Assessing the Energy-Water Nexus
Providing New Technologies for Efficient Energy Production

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NETL’s Strategic Goals

• Develop secure, affordable, and reliable fossil energy technologies to realize the full value of domestic energy resources.

• Enhance U.S. economic and energy security through prudent policy, advanced technology, and the use of strategic reserves.

• Promote exports of domestically produced hydrocarbons and fossil energy technologies.

• Develop and maintain world-class organizational excellence in research and operations to safely, securely, and reliably meet fossil energy challenges for the next generation.
NETL Competencies / Technology Thrusts

**Materials Engineering & Manufacturing**

**Geological & Environmental Systems**

**Energy Conversion Engineering**

**Systems Engineering & Analysis**

**Program Execution & Integration**

**Computational Science & Engineering**

**Carbon Capture**

**Sensors & Controls**

**Advanced Materials**

**Advanced Computing**

**Advanced Energy Systems**

**Water Management**

**Rare Earth Elements**

**Enhanced Resource Production**

**Environmentally Prudent Development**

**Methane Hydrates**

**Offshore**

**Natural Gas Infrastructure**

**Unconventional**

**Oil & Gas**

**Coal**

**Energy Efficiency & Renewable Energy (EERE)**

**Vehicles**

**Solid State Lighting**

**Geothermal**

**Microgrid**

**Energy Storage**

**Energy Security & Restoration**

**Support to Other DOE Offices**
If we are fully successful in NETL Crosscutting, coal will be able to cycle and produce power at rates required by the grid while maintaining high levels of reliability and environmental performance.
Water Management Goal

**Mission**: Provide leadership, raise awareness, and offer cost-effective technical solutions regarding potential national issues in water quality and availability, and mitigate the issues to support the existing coal fleet.

**How?**

- **Projections**: national perspectives, temperature extrapolations, models
- **Pinch Points**: Identifying and analyzing regions, recommending R&D technologies
- **Strategies to Reduce Risk**: management techniques, automation, advanced R&D suggestions
Energy and Water: Interdependent

Energy and power production require water for:

- Thermoelectric cooling
- Hydropower
- Energy / minerals extraction/mining
- Fuel production (e.g. fossil fuels, H₂, biofuels)
- Emissions control

Water production, processing, distribution, and end-use require energy:

- Pumping
- Conveyance and transport
- Treatment
- Use conditioning
- Surface and ground water
NETL Energy Water Modeling

**Submodels**

- **Techno-Economic Analyses & Models**
  - Model technologies both existing and advanced
  - Standalone models or Integrated models

**Larger Systems Models**

- **Short Term Planning Energy/Water Models**
  - Regional
  - National

- **Energy, Industry, Ag, Urban Futures**

- **Long Term Planning Energy/Water Models**
  - Regional
  - National

**Water Availability & Related Conditions/Stresses**

- **Environmental Stresses**
  - Droughts
  - Hurricanes

- **Regulation Stresses**
  - ELGs, FGD
  - 316b (cooling water intake)
  - Water limits (dry / hybrid cooling mandates)

- **Sector Stress**
  - Water competition with AG, Municipal and Industrial Sectors
Water Use in Power Plants

Integrated System Studies
Plant Level and Existing Fleet
Water Availability
(e.g. surface water, ground water, brackish water)
Water Demand
(e.g. power, agriculture, municipal, industry)

Plant Boundary

Moisture in Coal

Moisture in Air

Ash Processing

Ash Pond

Water IN to the plant

Water OUT of the plant

Water Vapor

Stack

Boiler

Particulate Removal

Flue Gas Desulfurization

Steam Turbine

Condenser

Cooling Tower

Condenser Water Makeup

Cooling Tower Blowout

Water Vapor

Wet Gypsum

FGD Makeup Water

Lime Stone Slurry

Waste Water

Flue Gas

Water Vapor

Water Source
(river, lake, municipal system)

Water Reuse

Water Availability
(e.g. surface water, ground water, brackish water)

Water Demand
(e.g. power, agriculture, municipal, industry)

Ash

Pond

Plant Boundary

Water IN to the plant

Water OUT of the plant
NETL:
Advancing Plant Operations Nationwide
How Can We Adapt to Change?

Adapting to a Changing Landscape: Objectives

• Develop tools and metrics that inform electric power generation design choices related to water availability and the cost of power plant water utilization.

• Explore electric power technology options and use results to:
  1. Study the impact of water availability on current and future thermoelectric electric power generation
  2. Inform R&D
  3. Test proposed solutions
Future Water Stress

Availability Data Enables Location Specific Estimates for Water Stress: 2020 Prediction

Water Used by Power/Water Available

Utilizes HUC 8 (hydrologic unit code) sub basin data (~2200 nation wide)

Increasing Stress

*Data from Sandia National Laboratory, Model and Analysis from NETL

Source: NETL
Current U.S. Power Plant Cooling Systems

- Cooling technologies vary across the United States.
- Examining which cooling technologies are prevalent in certain regions can inform future thermoelectric power about plant operations and water availability.

3.6% Dry cooling and Hybrid
43% Once Through
53% Recirculation
Potential Areas of Concern benefiting from R&D

Water scarcity, growing population

Increased thermoelectric water demand

Growing population, increased thermoelectric water demand

Available Water and Thermoelectric Power Plants: Areas of Concern

- Six circled locations in HUC 8 watersheds show where water R&D would have significant beneficial impact.

- Circled locations represent pinch points where water quality or availability may be an issue in the future.

- Planned thermoelectric power in circled regions can implement new technology from the start.
Four (4) HUC 8 watersheds outside of Phoenix plan to have increases in consumptive water use.

Change in Consumptive Use and City Growth

- Three circled regions represent significant growth in consumptive use.
- As consumptive use increases, utilities may utilize additional treatment technologies.
- Unconventional sources of water (brackish, municipal wastewater) may become more commonly used in thermoelectric power.
Western Gulf Coast: Thermoelectric Power and Water Availability

- Western Gulf is an excellent case study because it has: oil & gas exploration, growing population, arid climate, and diverse energy generation.

- Plant operations can be improved by viewing water availability and close plant proximity.

- Cooling technologies can be catered to this region.
Model Results – Texas Gulf Basin

Retrofits in the Texas-Gulf Basin 2015-2030

Water Purchases by Watershed in the Texas-Gulf Basin 2015-2030

Source: NETL
NETL: Adapting to a Changing Landscape
Internet of Things
Distributed sensor networks that can help optimize and automate power plant operations, smart manufacturing
20 Active Crosscutting Projects
$23M

Cyber Security
Next-Gen cyber security solutions that enable an automated power plant to remain secure
4 Active Crosscutting Projects
$800K

Big Data, Machine Learning
Advanced power plant controls and predictive maintenance solutions, materials discovery, model input gathering
20 Active Crosscutting Projects
$19M

High Performance Computing
Supercomputers that decrease development time for new alloys, big data analytics, CFD, process simulation
33 Active Crosscutting Projects
$21M

Advanced Manufacturing
Open manufacturing design space, new materials, techniques to repair power plant components, and printed/embedded sensors
23 Active Crosscutting Projects
$19M

Note: Active Projects as of July 1, 2018
NETL: Improving Water Management Technologies
Water Management R&D Themes

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<th>Water Treatment and Reuse (Power Plant Effluents)</th>
<th>Water Treatment and Reuse [High-TDS (&gt; 180,000 mg/L) Brines]</th>
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<td>Novel Patterned Surfaces for Improved Condenser Performance in Power Plants</td>
<td>Flue Gas Desulfurization Wastewater Treatment, Reuse and Recovery</td>
<td>Water Treatment and Water-Vapor Recovery Using Advanced Thermally Robust Membranes Power Production</td>
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**Process Efficiency and Heat Utilization**

**Water Treatment and Reuse (Power Plant Effluents)**

**Water Treatment and Reuse [High-TDS (> 180,000 mg/L) Brines]**

*Courtesy of: Virginia Polytechnic Institute and State University (Virginia Tech)*

*Courtesy of: University of New Mexico*

*Courtesy of: Los Alamos National Laboratory*
Water Treatment and Reuse
(Water Quality Sensors)

Applying Anodic Stripping Voltammetry to Complex Wastewater Streams for Rapid Metal Detection

Courtesy of: University of California at Los Angeles

Plant Level Techno-Economic Analysis
Water Management for Power Systems

Guiding R&D for Treatment of Coal Power Plant Effluent Streams

Courtesy of: NETL—Research and Innovation Center
Thank you. Questions?
Useful Links

NETL
www.netl.doe.gov

Office of Fossil Energy
www.energy.gov/fe

Crosscutting Research
www.netl.doe.gov/research/coal/crosscutting

Project Information
www.netl.doe.gov/research/coal/crosscutting/project-information

Project Portfolios/Publications
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