Economics of CCS in the Western Power Grid and CCS Deployment Strategies as a Function of Emission Allowance Market Prices

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Goals

- Review Dispatch Model
- Updates
- Methodology
- Results
- Conclusions and Future Work
Dispatch Model

- Motivation – accelerate deployment of CCS
  - determine effects of transmission constraint
  - ascertain best siting, policies and scenarios

- Transmission Dispatch Model
  - PowerWorld – commercial software
  - public databases – EIA, EPA
  - confidential data – WECC

Dispatch Model

- Western Interconnection
  - modeling entire area as dispatchable
  - (CAISO only restructured area)
  - 2,800 Generators of all types
  - 58,000 mi. of transmission
  - 190,000 MW of generation
  - August 25, 2005 data
Hypothetical IGCC Plants

- “Typical” IGCC with CCS equipment
  - Nth-of-a-kind
  - heat rate of 11,500 BTU per kWh
  - 100% capture
  - 500 MW-e capacity (except for a retrofit site)

- Drawbacks
  - only using marginal costs
  - does not model unit commitment, bilateral contracts
  - missing updates to generation, transmission, load

Updates Since Last Year

- More complete generator matching: >97% of capacity

- Using updated EPA eGRID data (eGRID2007), matches basecase annual emissions and heat rates

- Full scripted dispatch runs

- Linked geographical data to transmission data to allow for mapping
Model Area

- Using marginal costs for dispatch
  - fuel & emissions costs
  - unable to obtain exact costs - confidential

- Dispatching gas/coal/oil
  - have costs for other fuels
  - dispatching some other generation to prevent unsolvable situations

Methodology – (Last Year) – Individual Dispatches

- Gates Substation
  - Note abrupt turn-on with demand level

- Pastoria Substation
  - More gradual dispatch

Location dependent!
Methodology – System Load (2005)

- using CAISO hourly system load scaled up to WECC

![Graph showing hourly system load](image)
Methodology – Dispatches with System Loads

- economic dispatch with varying load

Methodology – Capacity Factor Calculations

- capacity factors calculated with dispatches

Gates Capacity Factor (for this scenario) 73.8%
Methodology – Carbon and Fuel Price Scenarios

- **Carbon Price scenarios**
  - add additional costs of carbon price based on generator emissions rates

- **Fuel Price scenarios**
  - comparing coal vs. natural gas
  - assuming hydro mostly limited to availability

<table>
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<th>(units)</th>
<th>Cost</th>
<th>Dispatch?</th>
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<tbody>
<tr>
<td>CO2 ($/CO2)</td>
<td>$100.00</td>
<td>n/a</td>
</tr>
<tr>
<td>NOX ($/t)</td>
<td>$ -</td>
<td>n/a</td>
</tr>
<tr>
<td>SOX ($/t)</td>
<td>$ -</td>
<td>n/a</td>
</tr>
<tr>
<td>Coal ($/t)</td>
<td>$25.00</td>
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<td>Coal ($/MMBtu)</td>
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<tr>
<td>Oil ($/gal)</td>
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<td>Oil ($/MMBtu)</td>
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<td>Gas ($/MMBtu)</td>
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<td>Wind ($/MWh)</td>
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<tr>
<td>Unknown ($/MWh)</td>
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<td>off</td>
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Methodology – Carbon Prices and Capacity Factors

Change in Capacity Factor with $100 / ton-CO₂
(weighted by maximum capacity)

Increases and decreases over 1000 MW @ 100% capacity
Results – Hypothetical IGCC Plants

- 15 test IGCC-CCS plants
  - thirteen 500 MW-e
  - Centralia, WA
    - 1528 MW-e “retrofit”
    - 1000 MW-e new IGCC

- dispatched individually

- using base fuel scenario
  - coal: $25 / ton
  - gas: $3 / MMBTU

Results – Hypothetical IGCC Plants – Fuel Scenarios

Capacity Factor with $100 (black line) and $0 (orange fill) / ton-CO₂ Carbon Price
(weighted by maximum capacity)

coal \ gas
$3 per MMBTU
$5 per MMBTU

$25 per ton
$40 per ton
Results – Hypothetical IGCC Plants – Other Carbon Price Scenarios

coal - $40 per ton-CO₂  gas - $3 per MMBTU

Results – Hypothetical IGCC Plants – Other Carbon Price Scenarios

gas

coal

$3 per MMBTU

$5 per MMBTU

$25 per ton

$40 per ton

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Results – Hypothetical IGCC Plants – Heat Rates

- coal: $25/ton & gas: $3/MMBTU
- could represent different costs/stages of IGCC development
Results – Hypothetical IGCC Plants – Capture Rates

- coal: $25/ton & gas: $3/MMBTU
- partial capture rate
- 11,500 BTU per kWh

IGCC Capacity Factor with $100 (black line) and $0 (orange fill) / ton-CO₂ Carbon Price (weighted by maximum capacity)

100% capture | 50% capture | 0% capture
Results – Hypothetical IGCC Plants – Partial Capture

- coal: $25/ton & gas: $3/MMBTU
- different IGCC capture rates

Results – Hypothetical IGCC Plants – Capture Rates

IGCC Capacity Factor with $100 (black line) and $0 (orange fill) / ton-CO$_2$ Carbon Price (weighted by maximum capacity)
Conclusions

- low gas + high coal price scenario demonstrates greatest capacity factor difference
- high carbon price will dispatch IGCC
- modest carbon price will provide substantial capacity factor increase

Future Work
- additional fuel price scenarios, sites
- sensitivities of efficiencies/heat rate and emissions rate
- total dispatch cost accounting, carbon price comparison

Thank you!

Questions and Comments Welcome

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Scenario Assumptions

• Fuel Costs
  - Using August 25, 2005 data
    • with slight modifications to validate case and model
    • issue: Hurricane Katrina
  - all generators face the same fuel costs
    • does not account for transportation or distribution cost
  - Coal (Powder River Basin): $1.42 / MMBTU
  - Natural Gas: $5.00 / MMBTU
  - NOX: $2,000 / ton
  - SOX: $700 / ton