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



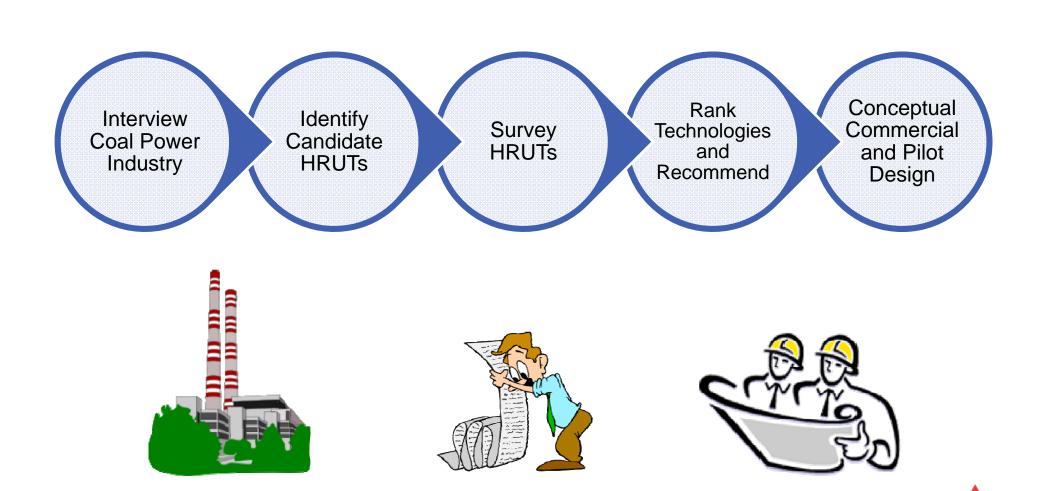
Objectives

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

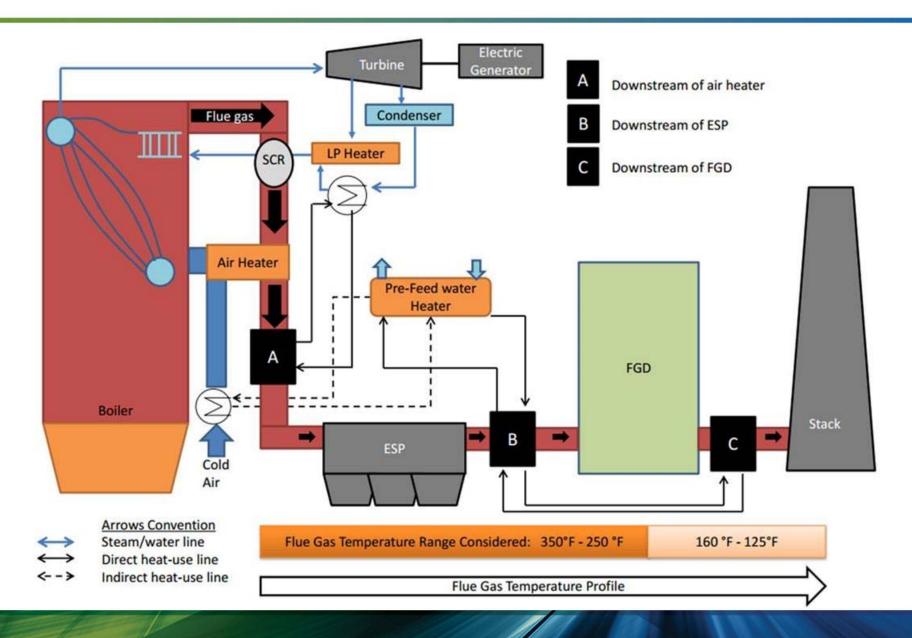
- Establishing relationships between coal power industry, technology providers, technology experts, and engineering firm
- Comparing cost and benefits of emerging technologies and of commercially available technologies
- Recommending technology(ies) for further analysis
- Developing costs for pilot test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



Project Task Structure



Heat Recovery Opportunities



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

- <u>Little new build</u> or retrofit planned for coal power in the U.S.
- Only <u>one</u> site uses HRUT (coal drying); all had implemented steam turbine upgrades
- New Source Review (NSR) is a <u>major obstacle</u> 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 <u>will be</u> considered
- Most sites <u>do not have space</u> to accommodate new processes
- Reducing the final flue gas temperature <u>may impact plume dispersion</u>
- No district heating opportunities identified; limited industrial possibilities
- Respondents generally <u>not water constrained</u>; 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

Criteria	Weight %	Total %
I. Organization Experience	10.0%	
A. Tech Experience	50.0%	5.0%
B. Organizational Experience	20.0%	2.0%
C. Size	30.0%	3.0%
II. Design and Operation	25.0%	
A. Design	30.0%	
1. Soundness of Design	50.0%	3.8%
2. Integration Complexity	50.0%	3.8%
B. Operation	70.0%	
1. Response to Load Changes	35.0%	6.1%
2. Impact on Startup Times	35.0%	6.1%
3. Acceptable Flue Gas Composition	15.0%	2.6%
4. Pressure Drop	15.0%	2.6%
III. Technology	30.0%	
A. Benefits	70.0%	
1. Efficiency	40.0%	8.4%
2. Water Treatment	15.0%	3.2%
3. Water Use/Generation	15.0%	3.2%
4. Environmental	30.0%	6.3%
B. Operations, Maintenance, Availability, and Safety	30.0%	
1. Operations	25.0%	2.3%
2. Maintenance	25.0%	2.3%
3. Availability	25.0%	2.3%
4. Safety	25.0%	2.3%
IV. Potential for Future Improvements	2.5%	
A. Future Technology Improvements	50.0%	1.3%
B. Future Integration Improvements	50.0%	1.3%
V. Costs	32.5%	
A. Commercial-Scale Plant Capital Cost	40.0%	13.0%
B. Cost-Benefit Analysis	40.0%	13.0%
C. Pilot Plant Capital Cost	20.0%	6.5%
Total Score (Out of 100)	100.0%	100%



Detailed Evaluation



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Rankings



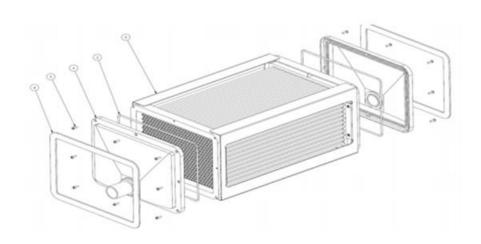
Organization	Туре	TRL
GTI	Heat Exchanger (Condensing Heat Recovery)	6
ARVOS	Heat Exchanger	9
ConDex	Heat Exchanger (Condensing Heat Recovery)	9
Sylvan Source International (SSI)	Heat Pipe	4
SSI	Water Treatment	5
Wallstein	Heat Exchanger	9
PAX Pure	Water Treatment	5
Flucorrex	Heat Exchanger	9
Mitsubishi Heavy Industries (MHI)	Heat Exchanger	9
Global Geothermal	Bottoming Cycle	8
Porifera	Water Treatment	4
Novus	Thermoelectric	5
Great River Energy (GRE)	Coal Drying	8
Turboden	Bottoming Cycle	8
Ormat	Bottoming Cycle	8
e-Tech	Heat Exchanger (Condensing Heat Recovery)	7
Vacom	Water Treatment	8



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





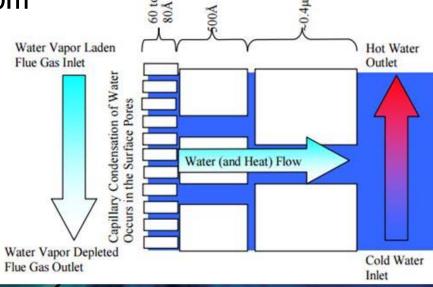
Selected Technology: GTI

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

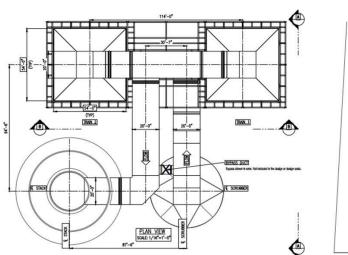
Sulfur resistance of tubes up to 300 ppm

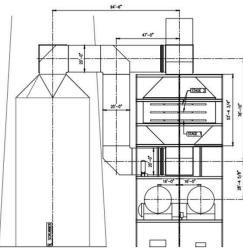


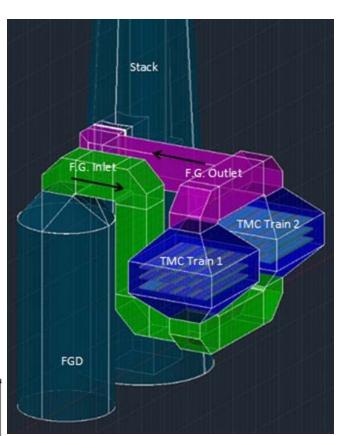
Commercial & Pilot Conceptual Designs: GTI

Commercial (550MW):

- Early stages of development
- Cost (high) reflects uncertainty
- Integration into FGD vessel lower \$\$
- Thermal heat recovery ~ 16 MWth
- Minimal plant output increase ~ 1 MW
- Water recovery of ~100 gpm





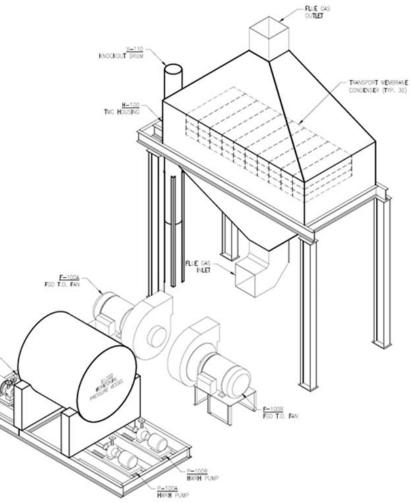




Commercial & Pilot Conceptual Designs: GTI

Pilot

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

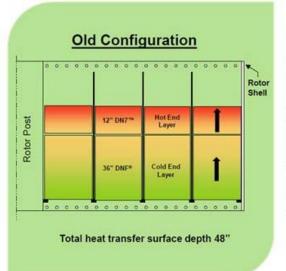


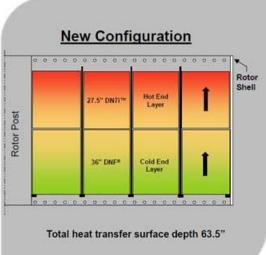


Selected Technology: ARVOS

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?

