NETL Power Plant Water Research Program

EPRI Advanced Cooling Technology Workshop
July 9, 2008

Barbara Carney, Thomas J. Feeley, III, Andrea McNemar
US Department of Energy, National Energy Technology Laboratory

National Energy Technology Laboratory

- **Only DOE national lab dedicated to fossil energy**
  - Fossil fuels provide 85% of U.S. energy supply
- **One lab, five locations**
- **Coal gasification, fuel cells, methane hydrates, carbon sequestration**
- **Research spans fundamental science to technology demonstrations**

Alaska

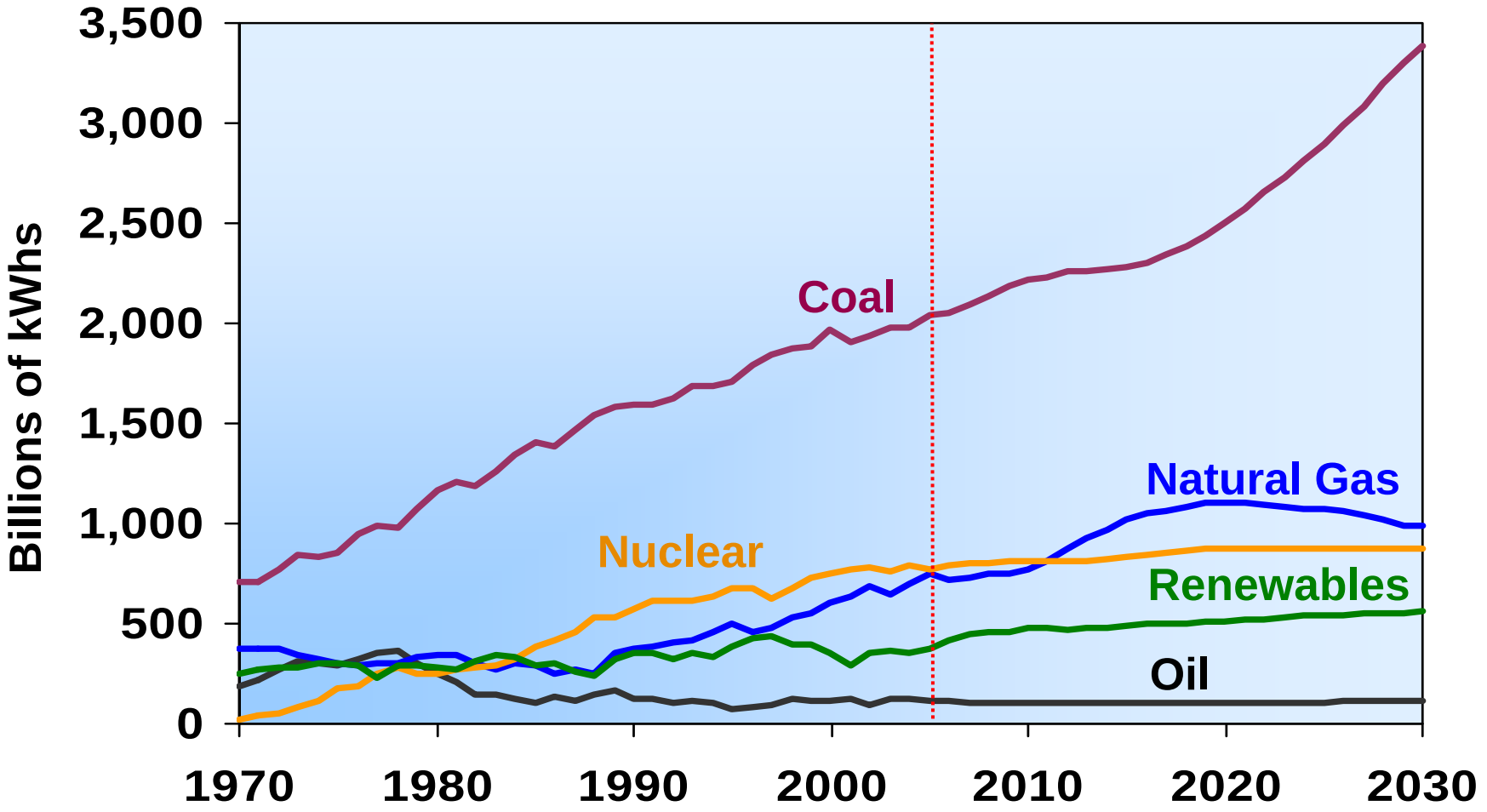
Oklahoma

Oregon

Pennsylvania

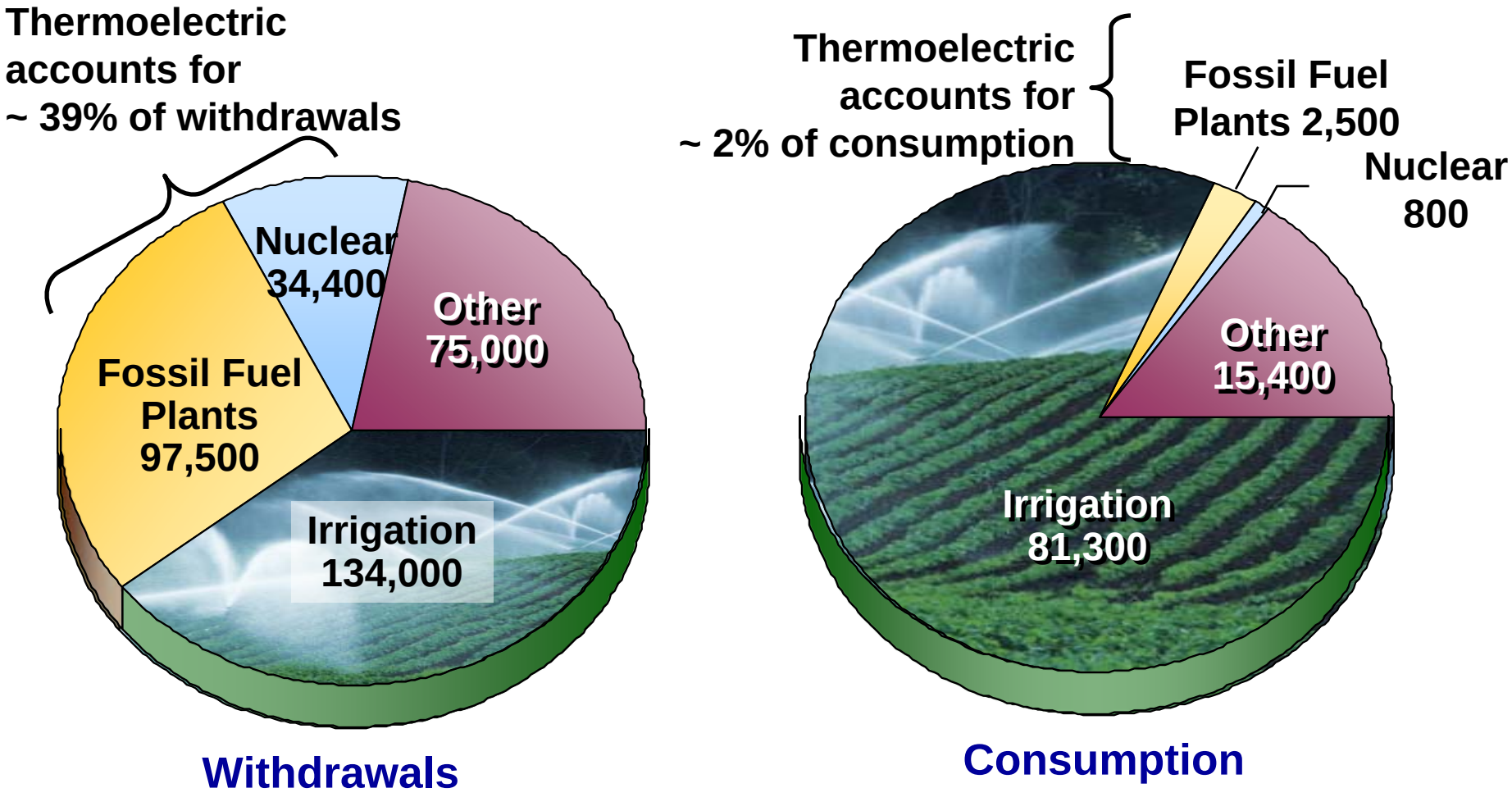
West Virginia

Electric Energy Demand Forecast for 2030



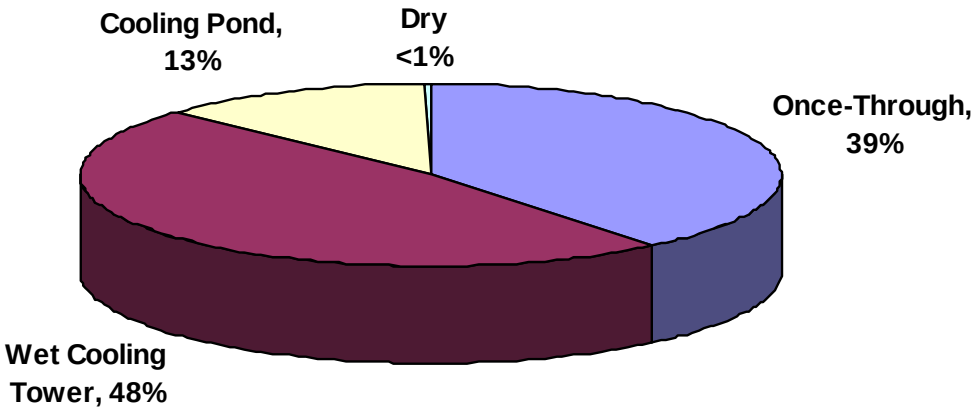
Freshwater Withdrawals and Consumption

Mgal/Day



Source: "Estimated Use of Water in the United States in 1995," USGS Circular 1200, 1998

Cooling System Technology Used by U.S. Coal-Fired Power Plants



Reference: Platts UDI Database, December 2005

Power Plant Water Usage, 500 MW

		gal/kWh	gal/min	gal/hour	MGD
Once Through	PC	38	317,000	19,000,000	456
Wet Cooling Tower	PC	1.1	9,200	550,000	13
	IGCC	0.8	6,700	400,000	10
	NGCC	0.5	4,100	250,000	6

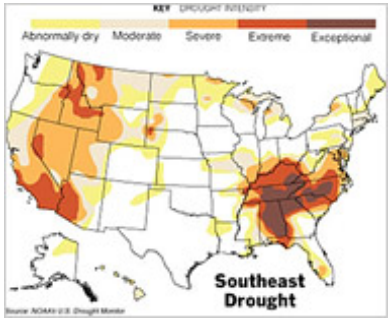
Water/Energy-Related Articles
Impacts on Power Plant Siting and Operation

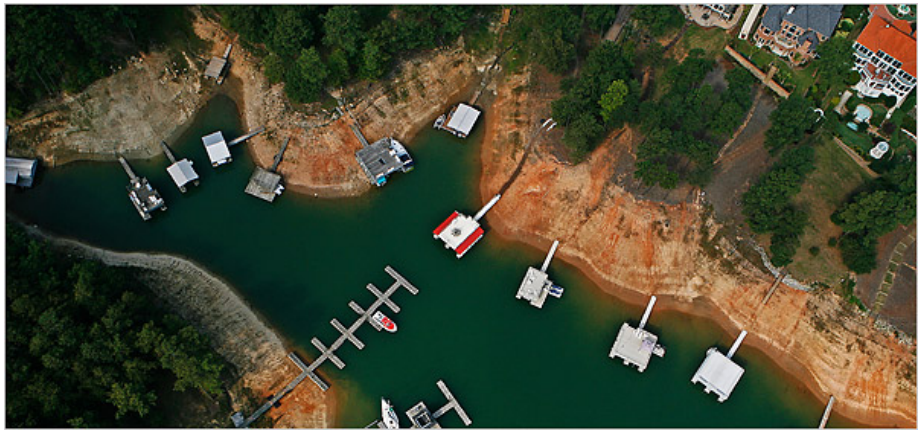
- **Drought Could Force Nuke-Plant Shutdowns**
  - *The Associated Press, January 2008*
- **Sinking Water and Rising Tensions**
  - *EnergyBiz Insider, December 2007*
- **Stricter Standards Apply to Coal Plant, Judge Rules; Activists Want Cooling Towers for Oak Creek**
  - *Milwaukee Journal Sentinel, November 2007*
- **Journal-Constitution Opposes Coal-Based Plant, Citing Water Shortage**
  - *The Atlanta Journal-Constitution, October 2007*
- **Maryland County Denies Cooling Water to Proposed power plant**
  - *E-Water News Weekly, October 2007*
- **Water Woes Loom as Thirsty Generators Face Climate Change**
  - *Greenwire, September 2007*

May 2006 Issue of Power Magazine

Drought

Southeast





Lake Lanier, Atlanta

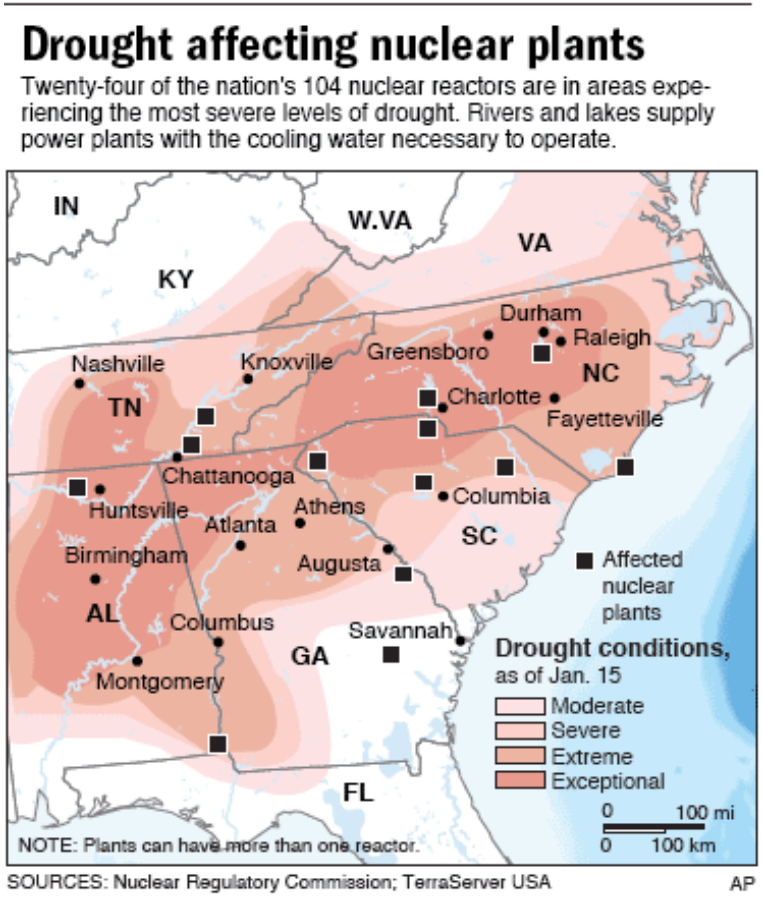
Southwest

Lake Powell, Utah

Lake Mead, Nevada

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



Future Concerns

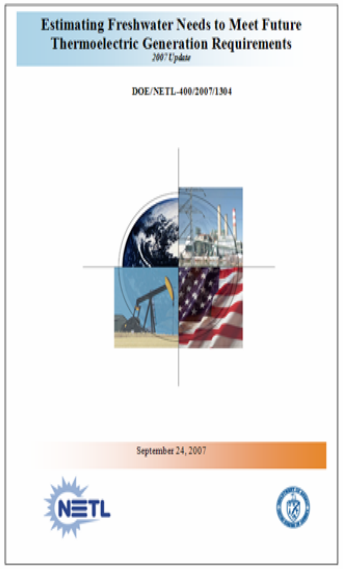
- Keeping up with demand
- Drought—Energy Security
- Climate change—Carbon Capture

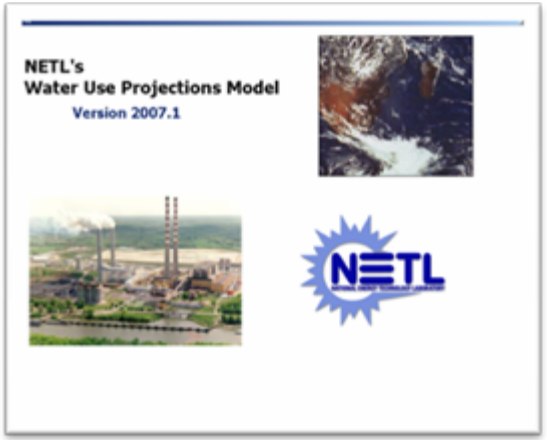
NETL's Energy-Water Analyses

- **Thermoelectric Power Generation**
  - coal steam, combined cycle, other fossil steam, and nuclear

- **Projected national and regional freshwater withdrawal and consumption through 2030**

- **Examine water use of deployed coal-fired power plants with carbon capture technologies**





Four Primary Research Areas

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

Power Plant Water R&D Program
Goal

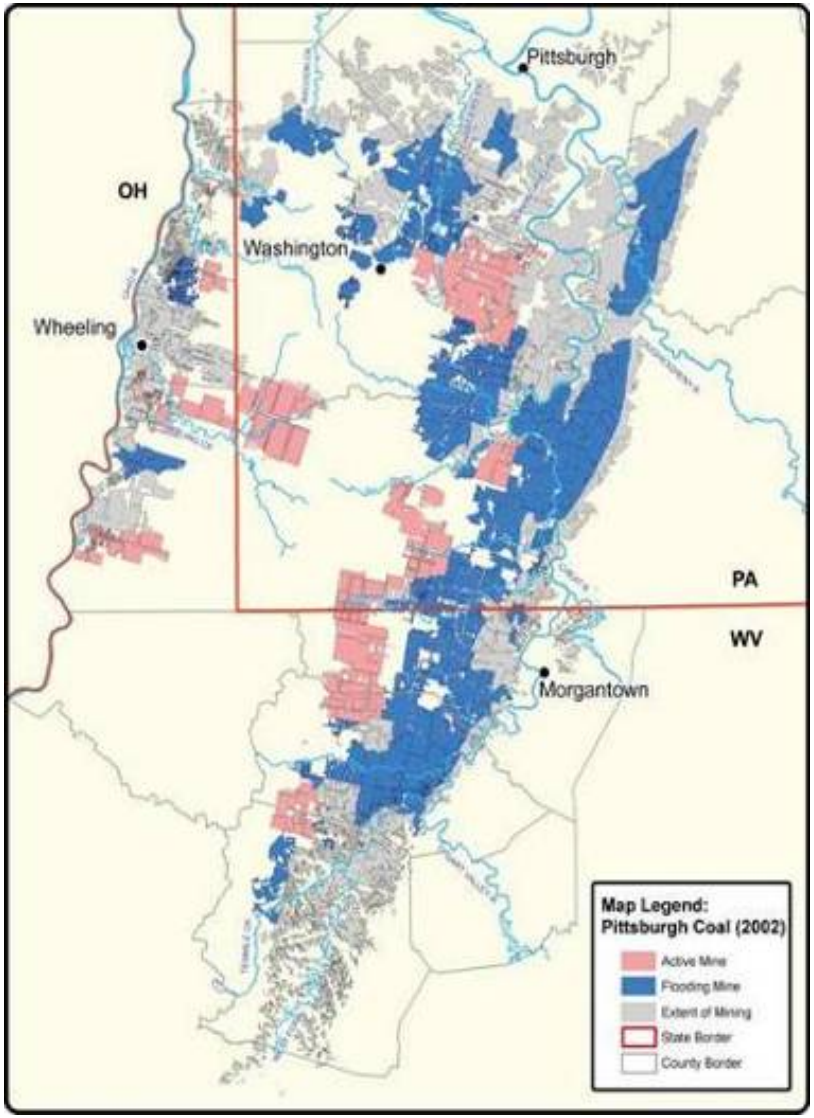
- **Reduce withdrawal and consumption of freshwater by thermoelectric power generation**
- **Minimize impact of coal-based power generation on freshwater quality**

Innovations for Existing Plants

- **Alternative Water Sources**
  - Treated municipal wastewater
  - Mine pool water
  - Produced water
- **Power Plant Water Savings**

Reclaimed Water Use--Panda-Brandywine Power Plant

Alternative Sources of Cooling Water - Mine Pools

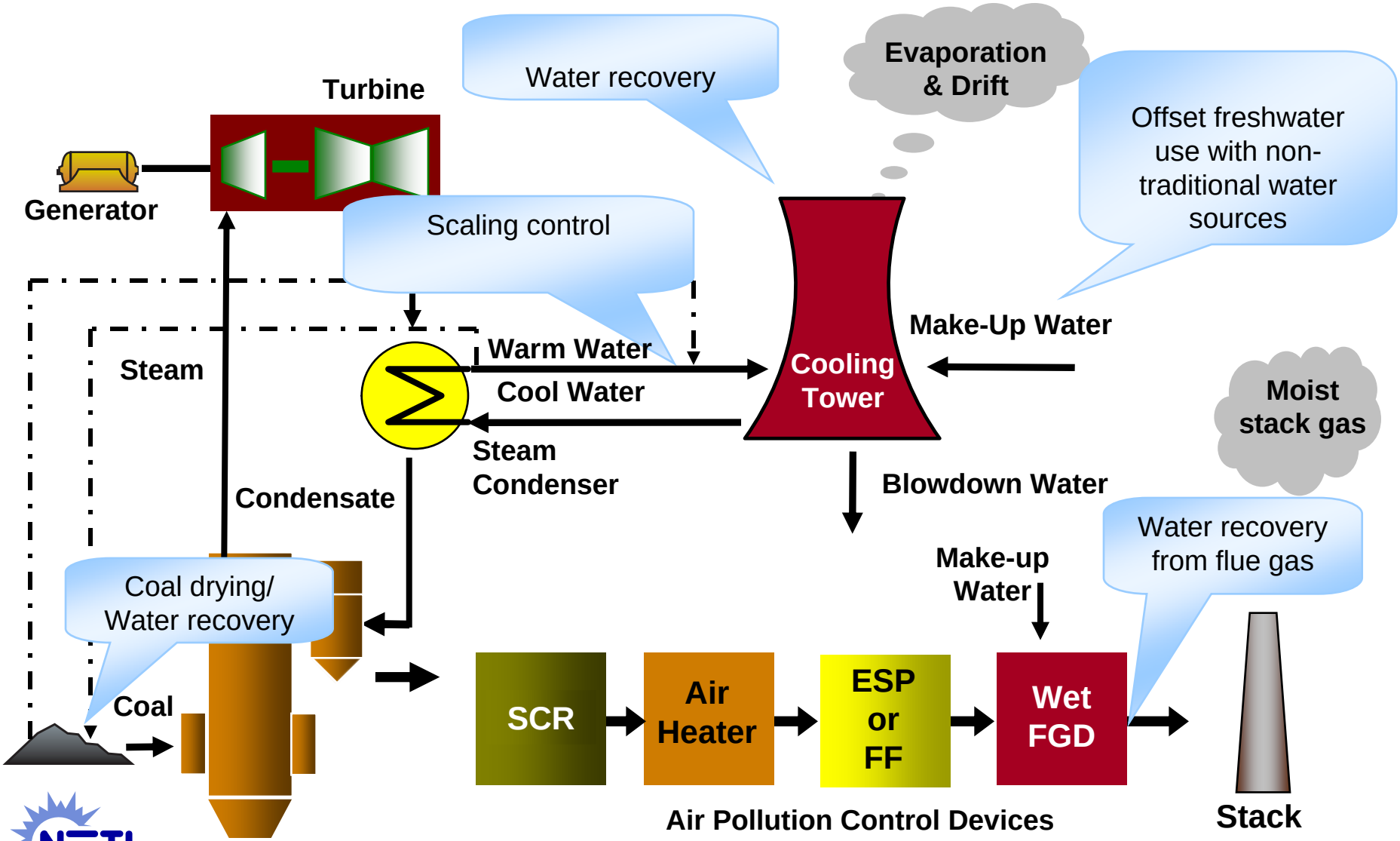


Use of Produced Water in Recirculated Cooling Systems at Power Generation Facilities

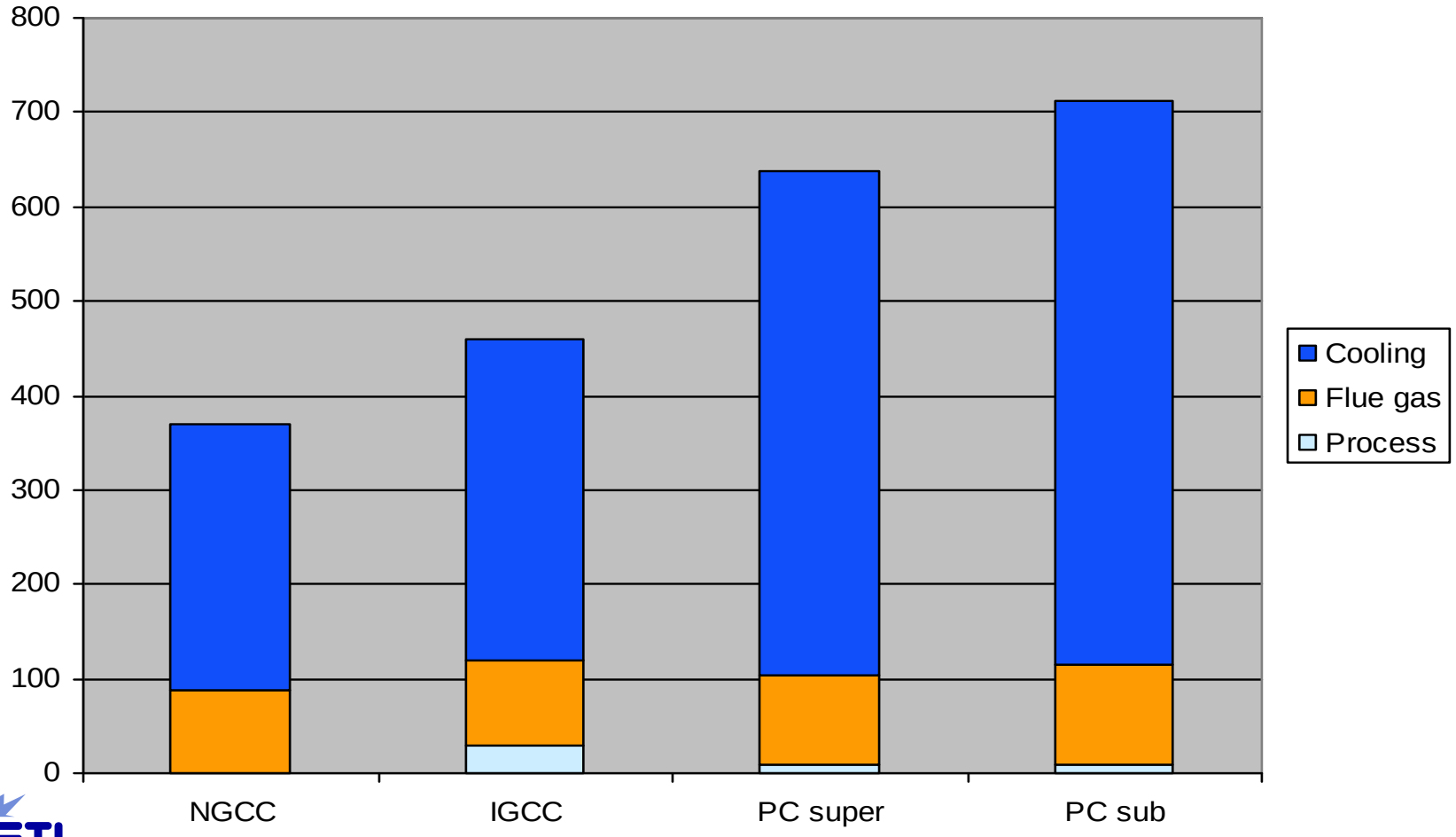
- **EPRI in partnership with Public Service of New Mexico**
- **Evaluate use of oil/gas produced water in re-circulating cooling systems at San Juan Generating Station in NW New Mexico**
- **Transportation (pipeline) and treatment costs (desalination) are high**

McGrath Salt Water Disposal Facility (SWDF)

NETL Water Management R&D

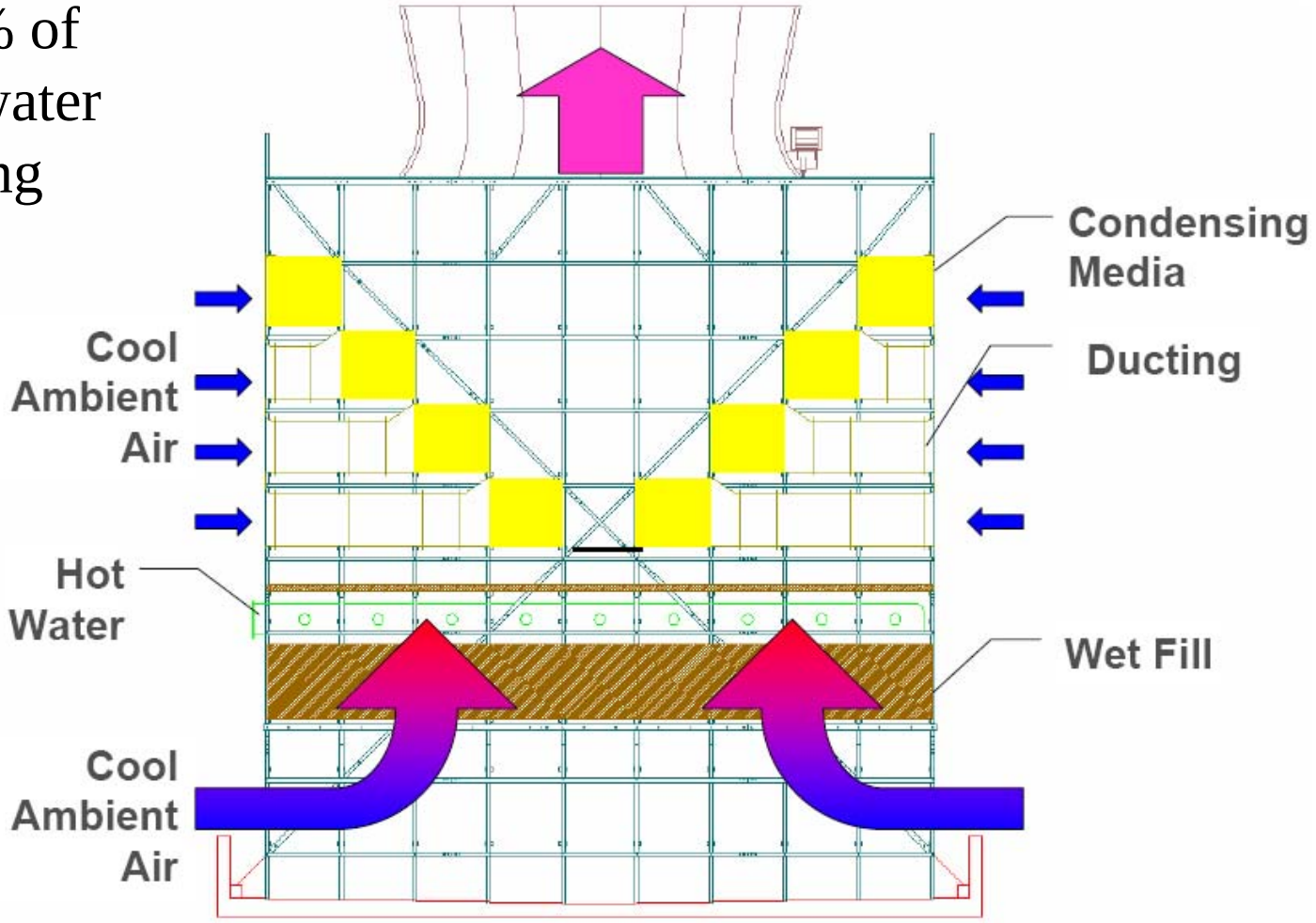


Water Loss (Gal/MWhr)



Air2Air™ Condensing Technology
SPX Cooling Technologies

Recover 20% of evaporated water from a cooling tower.



Air2Air in Operation

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

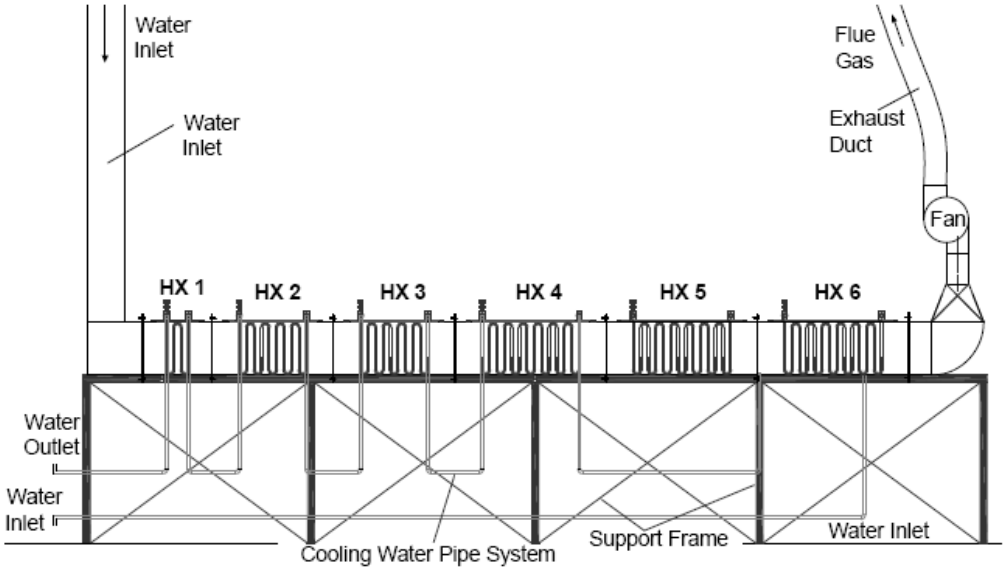
Tasks

➢ Smooth-walled heat exchanger constructed and tested in oil- and coal-fired slipstream test.

➢ Water recovery was 50-72% in coal-fired test.

➢ Finned-tube heat exchanger under construction.

➢Analysis will be done on possible reductions in heat rate due to heat recovery from flue gas



Recover flue gas water for use as make-up water

Water Extraction from Coal-Fired Power Plant Flue Gas

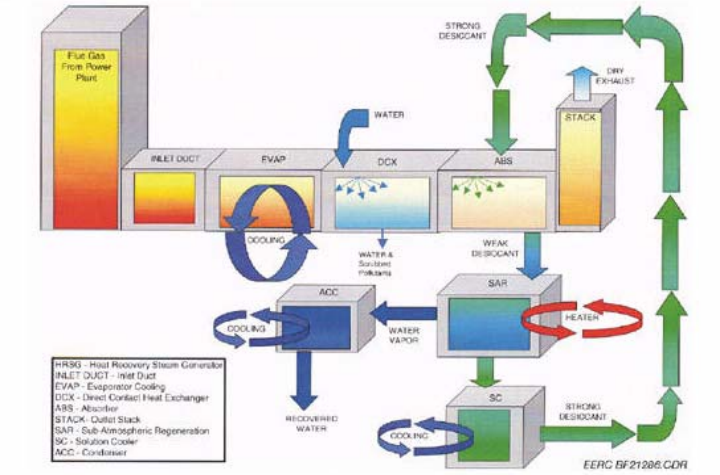
Energy & Environmental Research Center (EERC)

Objective

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

Tasks

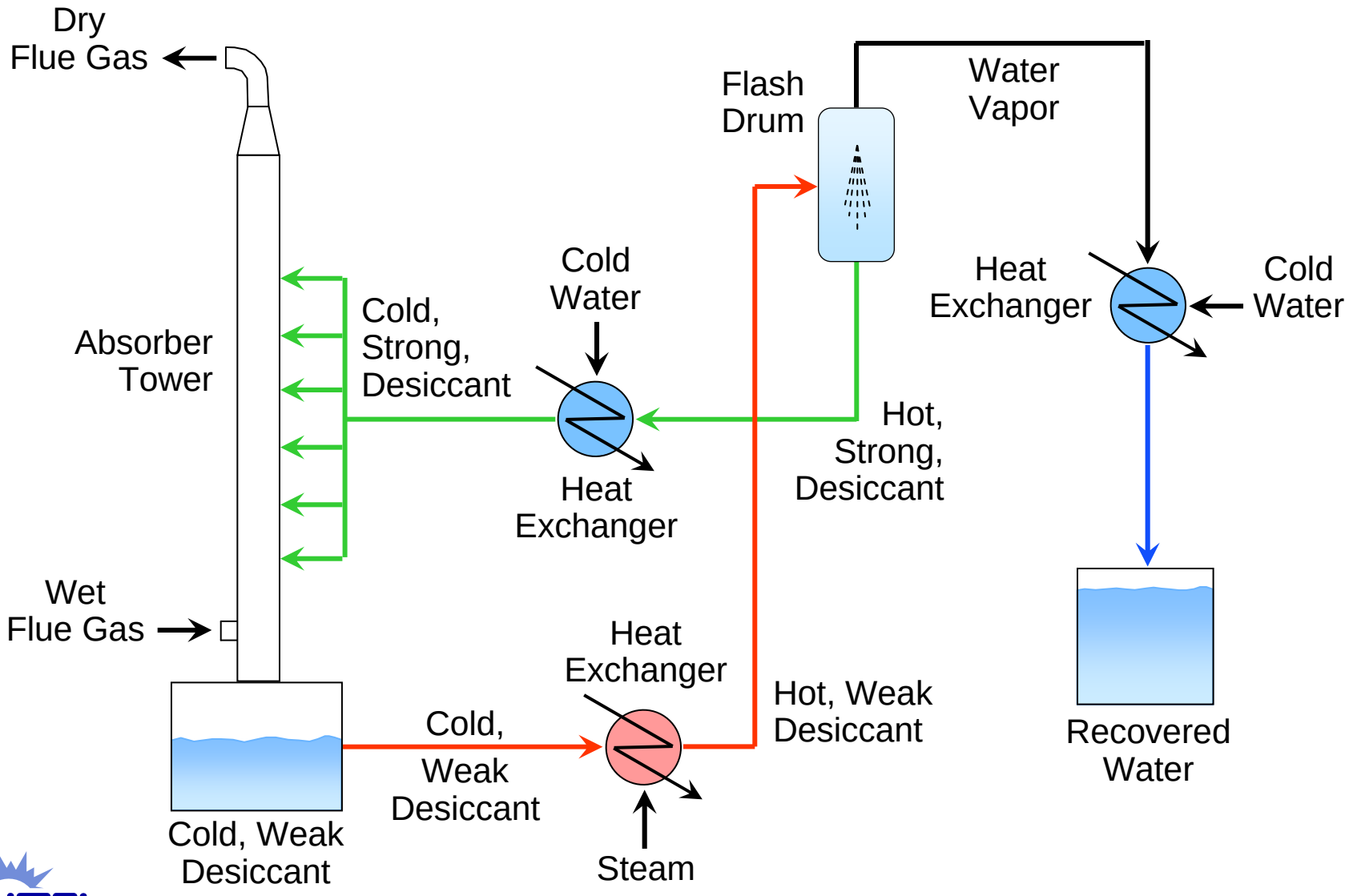
- ➢ Select desiccants for testing
- ➢ Conduct bench-scale desiccant evaluation
- ➢ Design test facility and equipment
- ➢ Conduct pilot-scale testing
- ➢ Evaluate test data results
- ➢ Conduct commercial power plant evaluation



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

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

Flue Gas Desiccant Process



Pilot Scale Test

Top of Flash Tank

Water Recovery

Natural gas test:
Desiccant flow: 10-50 gal/min
Water recovery: 0.07-0.11 gal/min, 4.4-6.9 gal/hr
Coal test:
Desiccant flow: 40-110 gal/min
Water recovery: 0.08-0.23 gal/min, 5-14 gal/h

Reduction of Water Use in Wet FGD Systems

URS Group

Objective

• Demonstrate use of regenerative heat exchange to reduce flue gas temperature and minimize evaporative water consumption in wet FGD systems

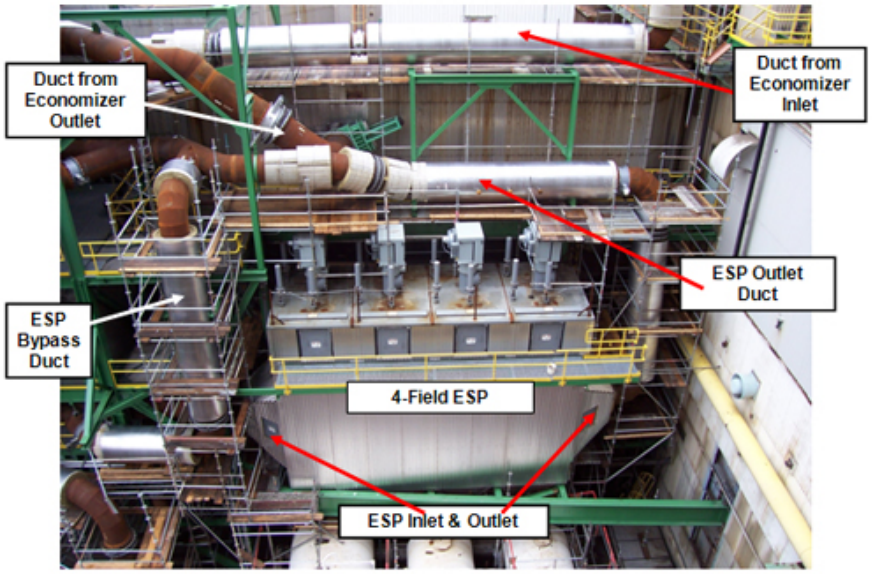
Tasks

➢ Determine reductions in evaporative water loss

➢ Evaluate the impact of regenerative heat exchange on the operation of air pollution control systems

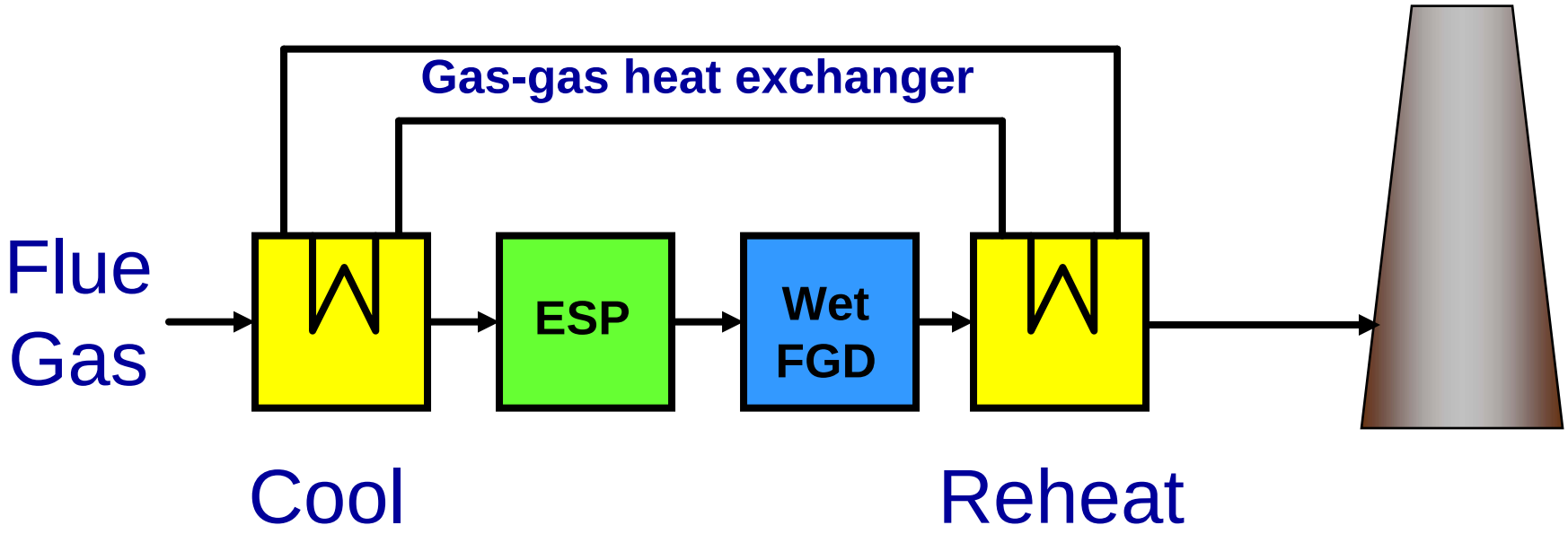
➢ Develop an understanding of potential corrosion in the regenerative heat exchanger

➢ Assess the benefits and costs of regenerative heat exchange



Minimize water loss in FGD systems

Regenerative Heat Exchange



Potential benefits:

1. Improve ESP performance due to reduced gas volume and improved ash resistivity.
2. Control SO_3 through condensation on fly ash.
3. Avoid need to install wet stack or provide flue gas reheat.

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

Application of Pulsed Electrical Fields for Advanced Cooling in Coal-Fired Power Plants

Drexel University

Objective

- Develop a scale prevention technology based on a novel filtration method and an integrated system of physical water treatment

Tasks

- Developing a self-cleaning metal membrane that:
  - Utilizes pulsed electric fields to dislodge particles
- Develop integrated physical water treatment method
- Conduct pilot-scale testing

Demonstrate the ability to operate at a higher cycle of concentration, thus reducing cooling tower blow down water requirements

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:

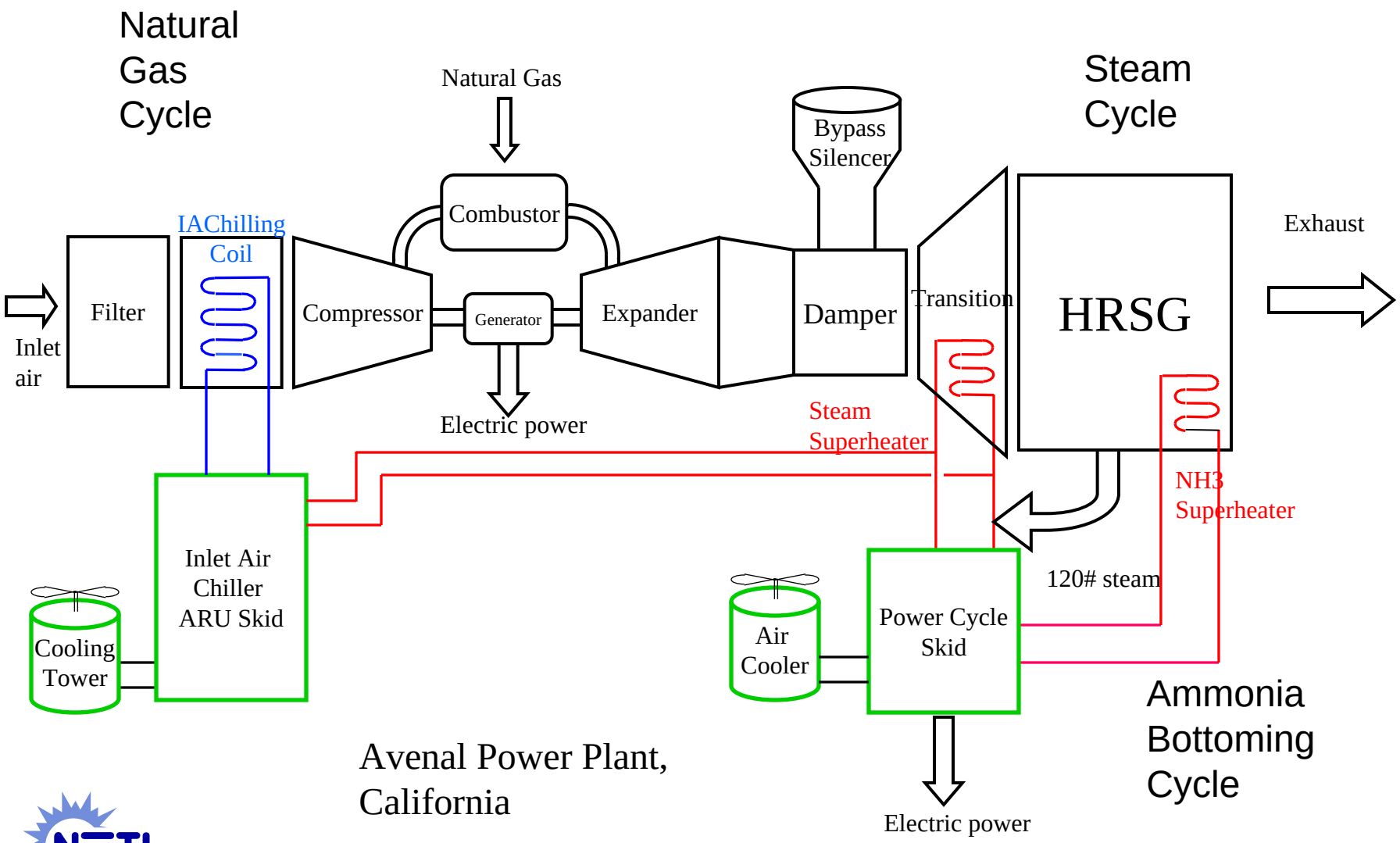
(1) Ash Pond Effluent

(2) Secondary Treated Municipal Wastewater

(3) Passively Treated AMD

Develop technologies to make use of impaired waters more feasible

Water-Conserving Steam Ammonia Power Cycle
Energy Concepts



Fresh Water Production Process Using Waste Heat from Power Plant Condenser Cooling Water

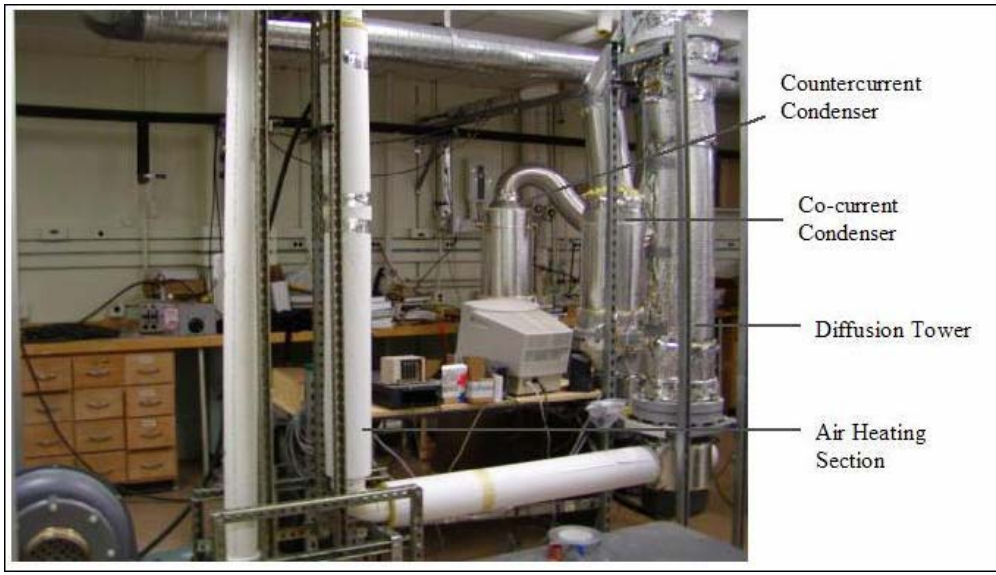
University of Florida

Objective

- Replace the cooling tower with an diffusion driven desalination (DDD) plant that will render the power plant a net producer of fresh water

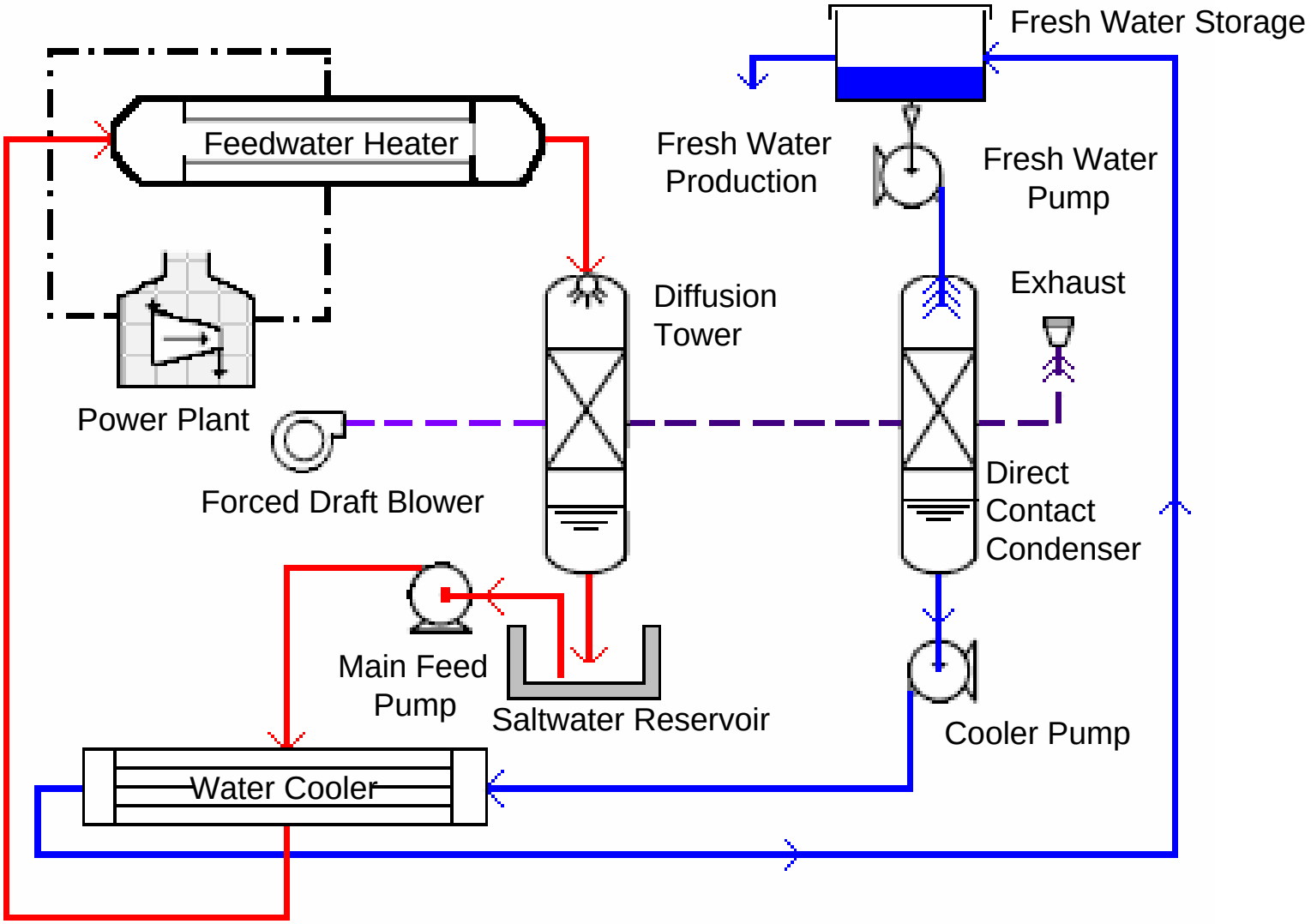
Results

- Detailed heat and mass transfer analysis completed.
- Bench scale test unit constructed and data collected.



Waste heat from a 100 MW power plant can produce 1 million gallons of fresh water per day

Diffusion Driven Desalination



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

Lehigh University

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

- Started as a lab scale project with fluidized bed coal drying
- Progressed to Clean Coal Demonstration project at Great River Energy
- Proprietary design uses hot water from condenser and some heat from the flue gas
- Less cooling water used, better heat rate in plant, less air emissions, less power consumption for pulverizers and ID fan
- Mine mouth coal drying project
- Vattenfall investigating similar coal drying process with waste heat from Air Separation Unit in oxy-fired combustion

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

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

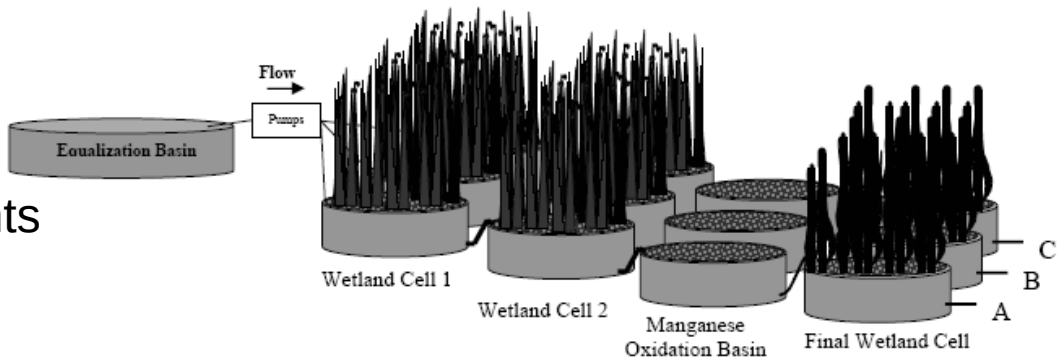
Clemson University

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

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

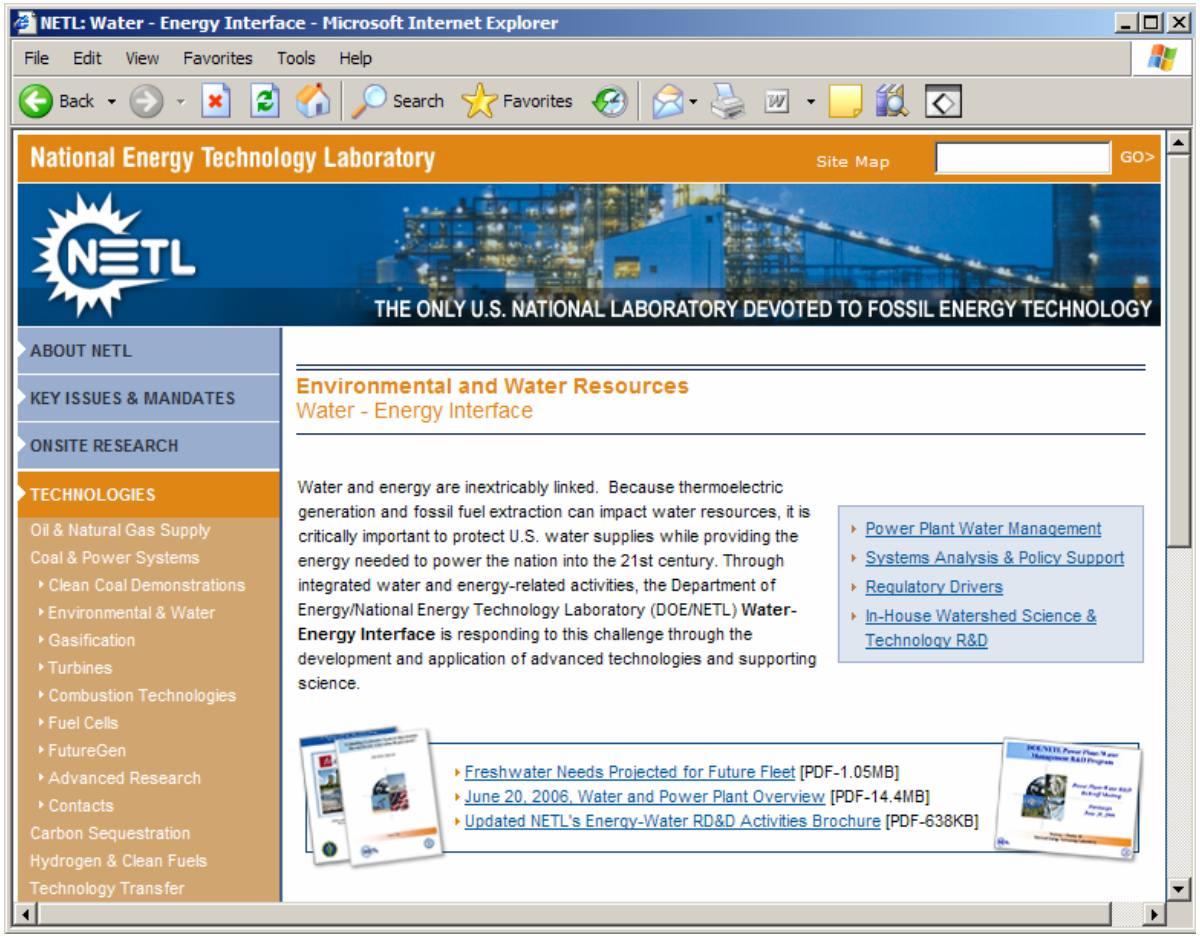
Evaluate the ability to reduce zebra mussel fouling while minimizing impacts to aquatic ecosystems

NETL

FY08 Power Plant Water Management Solicitation

- *Funding Opportunity Announcement DE-PS26-08NT00233-00*
- *"R&D of Advanced Technologies and Concepts for Minimization of Freshwater Withdrawal and Consumption in Coal-Based Thermoelectric Power Plants"*
- Technical areas:
  - Advanced Cooling Technology
  - Innovative Water Reuse and Recovery
  - Non-traditional Sources of Process and Cooling Water
- ~ $9-$15 million total funding available
- *Project awards by end of September 2008*

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



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