

# DOE/NETL Power Plant Water Management R&D Program



*A Water Constrained  
Future – How Power  
Producers Can Minimize  
the Impact in the West*

*May 1 - 2, 2007  
San Diego, CA*

**Andrea McNemar  
National Energy Technology Laboratory**

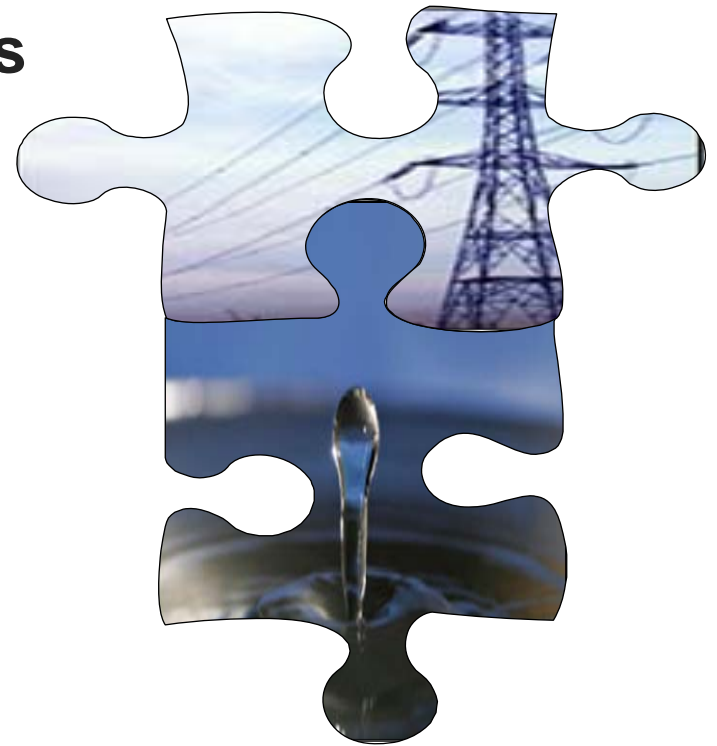


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# Outline

## NETL Power Plant Water Management Program Elements

- **Current IEP Energy-Water R&D Activities**
- **Questions?**



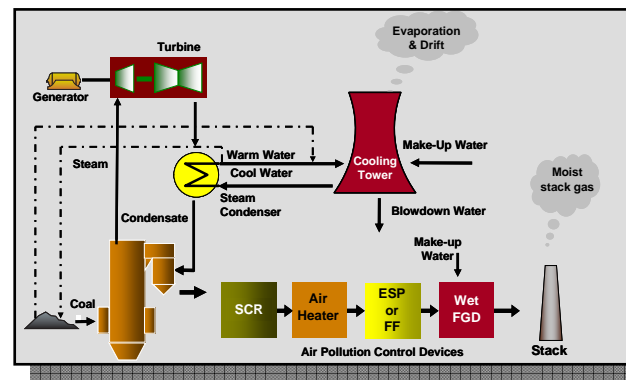
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## Key Takeaways

- Water is critical to thermoelectric generation
- DOE/NETL analysis projects that on a national basis freshwater withdrawals for the thermoelectric power industry will decrease almost 10% through 2030, however freshwater consumption is expected to increase over 30% (compared to a 2005 baseline)
- However, water is also a regional issue:
  - Population growth and concomitant increases in electricity demand will occur in regions that are water challenged
  - Demand for water for power will increasingly compete with other sectors such as agriculture, domestic, and in-stream use
- Environmental considerations such as §316(b) will impact permitting and operation of existing and new coal plants



# Innovations for Existing Plants (IEP) R&D Program



# NETL Strategic Center for Coal

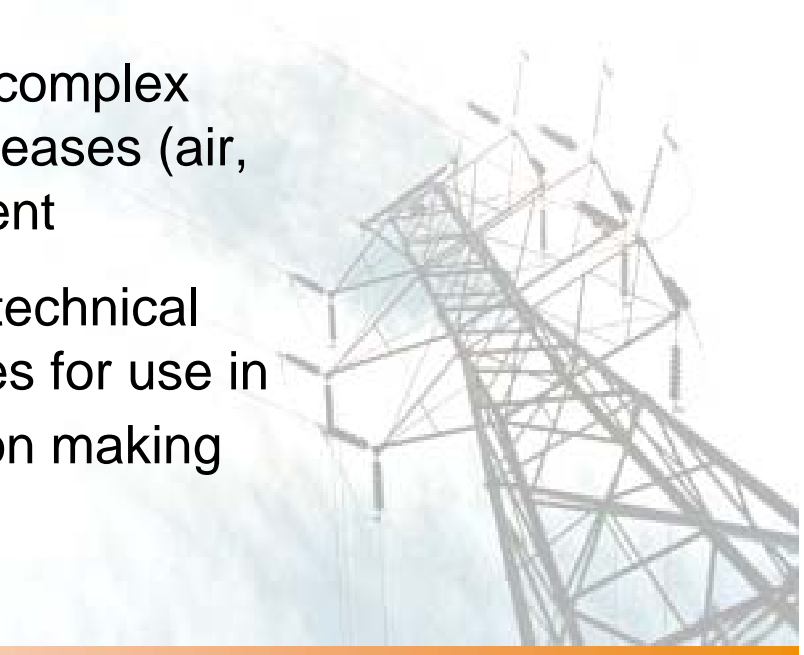
## *Innovations for Existing Plants (IEP) R&D Program*

- **Goal**

- Enhance environmental performance of existing fleet of coal power plants and advanced power systems

- **Objectives**

- Develop low-cost, integrated, non-complex technology to control emissions/releases (air, water, and solids) to the environment
- Provide high-quality scientific and technical information on environmental issues for use in future regulatory and policy decision making



# Innovations for Existing Plants

## *R&D Program Components*

- **R&D Activities**

- Mercury control
- Coal utilization by-products
- Water management
- NO<sub>x</sub> control
- Particulate matter control
- Air quality research



# IEP Water Management Program

## *Technical & Cost Goals*

- **Short Term – Have technologies ready for commercial demonstration by 2015 that, when used alone or in combination, can reduce freshwater withdrawal and consumption by 50% or greater for thermoelectric power plants equipped with wet recirculating cooling technology at levelized cost of less than \$2.40 per 1000 gallons freshwater conserved.**
- **Long Term – Have technologies ready for commercial demonstration by 2020 that when used in combination can reduce freshwater withdrawal and consumption by 70% or greater at levelized cost of less than \$1.60 per 1000 gallons freshwater conserved.**



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# Current IEP Energy-Water R&D Activities



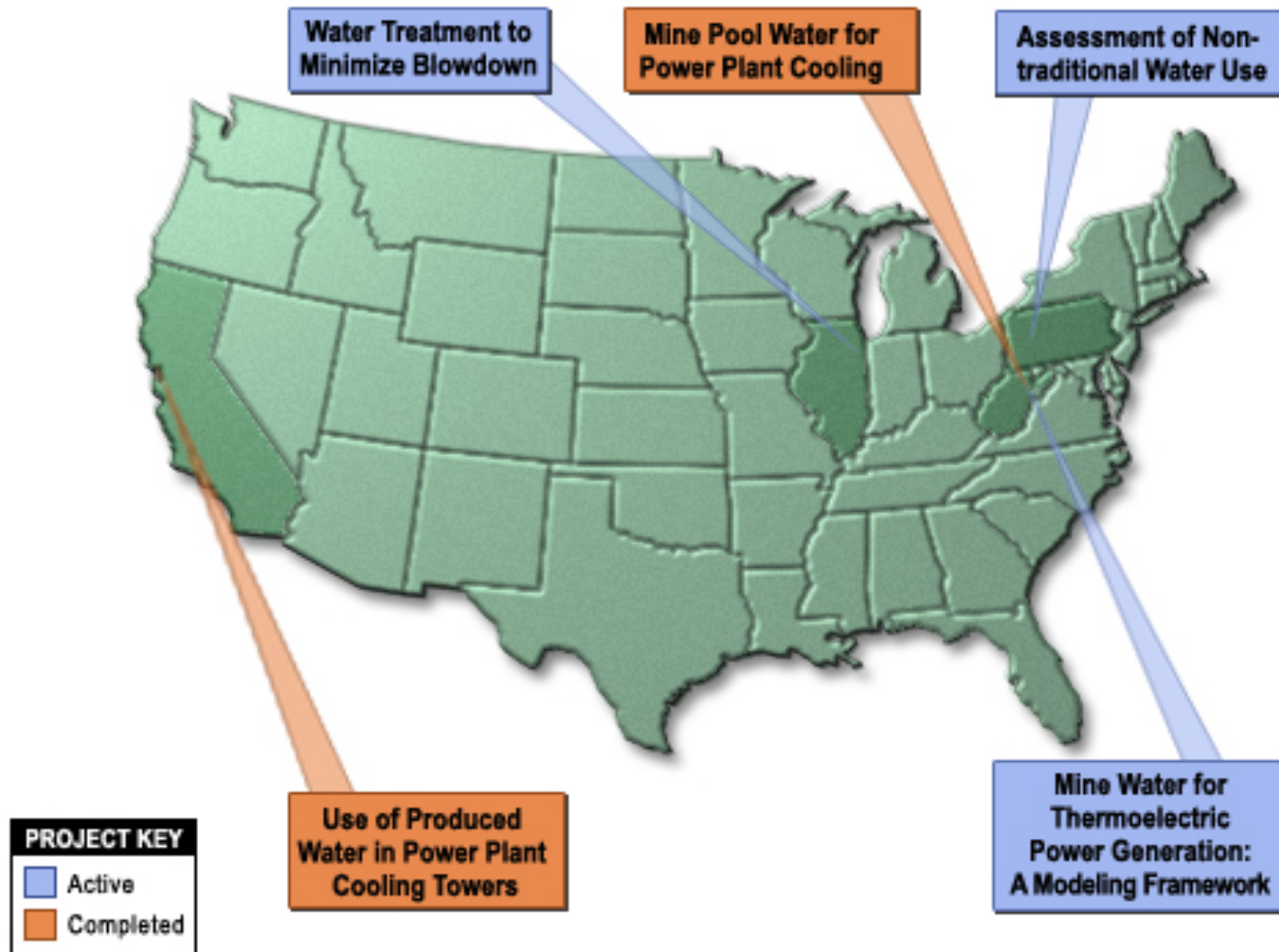


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## **Four Primary Research Areas**

- **Non-traditional sources of process and cooling water**
- **Innovative water reuse and recovery**
- **Advanced cooling technology**
- **Advanced water treatment and detection technology**

# Non-Traditional Sources of Process and Cooling Water Projects



# Advanced Separation and Chemical Scale Inhibitor Technologies for Use of Impaired Water in Power Plants

## *Nalco Company*

### **Objective**

- Develop advanced scale control technologies to enable coal-based power plants to use impaired water in re-circulating cooling systems

### **Tasks**

- Investigate synergistic combinations of physical and chemical treatment
- Develop scale inhibitor chemistries
- Develop separation processes
- Utilize pilot-scale tests to validate performance



**Development of technology necessary for economic utilization of impaired water by industry**



Project Status:  Active

# Strategies for Cooling Electric Generating Facilities Utilizing Mine Water

*West Virginia University*

## **Objective**

- Identify cost saving alternatives to the current coal-fired power plant cooling process using non-traditional water sources such as coal mine discharges

## **Tasks**

- Identification of suitable mine waters
- Design a collection system
- Determine treatment needs
- Evaluate environmental factors and permitting requirements
- Assess the economic feasibility



Untreated discharge from underground coal mine

**Coal mine discharge can reduce freshwater power plant cooling requirements while improving the efficiency of the cooling process**



Project Status:  Completed

# Reuse of Treated Internal or External Wastewaters in the Cooling Systems of Coal-Based Power Plants

*University of Pittsburgh*

## **Objective**

- Assess the potential of three types of impaired water for cooling water make-up in coal-based power plants

## **Tasks**

- Assess availability and proximity of impaired waters at twelve plant locations
- Evaluate relevant regulatory and permitting issues
- Pilot-scale testing of three different types of impaired water:

(1) Ash Pond Effluent



(2) Secondary Treated Municipal Wastewater



(3) Passively Treated AMD



**Develop technologies to make use of impaired waters more feasible**

Project Status:  Active

# Use of Produced Water in Recirculating Cooling Systems at Power Generating Facilities

*EPRI*

## **Objective**

- Evaluate using produced waters to meet up to 10% of the make-up cooling water demand for the mechanical draft cooling towers at the San Juan Generating Station in New Mexico

## **Tasks**

- Assess produced waters in the area
- Evaluate infrastructure and transport options
- Evaluate treatment technologies
- Determine compatibility of treated produced waters with generating station water needs
- Assess the economic feasibility
- Evaluate implementation options



1,800 MW San Juan Generating Station (SJGS)



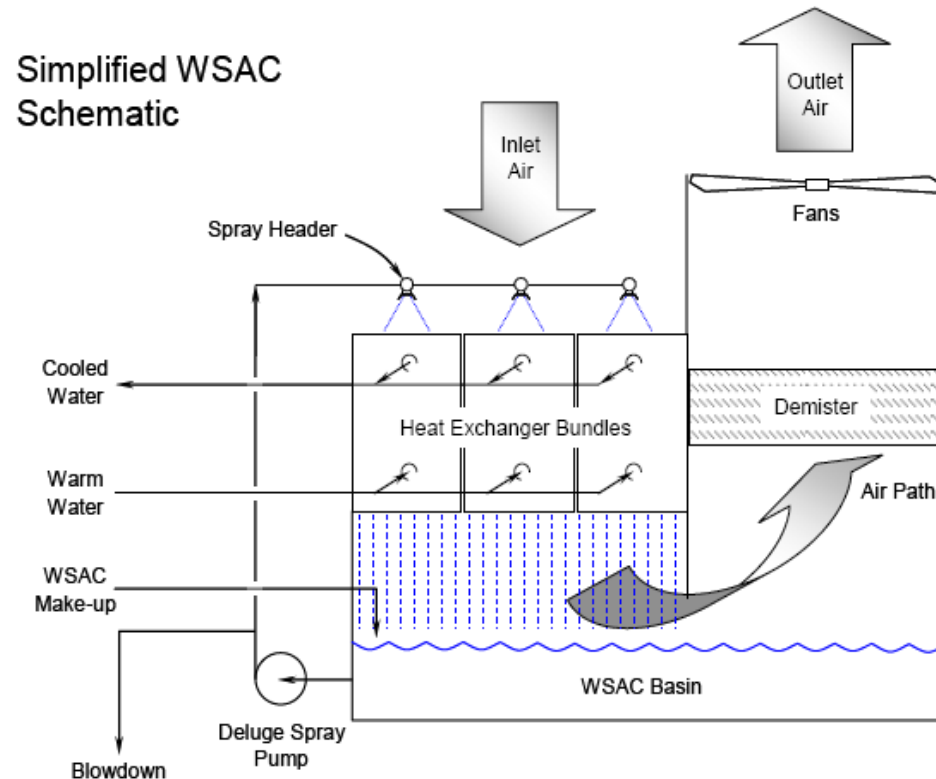
**Reduce power plant cooling freshwater make-up requirements**

Project Status:  Completed

# Use of Produced Water in Re-circulating Cooling Systems -- Wet Surface Air Cooler

## Completed testing at San Juan Generating Station Unit 3

- In service for 2,898 hours from 7/5/05 to 11/29/05
- Operated using blowdown from SJGS cooling tower
- Operated at equivalent of 24-70 COC without scaling/fouling

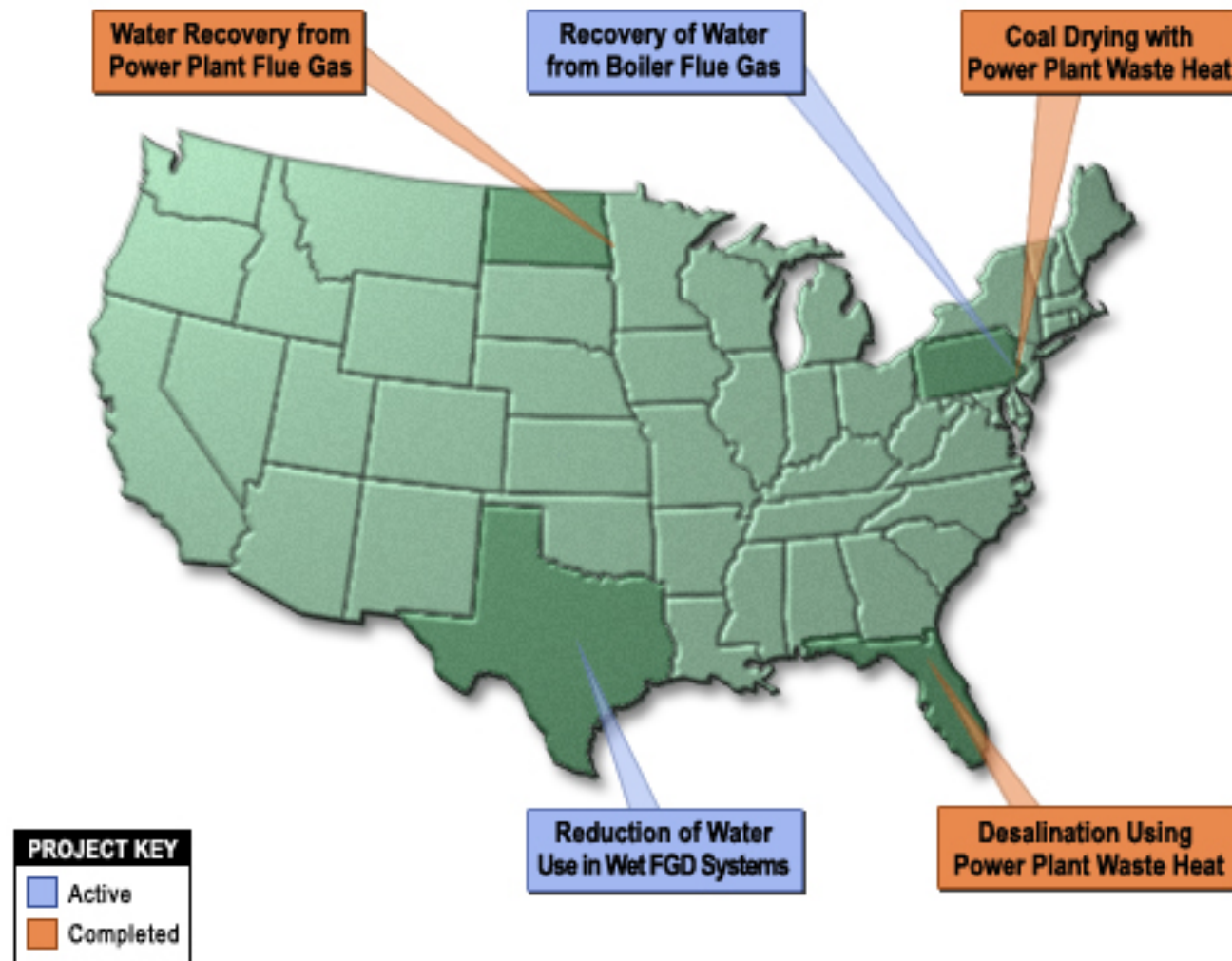


**Niagara Blower Corporation WSAC**



 -- Full-scale plant operation

# Innovative Water Reuse and Recovery Projects





# Water Extraction from Coal-Fired Power Plant Flue Gas

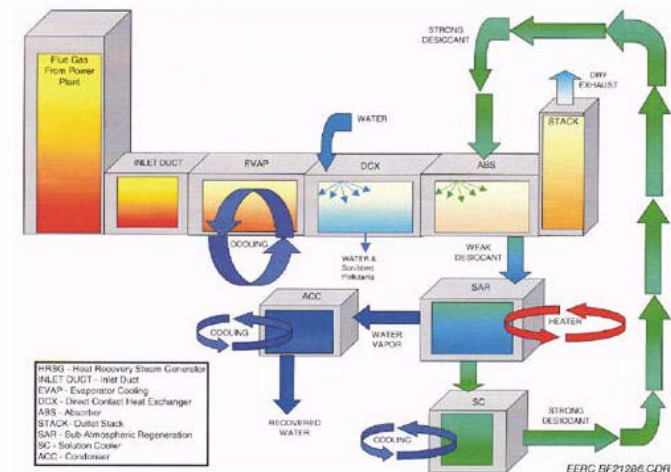
## Energy & Environmental Research Center (EERC)

### Objective

- Develop a liquid desiccant-based dehumidification system (LDDS) that can efficiently and economically remove water vapor from combustion flue gas

### Tasks

- Select desiccants for testing
- Conduct bench-scale desiccant evaluation
- Design test facility and equipment
- Conduct pilot-scale testing
- Evaluate test data results
- Conduct commercial power plant evaluation



Conceptual design of liquid desiccant-based dehumidification system (LDDS)

Enable the recovery of water vapor contained in power plant flue gas streams



Project Status:  Completed

# Recovery of Water from Boiler Flue Gas

## *Lehigh University*

### **Objective**

- Develop new designs for condensing heat exchangers to recover water vapor from flue gas at coal-fired power plants

### **Tasks**

- Utilize laboratory- and pilot-scale experiments; and computer simulations
- Design a compact tube heat exchanger
- Measure heat transfer effectiveness of the smooth-tube and fin-tube bundle
- Analyze possible reductions in heat rate due to heat recovery from flue gas



**Enhance flue gas water recovery for use as make-up water**

Project Status:  Active

# Use of Coal Drying to Reduce Water Consumed in Pulverized Coal Power Plants

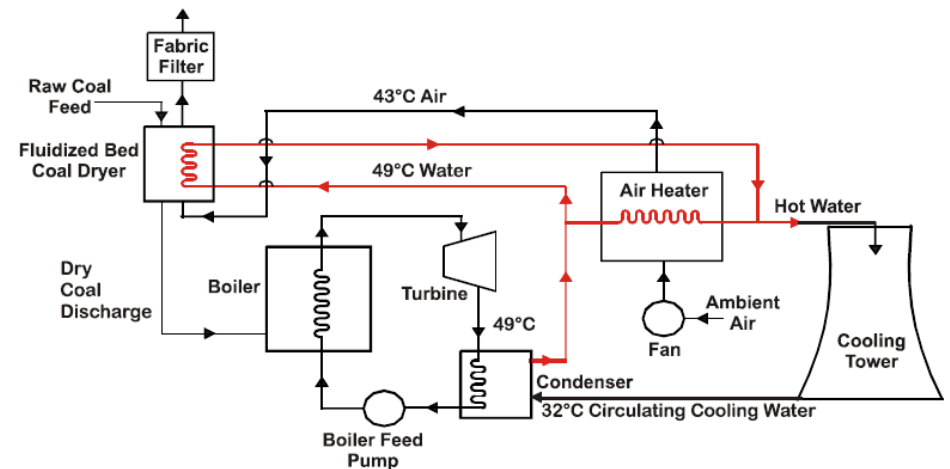
*Lehigh University*

## Objective

- Determine the feasibility of using low grade power plant waste heat to dry lignite and subbituminous coals before they are burned in utility boilers

## Tasks

- Fabricate and instrument equipment
- Perform drying experiments
- Develop drying models and compare to experimental data
- Design drying system
- Evaluate impacts of unit performance and cost of energy



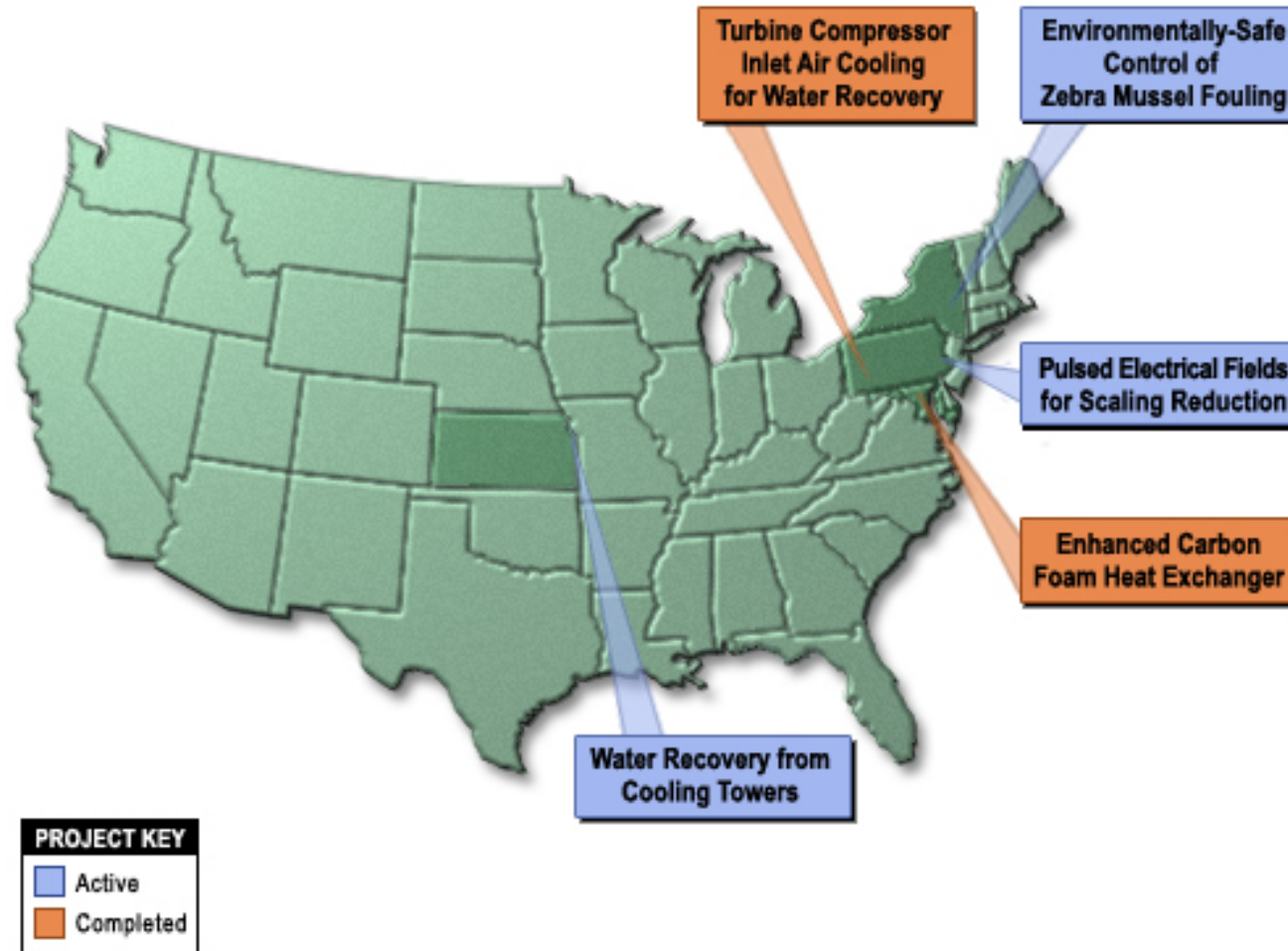
Schematic of plant layout showing air heater and coal dryer

**Waste heat from the cooling water system can reduce evaporative water loss and improve power plant efficiency**



Project Status:  Completed

# Advanced Cooling Technology Projects



# Environmentally-Safe Control of Zebra Mussel Fouling

## *New York State Education Department*

### **Objective**

- Conduct experiments with a strain of a naturally-occurring bacterium to evaluate its technical and economic feasibility to control zebra mussel fouling while minimizing the impacts to aquatic ecosystem

### **Tasks**

- Develop methods to increase bacterial cell toxicity
- Develop economical methods for bacterial mass production
- Conduct additional treatment trials in power plants to demonstrate effectiveness



**Evaluate the ability to reduce zebra mussel fouling while minimizing impacts to aquatic ecosystems**



Project Status:  Active

# Enhanced Performance Carbon Foam Heat Exchanger for Power Plant Cooling

*Ceramic Composites, Inc.*

## Objective

- Develop high thermal conductivity foam to be used as the heat transfer medium in an air-cooled condenser (ACC) for power plants equipped with a dry cooling system

## Tasks

- Design a carbon foam heat exchanger
- Develop the manufacturing technologies to support the fabrication process
- Construct and test the performance of the carbon foam heat exchanger
- Develop an economic model for high volume production



Carbon foam heat exchanger

**Improve the cost-effectiveness of the ACC to increase commercial acceptance of dry cooling systems with low water requirements**



Project Status:  Completed

# Use of Air2Air™ Technology to Recover Fresh-Water at Thermoelectric Power Plants

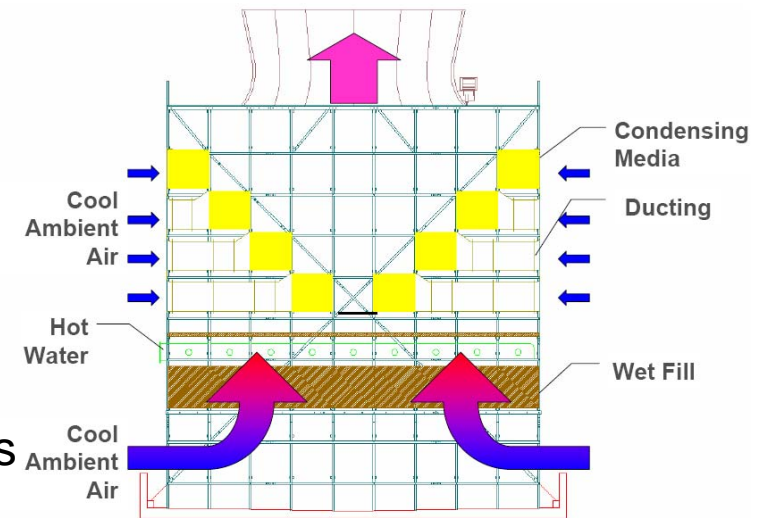
## *SPX Cooling Systems*

### **Objective**

- Research the benefits of deploying the Air2Air™ condensing technology in a cooling tower application at coal-fired power plants

### **Tasks**

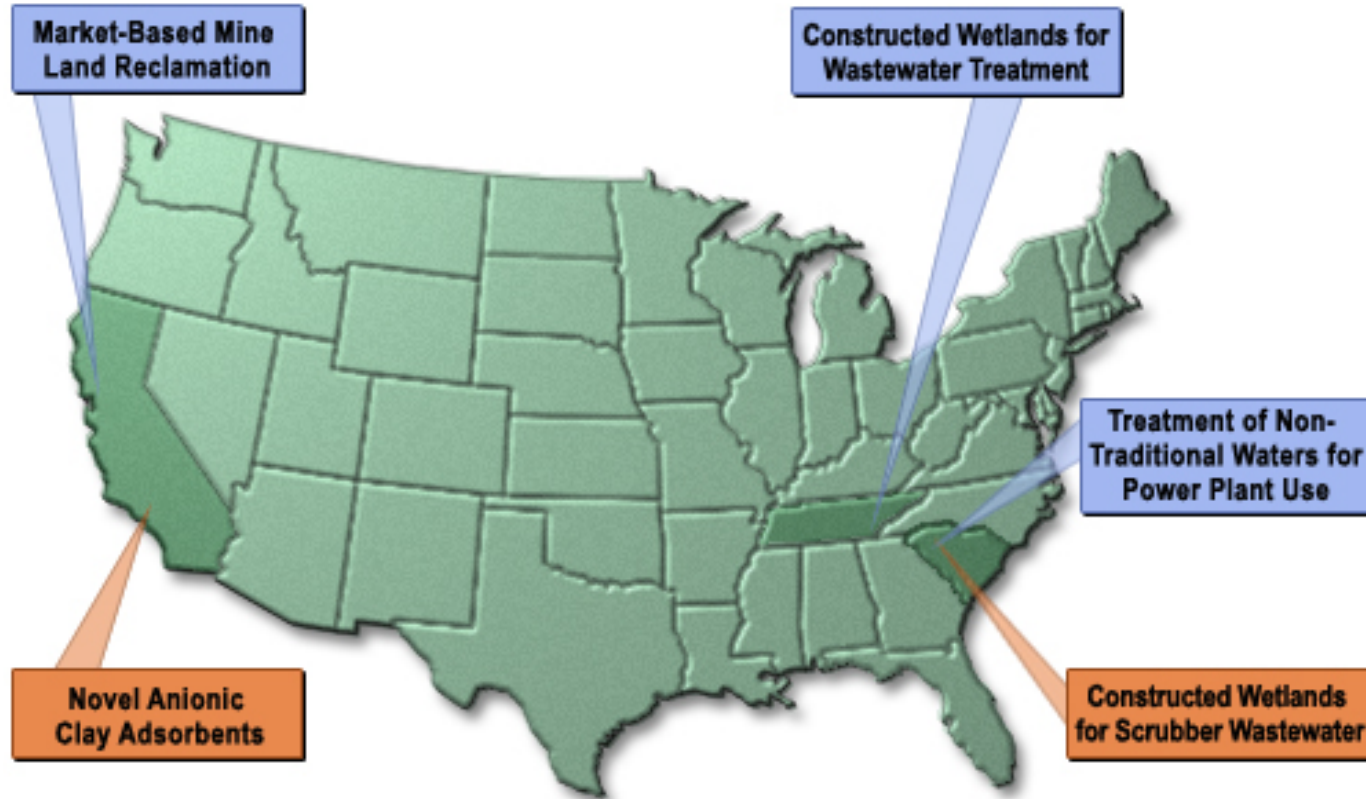
- Quantify water conservation segmented by season and time of day
- Analyze quality of condensed water
- Identify onsite processes capable of utilizing recovered water
- Examine operation during freezing conditions
- Investigate plume abatement methods



**Demonstrate water savings via use of the condensing technology**

Project Status:  Active

# Advanced Water Treatment and Detection Technology Projects



PROJECT KEY	
Blue box	Active
Orange box	Completed





# Demonstrating a Market-Based Approach to the Reclamation of Mined Lands in West Virginia

## *EPRI*

### **Objective**

- Demonstrate a market-based approach to abandoned mine land (AML) reclamation by creating marketable water quality and carbon emission credits

### **Tasks**

- Research status of existing environmental credit markets
- Develop a decision tree for evaluating environmental credit trading projects on AML sites
- Develop a spreadsheet tool to evaluate the costs of developing carbon and water quality credits at AML sites



Installation of passive treatment limestone channel

**Improving regional water quality from AML discharges increases freshwater availability/quality downstream**



Project Status:  Active

# Specifically Designed Constructed Wetlands: A Novel Treatment Approach for Scrubber Wastewater

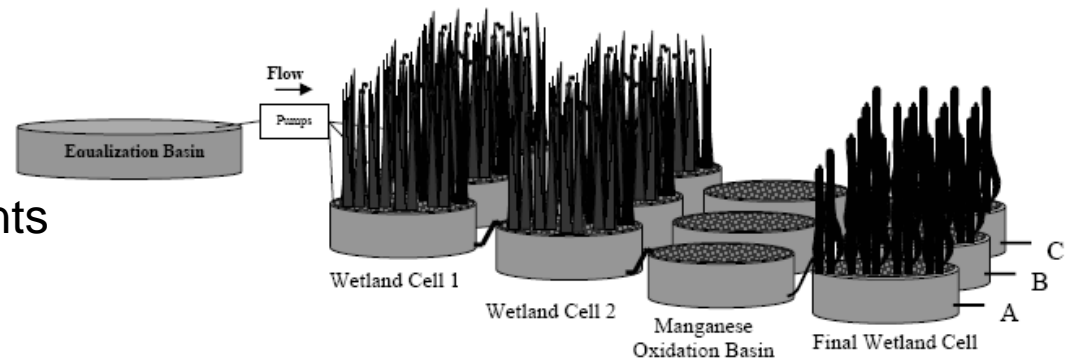
*Clemson University*

## Objective

- Evaluate pilot-scale constructed wetlands for treatment of targeted constituents in scrubber wastewater for reuse in thermoelectric power plants

## Tasks

- Measure performance in reducing target flue gas desulfurization (FGD) constituents
- Determine how the observed performance is achieved
- Evaluate overall system performance for decreased bioavailability and toxic constituents



Pictorial of specifically designed and constructed wetland – customizable to various applications

**Low cost passive treatment systems improve waste water quality for potential power plant reuse and/or discharge**



Project Status:  Completed

# An Innovative System for Treatment of Non-Traditional Waters for Reuse in Power Generation

*Clemson University*

## **Objective**

- Evaluate pilot-scale constructed wetland treatment systems (CWTS) to control targeted constituents in four non-traditional waters for reuse in thermoelectric power plants

## **Tasks**

- Develop and test a pilot-scale CWTS for each non-traditional water:
  - ash basin waters
  - cooling waters
  - flue gas desulfurization (FGD) waters
  - produced waters
- Develop a decision support tool for selecting optimal CWTS designs



Photo of detention basin, pump house, and pilot-scale CWTS designed for ash basin waters

**Low cost passive treatment systems improve waste water quality for potential power plant reuse and/or discharge**



Project Status:  Active

# Continued Development of Sustainable Energy-Water Practices are Key to the Future of the U.S. Thermoelectric Industry



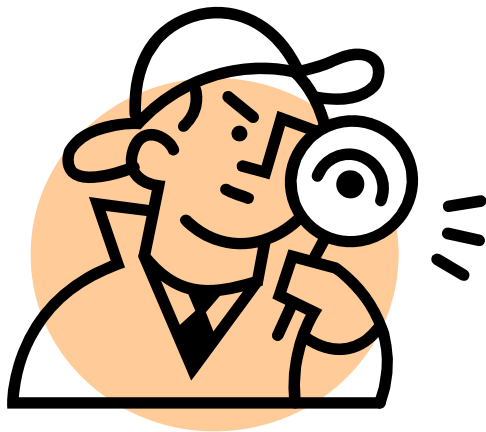
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## Summary

- **Water-related issues will continue to challenge siting of new and/or operation of existing thermoelectric power plants**
- **These issues may become more critical in future due to competing demands, population growth, and increased energy demands**
- **In response, NETL is conducting a comprehensive RD&D effort in the areas of:**
  - Non-traditional sources of process and cooling water
  - Innovative water reuse and recovery
  - Advanced cooling technology
  - Advanced water treatment and detection technology



# To Find Out More About NETL's Energy-Water R&D



NETL: Water - Energy Interface - Microsoft Internet Explorer

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THE ONLY U.S. NATIONAL LABORATORY DEVOTED TO FOSSIL ENERGY TECHNOLOGY

ABOUT NETL

KEY ISSUES & MANDATES

ONSITE RESEARCH

**TECHNOLOGIES**

- Oil & Natural Gas Supply
- Coal & Power Systems
  - Clean Coal Demonstrations
  - Environmental & Water
  - Gasification
  - Turbines
  - Combustion Technologies
  - Fuel Cells
  - FutureGen
  - Advanced Research
  - Contacts
- Carbon Sequestration
- Hydrogen & Clean Fuels
- Technology Transfer

**Environmental and Water Resources**  
Water - Energy Interface

Water and energy are inextricably linked. Because thermoelectric generation and fossil fuel extraction can impact water resources, it is critically important to protect U.S. water supplies while providing the energy needed to power the nation into the 21st century. Through integrated water and energy-related activities, the Department of Energy/National Energy Technology Laboratory (DOE/NETL) **Water-Energy Interface** is responding to this challenge through the development and application of advanced technologies and supporting science.

- Power Plant Water Management
- Systems Analysis & Policy Support
- Regulatory Drivers
- In-House Watershed Science & Technology R&D

Freshwater Needs Projected for Future Fleet [PDF-1.05MB]

June 20, 2006, Water and Power Plant Overview [PDF-14.4MB]

Updated NETL's Energy-Water RD&D Activities Brochure [PDF-638KB]

<http://www.netl.doe.gov/technologies/coalpower/ewr/water/index.html>



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# Questions?

