WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP
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Scenario analysis of carbon capture and sequestration generation dispatch in the western U.S. electricity system

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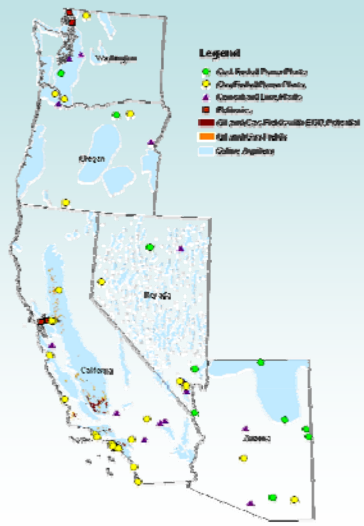
Goals of this Presentation

- Explain dispatch model
- Demonstrate model capabilities
- Present example results
- Look for input on future scenarios from you

Motivation

- Limitations for CCS Deployment:
  - Carbon sequestration sites are not ubiquitous
  - Generation is highly dependant on transmission features
- Dispatch determines generator revenue and capacity factor
- Understand the economics and trade-offs of CCS sites to look for features of “good” CCS sites



Model – Software

- PowerWorld Simulator 13
  - Calculates generation and load flows in electricity grid
  - Commercial software
  - Widely used in electricity industry
- Electricity Network Data
  - Acquired from WECC (Western Electricity Coordinating Council) – some confidentiality
  - Contains:
    - 14 US States, 2 Canadian provinces, northern Baja California, Mexico
    - Western Interconnection, CAISO, WESTCARB

Model – Data

- Electricity Network Data (cont.)
  - 2,800 Generators of all types
  - 58,000 mi. of transmission
  - 190,000 MW of generation
  - August 25, 2005 data

Source: Western Governors' Association

Model – Data (cont'd)

- Generator Data
  - PowerWorld data contains no emissions data
  - Matched with public data – EPA eGRID data
    - Also have WECC reports
  - For most plants: fuel type, heat rate, emissions
  - Cannot obtain: marginal cost / offer curves
    - Generator marginal costs are extremely confidential
  - What we use: an approximation
    - Heat rate and fuel costs
    - Pollution costs of NO_X and SO_X
    - Also, cost of CO_2 in scenarios

Model – Parameters

- Variable Parameters
  - Specific fuel costs
    - Coal, natural gas, oil
  - Non-dispatchable electricity costs
    - Hydro, nuclear, wind, solar, geothermal,
  - Pollution costs
  - Dispatch selection
    - Areas, specific plants
    - Fuels, types of plants
  - Load demand

Input Panel

	(units)	Cost	Dispatch?
CO2	**($/tCO2)**	$ 100.00	NA
NOX	**($/ton)**	$ 2,500.00	NA
SOX	**($/ton)**	$ 700.00	NA
Coal	**($/ton)**	$ 25.00	**ON**
	($/MMBtu)	$ 1.42	NA
Oil	**($/gal)**	$ 2.00	**off**
	($/MMBtu)	$ 14.39	NA
Natural Gas	**($/MMBtu)**	$ 5.00	**ON**
Wind	($/MWh)	$ 30.00	**off**
Hydro	($/MWh)	$ 30.00	**off**
Geothermal	($/MWh)	$ 50.00	**off**
Nuclear	($/MWh)	$ 40.00	**off**
Biomass	($/MWh)	$ 50.00	**off**
Other	($/MWh)	$ 1.00	**off**
Unknown	($/MWh)	$ 1.00	**off**

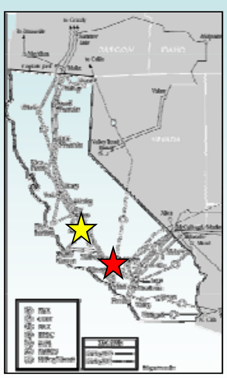
Model – Limitations

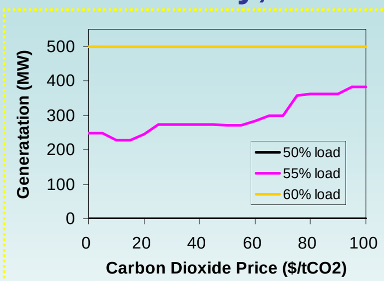
- Limitations of Dispatch Model
  - Marginal cost dispatch
    - Dispatch does **not** account for CapEx
    - **Not** a levelized cost of electricity calculation
    - Imperfect proxy for capacity factor due to markets/ contracts
  - Generator data is incomplete – especially marginal cost curves
    - Unless work for CAISO, will never be perfect
    - Future work will involve refinement of costs
  - Updates to grid (transmission, generation) not modeled

Scenario Assumptions

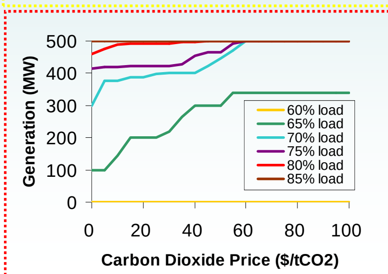
- Hypothetical IGCC-CCS Plants
  - Note: considering Nth-of-the-kind
  - Capacity: 500 MWe
  - Heat rate: 11,000 Btu/kWh
  - 100% capture
  - Reminder: marginal dispatch, no capital costs
- Transmission
  - Plants connected to largest, closest transmission substation
  - Transmission connections are short (minimize losses)
  - Transmission connections are large (no local congestion)

Results – Central Valley, California





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

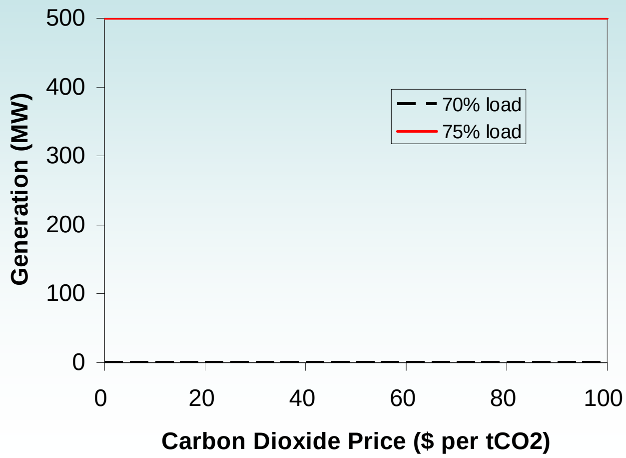


- Pastoria Substation
  - More gradual dispatch

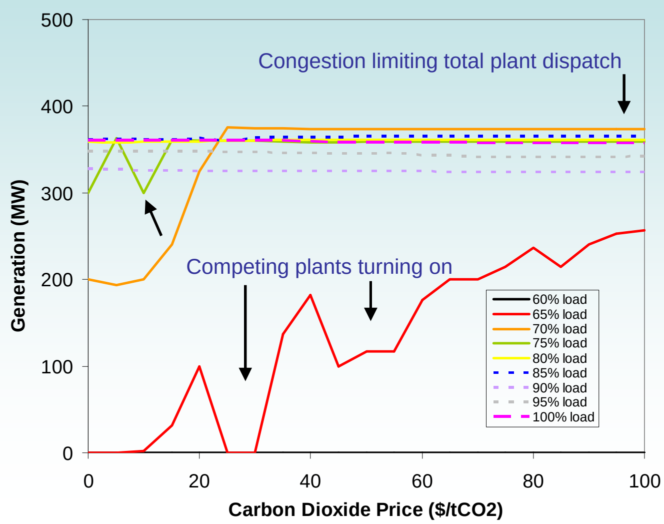
Location dependent!

Results – Burns Substation, Oregon

- Even more abrupt turn-on

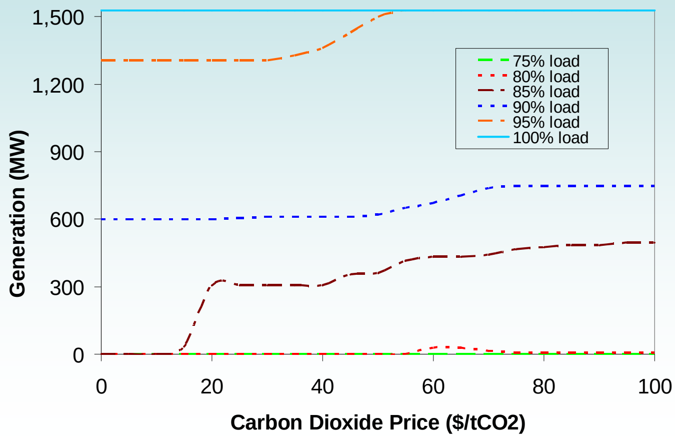


Results – Nevada-California Border (Inyo Substation)

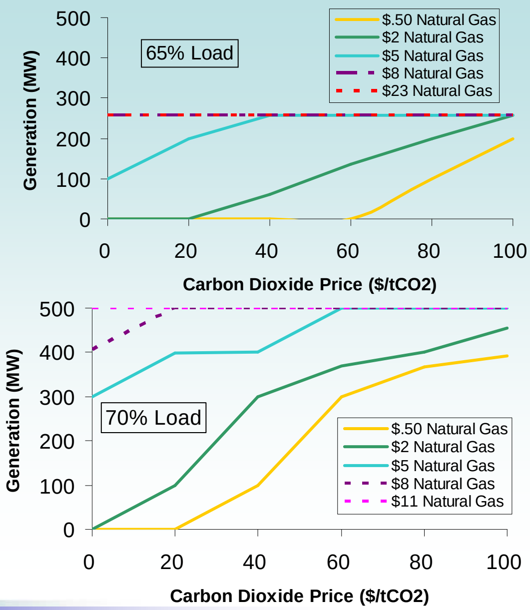


Results – Centralia, Washington (1528 MWe CCS Retrofit)

- Heat Rate: 15,000 Btu/kWh



Results – Pastoria Substation, California



- Note: Previous runs used $5/MMBtu Natural Gas

Fuel price affects dispatch

Summary

- Model is up and validated
  - Able to perform a variety of calculations
- Results show in general – CCS <u>will be dispatched</u> given high enough carbon price and load demand/congestion
- Next steps: calculate capacity factors and plant revenue
- Looking to members of WESTCARB for ideas of other types of simulations

Future Work

- Ideas
  - More specific capacity factor calculations
    - 24-hour dispatches
    - Seasonal dispatches
    - Revenue and profitability calculations against COE
  - More locations
    - Ideas greatly appreciated here
  - Different kinds of plants
    - Retrofits, IGCC, SCPC, oxy-fired, etc.
    - Variable capture percentage plants
  - Coals
    - Illinois #6 vs. PRB?

Thank you!

Questions and Comments Welcome

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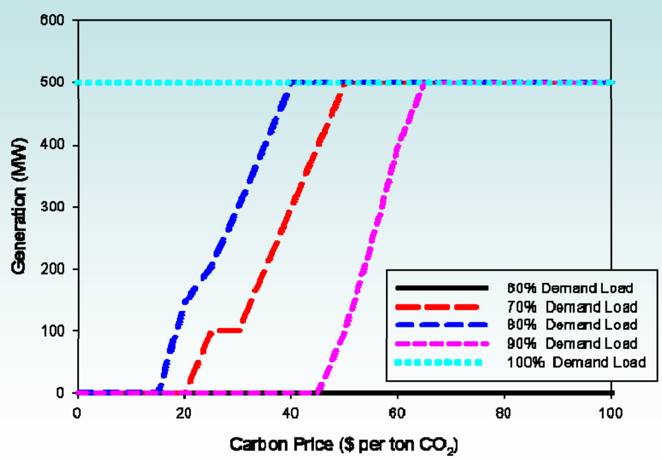
Appendix Slides

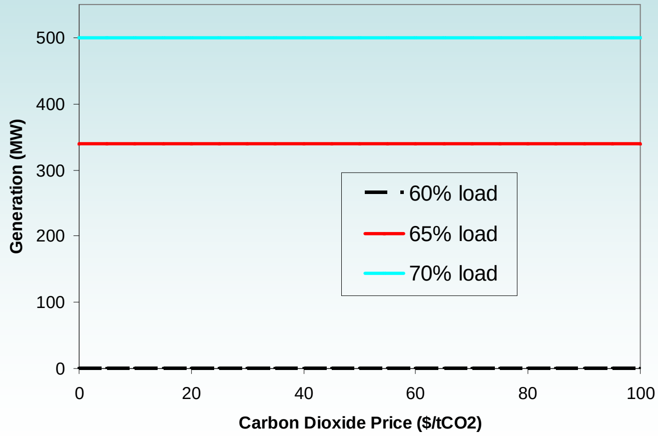
Scenario Assumptions

- 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
  - NO_X: $2,000/ton
  - SO_X: $700/ton

Results – Four Corners, New Mexico



Results – Midway Substation, California



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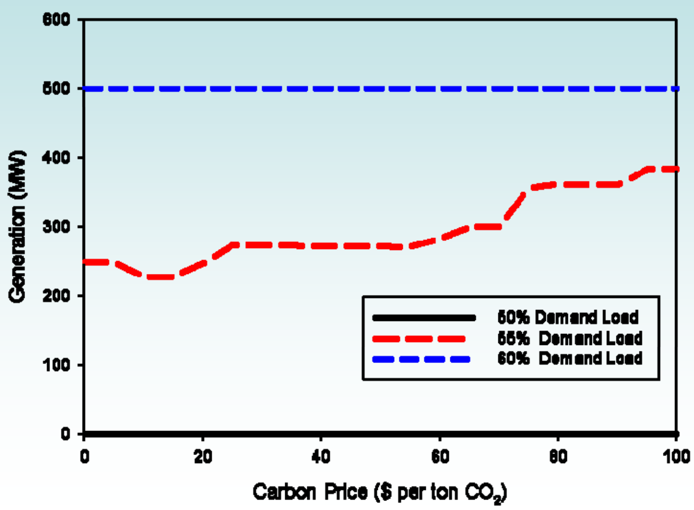
Results – Gates Substation, California



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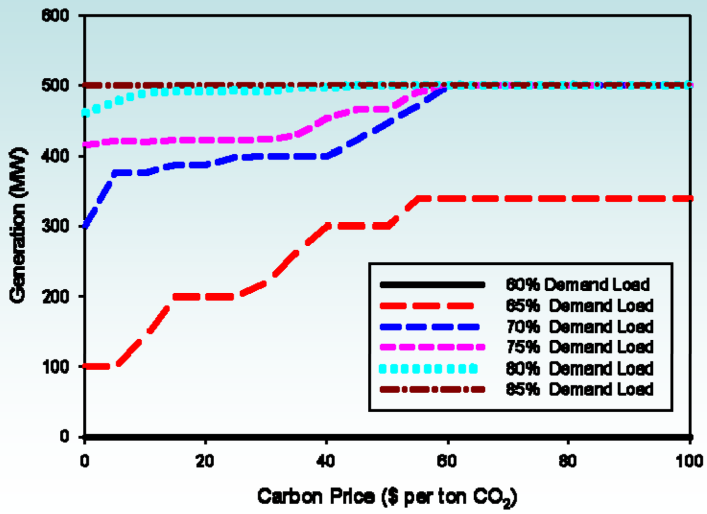
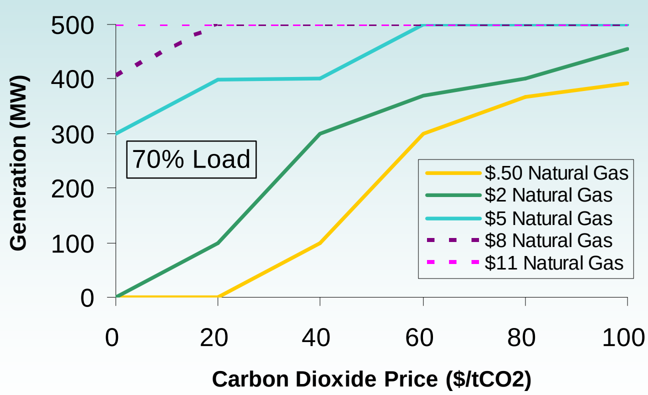
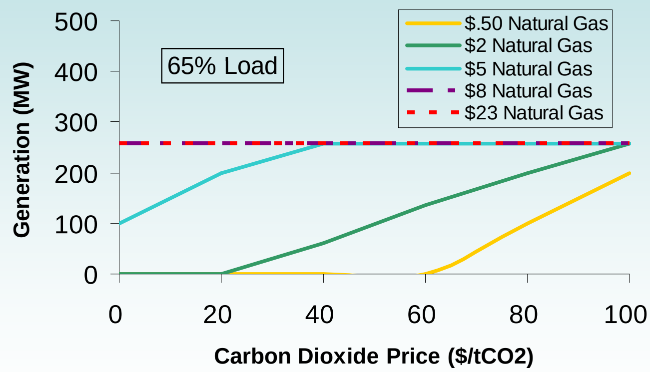
Results – Pastoria Substation, California



Results – Pastoria Substation, California (cont'd)



Results – Pastoria Substation, California (cont'd)



Model – Software

- PowerWorld Simulator 13
  - Calculates generation and load flows in electricity grid
  - Commercial software
  - Widely used in electricity industry

  - Optimal Power Flow (OPF)
    - Takes transmission constraints into account
    - Used in our model
  - Security-Constrained Optimal Power Flow (SCOPF)
    - Accounts for N-1 contingencies
    - Data currently unavailable