The Energy-Water Nexus and the Role of Carbon Capture and Sequestration

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Problem Statement

• There is growing evidence of human induced climate change.
• Various legislation has been introduced to cap carbon emissions.
• Fossil powered electric generation is responsible for over 30% of the U.S. emissions.
• Carbon Capture and Sequestration (CCS) technology is water and energy intensive.
Project Objectives

- Explore water consumption implications associated with full deployment of a Carbon Capture and Storage (CCS) future.
- Identify vulnerable areas in which water resources may be too limited to enable full deployment of CCS technology.
- Implement project with the cooperation of:
  - National Energy Technology Laboratory (NETL)
  - DOE Office of Policy and International Affairs
The Energy Water Nexus:  
A Plant-Level Analysis Model

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SANDIA NATIONAL LABORATORIES

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under Contract DE-AC04-94AL85000.
Model Overview
Mean Gauged River Flow

Installed Electrical Capacity (Megawatts, MW) for the U.S. North American Reliability Council (NERC) regions.

- Model Objectives:
  - Develop a general framework for "what if" policy analysis,
  - Adopt a national view while allowing regional analysis,
  - Provide interactive environment for stakeholder/decision maker engagement.
General Model Structure

Figure 1. Schematic of the general structure of the integrated energy-water planning model.

- General Model Structure
- Thermoelectric Water Use
- Demography
  - Census Bur.
  - BEA
- Water Use/Consumption
  - U.S. Geological Survey
- Electrical Power Production
  - EIA and eGRID
- Green House Gas Production
- Water Supply
  - U.S. Water Assessment
- Water Use/Consumption
  - Surface Water
  - Groundwater
- Energy Use for Water
  - Non Potable
CCS Model

• Assume a graduated carbon cap starting in 2013 consistent with the Waxman-Markey and Kerry-Lieberman bills.

• Individually evaluate which power plants will be retrofitted, decommissioned, or will operate and pay penalty.

• Decision based on cost to retrofit, with data coming from a study conducted by NETL.

• Assess associated water consumption and parasitic power implications at each plant.
Baseline Assumptions

• Future demand for electric power is simulated according to Electricity Market Module regions (13) as reported in the 2005 Annual Energy Outlook.

• Future fleet of electric generation adopts current fuel mix.

• No once-through cooling systems installed on new generation capacity.

• New power plants located so as to maintain current ratio of electric demand to production.

• 30% parasitic energy loss due to CCS on coal-fired power plants.
Results

Parasitic Power

Year

Year
Results
Projected Increase in Thermoelectric Water Consumption 2004-2030
Projected Increase in Non-Thermoelectric Water Consumption 2004-2030
Exploring the Nexus

Ratio of Sustainable Recharge to Groundwater Pumping: 2004
Future Siting at Risk

Future thermoelectric consumption in watersheds prone to groundwater stress

- 192 MGD consumption at risk
Exploring the Nexus

Ratio of Mean Stream Flow to Total Water Consumption: 2004
Future Siting at Risk

Future thermoelectric consumption in watersheds prone to surface water stress

• 494 MGD consumption at risk
Exploring the Nexus

Ratio of 5th Percentile Stream Flow (Low Flow) to Total Water Consumption: 2004
Future Siting at Risk

Future thermoelectric consumption in watersheds prone to drought stress

- 2224 MGD consumption at risk
Summary

• Thermoelectric consumption projected to increase by 3.7 BGD due to CCS by 2035, a doubling over 2004.

• This increase is equivalent to projected growth in consumption by all other sectors.

• Demand is not equally distributed across the U.S.

• 18.5% of this future demand is located in watershed prone to surface and groundwater stress.

• 30% of current and future demand is located in watersheds prone to drought stress.