PROJECT SUMMARY

40 MW PORT READING REFINERY CHP PROJECT
COMPREHENSIVE FEASIBILITY STUDY AND PRELIMINARY ENGINEERING

PROJECT SUMMARY

Bridgestone Associates performed a two phase CHP feasibility study with follow-on development and engineering work. Phase 1 of the study included a preliminary analysis of CHP plants ranging in size from 12 MW to 350 MW utilizing simple cycle, combined cycle and boiler/steam turbine configurations. Phase 2 of the study included detailed feasibility analysis of inside-the-fence generation configurations including equipment selection and preliminary engineering.

PROJECT STATISTICS

Client:	Hess Corporation
Project Type:	Combined Heat and Power Comprehensive Feasibility Study
Size:	Phase 1 Evaluation: 12 – 350 MW Phase 2 Evaluation: 40 MW
Plant Size:	40 MWe
Estimated Project Cost:	US$41.2 million including development and financing
Plant Location:	Port Reading Refinery, Woodbridge, NJ, USA
Plant Elevation:	< 50 feet above sea level
Interconnection Voltage:	26 kV
Primary Fuel:	Refinery gas
Fuel Characteristics:	1,150 – 1,220 Btu/cf with up to 20% H_2
Back-up Fuel:	Natural gas
Fuel Use:	363.6 MMBtu/hr summer peak conditions maximum output
Plant Steam Conditions:	665 psig, 750 ^{o}F steam turbine inlet
Design Conditions:	95 ^{o}F, 45% RH summer peak
Cooling:	Evaporative cooling
Combustion Turbines:	Siemens Cyclone
Steam Turbine Generator:	To be determined
Thermal Sales (CHP):	52,000 barrel/day catalytic cracker refinery
Electrical Sales:	Refinery has 26 MW load with >96% load factor year round

PROJECT DESCRIPTION

Bridgestone Associates performed a two phase CHP feasibility study with follow-on development and engineering work. Phase 1 of the study included a preliminary analysis of CHP plants ranging in size from 12 MW to 350 MW utilizing simple cycle, combined cycle and boiler/steam turbine configurations. Because of potential transmission congestion in the area of the refinery, a detailed electrical interconnection study, including load flow modeling of all local transmission lines and the affects of other planned generation on the transmission system, was performed to determine the potential to export power from the site to the grid. This showed that costs to upgrade transmission lines to export more than approximately 25 – 30 MW would be prohibitive.

Because of the availability of high hydrogen refinery gas, the utilization of high hydrogen refinery gas and its implications on emissions and combustion turbine performance was also studied. Currently this gas is sold to the local utility and blended with pipeline gas. However, during summer months when pipeline flows are low, the refinery gas allowed into the pipeline may be limited. This may result in the refinery having to lower plant production or shutdown completely as flaring of the refinery gas is not allowed. Interruptions and transients on the power grid have also caused expensive refinery shutdowns. All of these were to be taken into consideration in the evaluation.

In Phase 2, inside-the-fence CHP combined cycle configurations were examined in great detail. Heat balances were developed for all major operating conditions and seasons for seven different equipment combinations and manufacturers.

CASE 1 - SIEMENS CYCLONE 2 CTG + 1 STG (LARGE) + 2 AUX BOILER CONFIGURATION

FORCED OUTAGE

OPERATING EQUIPMENT ALTERNATIVES		OPERATING EQUIPMENT					PROBABILITY OF OPERATING						FORCED OUTAGE RATE
Operating Equipment Combinations	Scenario No.	CTG 1 + HRSG 1	CTG 2 + HRSG 2	STG	AUX BOILER 1	AUX BOILER 2	CTG 1 + HRSG 1	CTG 2 + HRSG 2	STG	AUX BOILER 1	AUX BOILER 2	TOTAL COMBINATION	TOTAL COMBINATION
2 x 1	1-1	Y	Y	Y	N	N	99.00%	99.00%	99.50%	0.00%	0.00%	97.51995%	2.48005%
1 x 1 (CTG1)	1-2	Y	N	Y	Y	Y	99.00%	0.00%	99.50%	99.50%	99.50%	97.52241%	2.47759%
1 x 1 (CTG2)	1-3	N	Y	Y	Y	Y	0.00%	99.00%	99.50%	99.50%	99.50%	97.52241%	2.47759%

Plant Forced Outage Rate:	0.001522%	Forced outage rate for all combinations capable of providing required Refinery load
Plant Probability of Operating:	99.998478%	Probability of Generating Equipment generating required Refinery loads
Probability of Other Systems Operating:	99.251257%	Probability of Gas Supply and miscellaneous equipment outages causing total cogeneration plant shutdown.
Cogen Probability of Operation:	99.248744%	Probability of Cogen Plant generating required Refinery loads
Cogen Plant Forced Outage Rate:	0.750256%	Forced outage rate for cogeneration plant
Cogen Plant Forced Outage Time/Year:	65.72	Hours per year
PSE&G Feeder Operational Probability:	99.950000%	Probability of PSE&G's 26.5 kV Feeders supplying without interruption
Overall Probability of Refinery Service:	99.999825%	Overall Probability of required electric service to Refinery
Overall Forced Outage Rate:	0.000356%	Forced outage rate for Refinery.
Equivalent Hours Without Service:	0.033	Hours per year

COMBINED FORCED AND UNFORCED OUTAGE

OPERATING EQUIPMENT ALTERNATIVES		OPERATING EQUIPMENT					PROBABILITY OF OPERATING						TOTAL OUTAGE RATE
Operating Equipment Combinations	Scenario No.	CTG 1 + HRSG 1	CTG 2 + HRSG 2	STG	AUX BOILER 1	AUX BOILER 2	CTG 1 + HRSG 1	CTG 2 + HRSG 2	STG	AUX BOILER 1	AUX BOILER 2	TOTAL COMBINATION	TOTAL COMBINATION
2 x 1	1-1	Y	Y	Y	N	N	97.00%	97.00%	98.50%	0.00%	0.00%	92.67995%	7.32005%
1 x 1 (CTG1)	1-2	Y	N	Y	Y	Y	97.00%	0.00%	98.50%	98.50%	98.50%	92.70014%	7.29985%
1 x 1 (CTG2)	1-3	N	Y	Y	Y	Y	0.00%	97.00%	98.50%	98.50%	98.50%	92.70014%	7.29985%

Plant Forced/Unforced Outage Rate:	0.030014%	Forced + unforced outage rate for all combinations capable of providing required Refinery load
Plant Probability of Operating:	99.969986%	Probability of Generating Equipment generating required Refinery loads
Probability of Other Systems Operating:	99.151685%	Probability of Gas Supply and miscellaneous equipment outages causing total cogeneration plant shutdown.
Cogen Probability of Operation:	99.112971%	Probability of Cogen Plant generating required Refinery loads
Cogen Plant Total Outage Rate:	0.887029%	Forced + unforced outage rate for cogeneration plant
Cogen Plant Total Outage Time/Year:	77.70	Hours per year
PSE&G Feeder Operational Probability:	99.950000%	Probability of PSE&G's 26.5 kV Feeders supplying without interruption
Overall Probability of Refinery Service:	99.999565%	Overall Probability of required electric service to Refinery
Overall Total Outage Rate:	0.000434%	Forced + unforced outage rate for Refinery.
Equivalent Hours Without Service:	0.039	Hours per year

A detailed economic model was developed and used to examine all configuration alternatives and sensitivity to variables. Equipment vendors were contacted, proposals provided, and interviews conducted. Particular emphasis was placed on the ability to burn high hydrogen refinery gases that contained methane, ethane, butane and pentane. Emphasis was also placed on overall reliability and the very high reliability requirements of the refinery. The final design included two combustion turbines, two HRSG's, duct burners, one steam turbine generator and an auxiliary boiler with a common steam header and the duct burners in the HRSG inlets. A probabilistic risk analysis was performed and showed the recommended equipment configuration provided a design with an estimated 99.9996% availability.

Bridgestone Associates also provided the preliminary designs for interconnection (steam, natural gas, water, compressed air, refinery gas) to the existing systems and re-design of the electric substation to allow work to be performed during a refinery turnaround. Bridgestone Associates supervised the contractor during the substation modifications during the refinery turnaround.