Russell City Energy Center Voluntary GHG BACT Determination

Bay Area Air Quality Management District

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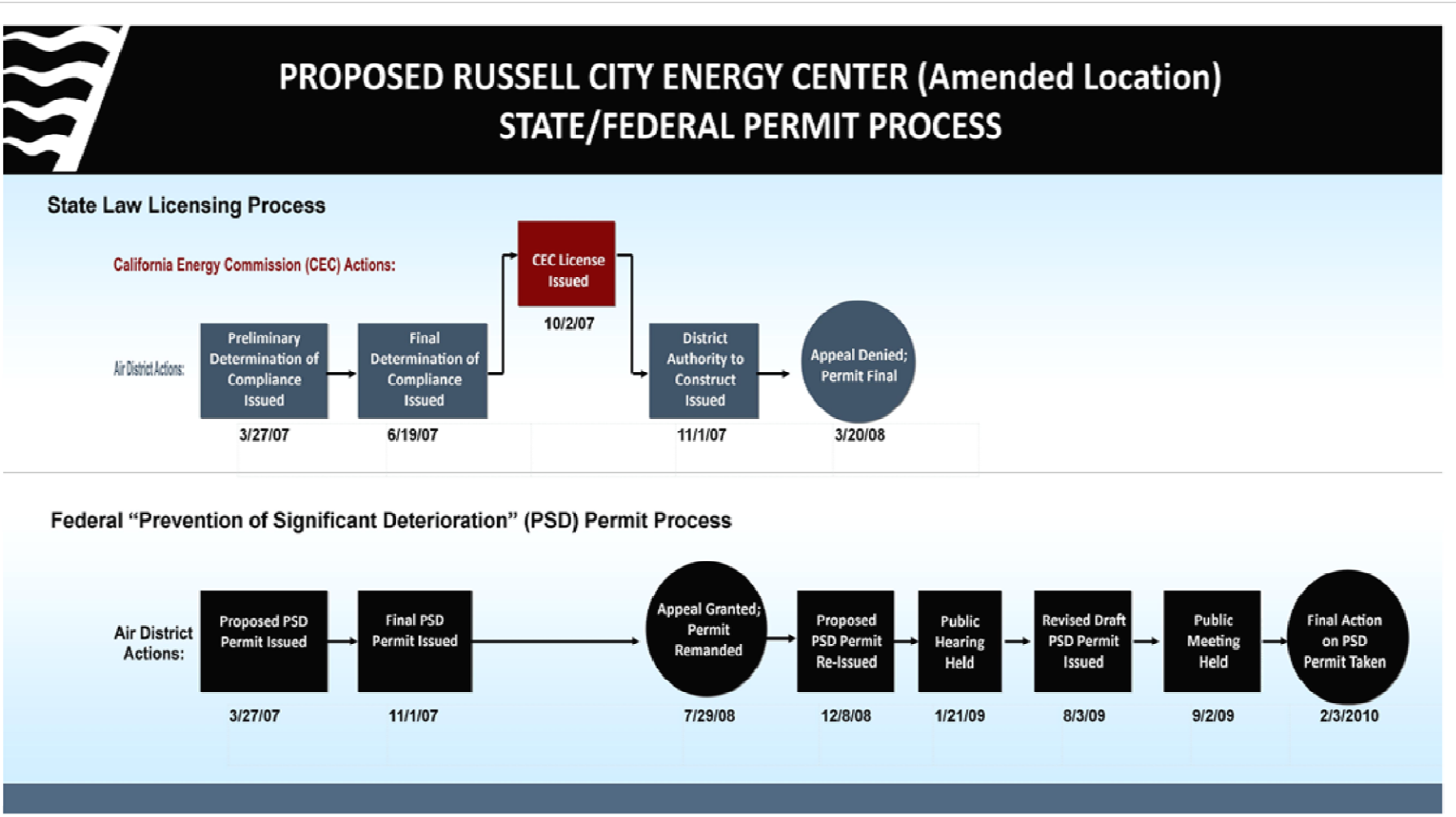
RCEC Project Description

- 600 MW (nominal) Combined Cycle Power Plant in Hayward, CA
- 2 - Siemens Westinghouse 501FD3 Combustion Turbines
  natural gas fired, 200 MW
- 2 - Heat Recovery Steam Generators, Supplemental Fired
  natural gas fired
- Combustion Controls: Dry Low NO_x Combustors
- Post Combustion Control: Selective Catalytic Reduction (SCR) and Oxidation Catalyst
- Steam Turbine, 235 MW, Triple Pressure
- Cooling Tower, 9-Cell, 141,352 gallons per minute
- Diesel Fire Pump Engine, Clarke JW6H-UF40, 300 hp
- 5 - Circuit Breakers (SF_6), Alstom Type HGF

Permitting Timeline for RCEC



RCEC Permitting Situation and Voluntary GHG BACT Limits

- PSD Permit remanded on 7/29/08
- State Law Non-Attainment NSR Permit upheld on Appeals in 2008
- Greenhouse Gas Regulations were uncertain, since the EPA's Johnson Memorandum (12/18/2008) had not yet been released
- EAB Deseret Power Decision (11/2008) was unclear regarding PSD GHG requirements
- Commenters participating in the permit process had significant interest in GHG emissions from the RCEC

Initial Voluntary GHG BACT Limit Combustion Turbines (12/2008)

- District proposed a limit of 1,100 lb CO_2e per MW hour based on California Senate Bill 1368 (Perata 2006)
- SB 1368 limits long-term investments in baseload generation by the state's utilities to power plants that meet an emissions performance standard (EPS) jointly established by the California Energy Commission (CEC) and the California Public Utilities Commission (CPUC)
- Commenters stated that the SB1368 limit was too high for BACT limit
- Two existing combined cycle power plants in the Bay Area operated at 855 lb CO_2e/MW-hr and 912 lb CO_2e/MW-hr based on 2006 operating data

Final Voluntary GHG BACT Limits Combustion Turbines (8/2009)

- Fuel Usage Limits
  - 2,238.6 MMBtu/hour
  - 53,726 MMBtu/day
  - 35,708,858 MMBtu/year
- CO_2e Limits
  - 242 metric tons of CO_2e/hour
  - 5802 metric tons CO_2e/day
  - 1,928,182 metric tons of CO_2e/year
- Maximum Heat Rate of 7,730 Btu/KW-hr (HHV, net) (~920 lb CO_2e/MW-hr) with Annual Verification
- Annual Heat Rate Test according to ASME PTC 46-1996

Top-Down GHG BACT Analysis Combustion Turbines

- Step 1 – Available Control Technologies
  - District identified energy efficiency and carbon capture and sequestration as available control technologies
  - Commenters suggested the District should consider alternative forms of energy such as solar and wind
    - District discussed CEC analysis of these technologies
    - CEC and CPUC are considered expert agencies on the types of generation needed for the State of California
    - Solar and wind power are not part of the BACT analysis, since mandating alternative energy would "redefine the source"

Top-Down GHG BACT Analysis Combustion Turbines (Cont'd)

- Step 2 – Eliminate Technically Infeasible Options
  - Carbon capture and sequestration not yet technically feasible for a full scale commercial project such as RCEC (not commercially available)
- Step 3 – Rank Remaining Technologies by Control Effectiveness
  - Energy Efficiency only option
- Step 4 – Evaluate Most Effective Controls
  - District compared RCEC thermal efficiency of 56.4% (LHV) to eight comparable CEC licensed projects (F-Class turbines)
  - District also evaluated Siemens G Class and GE H Class turbines with thermal efficiencies as high as 60%

Top-Down GHG BACT Analysis Combustion Turbines (Cont'd)

- Step 4 – Evaluate Most Effective Controls (Cont'd)
  - RCEC has High Thermal Efficiency due to the following:
    - Utilizes Combined Cycle Gas Turbine Technology
    - Uses Upgraded turbines (FD3) that increase efficiency from 55.8% to 56.4% by
      - decreasing clearances in the compressor section of the turbine
      - adjusting the inlet guide vanes (increasing air flow through turbine)
      - optimizing the control system components
  - The District has recently received a permit application for an existing Calpine combined cycle plant (not RCEC, not part of GHG BACT Determination) that improves turbine efficiency by
    - reducing clearances in the compressor section to reduce leakage losses
    - installing low pressure drop combustors
    - increasing firing temperature (required new metallurgy for hot gas path components)

Top-Down GHG BACT Analysis Combustion Turbines (Cont'd)

- Step 5 – Select BACT, Develop Permit Limits
  - BACT was determined to be the most efficient generation technology for F Class gas turbines (56.4% Thermal Efficiency LHV basis). A heat rate permit limit in units of Btu of fuel input (HHV) per KW-hr energy output (net) ensures high efficiency operation.

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

  - Heat Input Limits and corresponding CO_2e Limits also incorporated into GHG permit limits.

Top-Down GHG BACT Analysis
Other Sources

- Diesel Fire Pump Engine
  - Latest Tier Engine (Most Fuel Efficient Available)
  - Emissions limited to 7.6 metric tons of CO_2e/year
- Sulfur Hexafluoride (SF_6) Circuit Breakers
  - SF_6 emissions important due to high Global Warming Potential of this compound (23,900 CARB)
  - Annual Emissions Estimate assumed Leak Rate of 0.5% by weight
  - Leak Detection System required by conditions
  - Emissions limited to 39.6 metric tons of CO_2e/year

Conclusions

- RCEC was one of the first permits to include GHG permit limits (voluntary basis) and to include GHG BACT analysis
- Gas Turbines were upgraded to Siemens/Westinghouse 501FD3 to maximize efficiency, improve heat rate, and lower GHG emissions
- The maximum heat rate limit and the associated annual compliance demonstration ensures efficient operation and minimizes GHG emissions