Water and Energy: Integrated Challenges, Integrated Solutions

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National Energy Technology Laboratory
Where Energy Challenges Converge and Energy Solutions Emerge

- Only government owned & operated DOE national lab
- Dedicated to energy RD&D, domestic energy resources
- Fundamental science through technology demonstration
- Unique industry–academia–government collaborations
The Water-Energy Nexus
Growing Populations in Water-Challenged Regions
Southeastern U.S. 2007 Drought Impacts on Power Generation

- Duke Energy, Southern Company, and TVA’s hydroelectric plants were running at approx. 50% capacity.
- Duke Energy’s McGuire nuclear plant needs to re-design water intake system due to low water level in North Carolina’s Lake Norman.
- TVA’s Browns Ferry nuclear plant had one-day shutdown of one unit and 25% reduced output from other two units in August 2007 due to high water temperature.
Competing With Other Sectors

Withdrawal vs. Consumption
An Important Distinction

Withdrawal (BGD)

Thermoelectric 132
Commercial 9.6
Domestic 26
Mining 134
Industrial 2.6
Livestock 25.5

Water Consumption (BGD)

Sources: 
1. USGS, Estimated Use of Water in the United States in 2000, USGS Circular 1268, March 2004
Fossil Energy Continues to Dominate Supply

**U.S. Energy Demand 2006**

- **100 QBtu / Year**
- 85% Fossil Energy
  - Coal: 23%
  - Gas: 22%
  - Oil: 41%
  - Nuclear: 8%
  - Renewables: 6%

**U.S. Energy Demand 2030**

- **111 QBtu / Year**
- 78% Fossil Energy
  - Coal: 23%
  - Gas: 22%
  - Oil: 34%
  - Nuclear: 8%
  - Renewables: 13%

+ 11%

Sources: U.S. data from EIA, Annual Energy Outlook 2009 “ARRA” release

**Energy Demand Impacts on Water**

- Increased thermoelectric energy demand will increase freshwater requirements
- Carbon capture and sequestration will increase freshwater requirements
- Increased oil and gas production will increase produced water
Key Water-Energy Research Needs

DOE / Office of Fossil Energy’s water-energy R&D focused on:

- Thermoelectric power generation
- CO₂ capture & storage
- Oil & gas exploration & production
- Synfuels production
- Coal & uranium mining
- Hydroelectric power production
- Biofuels production
Thermoelectric Power Generation

*Freshwater Consumption Projections*

- 30 to 50% Increase in water demand by 2030
- 18% increase in thermoelectric demand by 2030

Sources:

Power Generation Water-Energy R&D Needs

**Advanced Cooling Technology**
- Improve performance & cost
- Reduce cooling water blowdown

**Use of Non-Traditional Water**
- Wastewater
- Mine pool
- Coal-bed methane
- Oil & gas produced
- CCS produced

**Recovery & Reuse of Flue Gas Water**
- Flue gas condensation
- Water optimization
- Dessicant systems
- Membrane systems

- 30 to 50% Increase in water demand by 2030
- Potential to reduce demand by >50%
Potential Water Impacts of CCS

*Increased cost of electricity & plant water demand*

- **Increased cost for treating, pumping water**
- **Decreased water availability, other sectors**
Thermoelectric Power Plant Water Consumption

Water Consumption (gal / MWh net)

- Natural Gas CC
- Coal IGCC
- Supercritical Coal
- Subcritical Coal
- Fossil–Biomass–Waste
- Nuclear
- Solar Thermal
- Geothermal Steam

~180
~290
~400
~450
~520
300 – 480
400 – 720
750 – 920
~1,150
~980
~1,400

Consumption for steam condensing in plants equipped with wet closed loop cooling

CO$_2$ Sequestration & Water

• Under DOE’s 7 Regional Carbon Sequestration Partnerships, water working group focused on protection of groundwater sources and investigating potential beneficial use of produced water from storage formations.

• Member of the SDWA Underground Injection Control (UIC) program regulatory development process group
  – EPA released the proposed rule for public comment in July 2008.
Oil & Gas Water-Energy Research

- Large fracture stimulations for shale plays
- Growth in demand for power generation
- Potential long-term demand from oil shale

**Challenges**

- Effective treatment technologies
- Low-volume fracturing technologies
- Produced water volume reduction technologies
- Demand-reducing processes
- Science-based regulations

**Demand Growth**

- Coalbed methane well dewatering
- Mature oil fields with high water cuts
- Increased drilling & fracturing activity

**Increased Output**

- Increased competition for water supply
- Tighter regulations for disposal
- Opposition to treatment and disposal

**Tighter Constraints**

[Image of drilling rig and water tank with text: Demand Growth, Increased Output, Tighter Constraints]
Oil & Gas Produced Water

• > 15 billion barrels of water produced with oil and gas each year, (~9.5 barrels of water per barrel of oil)

• Quality varies from low (hydrocarbons, salt, dissolved solids, etc) to very high

• Costs can be high to treat or dispose

• Surface discharge can affect soils, vegetation, and streams but if treated properly can be a valuable commodity

• Coal Bed Natural Gas Production (CBNG) is being limited because of produced water concerns
Marcellus Shale Development
WATER! -- Increasingly an Issue

3 to 5 million gallons of water required to develop each well
~800 truckloads of water!

Map Courtesy of 2008 Schlumberger Limited
Water Demand for Biofuels

- Most water for biofuel crops is used for irrigation
- Overall consumptive water use dependent on crop type and location
- Irrigated corn requires 2,000 – 4,000 gallons / bushel
- One bushel corn ≈ 3 gallons ethanol, 2 gallons gasoline equivalent

Collaboration on Water-Energy Activities
Key Take-Aways

- Water is critical to operation and permitting of thermoelectric power plants, as well as in production of oil and gas.

- Fossil-based energy use and production will compete for limited water resources with other use sectors including agriculture, domestic, and industrial.

- CO₂ capture has potential implications on water availability.

- CO₂ storage R&D focused on protection of groundwater sources and investigation of beneficial uses of produced water from storage formations.

- DOE’s Office of Fossil Energy actively engaged in water-energy research and supporting systems analysis and data management; but continued R&D needed to bring advanced water management technologies to state of commercial readiness.

- Continued collaboration and coordination with other Federal agencies critical to success.
DOE/NETL Water-Energy Publications

- Emerging Issues for Fossil Energy & Water (June 2006)
- DOE/NETL Water & Energy Brochure (October 2006)
- Energy Demands on Water Resources - DOE Report to Congress (December 2006)
- Water Requirements for Existing & Emerging Thermoelectric Plant Technologies (August 2008)
- Estimating Freshwater Needs to Meet Future Thermoelectric Generation Requirements (September 2008)
- State Oil and Natural Gas Regulations Designed to Protect Water Resources (April 2009)
- Modern Shale Gas Development in the United States: A Primer (April 2009)
To Find Out More About NETL’s Energy-Water R&D
