Co-Gen Wastewater Treatment for Coal-Fired Energy Plants

DOE-NETL Integrated Project Review Meeting
Water Management
DE-FE0031669
May 10, 2021

Co-Gen Wastewater Treatment for Coal-Fired Energy Plants Project

- Type of Contract:
  - DOE Co-Op (DOE/NETL)
- Period of Performance:
  - October, 2018 to March, 2021
- Total Contract Value:
  - $748.8K PLUS $187.2K Cost Share

Produced Water Proof-of-Concept Test

Produced Water (Inlet), Condensed steam (Outlet)

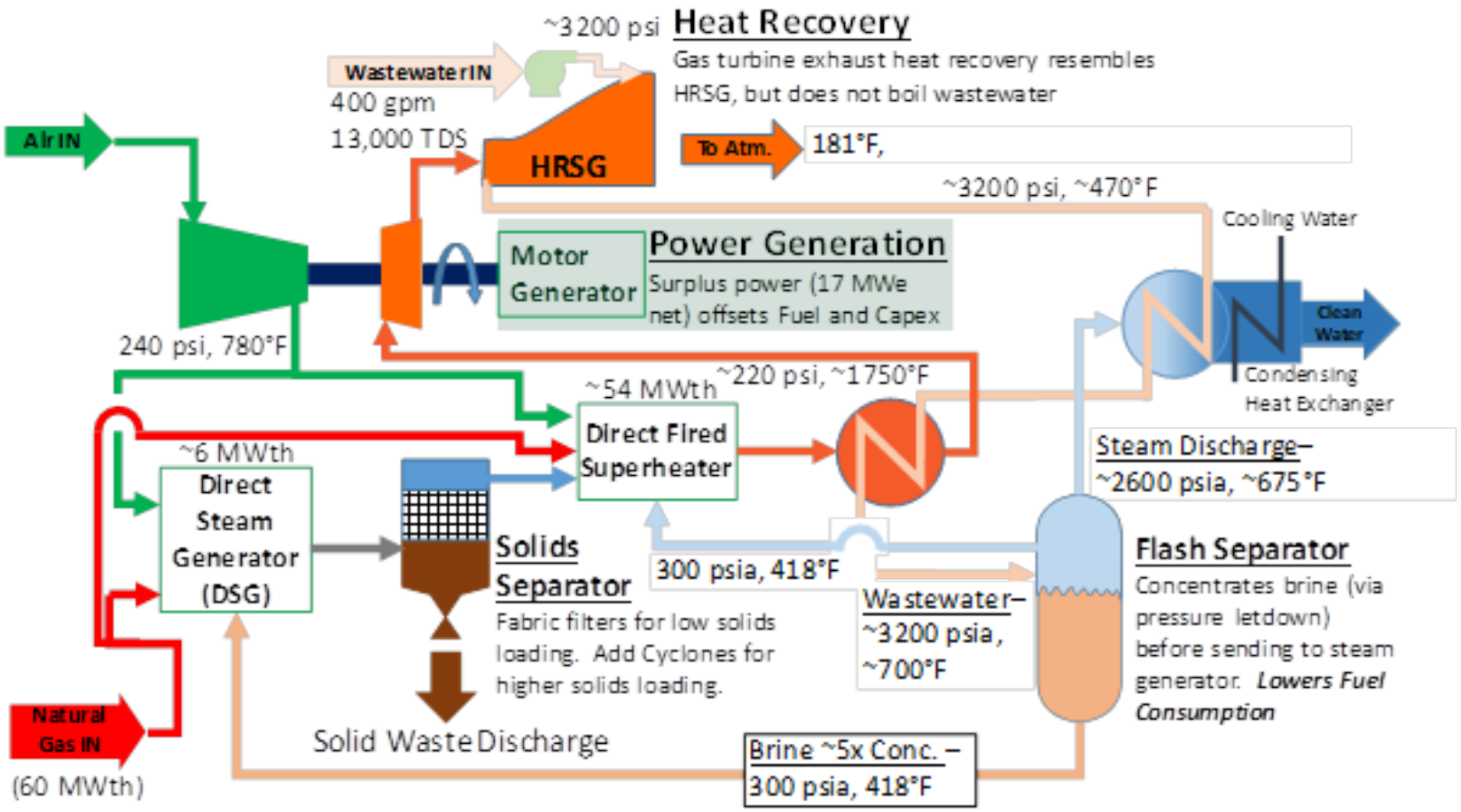
Project Objectives

- Show clear, economic solution for FGD wastewater treatment supported by detailed analyses and trade studies
  - Review system configuration options
  - Select an optimized solution
- Complete experiments to document the solubility, transport and/or capture of Critical Pollutants of Concern (CPoC) species
  - Liquid and gas phase
  - Information will be essential to guide work on the first objective and determine economic options for CPoC removal

Project Approach

- Innovative process will reduce the net cost of water treatment
  - Process has similar CAPEX to current chemical/biological systems
  - Generate power to offset capital investment and operational expenses
  - Portion of the wastewater stream will be heated and filtered and then used as a working fluid in a turbine
- Verify concept makes economic sense
  - Complete system modeling and economic assessment of options
  - System study and economic evaluation will define the most attractive system configuration
- Address a key implementation risk
  - Investigate additives in the case that some CPoC are not readily separated from the steam stream
  - Complete Filter Testing and Analysis
    - Size/Design/Procure/Fabricate Test System

Proposed System Configuration



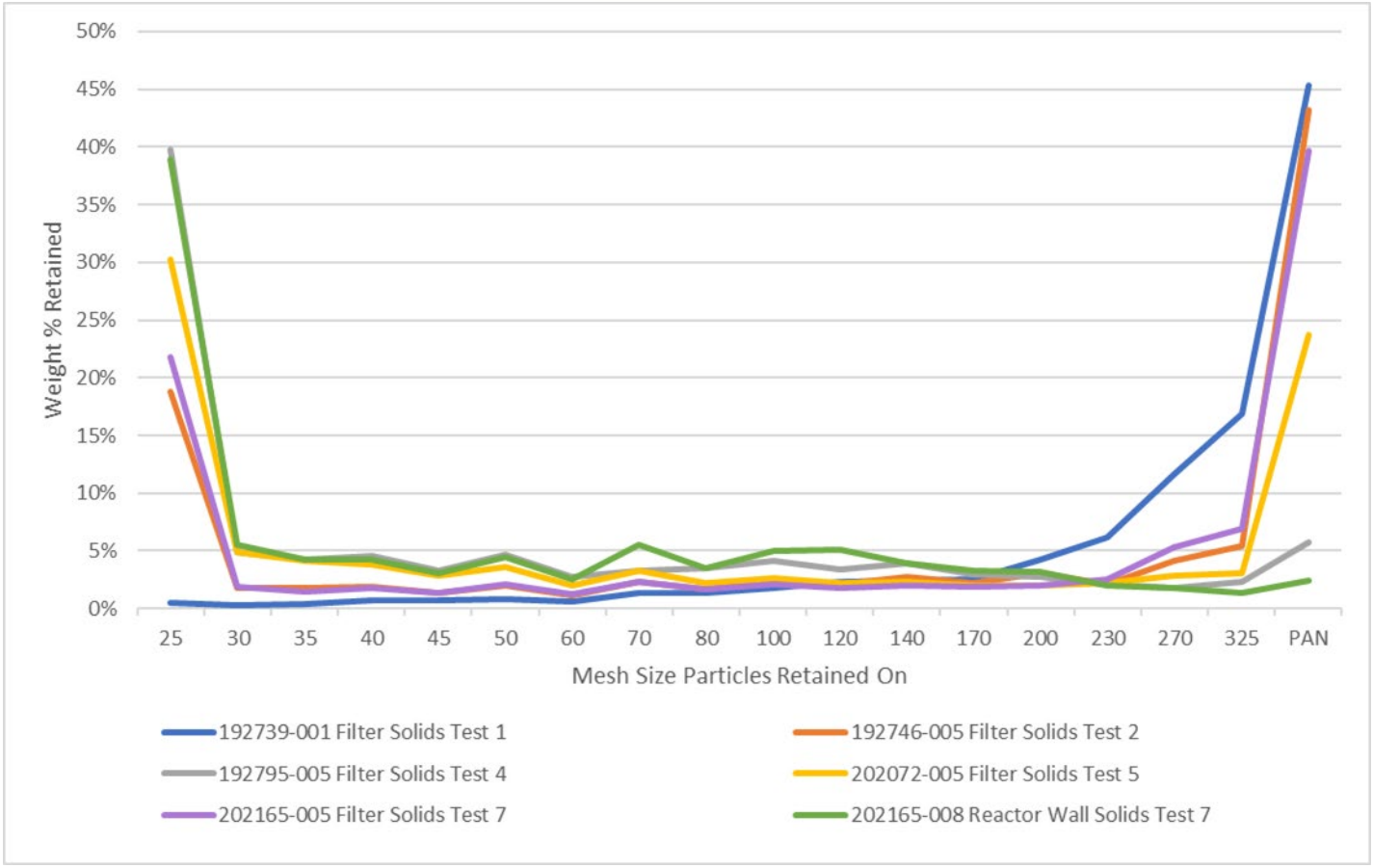
Hardware Assembly

- Test input – simulated or actual FGD water
- Heat water to conditions similar to direct steam generator system
- Filter steam/ combustion stream with candle filters as planned
- Evaluate success capturing CPoC

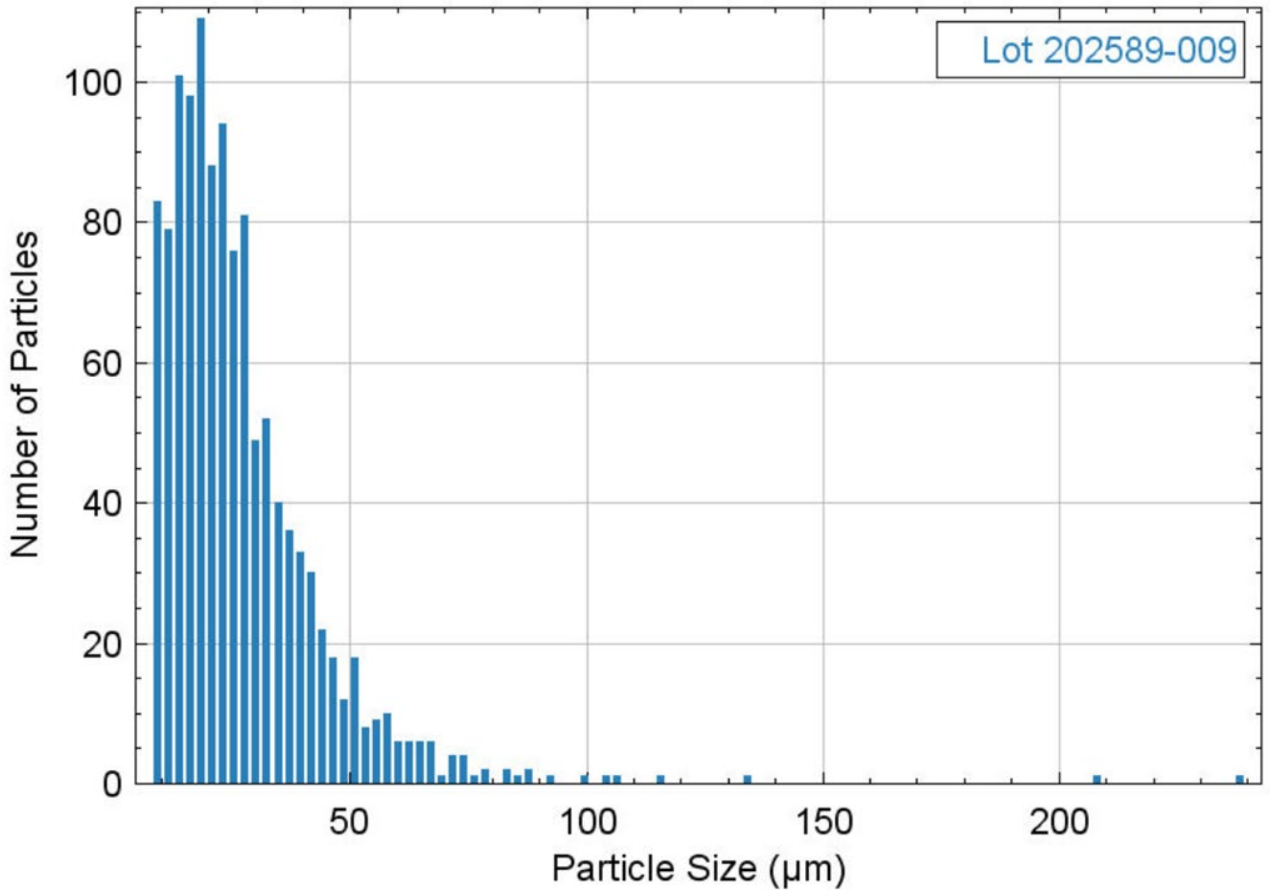
Testing Summary – Simulated FGD Water

- Focused on Effluent Limitation Guidelines from the 2015 Rule
  - Hg & Se - added As, Nitrates, other pollutants in later tests
- Completed 12 simulated water filtering tests
  - Examined three nozzles and three filters
  - Selected filter and nozzle for actual FGD water testing
  - Typically captured >83% of the water and solids (vapor small/not measured)
- Optimized test apparatus through simulated water testing
- Typical TDS results - Before ~27,000 ppm; After ~234 ppm
  - Se meets release criteria
  - Hg does not meet release criteria – very stringent
  - As meets criteria
  - Nitrates higher than release criteria
- Water available for re-use in the facility – reduce fresh water needed

Solids Summary
Broad size distribution good for candle filter



Solids Summary
Particle size analysis by XRD



Testing Summary – Actual FGD Water

- Completed 2 tests on AEP produced water and one test on EPRI-1.
  - Utilized a guard bed of HGR carbon to address mercury content in vapor phase.
  - Ran AEP a second time due to a wet filter cake and solids migrating through the filter.
- TDS reduction
  - EPRI-1 6,570 ppm before; 100 ppm after
  - AEP Test 2 – 18,000 ppm before; 240 ppm after
- Critical Pollutants of Concern
  - Se meets release criteria
  - Hg does meet criteria for effluent water
    - Hg HGR carbon treatment for vapor
  - As meets criteria
  - Nitrates met criteria
- Water available for re-use in the facility – reduce fresh water needed

System Performance - CPoC

	TDS		Se		Hg		As		Nitrates	
	Initial	After	Initial	After	Initial	After	Initial	After	Initial	After
AEP **	20,000	5700	0.180	0.1060	0.00333	<.0002	0.0098	<.0010	<1.8	1.41
AEP (2)	18,000	240	0.142	0.0039	0.00200	.000098	0.0093	0.0014	<89	<0.89
EPRI_1	6,570	100	0.094	<.0025	0.00094	.000093	0.0043	<0.001	<900	<9
Req't *	Not applicable		0.0075 mg/L		.000159 mg/L		0.00598 mg/L		1.3 mg/L	

Black = initial values or not applicable/unknown/reference, Red = does not meet, blue = meets

* EPA 2015 rule

** Filter breached by liquid – operational issue, not a valid test

- Cr increased in each test, ranged from 0.37-3.09 mg/L vs 0.1 mg/L requirement for EPA drinking water
- Ph ranged from 1.66-2.37, too low to release

Summary of Effluent Results
Mercury Analysis

	Synthetic Feed Water, mg/L	Hg Gas Phase No Guard (sorbent), ug/L gas	Hg Gas Phase With Guard (sorbent), ug/L gas	% Reduction
AEP1	0.00333	0.001244	0.0005627	0.54766881
AEP2	0.00202	0.00158	0.000095	0.94025892
EPRI1-1	0.000936	0.000102	0.00003	0.70588235

- Water and solid samples indicate Hg in vapor form as feared/expected
- EPRI1-1 passed criteria without need for treatment.
- AEP2 passes criteria after treatment with HGR carbon.

Summary

- Candle filter system captures majority of water contaminants
- TDS reduction to < ~250 ppm
- Critical Pollutants of Concern
  - Se meets release criteria
  - Hg meets criteria
    - Treat vapor with HGR carbon treatment
  - As meets criteria
  - Nitrates met criteria in one case
- Water available for re-use in the facility – reduce fresh water needed - or release
  - Ph is low – need to adjust prior to release
  - Cr is high – leaching from un-passivated tubing?
- Need to complete economic assessment to show viability

Next steps

- Complete analysis of results
- Complete TEA
  - Modify system model to include HGR Carbon addition
- Complete final report

Acknowledgment

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