Water Management R&D

Annual Program Review Meeting
Briggs White | May 10, 2021
In today’s power system, water is...
Adding CCS can increase water consumption by 50% + a Global Trend Through 2050:

30% ↑ total water withdrawals

85% ↑ energy water usage
Highly regional in its challenges

- More effective water management needed to keep operating costs low as thermoelectric power grows
- Dry cooling technologies available for water-stressed regions

In today’s power system, water is…

- Water scarcity
- Growing population
- Increased thermoelectric water demand

Potential Areas of water quality & availability concerns

Growing population, increased thermoelectric water demand

Growing population, increased thermoelectric water demand

Dry cooling technologies available for water-stressed regions

More effective water management needed to keep operating costs low as thermoelectric power grows
In today’s power system, water is... A platform for change

**H₂ Generation**

- **ELECTRICITY GENERATION**
  - Alkaline | PEM | SO
- **ELECTROLYSIS**
- **THERMOCHEMICAL CONVERSION**
  - SMR | POX | ATR | Pyrolysis
- **NATURAL GAS**
- **COAL | HYDROCARBONS | BIOMASS**
- **THERMOCHEMICAL CONVERSION**
  - Pyrolysis | Gasification
- **CO₂ from carbon capture**

**H₂ Storage**

- **LIQUID**
- **UNDERGROUND**
  - Salt Caverns | Depleted Oil/Gas Reservoirs
- **PRESSURE VESSELS**
- **ADSORPTION**

**H₂ End Use**

- **TRANSPORTATION**
  - Synthetic Fuels
  - Hydrogen Vehicles
- **INDUSTRIAL APPLICATIONS**
  - NH₃ | Metals Refining | Other
- **H₂/NATURAL GAS INFRASTRUCTURE**
  - NH₃/H₂ Turbines
  - NH₃/H₂ Reciprocating Engines
  - Fuel Cells (Alkaline, PEM, SO)
- **POWER GENERATION**
  - NH₃/H₂ Turbines
  - NH₃/H₂ Reciprocating Engines
  - Fuel Cells (Alkaline, PEM, SO)

**H₂**

**O₂ from ASU**

**N₂ from ASU**
The NETL Crosscutting program is organized to...
Develop diverse solution

- University Training
- High Performance Materials
- Energy Storage
- Water Management
- Sensors & Controls
- Modeling, Simulation & Analysis
The NETL crosscutting program is organized to...

Meet disparate stakeholder needs

Mission

• Reduce freshwater use by advanced energy systems

• Minimize impacts of plant operations on water quality

Outcomes

• Develop, scale, and deploy technologies
• Inform decision-makers
• Prioritize R&D for maximum impact
• Engage regional stakeholders

End-user objectives

- Flexibility
- Efficiency
- Reliability
- Environmental quality
The NETL crosscutting program is organized to...

**Increase Flexibility and Decarbonize**

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<tr>
<th>SEGMENTS</th>
<th>Existing fleet</th>
<th>Next Gen.</th>
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<td>Coal</td>
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<td>Carbon Storage</td>
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**NEEDS**

- Reliability
- Efficiency
- Flexibility
- Decarbonization
- Upkeep
- Competitiveness

**CHALLENGES**

- Management
- Repair & Maintenance
- Emissions
- Water use
- Cybersecurity
- Workforce
- RUL

**SOLUTIONS**

### Water treatment
- Effluent
- Recycle

### Cooling tower
- Dry cooling
- Novel
- Plume abatement

### Condensers
- Steam-side
- Water-side

### Systems analysis
- Policy
- Technology
- Scenario
Address broad challenges

A External sources
B Internal sources
C Plume abatement
D Condenser modifications
E Enhanced cooling towers
F Wastewater treatment
G Systems Analysis
Regulatory Drivers on Quantity & Quality

- Clean Water Act 816(b)
- Effluent Limitation Guidelines

Performance Drivers

- Waterside fouling and scaling
  - + Steam-side corrosion
  - + Steam-side air in-leakage

- Higher fuel costs,
- Expensive maintenance,
- Plant shut downs
Our program impacts stakeholders with...
SPX ClearSky-condenses average of 19% evaporated water

DryFining-uses waste heat from flue gas and condenser to dry coal prior to combustion, 5.8% efficiency improvement.

Our program impacts stakeholders with...

Commercial Successes

Spiritwood, Great River Energy, North Dakota, Combined Heat and Power for bio-refinery, 60% efficiency.
Emissions Control

Technological preparedness with a focus on cost and flexibility.

Water Use Optimization

A heightened focus on sustainability requires improved management of withdrawals.

Performance Optimization

Improving total plant efficiency and optimizing in real time to flexible operations.
Combined Technologies Could Reduce Thermoelectric Water Withdrawal by 603 BGY (1,653 MGD)
Consumption by 154 BGY (423 MGD)

Benefits to the environment

Based on a 50% market penetration and implementing 5 technologies
The current portfolio is...
Balanced across challenges/solutions

The current portfolio is...

22 projects
$17.5M invested
Driving towards near term impacts

- Minimize water use and effluent generation
- Enable flexible operation with reduced O&M
- Facilitate hydrogen, biomass, and CCS
- Increase plant efficiency
Redefining the possible

Application of Heat Transfer Enhancement (HTE) System for Improved Efficiency of Power Plant Condensers

- Demonstrated success from testing at full-scale across HVAC chillers, industrial heat exchangers, engine cooling, and a power plant condenser
- Test data revealed the reduced heat rate can save an ~$190k in fuel costs and 12,800 less tons CO2 produced

Produced Water and Waste Heat-Aided Blowdown Water Treatment: Using Chemical and Energy Synergisms for Value Creation

- Introducing Produced Water to Blowdown Water, without any chemical addition, and resulted in 100% Ba removal at ratio BD:PW = 10:1
- An activated carbon filtration unit showed >90% total organic carbon removal

Water Recovery from Cooling Tower Plumes

- Designed and produced a hot wire sensor capable of measuring the liquid water content of a plume
- Set and ran simulations of a full-scale plume were in Solidworks Flow Simulator.
- Completed a redesign and build of the lab cooling tower, with a new heater solving the rust issue seen in the first iteration.

Flue-Gas Desulfurization Effluent Management Using Innovative Low-Energy Biosorption Treatment System to Remove Key Contaminants

- Down-selected to adsorption media that demonstrates 90% selenium removal
- Completed testing protocol for demo scale set-up
- Procured and installed biosorption treatment system at Plant Bowen
We move forward, together, as...
A complete innovation ecosystem

Roles in the Ecosystem
- Objectives & aspirations
- Systems-level planning
- Policy & impact analysis
- Problem definition
- Product specifications
- Scale-up
- Transformational tech
- Workforce development
- Vision for the future

Collaboration Opportunities
- Many ways to partner:
  - Directly with lab
  - Through funded competitions
- Engage with RFI, Workshops
- Build on our efforts
  - USEA thought leadership
  - AWARE and IECM tools
  - Sandia Database
  - NETL RIC MVR baseline data
  - BEST testing infrastructure at EERC
  - NETL RIC Bias sorbent

S T A K E H O L D E R S

Government and Regulatory

Commercial value chain

External Innovators
  Academia, Small businesses, Research Institutes, National Labs
Water Management Program Contacts

https://www.netl.doe.gov/research/coal/crosscutting

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