

GHG BACT Analysis Case Study
Russell City Energy Center

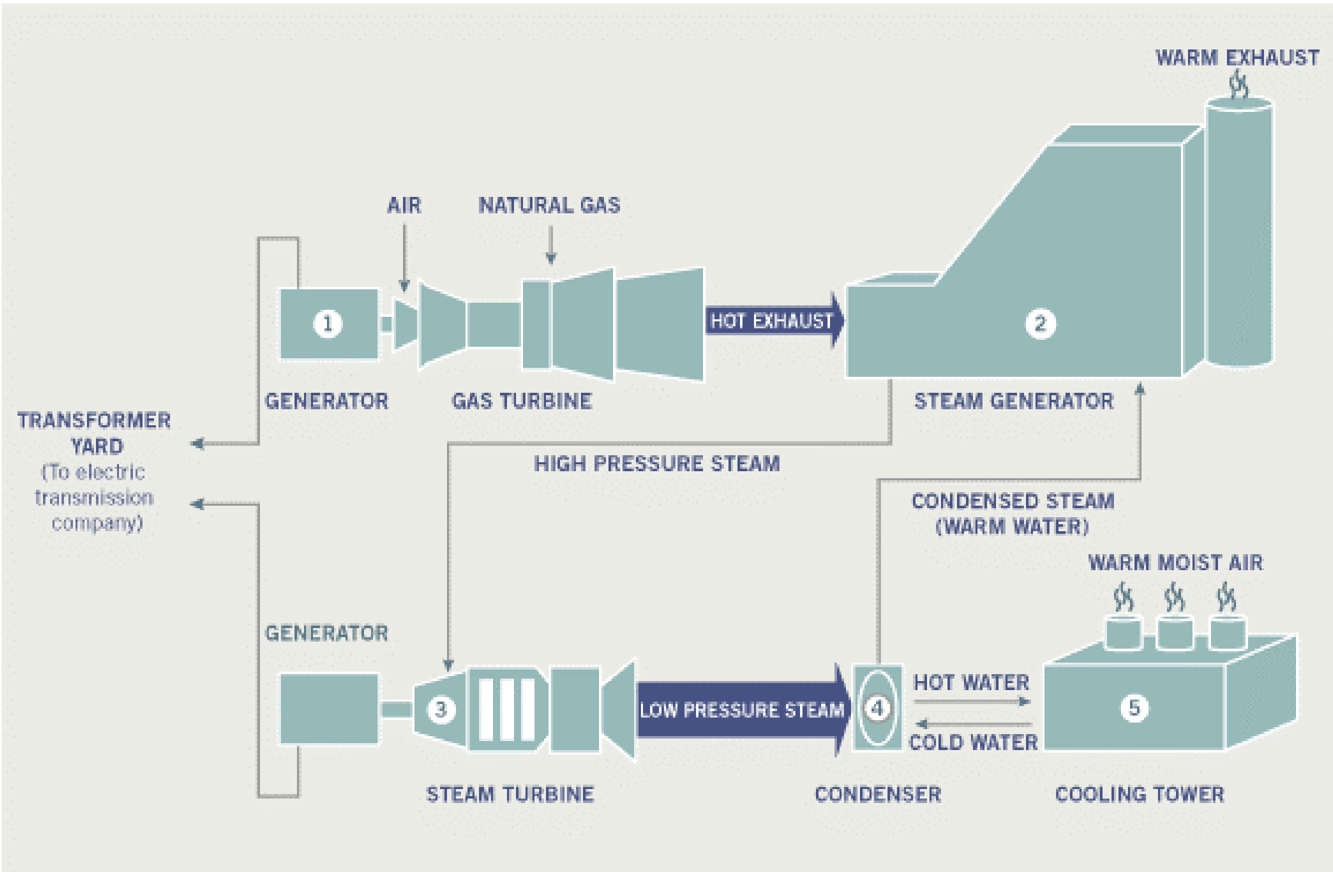
November 2009
Updated February 3, 2010

Project Description

- 612 megawatt natural gas fired combined cycle power plant in Hayward, CA.
- GHG emission sources
  - 2 Siemens Westinghouse 501FD3 combustion turbines – natural gas fired
  - 2 Heat Recovery Steam Generators with supplemental firing – natural gas fired
  - 1 Emergency Fire Pump – diesel fired
  - 5 Circuit breakers – SF_6
- Emission controls
  - Dry Low NOx Combustors
  - Selective Catalytic Reduction
  - Oxidation catalyst
- Power purchase agreement with PG&E
- Permits required from California Energy Commission and Bay Area Air Quality Management District



Project Description





Air Permit History

- Bay Area Air Quality Management District issued combined Authority to Construct and PSD Permit on November 1, 2007
  - Appeal to Air District Hearing Board denied
  - Petition to EAB resulted in remand of PSD Permit on July 29, 2008
  - EAB Deseret decision issued November 13, 2008
  - Johnson Memo December 18, 2008

- Draft PSD Permit issued December 8, 2008.
  - Public hearing held January 21, 2009
  - Public comment period extended until February 6, 2009
  - EPA approved Petition for Reconsideration February 19, 2009

- Revised Draft PSD Permit and Additional Statement of Basis Issued August 3, 2009
  - Included GHG BACT and voluntary GHG limits to address Deseret uncertainty
  - Public hearing held September 2, 2009
  - Public comment period closed September 16, 2009
  - Awaiting final permit

- http://www.baaqmd.gov/Divisions/Engineering/Public-Notices-on-Permits/2009/080309-15487/Russell-City-Energy-Center.aspx



General Approach

- Followed the 5 Step Approach
- Initial BACT Analysis in December 2008
- BACT Analysis modified in August 2009
    - Responses to comments
- Resulted in voluntary federally-enforceable GHG limits



Step 1 – Identify Control Technologies

- Combustion controls
  - No way to alter the chemical reaction ($CH4 + 2O_2 = CO_2 + 2H_20$)
  - Thermal efficiency was the only combustion control identified

- Post-combustion controls
  - Carbon capture and storage
  - Nothing else

- Response to comments
  - Evaluation of non-fossil electricity generation
    - BAAQMD sympathetic but deferred to California Energy Commission
    - BAAQMD states "… the federal BACT framework is clear that it does not require consideration … of non-fossil-fuel-fired alternatives …"



Step 2 – Eliminate Technically Infeasible Options

- Combustion controls
  - Energy efficiency is feasible and proven
- Post combustion controls
  - CCS not commercially available
  - DOE expects commercial deployment in 2025 (73 FR 44370)
  - Appropriate sequestration sites in bay area not demonstrated
  - Need further evaluation of environmental impacts of CCS
- Conclusion that high-efficiency power generation technology is the only available and feasible control technology
- Since top control technology chosen no further analysis required per EPA top-down BACT approach



BACT Emission Limit

- High efficiency power generation the only option
  - CEC data indicated CCGT can achieve 56% efficiency
  - Original project featured 501FD2 turbines achieving 55.8% efficiency
  - Project revised to FD3 achieving 56.45 efficiency
- Comparable projects

Facility	CEC Application Date	Facility Size (MW)	Thermal Efficiency (LHV)
Colusa Generation Station	11/6/2006	660	56%
Blythe Energy Project Phase II	2/19/2002	520	55-58% (est.)
Lodi Energy Center	9/10/2008	255	55.6%
CPV Vaca Station Power Plant	11/18/2008	660	55%
Victorville 2 Hybrid Power Project	2/28/2007	563	52.7% (w/ duct burn)
Avenal Energy Power Plant[44]	2/21/2008	600	50.5%
Palomar Energy Project	8/2003	550	55.3% (w/o duct firing) 54.2% (w/ duct firing)
SMUD Consumnes Phase I	9/13/2001	500	55.1%



BACT Emission Limit

- BAAQMD determined CO_2 emissions achievable for the level of efficiency
- CDC data showed CCGT power plants with emission rates ranging from 794 to 1058 lb/mwh
- BAAQMD cites EPA guidance that BACT limits should not necessarily reflect the maximum possible emissions control efficiency under the most favorable conditions but rather at levels that will allow facilities to achieve compliance consistently over time under all operating conditions
- Factors reducing CCGT efficiency:
  - Hot weather
  - Starting up or shutting down
  - Loads below 100 percent
  - Duct firing
  - Air cooling
- In December 2008 BAAQMD Proposed BACT Limit for CO_2 of 1100 lb/mwh
  - Lowest regulatory limit at the time (CA SB 1368)
  - Enforced through heat input limit



Revised BACT Limit – Comments on December 2008 BACT

- More efficient CCGT configurations exist - “G” and “H” turbine technology
  - G technology would be less efficient at 612 mw configuration
  - H technology not yet demonstrated at 60 Hz (Inland Empire just starting)
  - BAAQMD concluded FD3 was most efficient for this project
- BACT limit issues
  - BACT was established as thermal efficiency (%) but expressed as mass emissions per unit of power output (lb/mwh)
  - The permit limit of 1100 lb/mwh was developed to accommodate older, higher emitting facilities and should be considered a floor
  - Data shows achievable emission from new CCGT power plants as low as 800 lb/mwh
  - There was no justification for the compliance margin
  - Heat input limit justification was 35% higher than the rated maximum for the turbines
  - Heat input limit should instead be an output based limit – emissions could rise as efficiency declines yet heat input would remain the same
- BAAQMD legal counsel worked with Calpine and counsel for key commenters to revise limits
  - Absolute based on heat input
  - Efficiency based on heat rate
  - Monitoring and testing provisions



GHG BACT – Mass Emissions Limits

- Based on permitted heat input limits
- Expanded to include other GHGs
- Monitored real time
  - Fuel flow more accurate than CO2 CEMS
- Based on common emission factors (EPA and CARB)
- Most permits contain heat input limits

Averaging Period	Heat Input Limit (MMBtu)	Greenhouse Gas Emissions Limits (metric tons CO_2E)			
		CO_2	CH_4	N_2O	CO_2E
1-Hour	4,477.2	242	0.08	0.14	242
24-Hour	107,452.0	5,797	2.03	3.33	5,802
Annual	35,708,858.0	1,926,399	675	1,107.48	1,928,182

GHG BACT- Output Based Efficiency Limits

- Heat Rates (no duct firing)

Condition	Heat Rate (Btu/kwh)
Net Design Base (new and clean)	6,852
Installed Design Base (3.3% design margin)	7,080
Degraded Base (degradation between major overhauls and compliance margin)	7,730

- Factors affecting heat rate
  - Gas pressure variability
  - Gas quality variability
  - Cooling water quality variability
  - Turbine exhaust flow degradation
  - Steam turbine performance degradation
  - Gas turbine performance degradation
  - Parasitic load (water treatment)



Miscellaneous

- Fire pump BACT was limiting operation to testing and emergencies to achieve annual limit of 7.6 metric tons CO2E
- Circuit Breakers
  - Each breaker contains about 145 pounds SF6
  - No direct emissions – potential for fugitive emissions from leaks
- 5 Step BACT for breakers
  - Step 1: Identified SF6 alternatives (oil or air-blast) and SF6 breakers with leak detection
  - Step 2: SF6 alternatives eliminated due to space/safety considerations
  - Step 3: SF6 breakers with leak detection ranked highest but alternatives evaluated
  - Step 4: SF6 alternatives would require more land, generate more noise, and increase the risk of dielectric fluid release
  - Step 5: SF6 breakers with leak detection selected to maintain emissions below 39.3 metric tons CO2E per year

GHG BACT Permit Conditions

- Mass limits per previous table measured continuously
- Efficiency limit of 7,730 Btu/kwh
  - Initial compliance test within 90 days of commissioning
  - Annual compliance tests thereafter
  - ASME Performance Test Code on Overall Plant Performance (ASME PTC 46-1996)
  - BAAQMD concluded continuous monitoring not possible
  - Efficiency limit measured during baseload operation
- No substantive comments on GHG BACT of the 140 plus comment letters received

Lessons Learned

- Project configuration will drive the efficiency determinations
  - Simple cycle vs. combined cycle
  - Turbine scale (larger is more efficient but not always marketable)
  - Customer defines project configuration
    - Size (megawatts)
    - Characteristics (ramp rate, peaking capacity)

- Companies should be amenable to reasonable GHG limits based on efficiency
  - Important to maintain realistic estimate of heat rate degradation
  - Vendor heat rate projections cover first 48K hours

- Difficult to define efficiency except where design bases and heat rate guarantees exist
  - Many factors degrade efficiency



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