

CCS - An Electric  
Generator Perspective

Natural Gas CCS Forum  
November 4, 2011

Donald Neal, VP EHS

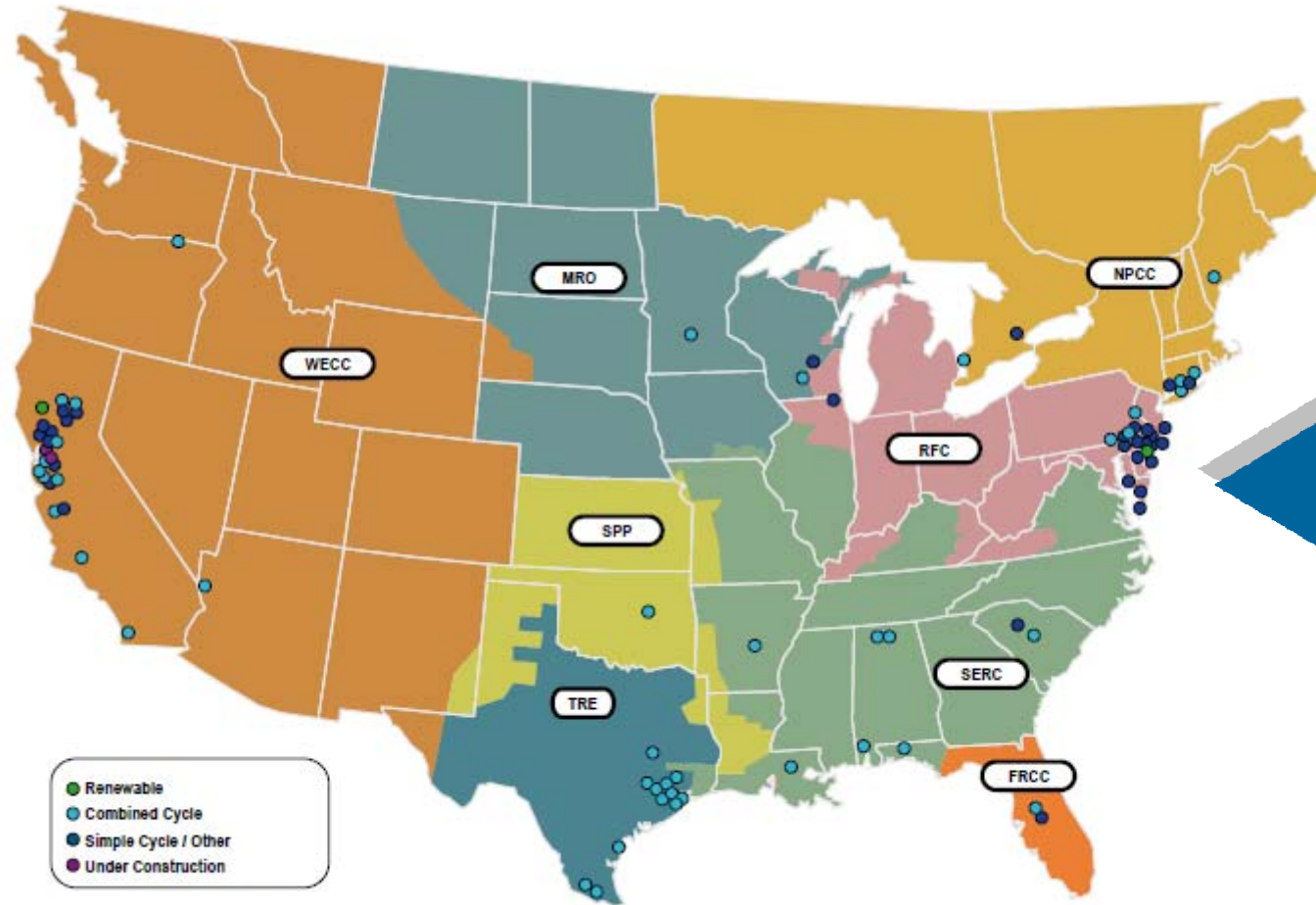


# Agenda



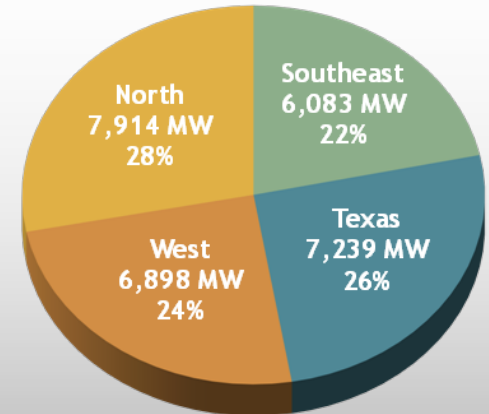
- Calpine Corporation description
- Russell City Energy Center GHG Permit and BACT
- Recent developments in GHG BACT
- Calpine's view on CCS

# National Portfolio of More Than 28,000 MW

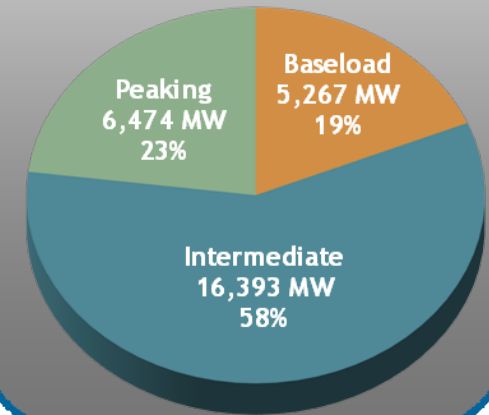


As of October 2011

## Geographic Diversity



## Dispatch Flexibility

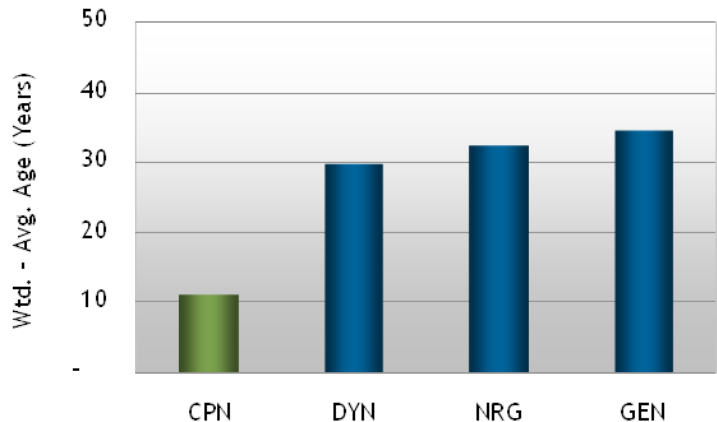


# Unique Independent Power Producer



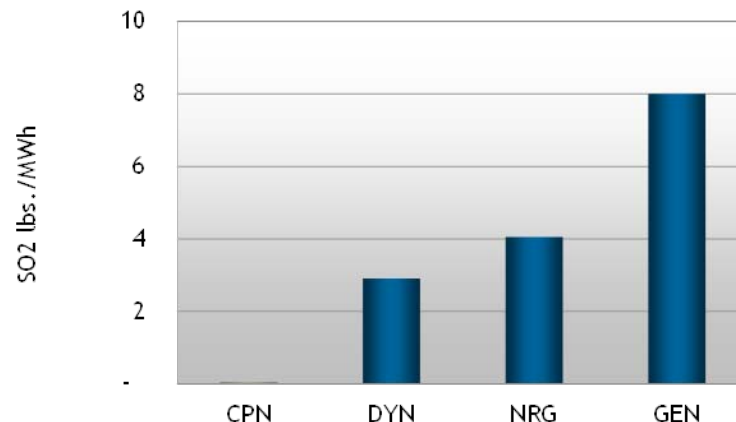
*Calpine is the nation's largest baseload renewable, natural gas and cogeneration power provider*

## Modern



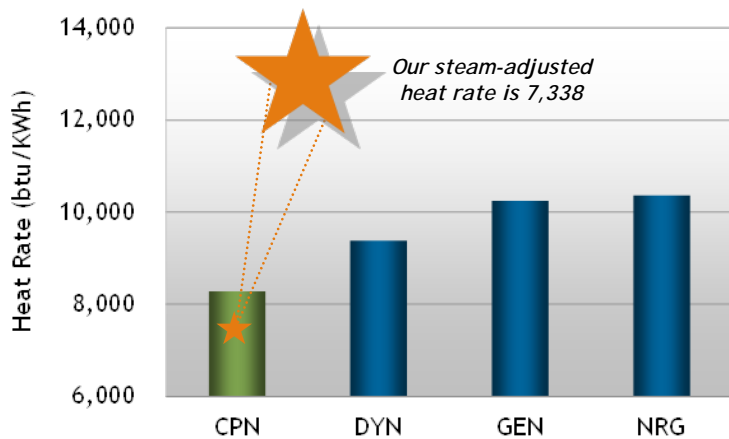
Source: Energy Velocity (2010).

## Clean



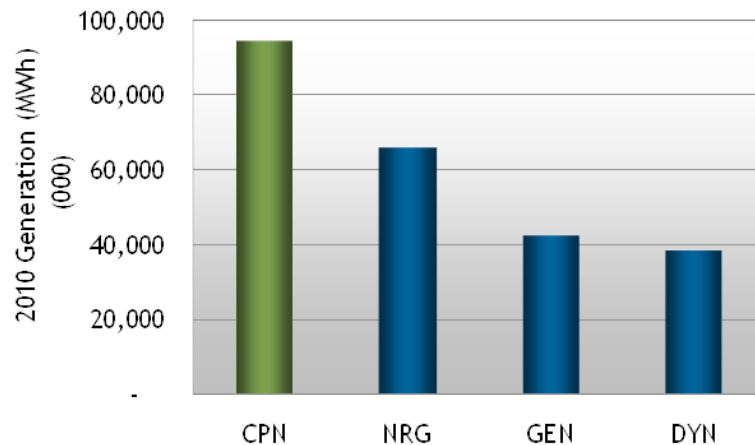
Source: Energy Velocity (2010).

## 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 <sub>2</sub> E) |                 |                  |                   |
|------------------|--------------------------|---|-----------------|------------------|-------------------|
|                  |                          | CO <sub>2</sub>   | CH <sub>4</sub> | N <sub>2</sub> O | CO <sub>2</sub> 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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