DOE/NETL’s Energy-Water RD&D Program

Jared Ciferno, Technology Manager
Existing Plants Program
DOE/NETL Water-Energy RD&D Activities

**Power Generation**
- Alternative “non-traditional” water sources
- Advanced cooling, recovery/reuse, and treatment technology
- Systems and engineering analysis

**Carbon Capture & Storage**
- Geological sequestration
- CO$_2$ capture technology
- Systems and engineering analysis

**Water Availability & Quality Issues**

**Oil & Gas Exploration**
- Water management technology
- Coal bed methane and produced water
- Systems and engineering analysis
NETL Power Generation Water Management R&D

1—Advanced Cooling

Evaporation & Drift

2—Non-traditional water sources

Moist stack gas

Make-Up Water

Blowdown Water

3—Reuse and Recovery

Make-up Water

Air Pollution Control Devices

Stack

SCR → Air Heater → ESP or FF → Wet FGD
Water-Energy R&D Goals

2015 Target
For plants equipped with wet recirculating cooling....Develop technologies at the demonstration scale that:

1. Reduce freshwater withdrawal and consumption by 50%
2. At a levelized cost that is at least 25% less compared to state-of-the-art dry cooling technology

2020 Target
For plants equipped with wet recirculating cooling....Develop technologies at the demonstration scale that:

1. Reduce freshwater withdrawal and consumption by 70%
2. At a levelized cost that is at least 50% less compared to state-of-the-art dry cooling technology
Advanced Cooling Technology

R&D Focus
Minimizing the amount of water consumed by power plant cooling systems

- Improve performance & cost
  - Wet and dry cooling systems
- Reduce cooling water blowdown

Project Types:
- Improved air cooled condenser
- Improved Air2Air® technology
- Cooling water anti-scaling

Partners:
- SPX Cooling Technologies
- Drexel University
Freshwater Recovery Using Air-2-Air Technology

SPX Cooling Technologies - ClearSky™ Technology

• 4-year, $2 million project conducted under Existing Plants water-energy R&D program
• Develop technology to reduce evaporative water loss from wet cooling towers
• Utilizes air-to-air heat exchanger to condense water from air prior to discharge
• Full-scale testing conducted on one cooling tower cell at San Juan Power Station in New Mexico
• Achieved 18% water usage reduction

“Public Service Company of New Mexico was pleased to partner with SPX Cooling Technologies and the Department of Energy on the new technology… Now that data has been collected for the year under both summer and winter conditions, we are very pleased with an 18% water usage reduction proven by the ClearSky cell.”

Alan Benefiel, San Juan Generating Station
Non-Traditional Sources of Process and Cooling Water

**R&D Focus**
Evaluate and develop low cost approaches to using non-traditional water (mine pool, coal-bed methane produced, geological CO₂ sequestration produced) to supplement or replace power plant freshwater consumption.

**Project Types:**
- Saline formation produced water
- GIS catalog of non-traditional sources
- Treated municipal water
- Reuse of impaired water
- Advanced separation
- Produced water (EOR, mine pool)

**Partners:**
- Sandia National Lab
- Arthur Langhus Layne
- Carnegie Mellon Univ.
- Univ. of Pittsburgh
- GE Global Research
- Univ. of Illinois
Carbon Sequestration Produced Water

Sandia National Laboratory

- Development of integrated modeling tool to assess integrated approach to CO$_2$ sequestration and produced water for plant use

- Studying geomechanical flow models

- Assessment of water treatment options (nano-filtration, RO..)
GIS Catalog of Non-Traditional Sources

Arthur Langhus Layne

- Identify location and water needs of current and planned coal fired power plants
- Identify location, quality, and volume of water sources
  - Produced waters
  - Mine pool waters
  - Industrial
  - Municipal
- Internet-Based GIS Catalog
Water Reuse and Recovery

R&D Focus
Reduce freshwater consumption by reusing or recovering power plant water resources

Project Types:
- Nanofiltration membranes
- Condensing heat exchangers
- Transport membrane condenser
- Restored wetlands water reuse
- Power plant water optimization
- Flue gas desiccant systems

Partners:
- Sandia National Lab
- Lehigh University
- Gas Technology Institute
- Applied Ecological Services
- EERC
Water Recovery from Boiler Flue Gas: Condensing Heat Exchangers

Lehigh University

- Develop new designs for condensing heat exchangers
- Perform pilot scale tests and measure acid and water condensation patterns
- Determine maximum recoverable water from flue gas
- Determine potential heat rate benefits
Water Recovery from Boiler Flue Gas: Transport Membrane Condenser (TMC)

- Develop, model, and evaluate two-stage TMC water recovery
- Optimize currently available ceramic membrane for flue gas
- Design and fabricate pilot-scale TMC system for power plant use
- Test at different flue gas conditions
- Develop scaling algorithm
- Develop path for commercial deployment
Water R&D Benefits

Up to 60% Water Consumption Reduction

- **Alternate water sources (30% reduction)**
  - Mine pool water
  - Waste water

- **Adv. Cooling (20% reduction)**
  - Vapor Recovery

- **Water reuse (5% reduction)**
  - Flue Gas Condensation

Dry cooling ~$5.86/thousand gallons conserved

2015 Target: Reduce water conservation cost by 25% ($4.40/gallon)
2020 Target: Reduce water conservation cost by 50% ($2.90/gallon)
Carbon Dioxide Capture & Water
Potential Water Impacts of CCS

*Increased cost of electricity & plant water demand*

- **Increased cost for treating, pumping water**
- **Decreased water availability, other sectors**
Water Withdrawal and Consumption Factors

- **127% Withdrawal** 118% Consumption
- **124% Withdrawal** 113% Consumption
- **37% Withdrawal** 42% Consumption

- **New Plants @ full load**
- **IGCC average of 3 O₂-blown gasifier technologies**
CO₂ Sequestration & Water

- Under DOE’s 7 Carbon Sequestration Regional Partnerships characterizing impacts of geological storage of CO₂ on subsurface water quality and availability

- Member of the SDWA Underground Injection Control (UIC) program regulatory development process group

- Interagency working group
  - Quarterly director meetings and staff collaborations
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)
Key Take-Aways

- Water is critical to operation and permitting of thermoelectric power plants, as well as in production of fossil energy.
- 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 has a focus 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 energy-water research and supporting systems analysis and data management; but continued R&D needed to bring advanced water management technologies to state of commercial readiness.
- NETL’s R&D is part of broader U.S. national laboratory effort directed at the link between energy and water.
- Continued collaboration and coordination with other Federal agencies critical to success.
For More Information About the NETL Existing Plants Program

- NETL website:  
  - www.netl.doe.gov

- Office of Fossil Energy website:  
  - www.fe.doe.gov

Reference Shelf

- Annual CO2 Capture Meeting

Jared P. Ciferno  
Technology Manager, Innovation for Existing Plants  
National Energy Technology Laboratory  
U. S. Department of Energy  
(Tel) 412 386-6002  
jared.ciferno@netl.doe.gov