Field Demonstration Study for Heat and Water Recovery at a Coal-Fired Power Plant

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Overview

• Project Objectives
• Tasks
• Coal industry interviews
• Identification of technologies
• Selection process and scoring
• Discussion of selected technologies
• Going forward
Objectives

Advance the path toward a field demonstration of waste (low-grade) heat recovery/use technology (HRUT) for a coal-fired power by:

- Establishing relationships between coal power industry, technology providers, technology experts, and engineering firm
- Comparing cost and benefits of emerging technologies and of commercially available technologies
- Recommending technology(ies) for further analysis
- Developing costs for pilot test at a Southern Company facility
- Developing costs for a conceptual commercial unit
Project Task Structure

- Interview Coal Power Industry
- Identify Candidate HRUTs
- Survey HRUTs
- Rank Technologies and Recommend
- Conceptual Commercial and Pilot Design
Heat Recovery Opportunities

Arrows Convention
- Steam/water line
- Direct heat-use line
- Indirect heat-use line

Flue Gas Temperature Range Considered: 350°F - 250°F
160°F - 125°F

Flue Gas Temperature Profile
Coal Power Industry Interviews

Interview topics
• Appetite for low-temp HRUTs
• Previous experience with HRUTs
• HRUT integration flexibility/requirements

Interview group
• Eight U.S. coal power utilities
• Over 500 GW collectively
• Mostly base load or daily cycling operation
Interview Results

- Little new build or retrofit planned for coal power in the U.S.
- Only one site uses HRUT (coal drying); all had implemented steam turbine upgrades
- New Source Review (NSR) is a major obstacle for any efficiency/output changes: “NSR is not insurmountable but is a legal and political risk”
- If the efficiency improvement is large or the payback is short, it will be considered
- Most sites do not have space to accommodate new processes
- Reducing the final flue gas temperature may impact plume dispersion
- No district heating opportunities identified; limited industrial possibilities
- Respondents generally not water constrained; reducing FGD or cooling water makeup could be of interest
- Regulations (e.g., 111d) could increase interest in HRUTs
Candidate HRUTs

**Identified through:**
- Conference proceedings
- Industry experts
- Internet searches & literature review
- Similar DOE awards

**Resulted in 40 technologies for consideration**
- Ranged from commercial to conceptual

**Can be categorized into**
- Bottoming cycles
- Heat exchangers (incl. condensing)
- Thermoelectric
- Water treatment technologies
- Other (e.g., fuel drying)
Screening Process

40 technologies
• High level questionnaire
• Interviews with technology providers
• Eliminated those not feasible, leaving 24
  – Public sharing; uses flue gas; ≤300F; pilot in 2 yrs

Remaining 24
• Detailed questionnaire
  – Organization, design, technology, environmental, costs
• 550MW reference plant for consistency
• Limited response

Final 17 candidate technologies
• Scoring matrix applied
## Technology Vendors for Scoring

### Bottoming cycles
- Global Geothermal
- Ormat
- Turboden

### Heat exchangers
- ARVOS
- ConDex
- E-Tech
- Flucorrex
- Gas Technology Institute (GTI)
- Mitsubishi Heavy Industries (MHI)
- Wallstein

### Water treatment
- PAX Pure
- Porifera
- Sylvan Source International (SSI)
- Vacom

### Other
- Great River Energy (GRE)
  - DryFining process; coal drying
- Novus
- SSI
  - Heat feedwater
### Scoring Criteria and Weight

**Emphasis:**
- Costs
- Technology
- Operation
- Design

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## Rankings

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<td>e-Tech</td>
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<td>Vacom</td>
<td>Water Treatment</td>
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Selected Technology: GTI

Transport Membrane Condenser

- Uses a nano-porous ceramic membrane to capture waste heat and water vapor downstream of the wet FGD
- Previously demonstrated at a coal plant at ~500 scfm (0.2 MWe) scale
- Recovered heat and water can be used as boiler feedwater
- Some increase in net plant efficiency depending on coal moisture content and ambient temperatures
**Selected Technology: GTI**

**Water is captured via capillary condensation**

- Capillary condensation can occur at 50-80% of the saturation vapor pressure
- Significant portion of the thermal energy as latent heat
- Captured water is pure enough to use as boiler feed water

**Modules also act as heat exchangers capturing sensible heat**

**Sulfur resistance of tubes up to 300 ppm**
Commercial (550MW):

- Early stages of development
- Cost (high) reflects uncertainty
- Integration into FGD vessel – lower $$
- Thermal heat recovery ~ 16 MW\text{th}
- Minimal plant output increase ~ 1 MW
- Water recovery of ~100 gpm
Commercial & Pilot Conceptual Designs: GTI

Pilot

- 2 MW slipstream basis
- Potentially located at SoCo Water Research Center
- Skid cost: approximately $1M
- Tie-ins, foundations and operation not included
**Selected Technology: ARVOS**

**ARVOS: Air Heater Improvements**

- Extends and modifies heat transfer surface further decreasing flue gas outlet \( T \)
- Sulfuric acid condensation mitigated via SBS™ (sodium-based solution) injection upstream of the air heater
- Increased combustion air temperature improves boiler efficiency by 1-3%
- Decreased flue gas outlet temperature reduces water consumption in wet FGD
- Can be implemented easily as air heater is already present
Commercial & Pilot Conceptual Designs: ARVOS

Commercial only; no need for pilot

- 550 MW reference - retrofit
- Full air pre heater rotor replacement
- New SBS system
- Total: ~$19M
- At least one system in service
What’s Next

• Final report in preparation
  – Details of evaluation
  – Pilot recommendation & cost

• Funding for pilot?

• Some general takeaways
  – Low grade heat is difficult to recover/use
  – Steam cycle integration is not optimal
  – Space requirements are a barrier
  – Little funding for coal plant upgrades
  – NSR threat
QUESTIONS?