Impact of Carbon Capture and Sequestration on Water Demand for Existing & Future Power Plants

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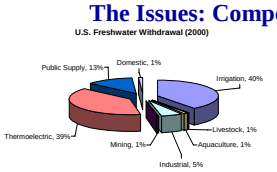
Carbon capture from power plants necessitates additional water consumption beyond that for a facility which simply vents carbon dioxide to the atmosphere. In addition, carbon dioxide capture, transportation and sequestration requires a significant energy expenditure. This directly results in increased water requirements. Carbon sequestration—on the other hand—may have a positive or negative impact on overall water utilization.

Localized water utilization/consumption is a critical component for evaluating capture and sequestration feasibility in arid regions. This will be an important element to consider when determining the viability of carbon capture and sequestration for pre-existing and future power generation facilities.

+ NETL
*** RDS**

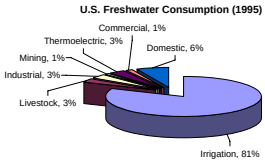
The Issues: Competing Water Uses



2000 thermoelectric water requirements:

- **Withdrawal: ~ 136 BGD**
- **Consumption: ~ 3 BGD**

• Thermoelectric competes with other users.



Sources: USGS, Estimated Use of Water in the United States in 2000, USGS Circular 1268, March 2004
USGS, Estimated Use of Water in the United States in 1995, USGS Circular 1200, 1998

Carbon Dioxide Capture, Transportation, and Sequestration Process

Capture → **Compression** → **Pipeline Transport** → **Underground Injection**

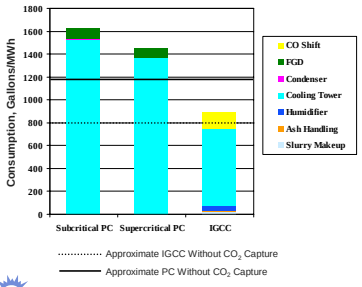
Impacts of Operation on Water:

Capture & Compression: Increased power consumption for capture and compression directly reduces the facility power output -- results in increased water consumption above that for a similar facility without capture

Pipeline Transport: Pumping power required to boost carbon dioxide pressure during pipeline transport to maintain supercritical conditions further diminishes power generation facility output -- results in increased water consumption

Underground Injection: Additional power may be required for injection operations -- indirectly increases water consumption; water may be produced by sequestration operations which displace reservoir fluids

CO_2 Capture & Compression Impact on Water Usage at PC & IGCC Power Generation Facilities



Water Consumption (gallons/kWh)

Subcritical PC	1.6
Supercritical PC	1.4
IGCC	0.9

Source: DOE/NETL Calculations

Transport

Transport and injection activities indirectly add to water requirements as energy is required to boost CO_2 pipeline pressure to ensure the stream remains a supercritical fluid during transport.

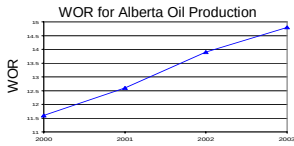
The stream pressure may need to be boosted prior to injection in a reservoir.

Water requirements ~ 0.01 gallons per kWh of power

CO_2 Sequestration Scenario: Injection for Enhanced Oil Recovery (EOR)

Average US Water-to-Oil (WOR) Ratio = 9.5 barrel water/barrel oil in 2002

Water production rates ~ 1+ gallon water per kWh of power



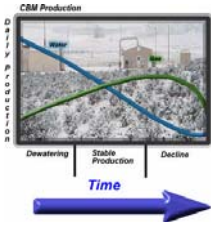
WOR increases with the age of the field

(Source: Alberta Research Council, 2005

- Water produced during enhanced oil recovery is used to facilitate continued oil production by re-injecting the water back into the oil reservoir.
- WOR can dictate viability of a well because costs associated with extensive water separation equipment/operations are significant economic factors

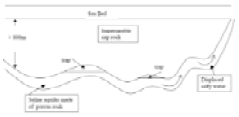
CO_2 Sequestration Scenario: Injection into Coal Seams for Coal Bed Methane (CBM) Recovery

0.01 to 1+ gallon of water per kWh power, decreasing as field ages



CO_2 Sequestration Scenario: Injection into Salt-water Formations

CO_2 can be injected into closed saline formations with no water production or "open formations" which result in displacement of saline water as shown below:



(Source: Tyndall Centre for Climate Change Research, 2002)

Water production rates from 0 to 0.5 gallons of water per kWh power

Salt water obtained from saline formations does not generally result in a value added benefit due to the expense to clean the water to the point where it is potable or useful for irrigation

CO_2 Sequestration Scenario: Injection into Depleted Oil and Gas Reservoirs

- Water production for CO_2 sequestration in depleted oil and gas reservoirs should be negligible for a depleted reservoir
- If the reservoir has been back-filled with water, water may be displaced by CO_2.

Water production rates from 0 to 0.5 gallons of water per kWh power

Summary

Operation	Water Consumption/Production (gallons/kWh)
Electricity Production, CO_2 Capture and Compression:	
Subcritical PC	1.6
Supercritical PC	1.4
IGCC	0.9
Transport	0.01
Enhanced Oil Recovery (EOR)*	0 – 1+
Coal Bed Methane (CBM) Recovery*	0.01 – 1+
Salt-water Formations*	0 – 0.5
Depleted Oil and Gas Reservoirs*	0 – 0.5

* Potential water consumption during sequestration under certain conditions

Conclusions

- Extreme variability exists in water production rates associated with geological sequestration operations
  - The viability of potential sequestration locations requires assessment of the geological features of each specific site
- In some cases, water production during sequestration activities can be greater than water consumption during power generation and carbon capture
  - Water generated during sequestration is often re-injected into a reservoir to aid continued oil/gas production
  - Water produced during sequestration activities may require extensive remediation to make it potable or acceptable for agricultural uses
- Water production/usage during sequestration operations can dramatically effect the economic feasibility and practical operation of sequestration operations