



Meeting California's Greenhouse Gas Emission Performance Standard for Western Coal Plants

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CO₂ Capture for Existing Plants R&D Meeting

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Global Warming Solutions Act of 2006 (AB32)

Established greenhouse gas emission performance standards for CA

- Requires that “all new long-term commitments for baseload generation to serve California consumers be with power plants that have emissions no greater than a combined cycle gas turbine plant.”
- “That level is established at **1,100 pounds of CO₂ per megawatt-hour.**”
- "New long-term commitment" refers to:
 - ✓ New plant investments (new construction)
 - ✓ New or renewal contracts with a term of five years or more
 - ✓ Major investments by the utility in its existing baseload power plants.

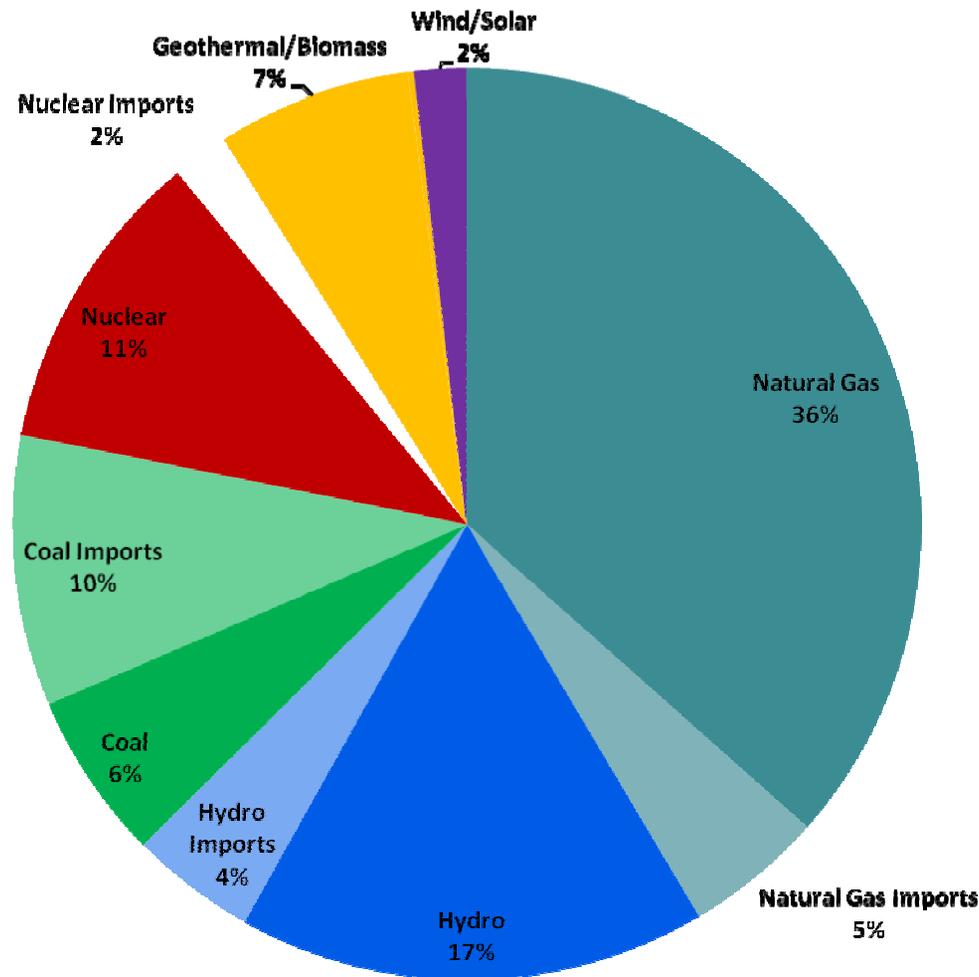
California's Electricity Mix

- **California consumes more energy than they produce**
- **Most of California's electricity comes from natural gas (36%)**
- **Next to natural gas, power imported from neighboring states is the next largest source in California (21%)**
- **The imported power is primarily:**
 - 1. Coal-fired (48%)**
 - 2. Natural gas-fired (24%)**
 - 3. Hydroelectric (19%)**



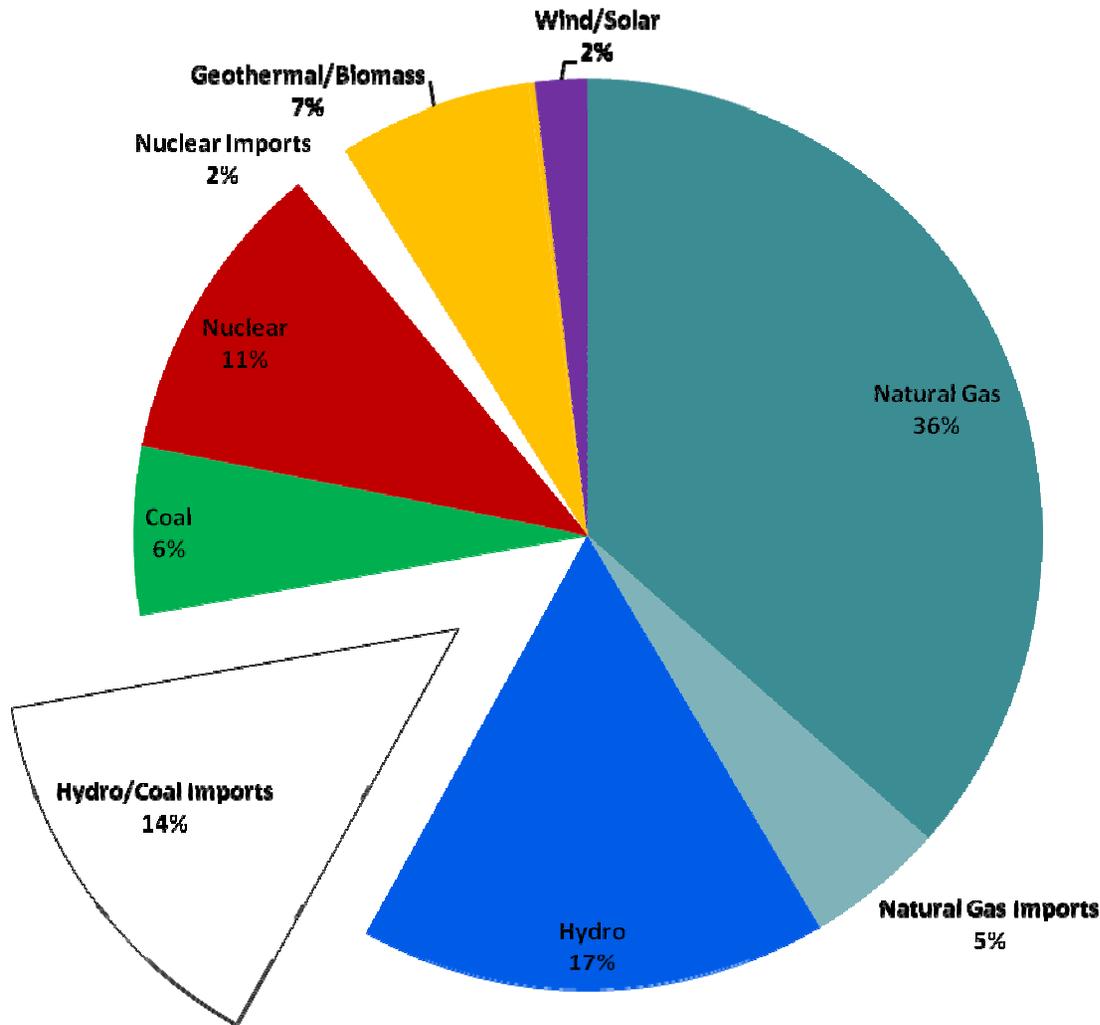
California's Electricity Mix¹

21% of CA's power is imported from neighboring states



California's Electricity Mix¹

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Study Purpose

- **What are the cost and performance impacts of an 1,100 lb CO₂/MWh limit on western coal plants?**
- **How might California's energy portfolio be affected by such a standard?**
- **If deeper emission cuts are required (250 – 350 lb CO₂/MWh), what are the technical and economic impacts, and what would the effect on California be?**

Study Basis

1. Low Rank Coal

- PRB Coal = 8,564 Btu/lb, 25.8% H₂O
 - Bituminous Coal = 11,666 Btu/lb, 11.1% H₂O

2. Site Elevation

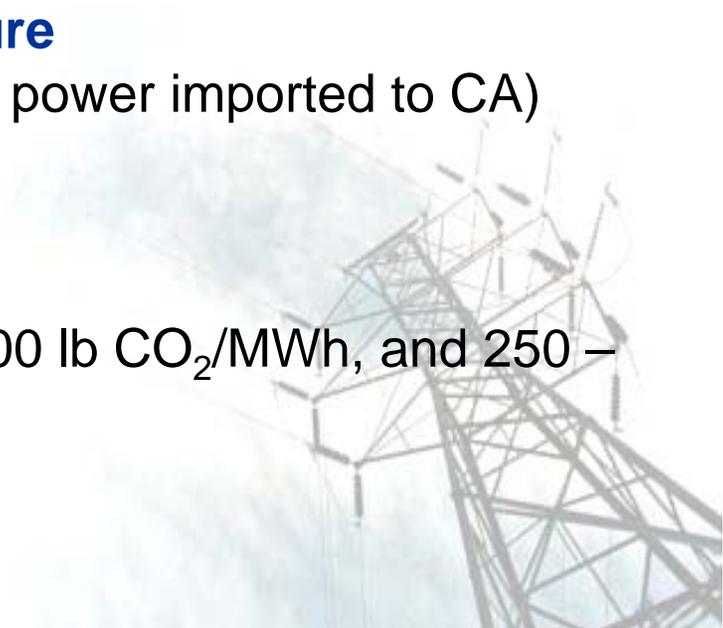
- Wyoming (6,700 ft)
 - Bituminous Baseline Study assumed sea level

3. Existing Coal Plants with CO₂ capture

- Existing subcritical PC (represents power imported to CA)
- Greenfield Supercritical PC, IGCC

4. Carbon Capture

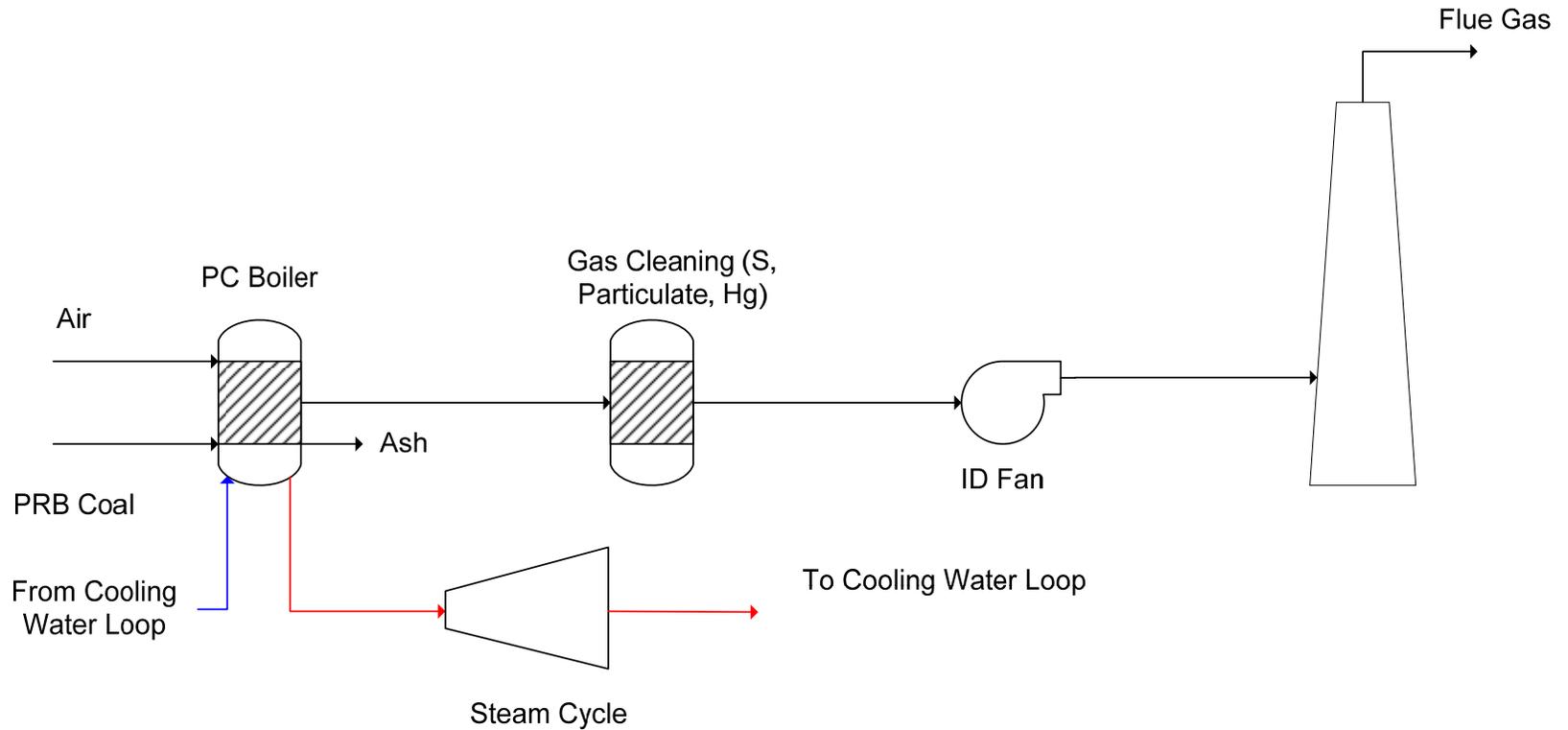
- Two levels of carbon capture: 1,100 lb CO₂/MWh, and 250 – 350 lb CO₂/MWh



Key Study Findings

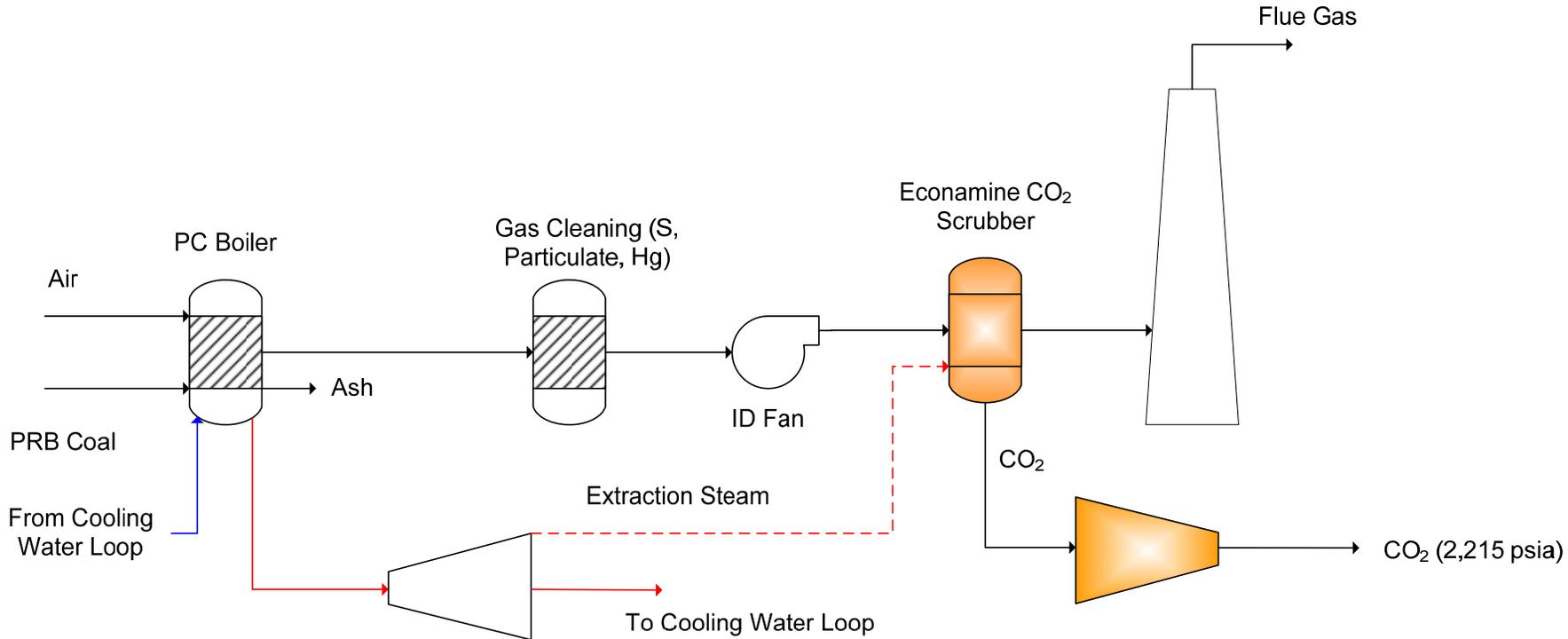
- 1. Existing PC meeting AB32 (1,100 lb CO₂/MWh, 62% CCS) is at price parity with NGCC at natural gas price of ~ \$5 / MMBtu (assuming PC plant paid off)**
 - Henry Hub spot prices Monday (3-23) ~ \$4.30 per MMBtu
 - EIA *Preliminary AEO '09* projects \$6.87 per MMBtu in '10
 - Under AB32, California would have to make up for a 3% deficit in supply due to reduced PC efficiency
- 2. Requiring deeper controls (250 – 350 lb CO₂/MWh) would impact all coal and natural gas sources supplying CA**
 - \$/ton CO₂ avoided reduced at higher levels of CCS
 - At nominal 300 lb CO₂/MWh, existing PC at price parity with NGCC at natural gas price of ~ \$5.50 per MMBtu
 - Under this standard, California would have to make up for a 9% deficit in supply due to reduced PC, NGCC efficiency

Pulverized Coal Power Plant



Pulverized Coal Power Plant with CCS

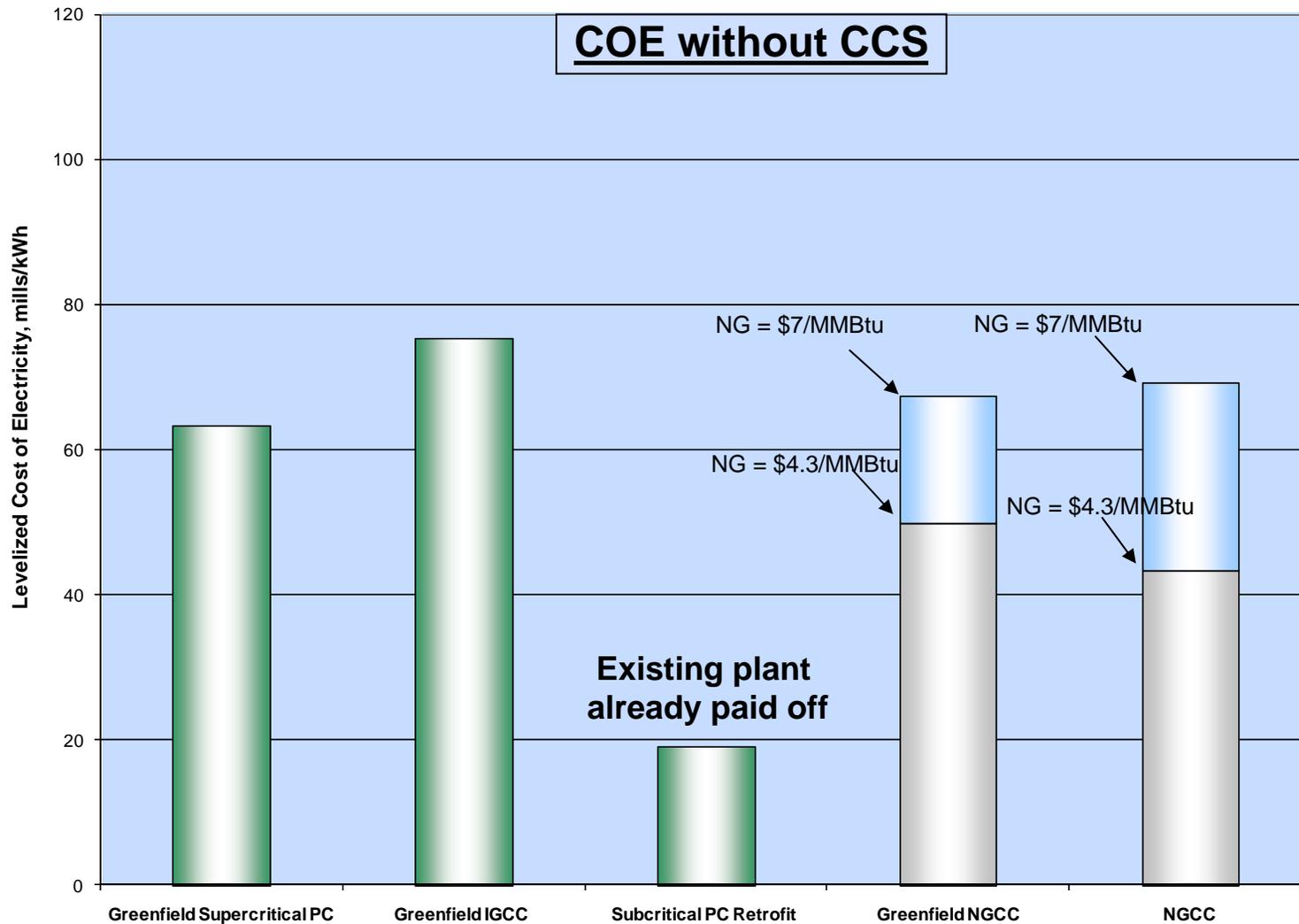
Removal level needs to achieve 1,100 lb CO₂/MWh



Additional equipment required for CO₂ capture:

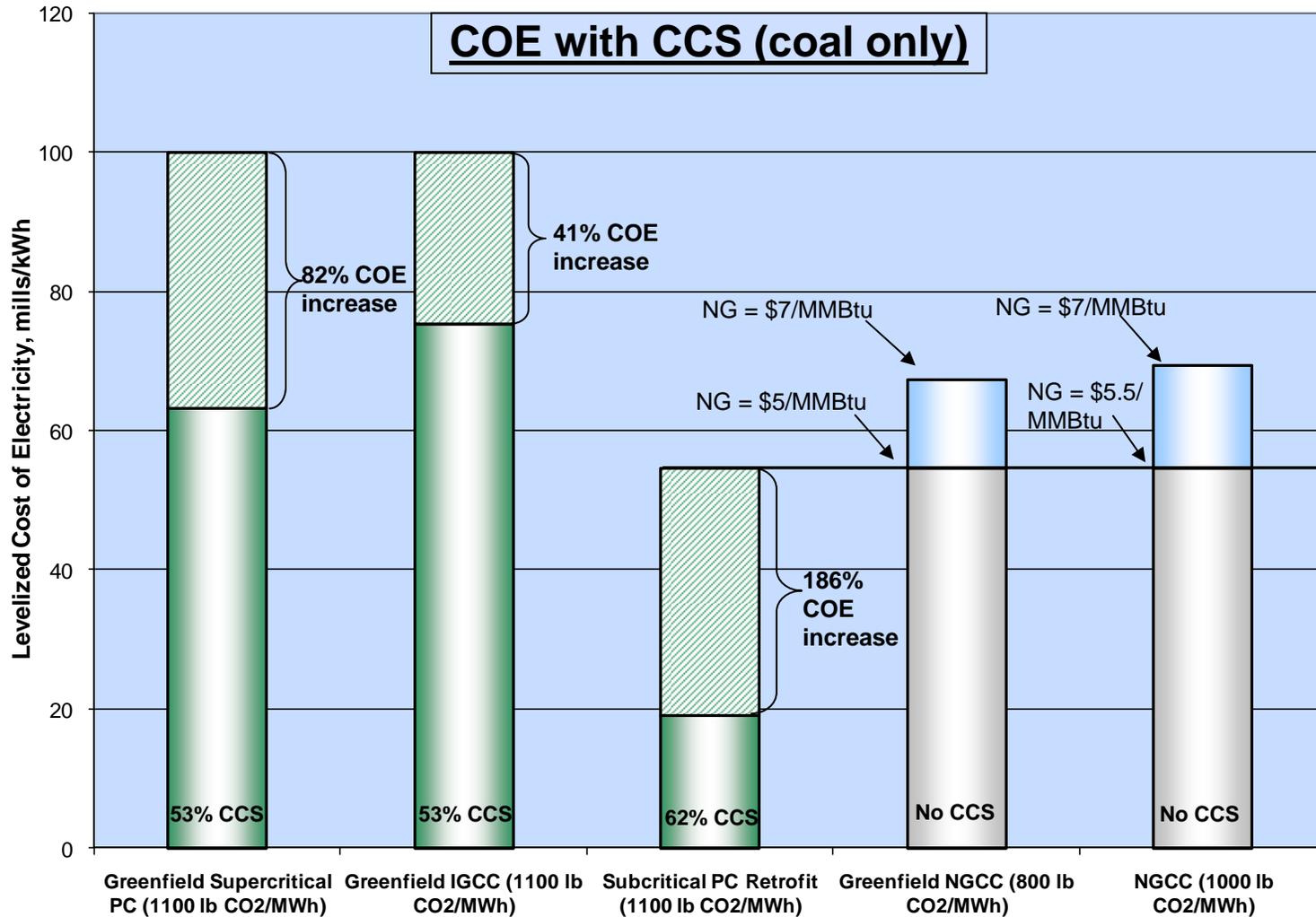
1. Econamine CO₂ Scrubber
2. CO₂ compression train
3. Steam extraction for solvent stripping

Options for Meeting CA's GHG Emission Standard



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Each case reduces emissions to 1,100 lb CO₂/MWh



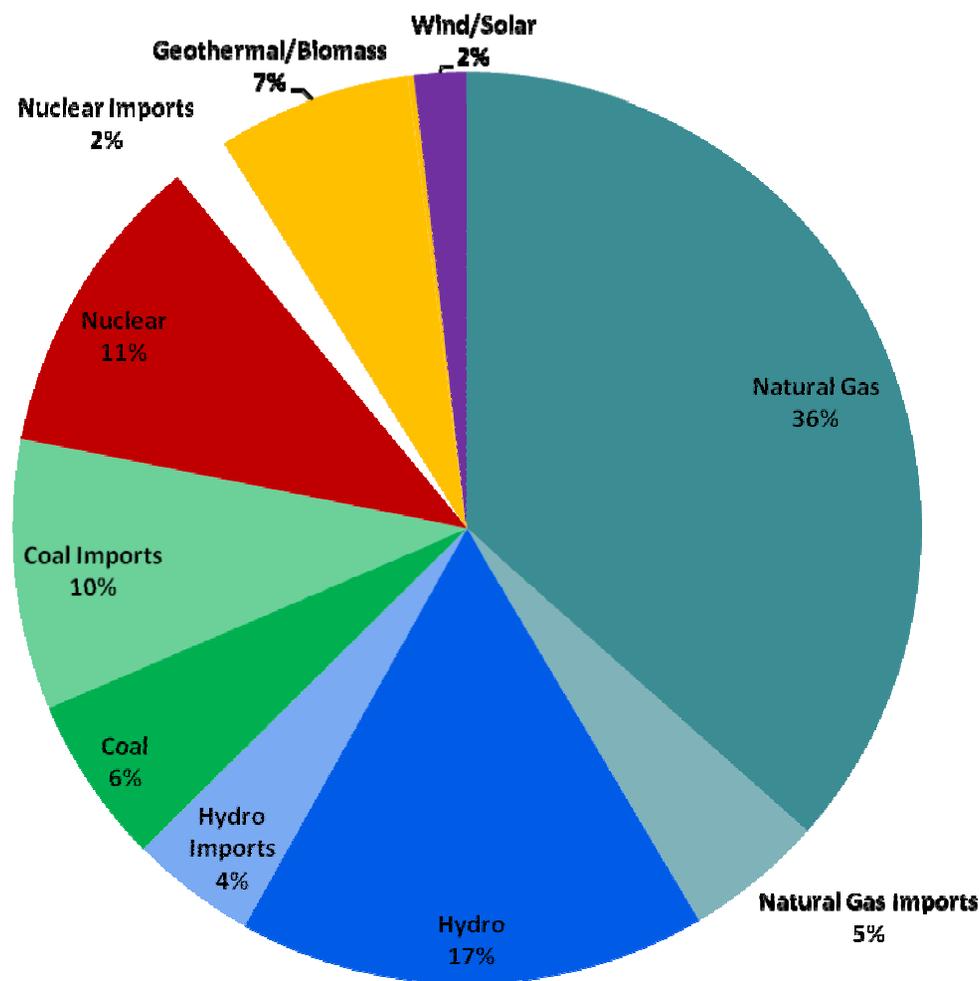
Options for Western Coal Plants

- 1. Retrofit to meet 1,100 lb CO₂/MWh standard**
 - i. New plant efficiency 25.3%
- 2. Do nothing, and stop selling power to CA**
 - i. Capital outlay to retrofit might not be worth investment, given the remaining life of the plant
- 3. Retire plant**

Assume that all western plants will retrofit to meet California's emission standard...

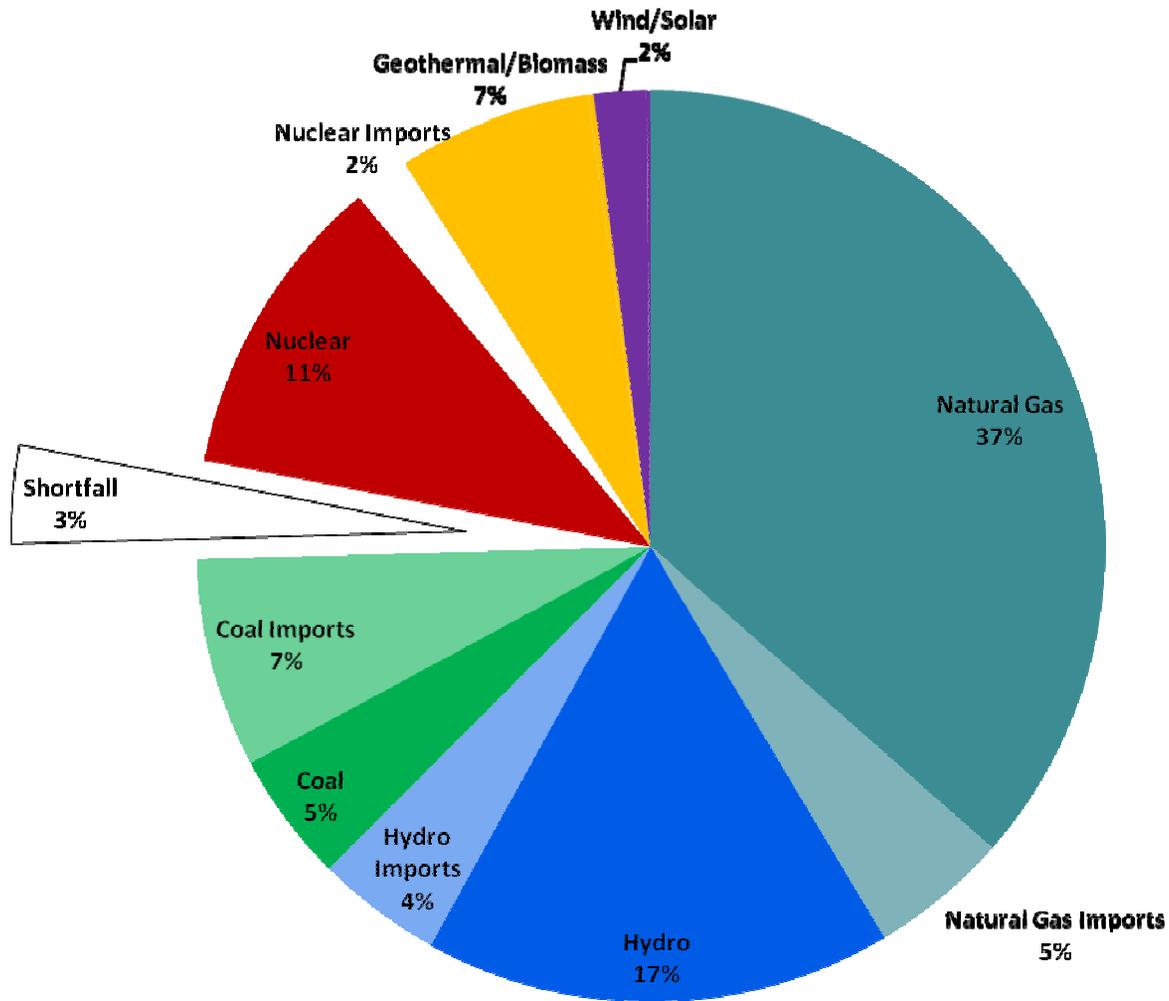
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Effect of 1,100 lb CO₂/MWh standard on CA's consumption



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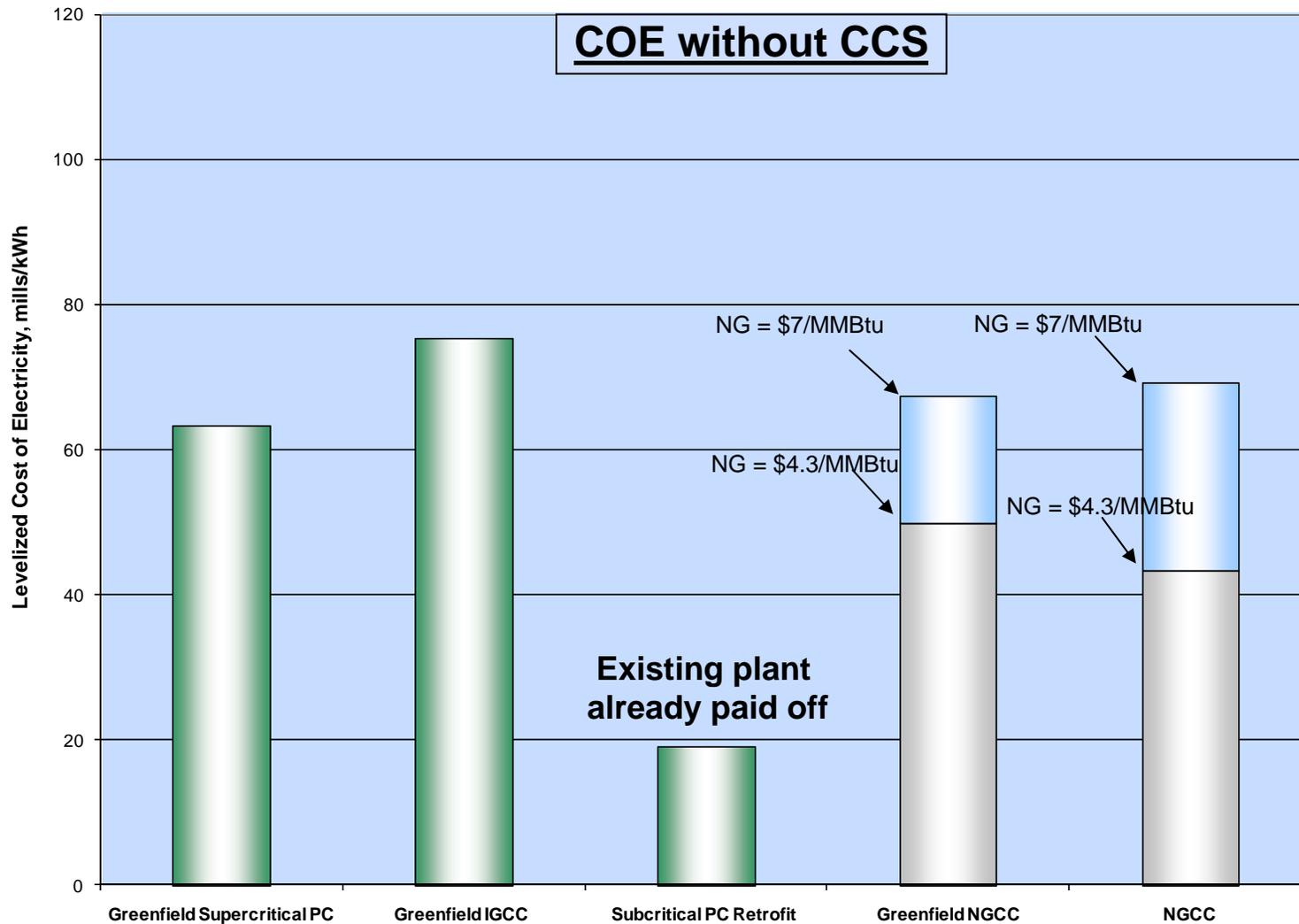
Meeting Deeper Emission Cuts

250 – 350 lb CO₂/MWh Emission Standard

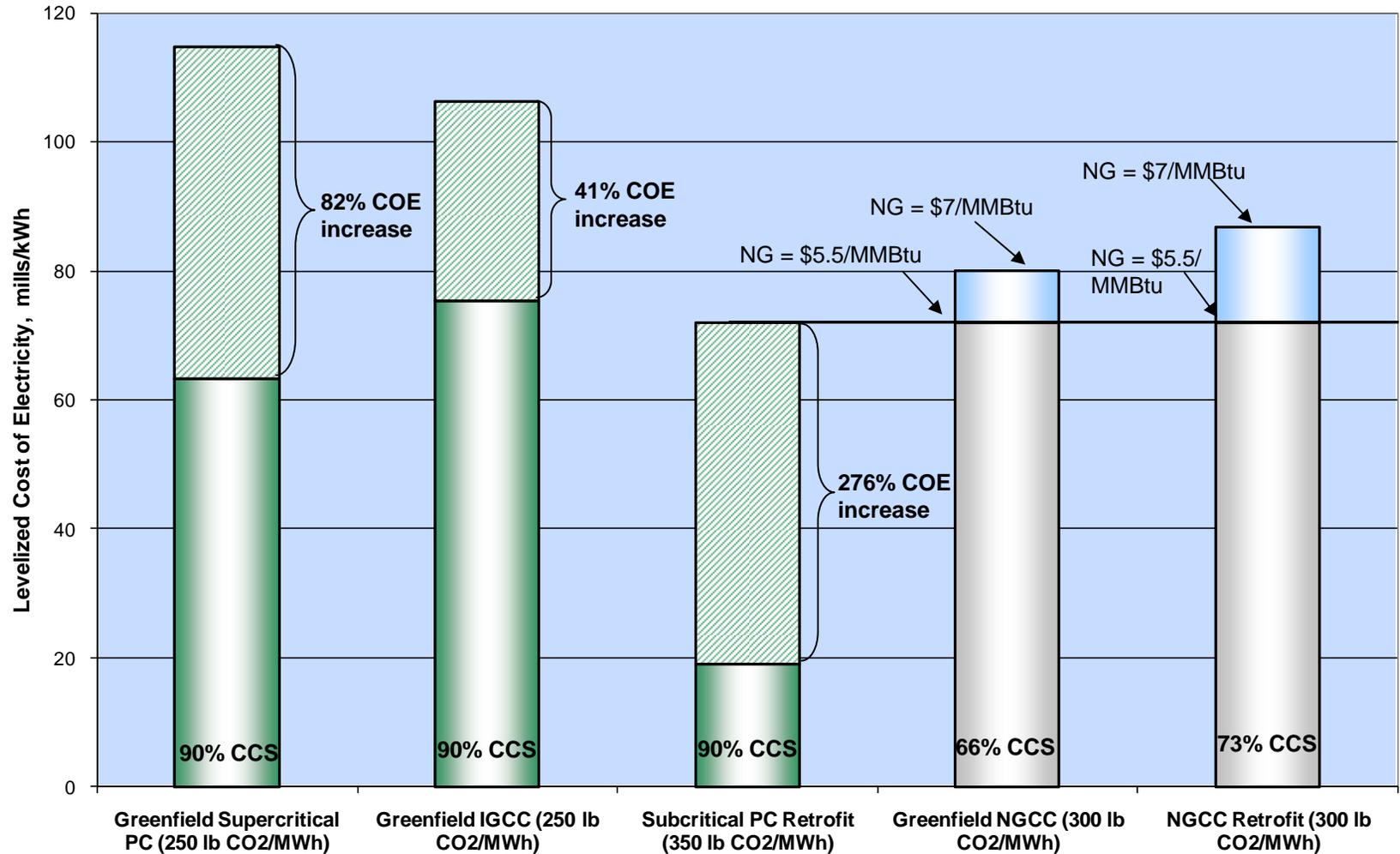
- **Stabilizing atmospheric CO₂ concentration may well require greater emission reductions than 1,100 lb CO₂/MWh**
- **All fossil energy sources would be affected in CA (coal and natural gas)**
- **Nominal 90% CCS on coal plants would reduce emissions to 250 – 350 lb CO₂/MWh**
- **What effect would this have on CA's energy portfolio?**



Options for Meeting CA's GHG Emission Standard

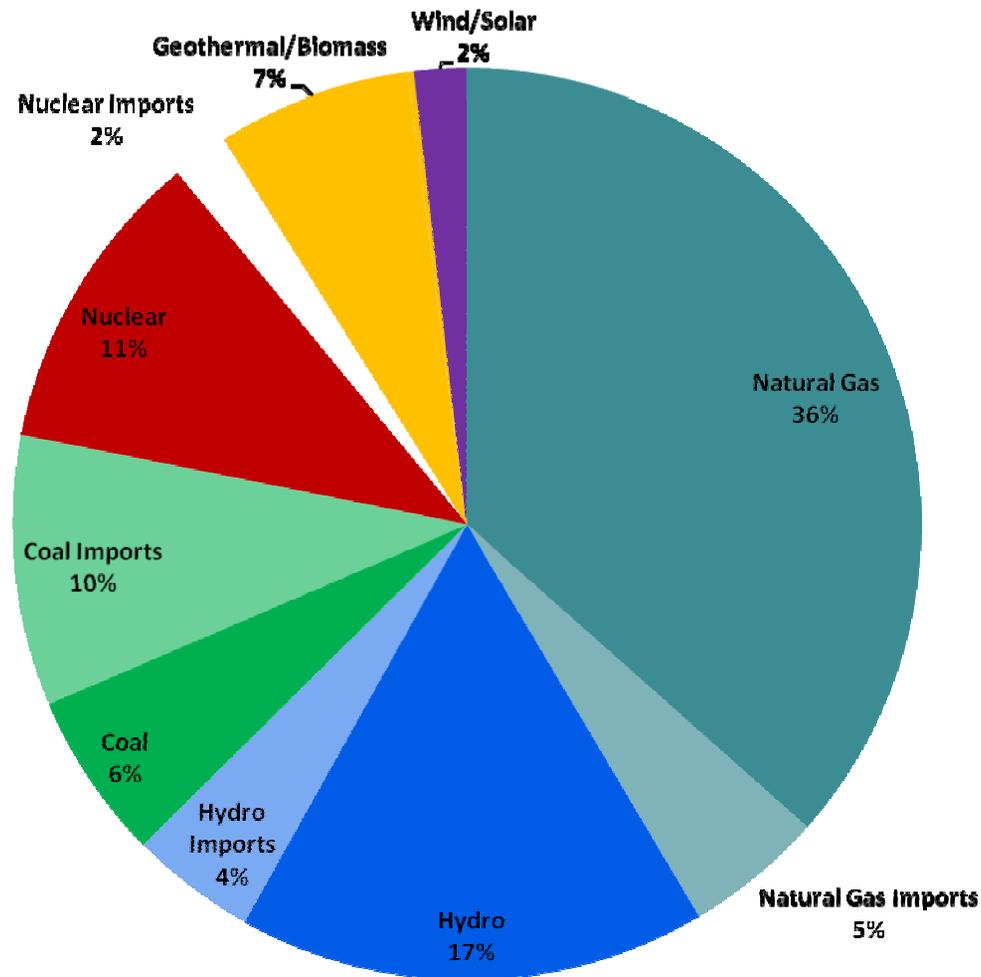


Meeting an Emission Standard of 250 – 350 lb CO₂/MWh *Impact on COE if both Coal and Natural Gas Plants Include CCS*



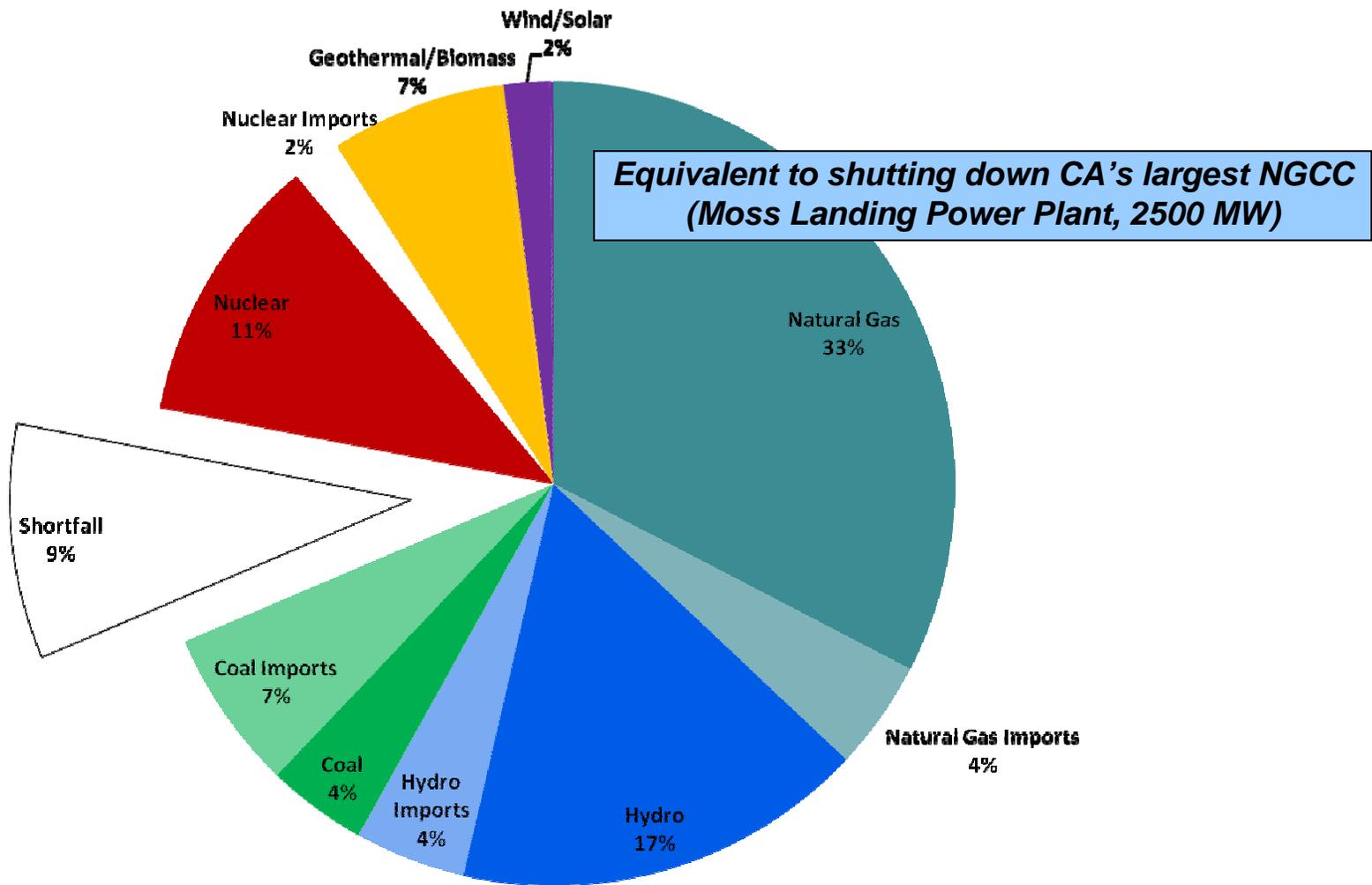
California's Electricity Mix¹

Impact of meeting 250 - 350 lb CO₂/MWh



California's Electricity Mix¹

Impact of meeting 250 - 350 lb CO₂/MWh



Conclusions

- 1. Existing PC meeting AB32 (1,100 lb CO₂/MWh, 62% CCS) is competitive with NGCC at natural gas price of ~ \$5 / MMBtu (assuming PC plant paid off)**
 - Current natural gas prices ~ \$4.30 per MMBtu, but expected to rise
 - Due to reduction in PC efficiency, CA would experience 3% loss in supply
- 2. Requiring deeper controls (250 – 350 lb CO₂/MWh) would impact all coal and natural gas sources supplying CA**
 - At nominal 300 lb CO₂/MWh, existing PC competitive with NGCC at natural gas price of ~ \$5.50 per MMBtu
 - Due to reduction in PC and NGCC efficiency, CA would experience 9% loss in supply