WESTCARB Annual Business Meeting

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

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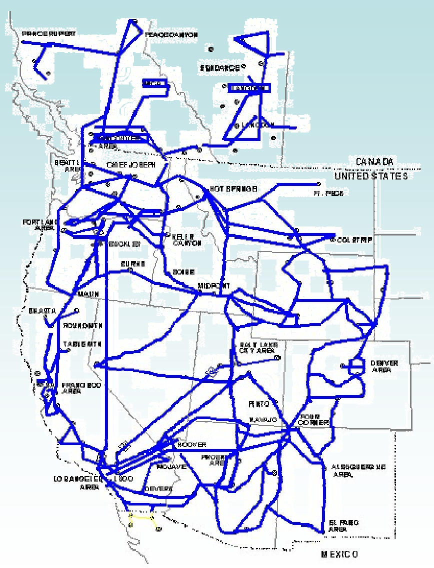
Dispatch Model

- 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



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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

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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

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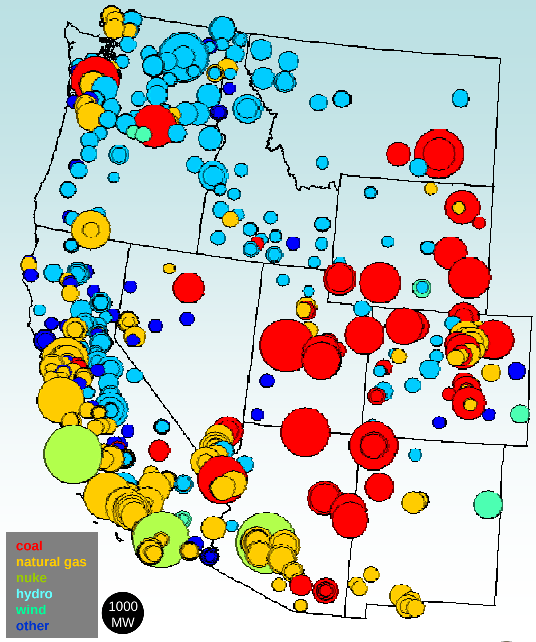
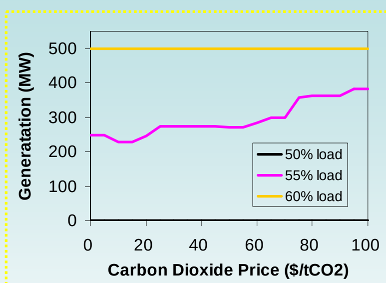
Model Area

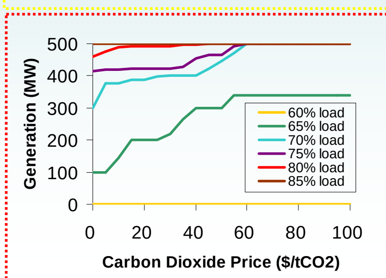
- Using marginal costs for dispatch
  - fuel & emissions costs
  - unable to obtain exact costs - confidential
- Dispatching gas/coal/oil
  - have costs for other fuels
  - dispatching some other generation to prevent unsolvable situations



Methodology – (Last Year) – Individual Dispatches



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

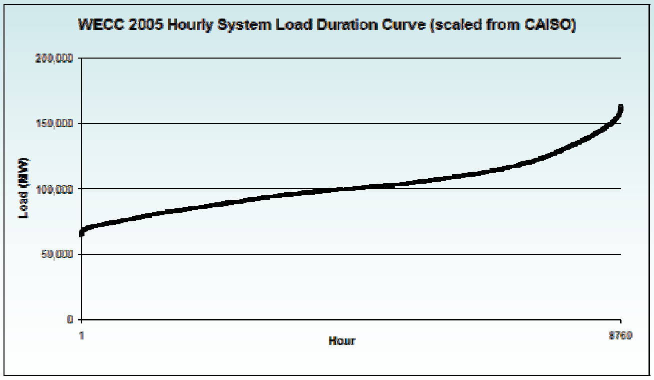


- Pastoria Substation
  - More gradual dispatch

Location dependent!

Methodology – System Load (2005)

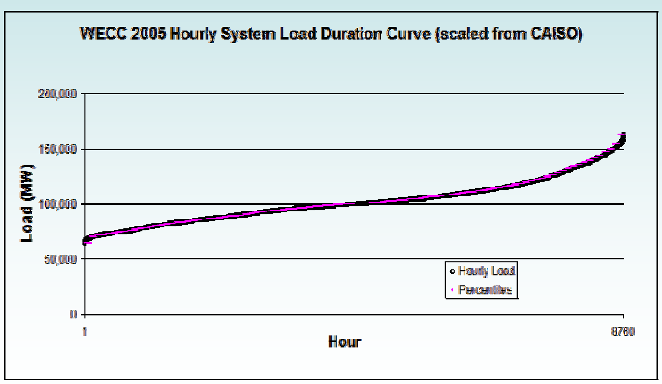
- using CAISO hourly system load scaled up to WECC



West Coast Regional Carbon Sequestration Partnership 9

Methodology – System Load (2005)

- using CAISO hourly system load scaled up to WECC



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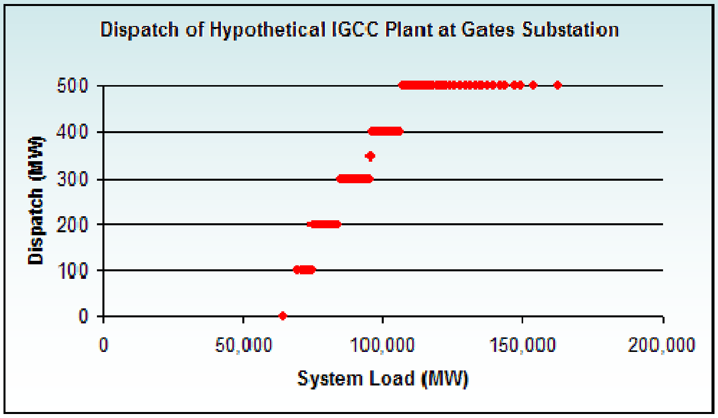
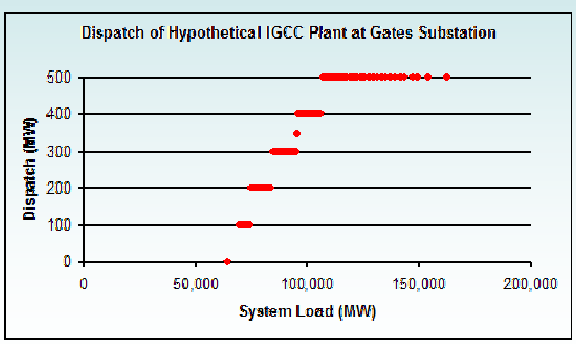
Methodology – Dispatches with System Loads

- economic dispatch with varying load



Methodology – Capacity Factor Calculations

- capacity factors calculated with dispatches



total dispatched energy
/
total possible energy capacity

Gates Capacity Factor

(for this scenario)

73.8%

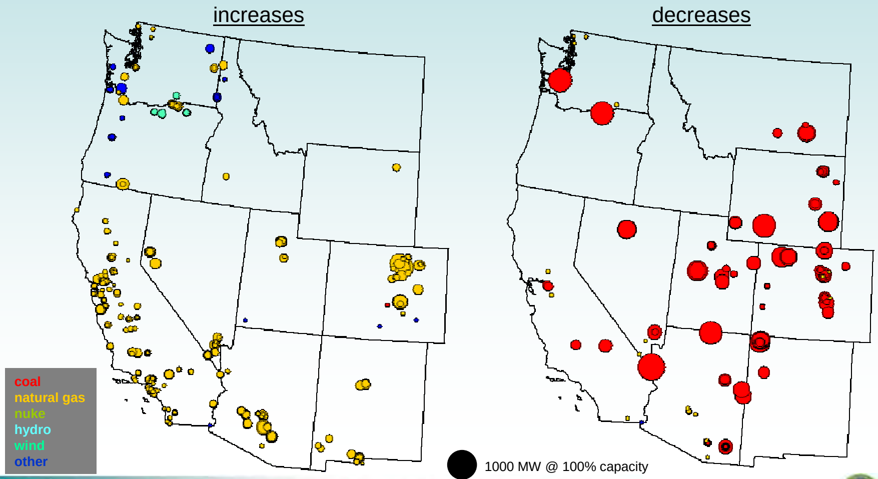
Methodology – Carbon and Fuel Price Scenarios

- 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

	(units)	Cost		Dispatch?
CO2	**($/tCO2)**	$	100.00	NA
NOX	**($/ton)**	$	-	NA
SOX	**($/ton)**	$	-	NA
Coal	**($/ton)**	$	25.00	**ON**
	($/MMBtu)	$	1.42	NA
Oil	**($/gal)**	$	2.00	**ON**
	($/MMBtu)	$	14.39	NA
Gas	**($/MMBtu)**	$	5.00	**ON**
Wind	($/MWh)	$	30.00	**off**
Hydro	($/MWh)	$	30.00	**off**
Geothermal	($/MWh)	$	50.00	**off**
Solar	($/MWh)	$	100.00	**off**
Nuclear	($/MWh)	$	30.00	**off**
Biomass	($/MWh)	$	50.00	**off**
Other	($/MWh)	$	1.00	**off**
Unknown	($/MWh)	$	1.00	**off**

Methodology – Carbon Prices and Capacity Factors

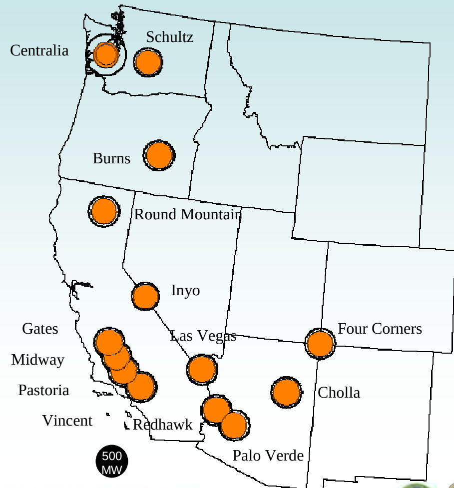
Change in Capacity Factor with $100 / ton-$CO_2$
(weighted by maximum capacity)



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

IGCC Capacity Factor with $100 (black line) and $0 (orange fill) / ton-$CO_2$ Carbon Price
(weighted by maximum capacity)



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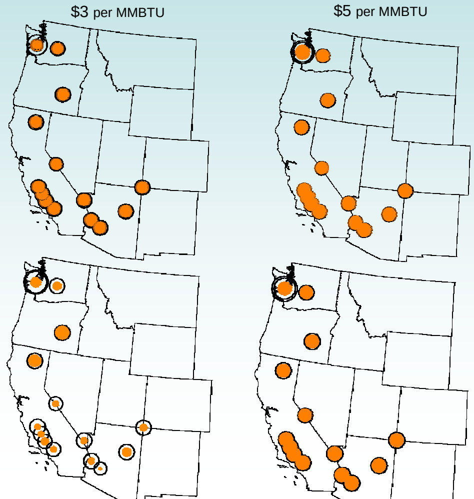
Results – Hypothetical IGCC Plants – Fuel Scenarios

Capacity Factor with $100 (black line) and $0 (orange) / ton-$CO_2$ Carbon Price
(weighted by maximum capacity)

coal \ gas — $3 per MMBTU — $5 per MMBTU

$25 per ton

$40 per ton



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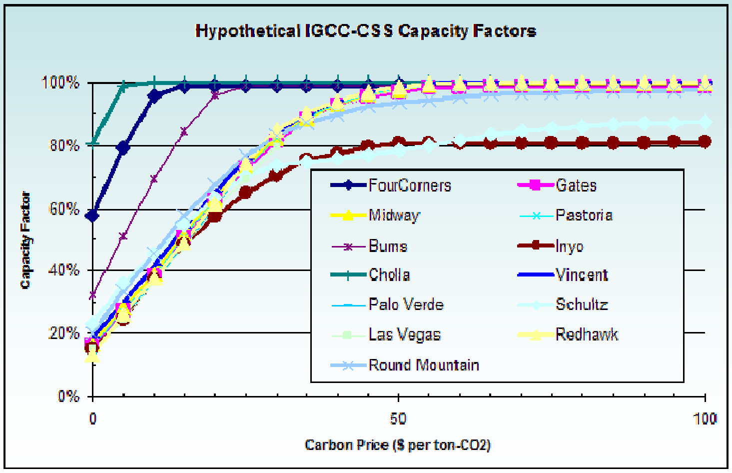
Results – Hypothetical IGCC Plants – Other Carbon Price Scenarios

coal - \$40 per ton-CO_2 gas - \$3 per MMBTU



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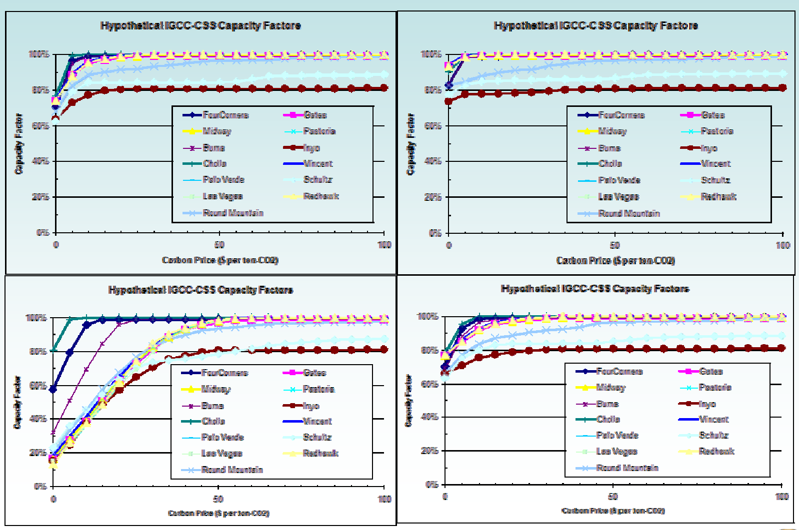
Results – Hypothetical IGCC Plants – Other Carbon Price Scenarios

gas: \$3 per MMBTU; \$5 per MMBTU

coal: \$25 per ton; \$40 per ton



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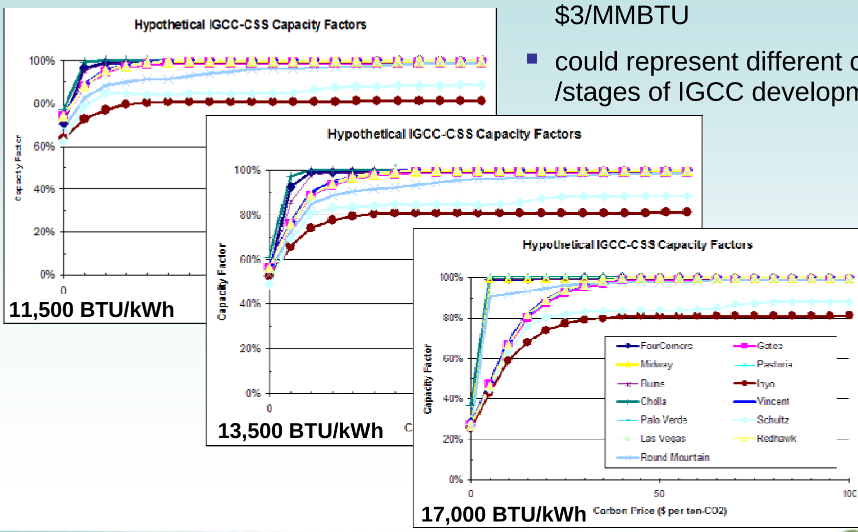
Results – Hypothetical IGCC Plants – Heat Rates

- coal: $25/ton & gas: $3/MMBTU
- could represent different costs /stages of IGCC development



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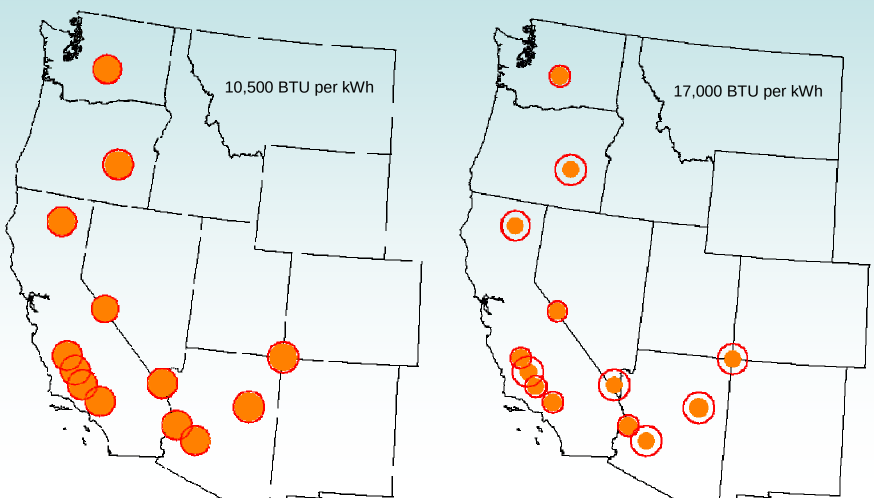
Results – Hypothetical IGCC Plants – Heat Rates

IGCC Capacity Factor with $5 (red line) and $0 (orange fill) / ton-$CO_2$ Carbon Price
(weighted by maximum capacity)



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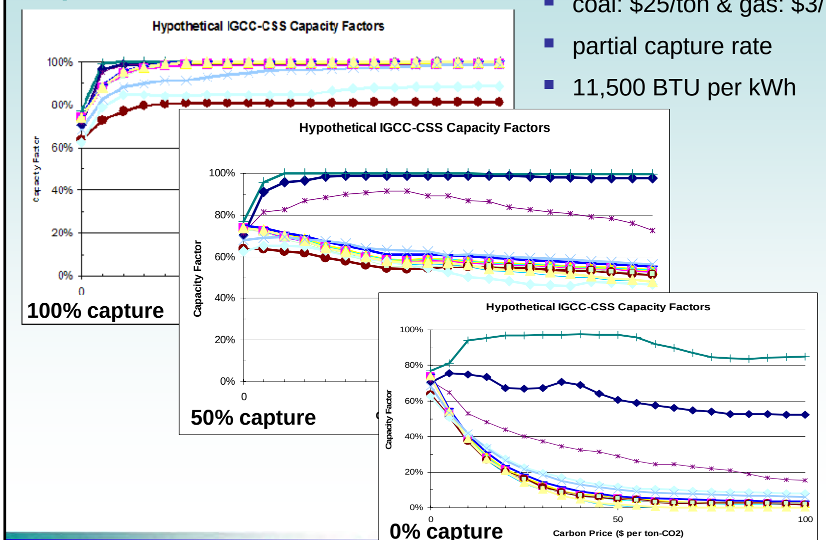
Results – Hypothetical IGCC Plants – Capture Rates

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



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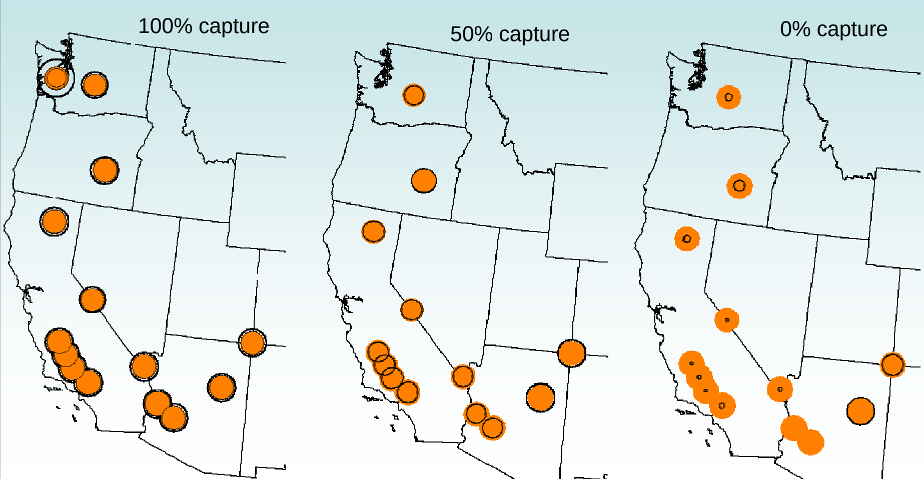
Results – Hypothetical IGCC Plants – Capture Rates

IGCC Capacity Factor with $100 (black line) and $0 (orange fill) / ton-$CO_2$ Carbon Price
(weighted by maximum capacity)



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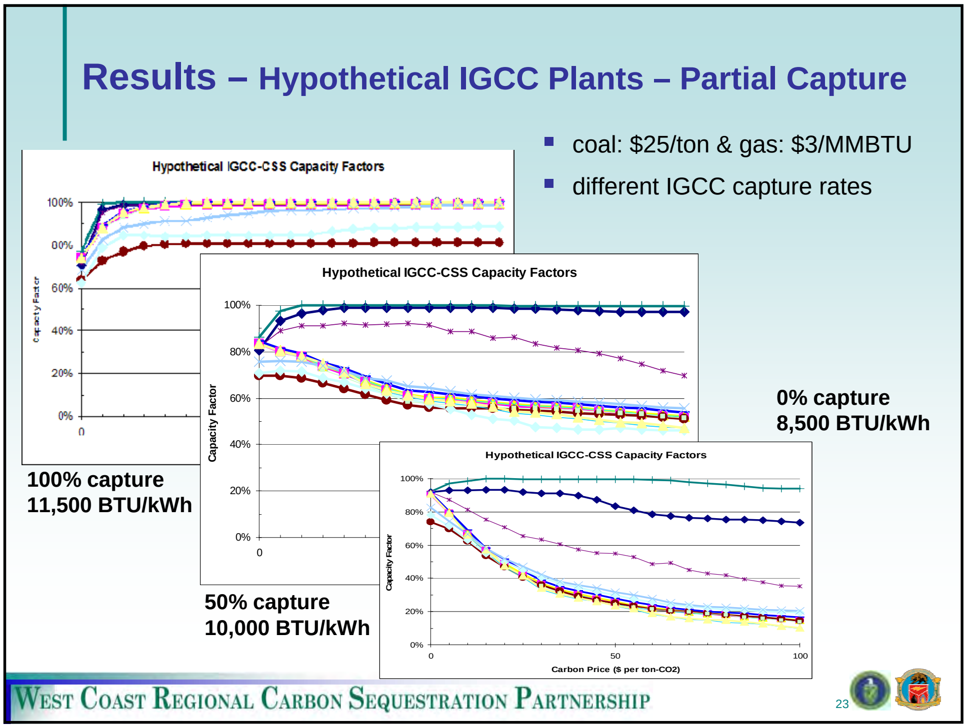
Results – Hypothetical IGCC Plants – Partial Capture
coal: $25/ton & gas: $3/MMBTU
different IGCC capture rates
Hypothetical IGCC-CSS Capacity Factors
100% capture
11,500 BTU/kWh
Hypothetical IGCC-CSS Capacity Factors
Capacity Factor
50% capture
10,000 BTU/kWh
0% capture
8,500 BTU/kWh
Hypothetical IGCC-CSS Capacity Factors
Carbon Price ($ per ton-CO2)
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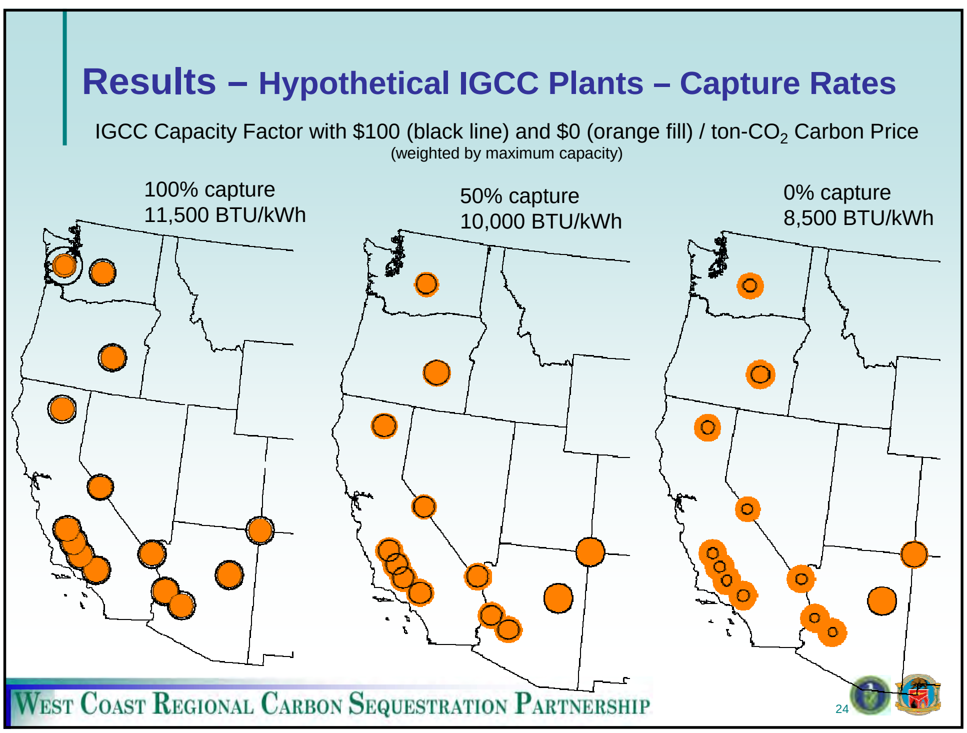
Results – Hypothetical IGCC Plants – Capture Rates
IGCC Capacity Factor with $100 (black line) and $0 (orange fill) / ton-$CO_2$ Carbon Price
(weighted by maximum capacity)
100% capture
11,500 BTU/kWh
50% capture
10,000 BTU/kWh
0% capture
8,500 BTU/kWh
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Conclusions

- 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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Appendix Slides

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