to the Agreement. Purchaser will keep in confidence and will not disclose any such information which is specifically designated as being confidential to Siemens or use any such information for other than the purpose for which it is supplied without the prior written permission of Siemens. The provisions of this Paragraph shall not apply to information, notwithstanding any confidential designation thereof, which is known to Purchaser without any restriction as to disclosure or use at the time it is furnished, which is or becomes generally available to the public without breach of any confidentiality obligation of Purchaser, or which is received from a third party without limitation or restriction on said third party or Purchaser at the time of disclosure.

B. Siemens also has a confidential interest in its proposal and the Agreement. Accordingly, neither document will be disclosed in whole or in part to third parties without the prior written permission of Siemens.

C. When required by appropriate governmental authority, including governmental regulations, applicable law or regulation, by order of a court of competent jurisdiction or lawful subpoena (hereinafter collectively referred to as "Governmental Authority"), Purchaser may disclose such confidential information to such Governmental Authority; provided, however, that prior to making any such disclosure, Purchaser will: (a) provide Siemens with timely advance written notice of the confidential information requested by such Governmental Authority and Purchaser's intent to so disclose; (b) minimize the amount of confidential information to be provided consonant with the interests of Siemens and its Suppliers and the requirements of the Governmental Authority involved; and (c) make every reasonable effort (which shall include participation by Siemens in discussions with the Governmental Authority involved) to secure confidential treatment and minimization of the proprietary information to be provided. In the event that efforts to secure confidential treatment are unsuccessful, Siemens shall have the prior right to revise such information to minimize the disclosure of such information in a manner consonant with its interests and the requirements of the Governmental Authority involved.

14. Limitation of Liability

A. NOTWITHSTANDING ANY OTHER PROVISION OF THE AGREEMENT, PURCHASER EXPRESSLY AGREES THAT NEITHER SIEMENS NOR ITS SUPPLIERS WILL UNDER ANY CIRCUMSTANCES BE LIABLE UNDER ANY THEORY OF RECOVERY, WHETHER BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), UNDER WARRANTY, OR OTHERWISE, FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL LOSS OR DAMAGE WHATSOEVER; DAMAGE TO OR LOSS OF ANY PROPERTY OR EQUIPMENT; LOSS OF PROFITS OR REVENUE OR LOSS OF USE THEREOF; LOSS OF USE OF PURCHASER'S MATERIAL, EQUIPMENT OR POWER SYSTEM; COST OF CAPITAL: COST OF FUEL; COST OF PURCHASED OR REPLACEMENT POWER; INCREASED COSTS OF ANY KIND; OR ANY CLAIMS OF CUSTOMERS OF PURCHASER.

B. PURCHASER EXPRESSLY AGREES THAT THE REMEDIES PROVIDED IT IN THE AGREEMENT ARE EXCLUSIVE, AND THAT NOTWITHSTANDING ANY OTHER PROVISION OF THE AGREEMENT, UNDER NO CIRCUMSTANCES SHALL THE TOTAL AGGREGATE LIABILITY OF SIEMENS UNDER ANY THEORY OF RECOVERY, WHETHER BASED IN CONTRACT, IN TORT (INCLUDING NEGLIGENCE AND STRICT LIABILITY), UNDER WARRANTY, OR OTHERWISE, EXCEED THE TOTAL PRICE PAID TO SIEMENS UNDER THE AGREEMENT.

C. ALL LIABILITY OF SIEMENS AND ITS SUPPLIERS UNDER THIS AGREEMENT SHALL TERMINATE NO LATER THAN TWELVE (12) MONTHS AFTER THE EXPIRATION OF THE WARRANTY PERIOD.

D. THE PROVISIONS OF THIS ARTICLE SHALL PREVAIL OVER ANY CONFLICTING OR INCONSISTENT PROVISIONS SET FORTH ELSEWHERE IN THE AGREEMENT.

15. Transfer and Export Compliance

A. Prior to the transfer to another party of any Equipment or Purchaser's Material or the transfer of any interest in said Equipment or Purchaser's Material or Purchaser's facility in which said Equipment or Purchaser's Material is installed, Purchaser shall obtain for Siemens written assurances from the transferee of limitation of and protection against liability following the proposed transfer at least equivalent to that afforded Siemens and its Suppliers under the Agreement. Transfer contrary to the provisions of this Article shall make Purchaser the indemnitor of Siemens and its Suppliers against any liabilities incurred by Siemens and its Suppliers in excess of those that would have been incurred had no such transfer taken place.

B. Purchaser acknowledges that Siemens is required to comply with all applicable export laws and regulations relating to the sale, exportation, transfer, assignment, use and/or disposal of the Equipment supplied and Purchaser's Material Serviced under the Agreement, including without limitation all export license requirements. Purchaser agrees that the Equipment provided and Purchaser's Materials Serviced under the Agreement shall not at any time, directly or indirectly, be sold, exported, transferred, assigned, used or otherwise disposed of in any manner which shall or may result in any non-compliance with such export laws and regulations. It is a condition to the continuing performance by Siemens of its obligations under the Agreement that compliance with such export laws and regulations be maintained at all times.

16. Software License

Siemens grants to Purchaser a nonexclusive, nontransferable license to utilize the Siemens Software furnished hereunder. Such license is limited to Purchaser's internal use at or for the Equipment with which such Software is incorporated. All title and ownership of the Siemens Software, including, without limitation, the copyright to such Software, shall remain exclusively with Siemens. Purchaser may make a reasonable number of backup copies of the Software for evaluation, installation, and maintenance of the Siemens Equipment. Purchaser shall not itself, or with the assistance of others, reverse compile, reverse engineer, or in any other manner attempt to decipher in whole or in part the logic or coherence of any Software licensed hereunder. Third party Software provided by Siemens may be subject to a separate license agreement and /or registration requirements and limitations on copying and use.

17. Compliance with Laws

The price for the work is based on compliance by Siemens with the applicable laws, regulations and technical codes and standards as they are in effect on the date of the Siemens proposal (or the effective date of the Agreement if no proposal was provided).

18. Changes

A. Purchaser may request changes within the scope of the Agreement and, if accepted by Siemens, the price, performance, schedule and other pertinent provisions of the Agreement will be adjusted by mutual agreement of the parties prior to implementation of the change.

B. Expenses incurred by Siemens due to (i) delays, other than delays which are deemed to be within the reasonable control of Siemens, and (ii) changes in applicable laws, regulations and technical codes and standards or the imposition of new laws, regulations and/or technical codes and standards after the applicable date set forth in Article 17 will be treated as changes to the scope of work and the Agreement will be adjusted as set forth in the previous Paragraph.

C. Siemens may make a change(s) in the Equipment, Services on Purchaser's Material or the other Services without additional compensation from Purchaser if such change(s) does not adversely affect the warranties, the interface with Purchaser's equipment, materials and plant, the technical soundness of the work, the operability of the facility where the Equipment or Purchaser's Material is installed or for which Siemens is providing Services under the Agreement, or the schedule.

19. Inspection by Purchaser

Purchaser shall have reasonable access to the areas of the Siemens plants where work under the Agreement is being performed to enable Purchaser to observe tests on the work. Siemens, if requested, will inform the Purchaser of those tests and procedures which can be witnessed. Should Purchaser elect to witness specific tests, Purchaser must so specify such requirement in ample time to permit Siemens to include said witness tests in the schedule. Siemens, if requested, will advise Purchaser of the schedule of such tests. However, no rescheduling of tests or delays in manufacturing or shipment will be made to accommodate such inspection. Siemens will exercise reasonable efforts to secure similar rights with respect to the inspection of Purchaser's work at Supplier's premises.

20. Returning Equipment or Purchaser's Material

Prior to the return of any Equipment or Purchaser's Material to Siemens, the Purchaser must obtain authorization and shipping instructions from Siemens and remove all asbestos material.

The Equipment or Purchaser's Material must be returned with complete identification in accordance with instructions furnished by Siemens. In no event will Siemens be responsible for Equipment or Purchaser's Material returned without proper authorization and identification.

21. Purchaser's Third Party Parts Warranty

Purchaser warrants that any and all Third Party Parts which may be the subject of any Services shall (a) be fully compatible with the corresponding part, component, equipment or material of the Original Equipment Manufacturer ("OEM") in terms of form, fit, and function; (b) shall be timely provided to Siemens hereunder; and (c) shall be capable of installation in the same manner and within the same time as the corresponding OEM part, component, equipment, or material.

22. Indemnity

Until the expiration of the applicable Warranty Period, Siemens shall indemnify, hold harmless and defend Purchaser its officers, directors and employees from and against any claims, demands, suits, liabilities, judgments, losses, damages, costs or expenses (including reasonable legal fees, costs and charges) for personnel injury or death or loss of or damage to third party property (except property of customers of Purchaser or property incorporated in or intended to be incorporated in the project), to the extent caused by or arising out of any negligent act or omission or willful misconduct of Siemens, or any of its officers, directors, agents, employees or Suppliers in connection with performance of work under the Agreement.

23. Siemens Insurance

In connection with the Agreement, Siemens shall maintain insurance (or self insurance) as specified below:

A. Worker's Compensation: Siemens shall comply with workers compensation laws (or equivalent) in each jurisdiction where work is performed, and shall maintain a Workers Compensation and Employers Liability insurance policy. If any work is to be performed on or near navigable waters, the policy shall include coverage for United States Longshoreman's and Harbor Worker's Act, Death on the High Seas Act, Jones Act, or their equivalent as required by the applicable law in the jurisdiction where such work is performed. The limits of such insurance shall be as follows:

Worker's Compensation – Statutory
Employer's Liability – $1,000,000 each accident and in the aggregate
$1,000,000 disease each employee.

B. Commercial General Liability: Siemens shall maintain commercial general liability insurance on an occurrence basis to provide coverage for: Bodily Injury; Personal Injury and Death, Property Damage, Explosion, Collapse and Underground hazards; Contractual Liability (particularly applicable to the provisions of the Indemnity Article of this Agreement); and Products and Completed Operations with limits as follows:

$1,000,000 each occurrence and in the aggregate.

C. Business Automobile Liability: Siemens shall maintain business automobile liability insurance which shall include coverage for all owned, non-owned and hired vehicles with the following limit:

$1,000,000 Combined Single Limit Bodily Injury and Property Damage

D. Umbrella Liability: Siemens shall maintain umbrella liability insurance with a limit of $2,000,000 each occurrence and in the aggregate. The policy shall be excess over the Commercial General Liability, Business Automobile Liability, and Employer's Liability coverages.

24. Purchaser's Insurance

In connection with the Agreement, Purchaser shall purchase and maintain insurance as specified below:

A. All Risk Builders Risk: Purchaser shall purchase and maintain throughout construction of the project, "All Risk" Builders Risk insurance for the Site. Such insurance shall be purchased and in effect at least ten (10) calendar days before the start of any Services at the Site or the arrival of the first item of Equipment at the Site, whichever first occurs. Siemens and its Suppliers shall be named as an additional insured, with a waiver of subrogation, for physical loss or damage to the property at the Site (including the Equipment once at the Site and the Purchaser's Material) on such All Risk Builders Risk policy.

B. Property Insurance: Upon completion of the project, Purchaser shall purchase and maintain property damage insurance for the facilities at the Site until the expiration of the last of the applicable Warranty Periods. Such insurance will name Siemens and its Suppliers as an additional insured, with a waiver of subrogation, for physical loss or damage to the property at the Site (including the Equipment and Purchaser's Material).

25. Miscellaneous Provisions

A. Shipment Dates

Shipment dates are the dates the Equipment or Purchaser's Material will be ready for shipment from the manufacturing plant, Siemens repair facility or other facility where the Services are performed and are predicated on the prompt receipt by Siemens from Purchaser of all information necessary to commence and complete the work without delay or interruption.

B. Waivers

The failure of either Party to enforce at any time any of the provisions of the Agreement or to require at any time performance by the other Party of any of such provisions, shall in no way be construed to be a waiver of such provision, nor in any way to affect the validity of the Agreement or any parts thereof, or the right of either Party thereafter to enforce each and every provision.

C. Modification

No waiver, modification, or amendment of any of the provisions of the Agreement shall be binding unless it is in writing and signed by duly authorized representatives of both parties.

D. Headings

The headings used in the Agreement are not to be construed as modifying, limiting or expanding in any way the scope or extent of the provisions in the Agreement.

E. Assignment

Except for assignment by Siemens to an affiliate of Siemens, the Agreement will not be assigned by either Party without the prior written consent of the other Party, which consent will not be unreasonably withheld. Any purported assignment without such prior written consent shall be null and void.

F. Governing Law

The Agreement will be construed and interpreted in accordance with the laws of the State of New Jersey without application of its choice of law or conflict of law rules.

G. Personnel

Siemens reserves the right to change any of its personnel performing Services under the Agreement. In such event, Siemens will provide replacement personnel of equivalent capabilities and bear any additional travel and living expense associated with providing such replacement personnel.

H. Environmental Compliance

Purchaser recognizes that the performance of Services at the Site may involve the generation of hazardous waste as such term is defined by the laws of the United States, the laws of the state in which the Site is located and the rules or regulations issued thereunder as are now in effect or hereafter amended from time to time (such generated hazardous waste being herein referred to as "Hazardous Waste").

Purchaser shall at its expense furnish Siemens with containers for Hazardous Waste and shall designate a waste storage facility at the Site where such containers are to be placed by Siemens. Purchaser shall handle, store and dispose of Hazardous Waste in accordance with all applicable federal, state and local laws, rules, regulations and ordinances. Purchaser shall reimburse Siemens for additional costs, if any, incurred in complying with any such laws, regulations, rules and/or ordinances.

Siemens shall have no responsibility or liability with regard to any Hazardous Waste which it does not know or have reason to know will be generated in the performance of the Services, and Purchaser shall be responsible for all pollution and environmental impairment arising from the Purchaser's property, the Equipment and the Services.

I. Asbestos and Thermal Insulation
The terms "Asbestos" and "Presumed Asbestos Containing Material" shall have the meanings set forth in United States Code of Federal Regulations Chapter 29 Section CFR 1926.1101 et seq.

(1) The Purchaser, by allowing access to the Site, thereby warrants, represents, and certifies that any areas there associated with the Siemens scope of work, including, without limitation, areas of ingress and egress thereto (the "Work Areas") either (a) are free of asbestos or asbestos containing materials (collectively "ACM"), or (b) any ACM there present is lawfully abated and conspicuously and specifically marked as asbestos or ACM.

(2) Prior to Siemens' commencement of Services at the Site:

(a) The Purchaser shall, at Purchaser's expense remove all thermal insulation, sprayed-on surfacing material, and/or Presumed Asbestos Containing Material ("PACM") the disturbance of which could occur in or removal of which is required for the performance of the Services; and,

(b) The Purchaser shall ensure that any areas where any activities involving the abatement or removal of thermal insulation or ACM shall be conspicuously identified, posted and isolated, all as required by applicable law.

PURCHASER EXPRESSLY ACKNOWLEDGES AND AGREES THAT SIEMENS IN PERFORMING THE SERVICES AND PERMITTING EMPLOYEES TO ENTER THE WORK AREAS IS RELYING UPON THE COVENANTS, AGREEMENTS, WARRANTIES, CERTIFICATIONS AND REPRESENTATIONS MADE BY PURCHASER ABOVE.

Without limiting its other rights and remedies Siemens shall not be obligated to commence or may stop any work in any Work Areas unless fully satisfied that the Purchaser is in compliance with Paragraph 25.I.(1) above and this Paragraph 25.I.(2), and shall be entitled to an equitable adjustment in the schedule, price and other provisions of the Agreement affected thereby or otherwise affected by Purchaser's non-compliance.

(3) In no event shall Siemens be obligated to install, disturb, handle, or remove any thermal insulation, sprayed-on surfacing material, or PACM except as specifically agreed in writing by Siemens and only after Siemens has been provided acceptable chemical analyses verifying that the same are not ACM.

(4) Siemens does not represent that it is licensed to abate ACM. Where the Services include activities such as handling, modification, removal, or reinstallation of generator wedges, packing, or high temperature gaskets (such materials herein "GPW"), then, and unless Siemens is provided satisfactory written evidence that such GPW is not ACM, Siemens shall be obligated only to the extent (a) such activities do not require a permit, license, or authorization, (b) such activities are not likely to generate airborne asbestos fibers, and (c) all such GPW is non-friable. In all other cases, such activities shall be Purchaser's responsibility and Siemens shall be entitled to an equitable adjustment in the schedule, price and other pertinent affected provisions of the Purchase Order should the same not be performed in a timely manner. The disposal of any GPW or scrap or waste material resulting from its disturbance or removal shall in all cases be the Purchaser's responsibility.

(5) Purchaser shall defend, indemnify and hold Siemens harmless against any and all claims, demands, damages, losses, liabilities, fines, penalties, costs or expenses, including without limitation any clean up or remedial measures arising out of, connected with, or resulting from the Purchaser's failure to comply with the provisions of this Article 25.I.

J. Integration
The Agreement contains the entire agreement and understanding between the parties as to the subject matter of the Agreement, and merges and supersedes all prior or contemporaneous agreements, commitments, representations, writings, and discussions between them. Neither of the parties will be bound by any prior or contemporaneous obligations, conditions, warranties, or representations with respect to the subject matter of the Agreement.

K. Survival
The provisions entitled "Intellectual Property," "Additional Conditions Applicable to Nuclear Installations," "Confidential Information," "Limitation of Liability," "Transfer and Export Compliance," "Software License" and the second Paragraph of "Delivery, Title and Risk of Loss or Damage" shall survive termination, expiration or cancellation of the Agreement.

Design Build CHW Thermal Storage Cost Estimate for DOE

6/10/2010

System								
	Ton-hours		100,000		75,000		50,000	
Tank Data								
	Tank Diameter (ft.)		172		160		130	
	Tank Height (ft.)		80		70		70	
	Tank Volume (gallons)		13,900,000		10,478,000		6,917,000	
Piping & Pumps								
	Maximum Discharge Time (hours)		9		9		9	
	Maximum flow rate (gpm)		11,111		8,333		5,556	
	Pipe Size		24"		20"		18"	
	Pump head (ft)		100		100		100	See Note1
	Pump hp		400		300		200	
Cost Estimates								
	Tank (CB&I estimate)	$	8,600,000	$	6,900,000	$	4,800,000	
	Site preparation	$	150,000	$	125,000	$	100,000	
	Piping, valves & fittings	$	315,000	$	270,000	$	225,000	See Note 2
	Pumps	$	225,000	$	185,000	$	150,000	
	Electrical	$	175,000	$	150,000	$	125,000	See Note 3
	Controls	$	125,000	$	125,000	$	125,000	
	Engineering	$	650,000	$	650,000	$	650,000	
	Contractor OHP		1,843,200		1,512,900		1,111,500	
	Totals	**$**	**12,083,200**	**$**	**9,917,900**	**$**	**7,286,500**	
	$ / ton hour	$	121	$	132	$	146	

Notes

1. Based on CHW system pressure of 70 psi at tie-in point.
2. Based on the tank being within 100 feet of tie-in point.
3. Based on 480 volt power being available within 100 feet of pump.
   Includes 480V VFD drive on pump.