WESTCARB Annual Business Meeting

Impact of Carbon Management on Plant Site Selection

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Objective and Focus of the Presentation

- Objective
  - Evaluate the Impact of Adding a Carbon Capture and Sequestration (CCS) Plant on the Site Selection Process of a New Power Plant
- Focus
  - Additional Considerations and Requirements Imposed by a CCS Plant on Top of the Standard Criteria for a Power Plant Without a CCS

Power Plant Site Selection Criteria

- Land Availability or CCS Footprint
- Seismic Stability
- Floodplain
- Weather
- Existing Site Hazards
- Existing Land Use
- Restricted Air Space
- Cultural Resources
- Threatened and Endangered Species
- Proximity to Public Access Areas

Power Plant Site Selection Criteria (cont'd)

- State/Local Environmental Requirements
- Proximity to Class I Visibility Areas
- Proximity to Tribal Lands
- Access to Cooling Water
- Fuel Supply Environment
- Access to Grid
- Rights of Way
- Transportation Options Available
- Labor and Skills Availability
- Cost and Economic Environment

Power Plant Site Selection Criteria (cont'd)

- **Focus Criteria**
  - **Cooling Water Consumption & Availability**
  - **CO_2Transportation and Storage**
  - **Land Availability & CCS Footprint**
  - **Labor and Skills Availability**
  - **Fuel Supply Consideration**

Power Plant Site Selection Criteria Cooling Water Consumption

- **Majority of cooling water consumption are losses through cooling tower**
  - **Evaporation; blowdown; drift**
- **Additional water consumption is primarily due to additional power generation**
  - **A CCS plant reduces power generation for a fixed fuel input – steam diverted for CO_2 stripping**
  - **A CCS plant requires additional generation for a fixed electric output**

Cooling Water Consumption

	Without CO_2 Capture Tons/Yr/MWe*	Without CO_2 Capture GPM/MWe	With CO_2 Capture Tons/Yr/MWe*	With CO_2 Capture GPM/MWe**
Natural Gas Combined Cycle	8,350	4.5	18,100	9.7
IGCC	11,640	6.3	15,340	8.2
Supercritical PC	18,440	9.9	41,480	22.2
* At 85% Capacity Factor				** Per Net MWe

Cooling Water Cost

Ultra-Supercritical PC Plant

750 MWe w/o and with CO_2 Capture

	Unit Rate Per 1,000 Gallons	Annual Cost* Without CO_2 Capture	Annual Cost* With CO_2 Capture	Annual Incremental Cost
Large Body of Water	$0.38	$1.3 Million	$1.8 Million	$0.5 Million
Municipal (Average)	$2.50	$8.5 Million	$11.8 Million	$3.3 Million
Total O&M Cost w/ fuel	$0.38	$186 Million	$246 Million	$60 Million
* At 85% Capacity Factor				

Power Plant Site Selection Criteria Cooling Water Consumption

- **Impact of incremental cost of water is small:**
  - **Approx. 40% additional water cost over the non-CCS case**
  - **Approx. 0.8% additional O&M cost over the non-CCS case**
- **Availability (opposed to cost) of makeup water is a key issue in site selection**

Power Plant Site Selection Criteria Cost of CO_2 Pipeline Transport

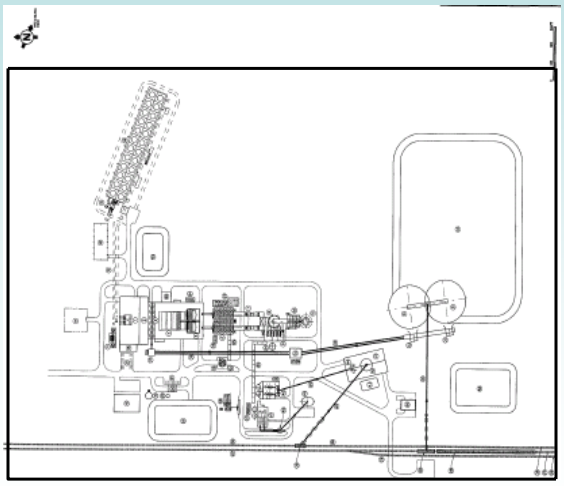
- **CO_2 transport system cost**
  - **150 miles of pipeline**
  - **50 million tons per year (equivalent to about 10 x 750 MWe PC plants)**
  - **2,200 psia CO_2 pressure (determines pipe size)**
  - **Total cost – approx. $1.50 per ton transported**
  - **Approx. $7.5MM per plant-year**
- **Cost of CO_2 removed ~$225MM per plant-year**
- **Conclusion: Impact of CO_2 transport is small**

Power Plant Site Selection Criteria
Cost of CO_2 Injection and MMV

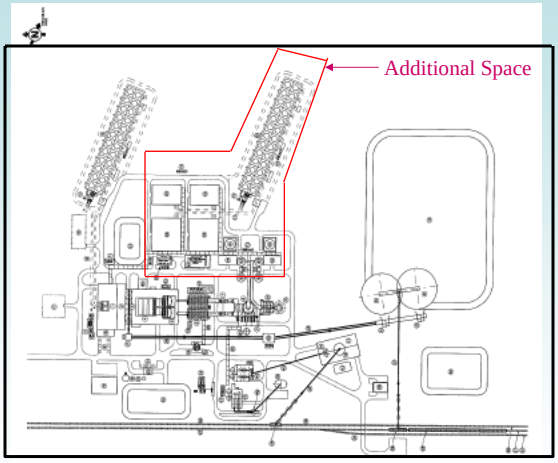
	Depth 1,000 meters	Depth 2,000 meters	Depth 3,000 meters
Saline Aquifer **Cost to a Power Plant**	**1.75 $/Ton** **$8.75MM/Plant-Yr**	**2.50**	**5.00**
Natural Gas or Oil Field **Cost to a Power Plant**	**0.85 $/Ton** **4.25MM/Plant-Yr**	**1.75**	**3.40**
Ocean Storage **Cost to a Power Plant**	**5 $/Ton** **25MM/Plant-Yr**	Includes 150 miles on-shore & 65 miles off-shore transportation	

Storage cost could be significant depending on the type of storage

Land Availability
750 MWe USC PC Plant without CCS



Land Availability
750 MWe USC PC Plant with CCS



Land Availability
PC Plant with CCS

- 750 MWe Ultra Supercritical PC Plant with CCS
  - About 30% additional space needed for a CCS facility (approx. 520,000 ft^2 – i.e., 12 acres)
  - No additional land needed – same site boundary
- Conclusion: Generally, land availability has negligible impact on site selection

Labor and Skills Availability
750 MWe USC PC Plant with CCS

- **Addition of chemical plant at a power generation facility**
  - **May not be an issue for an IGCC plant**
  - **Will the needed skilled workers be available?**
  - **New or different union agreements; new permitting & reporting; health & safety requirements**
- Conclusion: Availability of skilled workers will have a minor impact on site selection

Fuel Availability
750 MWe USC PC Plant with CCS

- Coal Consumption
  - 8,000 hours annual operation at full load
  - PRB sub-bituminous coal
  - Net efficiency: 38.4% w/o; 25.2% with CCS
- For 750 MWe Net Output for Both Cases:
  - 3.2 million tons per year without CO_2 capture
  - 4.9 million tons per year with CO_2 capture
  - 50% additional consumption
- Conclusion: Fuel Availability May be a Consideration

Power Plant Site Selection Criteria
Power Plant with CCS
Summary Conclusion

Focus Criteria	Impact
▪ Cooling Water Consumption	
- Availability	Availability is key
- Cost	<1% to about 5% of incremental O&M cost
▪ CO_2 Transportation	Approx. 3% of cost of CO_2 removed

Power Plant Site Selection Criteria
Power Plant with CCS
Summary Conclusion (cont'd)

Focus Criteria	Impact
▪ CO_2 Injection & MMV	Approx. 2% to 4% of cost of CO_2 removed
▪ Land Availability & CCS Footprint	Very Small
▪ Labor and Skills Availability	Very Small
▪ Fuel Supply Consideration	Could be Important Requires 50% more fuel for the same net output