

CCS - An Electric
Generator Perspective

Natural Gas CCS Forum
November 4, 2011

Donald Neal, VP EHS

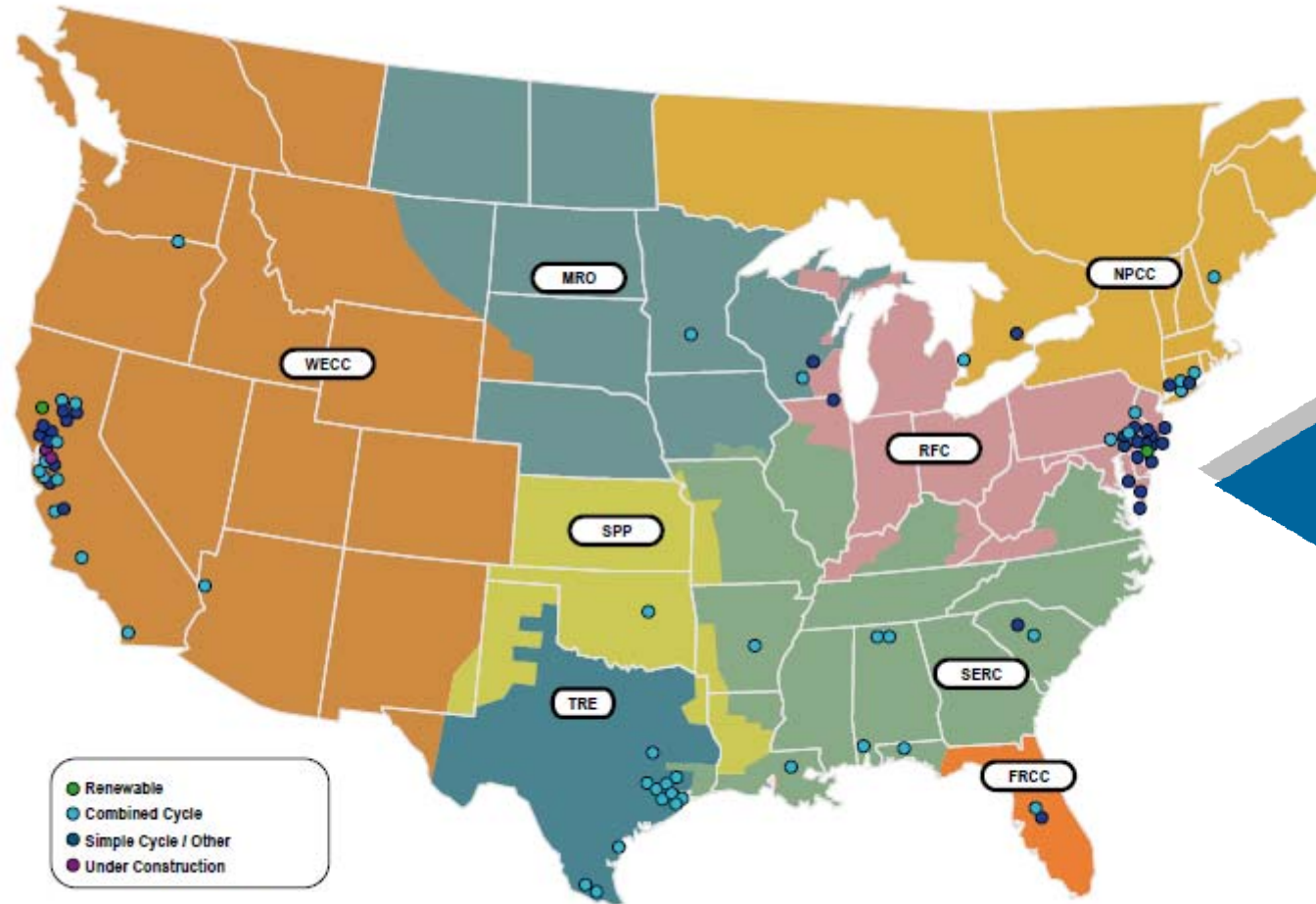


Agenda



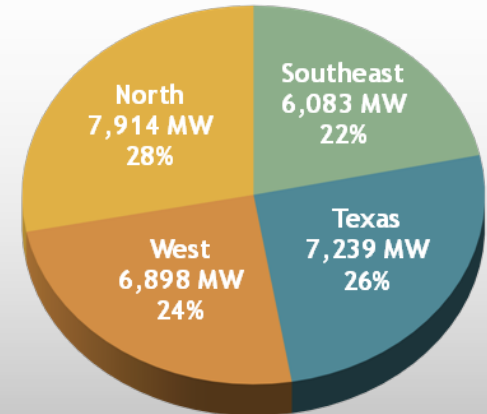
- Calpine Corporation description
- Russell City Energy Center GHG Permit and BACT
- Recent developments in GHG BACT
- Calpine's view on CCS

National Portfolio of More Than 28,000 MW

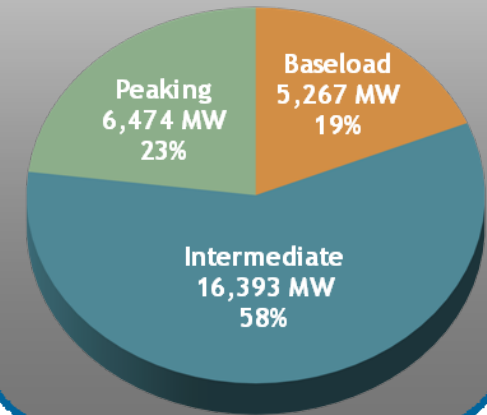


As of October 2011

Geographic Diversity



Dispatch Flexibility

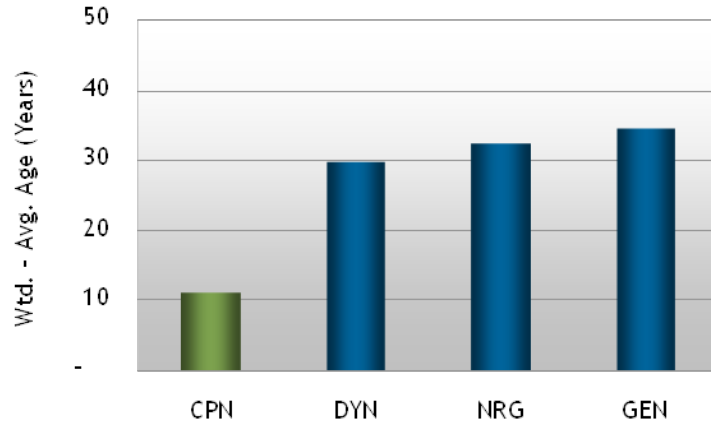


Unique Independent Power Producer



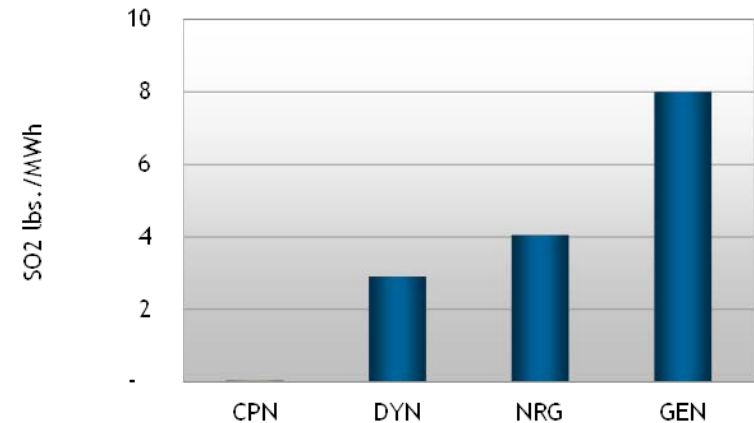
Calpine is the nation's largest baseload renewable, natural gas and cogeneration power provider

Modern



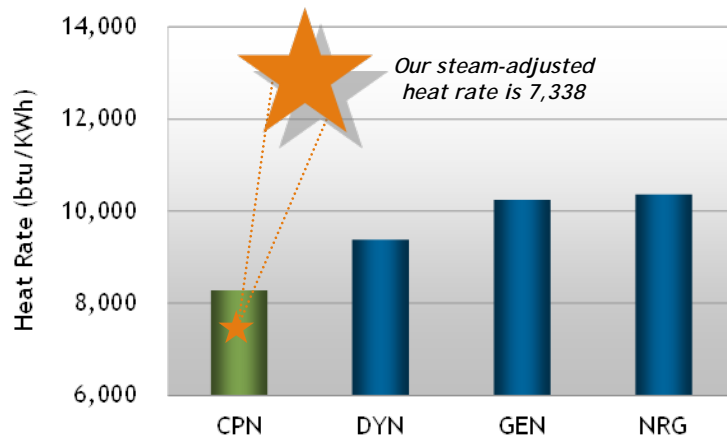
Source: Energy Velocity (2010).

Clean



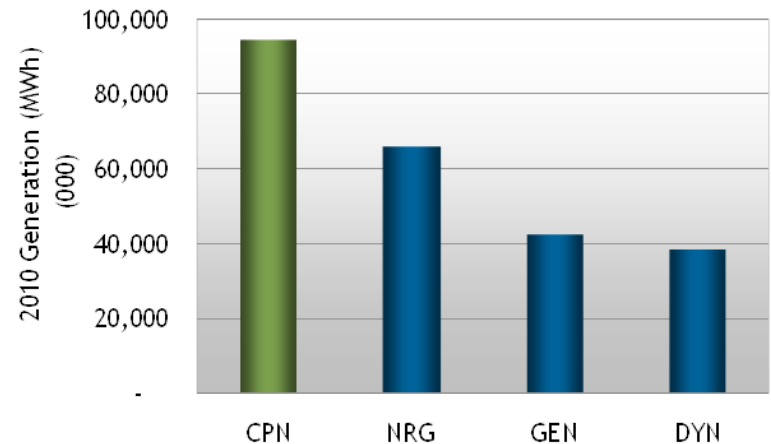
Source: Energy Velocity (2010).

Efficient



Source: Energy Velocity (2010). Not adjusted for steam, and excluding non-fossil fuel generation. Steam-adjusted heat rate does not include peakers.

Scale



Source: 2010 SEC filings.

- First power plant to have federally-enforceable GHG limits through permit issued by Bay Area Air Quality Management District (BAAQMD)
- 612 megawatt natural gas fired combined cycle power plant in Hayward, CA.
- Performed 5-Step BACT analysis before EPA Guidance was issued
 - Step 1: Identify control technologies
 - Combustion controls identified thermal efficiency
 - Add on controls identified CCS
 - Step 2: Eliminate technically infeasible options
 - CCS not commercially available
 - DOE expects commercial deployment in 2025 (73 FR 44370)
 - Appropriate sequestration sites in bay area not demonstrated
- Conclusion that high-efficiency power generation technology is the only available and feasible control technology
- BAAQMD determined that BACT limit in permit would have both mass and efficiency limits
 - Permit issued February 2010
 - EAB denied all appeals November 2010

Russell City Energy Center BACT Limits



- Mass emission limits based on permitted heat input

Averaging Period	Heat Input Limit (MMBtu)	Greenhouse Gas Emissions Limits (metric tons CO ₂ E)			
		CO ₂	CH ₄	N ₂ O	CO ₂ E
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

- Efficiency limits based on baseload heat rate plus degradation factors

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

- November 10, 2010 - EPA issued PSD and Title V Permitting Guidance for GHGs
- Step 1 - Identify all available control options
 - CCS specifically listed as “available” for fossil fuel-fired power plants
- Step 2 - Eliminate technically infeasible options
 - Lack of a commercial guarantee does not render CCS technically infeasible
 - CCS has three main components any of which may be technically infeasible:
 - Capture and compression
 - Transport
 - Storage
 - EPA concludes at this time CCS is likely to be deemed technically infeasible
 - Permitting record does not show CCS is “demonstrated in practice” or “available and applicable”
- Significant hurdles
 - Contracts for off-site land
 - Funding
 - Availability of transportation infrastructure
 - Long term storage site

- Calpine Deer Park expansion filed with EPA Region VI September 2011 rejected CCS in Step 2
 - Amine absorption not commercially available for gas fired power plants that have larger flow volumes and lower CO2 concentrations
 - Uncertainty regarding transportation arrangements (10-250 mile pipeline)
 - No proven sequestration site
- Draft GHG permit issued by EPA Region VI to Lower Colorado River Authority September 2011:
 - CCS not specified
 - Average net heat rate of 7720 Btu/kwh

Parameter	Without CCS	With CCS	Diff. (%)
Net power output (MW)	528	461	-13
Net Efficiency (%)	56.6	48.4	-14
CO2 Emissions (kg/MWh)	370	55	-85
Capital Cost (\$/kw)	960	1715	+79
Cost of CO2 Avoided (\$/tCO2)	n/a	80	n/a

Note: Average of nine estimates using F-Class Gas Turbine. Does not include transportation and storage

Source: Finkenrath, Matthias, 2011, Cost and Performance of Carbon Dioxide Capture from Power Generation. International Energy Agency Working Paper. Paris, France.

- \$80 CO2 removal cost for CCGT compares to \$55 removal cost for PC
- Calpine has no plans to install CCS even at a pilot scale



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