http://www.netl.doe.gov/KMD/cds/disk50/NGCC%20Plant%20Case_FClass_051607.pdf

Natural Gas Combined-Cycle Plant

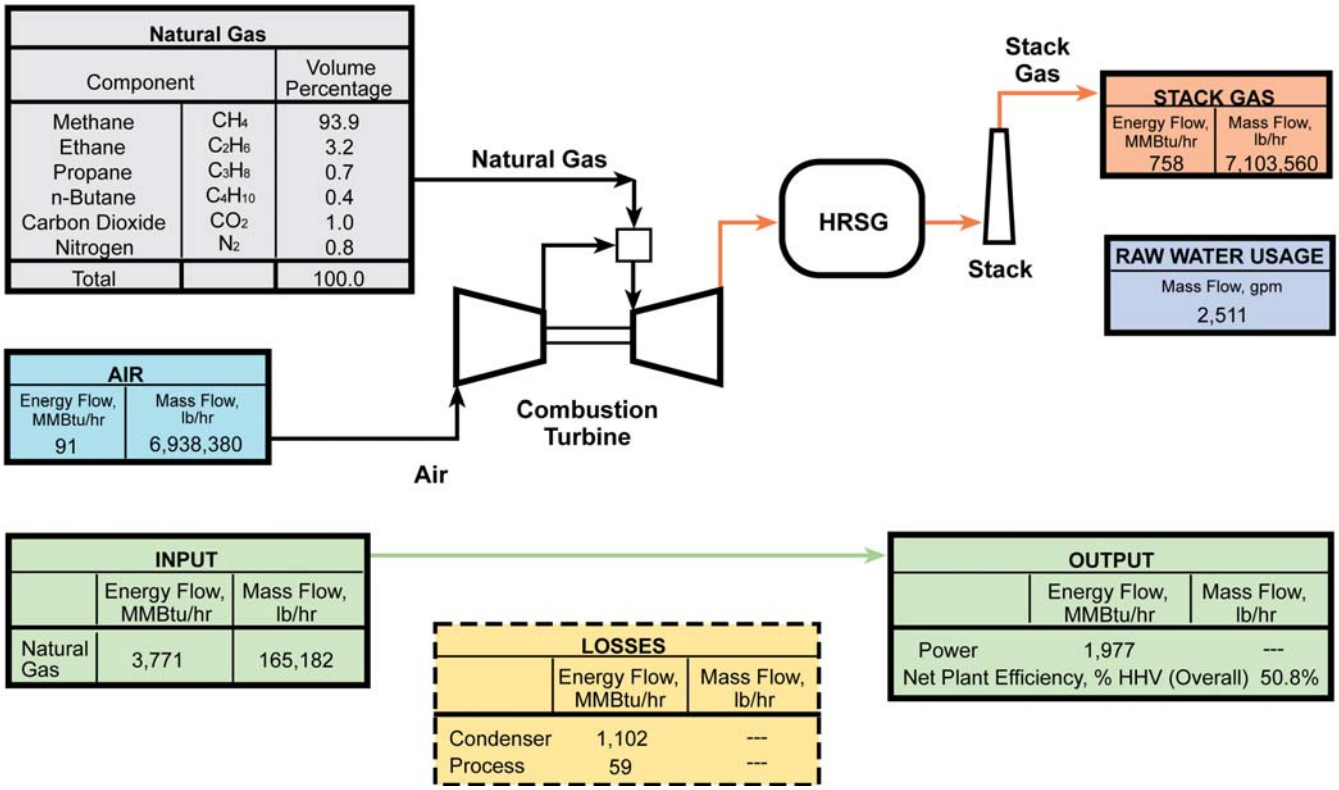
Plant Overview

This analysis is based on a 560 MWe (net power output) natural gas combined-cycle (NGCC) plant located at a greenfield site in the midwestern United States. This plant is designed to meet Best Available Control Technology (BACT) emission limits. The combination process, heat, and mass balance diagram for the NGCC plant is shown in Figure 1. The primary fuel is natural gas (NG) with a higher heating value (HHV) of 22,792 Btu/lb. The plant is assumed to operate in baseload mode at a capacity factor (CF) of 85 percent without sparing of major train components. A summary of plant performance data for the NGCC plant is presented in Table 1.

Table 1. Plant Performance Summary

Plant Type	NGCC
Carbon capture	No
Net power output (kWe)	560,360
Net plant HHV efficiency (%)	50.8
Primary fuel (type)	Natural Gas
Levelized cost-of-electricity (mills/kWh) @ 85% capacity factor	68.4
Total plant cost ($ x 1,000)	$310,710

Figure 1. Process Flow Diagram
NGCC



Note: Diagram is provided for general reference of major flows only. For complete flow information, please refer to the final report.

Technical Description

Table 2. Advanced Gas Turbine Performance[1]

	Advanced F-Class
Net output, MWe	185
Pressure ratio	18.5
Airflow, kg/s (lb/s)	431 (950)
Firing temperature, °C (°F)	>1,371 (>2,500)

[1]At International Standards Organization conditions firing natural gas.

The analysis for the NGCC plant is based on two advanced F-Class combustion turbine generators (CTGs), which are assumed to be commercially available to support startup in 2010; two heat recovery steam generators (HRSGs); and one steam turbine generator (STG) in a multi-shaft 2x2x1 configuration with a recirculating wet cooling tower for cycle heat rejection. A performance summary for the advanced F-Class CTGs is presented in Table 2. The unit consists of an NG system that feeds NG at the required pressure and temperature to the two axial flow, constant-speed CTGs with variable inlet guide vanes, and a dry low-NOx (DLN) burner combustion system. Each CTG exhausts to an HRSG configured with high-, intermediate-, and low-pressure steam systems, including drum, superheater, reheater, and economizer sections. Steam from both HRSGs flows to a conventional steam turbine for power generation. The Rankine cycle consists of a single reheat system with steam conditions of 16.5 MPa/566°C/510°C (2,400 psig/1,050°F/950°F). Nitrogen oxides (NOx) emissions are controlled to 25 ppmvd (referenced to 15 percent oxygen (O_2)) by the DLN combustion system and then further reduced by a selective catalytic reduction (SCR) system. The SCR system was designed for 90 percent reduction of NOx. These together achieve the emission limit of 2.5 ppmvd NOx (referenced to 15 percent O_2). All other support systems and equipment are typical for a conventional NGCC plant. Plant performance is based on the properties of pipeline-quality NG.

Table 3. Plant Electrical Generation

	Electrical Summary
Advanced gas turbine x 2, MWe	370.2
Steam turbine, MWe	200.0
Gross power output, MWe	570.2
Auxiliary power requirement, MWe	(9.8)
Net power output, MWe	560.4

Achieving a nominal 560 MWe net output with such a plant configuration results in an HHV thermal input requirement of 1,103,362 kWt (3,765 MMBtu/hr basis). This thermal input is achieved by burning NG at a rate of 165,182 lb/hr, which yields an HHV net plant heat rate of 6,719 Btu/kWh (HHV efficiency of 50.8 percent). The gross power output of 570 MWe is produced from the advanced CTGs and the STG. With an auxiliary power requirement of 10 MWe, the net plant output is 560 MWe. The summary of plant electrical generation performance is presented in Table 3.

Environmental Performance

This study assumes the use of BACT to meet the emission requirements of the 2006 New Source Performance Standards.

NGCC plants use NG as their fuel, which creates negligible emissions of sulfur dioxide (SO_2), particulate matter (PM), and mercury (Hg); therefore, NGCC plants require no emissions controls equipment or features to reduce these emissions. NOx emissions are controlled to 25 ppmvd (referenced to 15 percent O_2) by the DLN combustion system and then further reduced by an SCR system. The SCR system was designed for 90 percent reduction while firing NG. The DLN burner, together with the SCR, achieves the emission limit of 2.5 ppmvd (referenced to 15 percent O_2).

A summary of the resulting air emissions is presented in Table 4.

Cost Estimation

Plant size, primary/secondary fuel type, construction time, total plant cost (TPC) basis year, plant CF, plant heat rate, fuel cost, plant book life, and plant in-service date were used as inputs to develop capital cost, production cost, and levelized cost-of-electricity (LCOE) estimates. Costs for the plant were based on adjusted vendor-furnished and actual cost data from recent design/build projects. Values for financial assumptions and a cost summary are shown in Table 5.

Project contingencies were added to each case to cover project uncertainty and the cost of any additional equipment that could result from detailed design. The project contingencies represent costs that are expected to occur. Project contingency was 10.6 percent of the TPC.

No process contingency is included in this case because all elements of the technology are commercially proven.

This study assumes that each new plant would be dispatched any time it is available and would be capable of generating maximum capacity when online. Therefore, CF is assumed to equal availability and is 85 percent for NGCC cases.

Table 4. Air Emissions Summary @ 85% Capacity Factor

Pollutant	NGCC Without CCS
CO_2	
• tons/year	1,661,720
• lb/MMBtu	119
• cost of CO_2 avoided ($/ton)	N/A
SO_2	
• tons/year	Negligible
• lb/MMBtu	Negligible
NOx	
• tons/year	127
• lb/MMBtu	0.009
PM (filterable)	
• tons/year	Negligible
• lb/MMBtu	Negligible
Hg	
• tons/year	Negligible
• lb/TBtu	Negligible

The 560 (net) MWe NGCC plant was projected to have a TPC of $554/kWe, resulting in a 20-year LCOE of 68.4 mills/kWh.

Table 5. Major Financial Assumptions and Resulting Cost Summary[1]

Major Assumptions					
Case:	**1x560 MWe net NGCC**				
Plant Size:	560.4	(MWe, net)	Heat Rate:	6,719	(Btu/kWh)
Primary/Secondary Fuel (type):	Natural Gas		Fuel Cost:	6.75	($/MMBtu)
Construction Duration:	3	(years)	Plant Life:	30	(years)
Total Plant Cost[2] Year:	2007	(January)	Plant in Service:	2010	(January)
Capacity Factor:	85	(%)	Capital Charge Factor:	16.4	(%)
Resulting Capital Investment (Levelized 2007 dollars)					**Mills/kWh**
Total Plant Cost					12.2
Resulting Operating Costs (Levelized 2007 dollars)					**Mills/kWh**
Fixed Operating Cost					1.5
Variable Operating Cost					1.5
Resulting Fuel Cost (Levelized 2007 dollars) @ $1.80 / MMBtu					**Mills/kWh**
					53.1
Total Levelized Busbar Cost of Power (2007 dollars)					**Mills/kWh**
					68.4

[1]Costs shown can vary ± 30%.

[2]Total plant cost includes all equipment (complete with initial chemical and catalyst loadings), materials, labor (direct and indirect), engineering and construction management, and contingencies (process and project). Owner's costs are not included.

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Reference: Cost and Performance Baseline for Fossil Energy Plants, Vol. 1, DOE/NETL-2007/1281, May 2007.
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