Development and Demonstration of Waste Heat Integration with Solvent Process for More Efficient CO_2 Removal from Coal-Fired Flue Gas

DE-FE0007525

Project Review Meeting

July 10, 2012

SOUTHERN COMPANY

Project Overview

- Develop viable heat integration methods for CCS
- Integrate a waste heat recovery technology into an existing amine-based CO_2 capture process
- Evaluate improvements in the energy performance of the integrated plant

Presentation Outline

- Project Description
- Technology Background
- Technical Approach

Project Budget

	DOE Share	Recipient Share	% Cost Share
BP1	$1,599,484	$468,484	
BP2	$10,959,677	$3,210,053	
BP3	$1,571,032	$460,149	
TOTAL	**$14,130,193**	**$4,138,686**	**22.5%**

Project Participants

Organization	Project Manager/ Project Engineer
SCS	Nick Irvin, Todd Wall
MHIA	Paul Wood, Tiffany Wu Takahito Yonekawa Shintaro Honjo
URS	Katherine Dombrowski
DOE-NETL	Bruce Lani

Host Site:

Southern Company’s Plant Barry: 25 MW amine-based CO_2 capture process

25 MW KM-CDR at Plant Barry

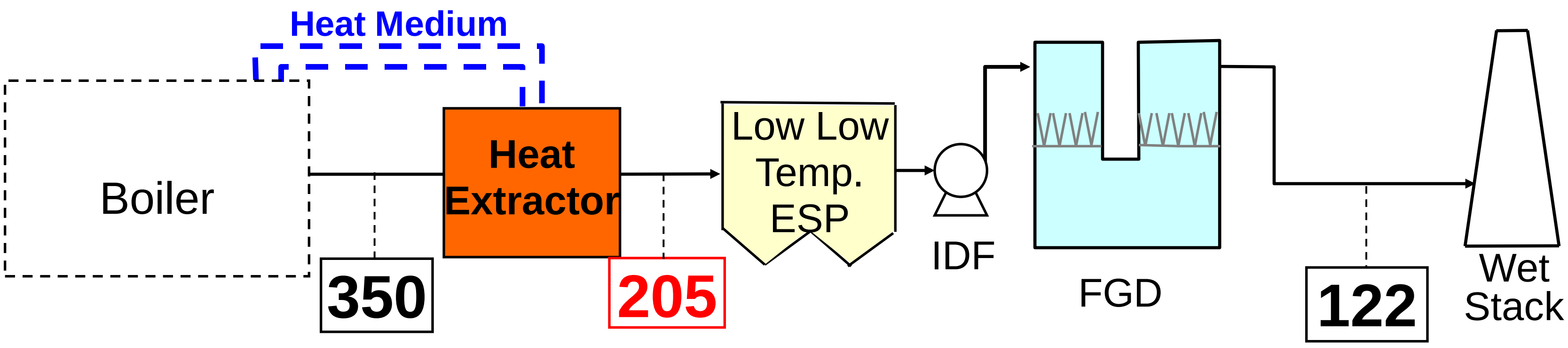
25 MW KM-CDR at Plant Barry

- Funded by an industry consortium
- Started operation: June 2nd, 2011
- Fully integrated CO_2 capture and compression facility
  - Replicates conditions of a commercial unit
  - Designed for 90% CO_2 capture and compression to 1500 psig
  - Produces 500 metric tons CO_2 per day (>99.9% purity)
- Transport and storage in a saline formation at a nearby oil field (SCS and SECARB)

Work Plan

- A 25-MW High Efficiency System (HES) will be designed and installed to operate for 12 months in conjunction with the 25-MW MHI KM-CDR pilot process at Southern Company's Plant Barry

High Efficiency System



Project Objectives

- Quantify energy efficiency improvements to the CO_2 capture process when integrated with the HES and the host power plant
- Identify and resolve operational and control problems from the integration of the HES and KM-CDR
- Quantify the tangential benefits of the HES technology
  - Better ESP performance due to lower ash resistivity
  - Better SO_3 capture in existing systems
  - Reduced solvent consumption by reducing impurity load to the CO_2 capture process island
  - Reduced water consumption in FGD due to lower flue gas temperature

Schedule

- Budget Period 1: through June 2013
  - Task 2: Front End Design and Target Cost Estimate
  - Task 3: Permitting
- Budget Period 2: July 2013 – July 2014
  - Task 4: Engineering, Procurement, and Construction
- Budget Period 3: Aug 2014– February 2016
  - Task 5: Operations
  - Task 6: Field Testing and Analysis

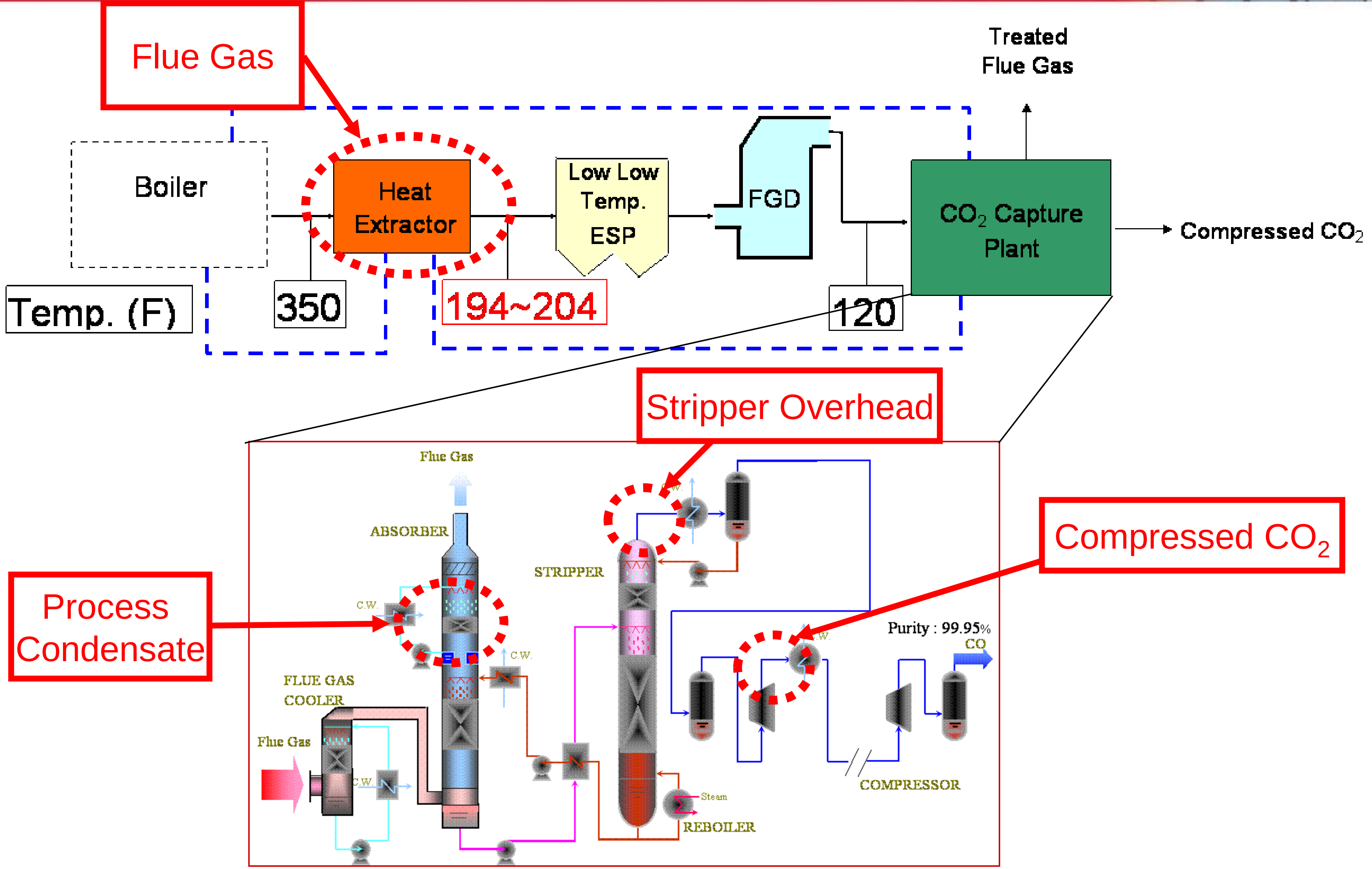
Task 2: Front End Design and Target Cost Estimate

- Deliverable: Final design package with cost to build
- Basic Engineering
  - Heat and material balances
  - General arrangement drawings
  - Equipment sizing and duties
  - Control system architecture
  - Process control philosophy

Relevance of Work

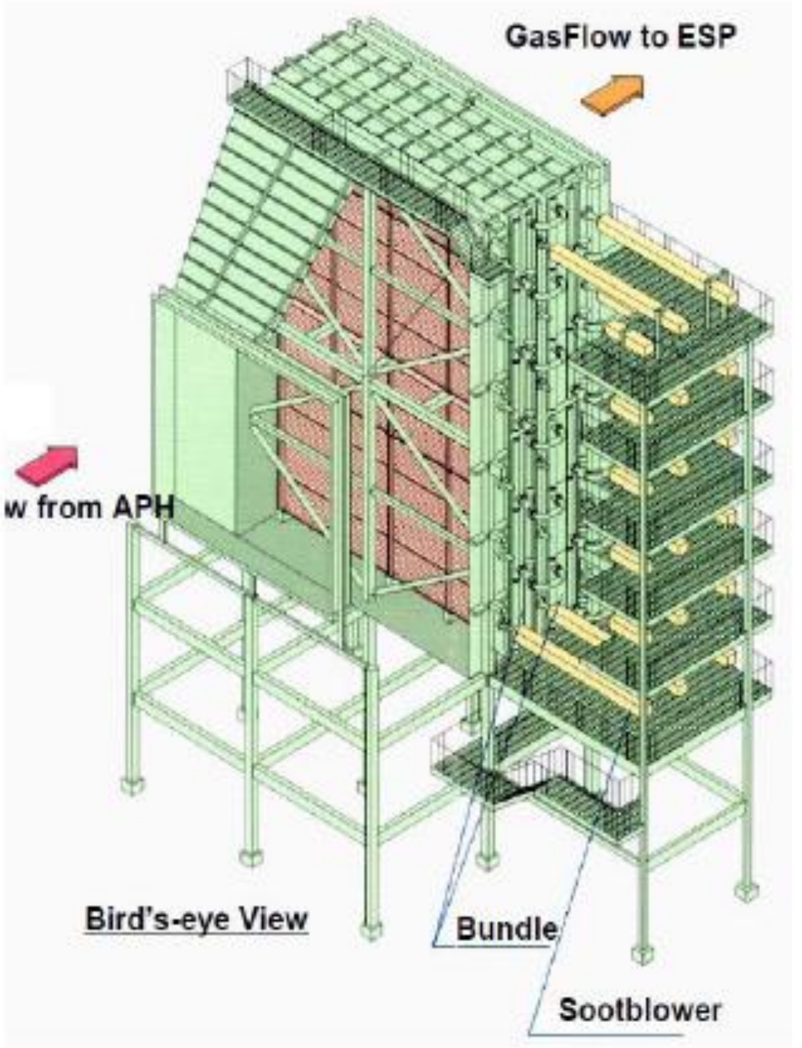
- Typical steam systems dispose a lot of heat through steam condensation then extract a significant amount of steam from the turbines to reheat for boiler feed water
- Carbon capture plants require up to 50% of LP steam for the CO_2 Regenerator Reboiler to regenerate the solvent
- Heat integration system between boiler and CO_2 plant will reduce LCOE by minimizing the amount of steam extracted for reheating condensate and reduce steam to the CCS plant

Sources of Waste Heat

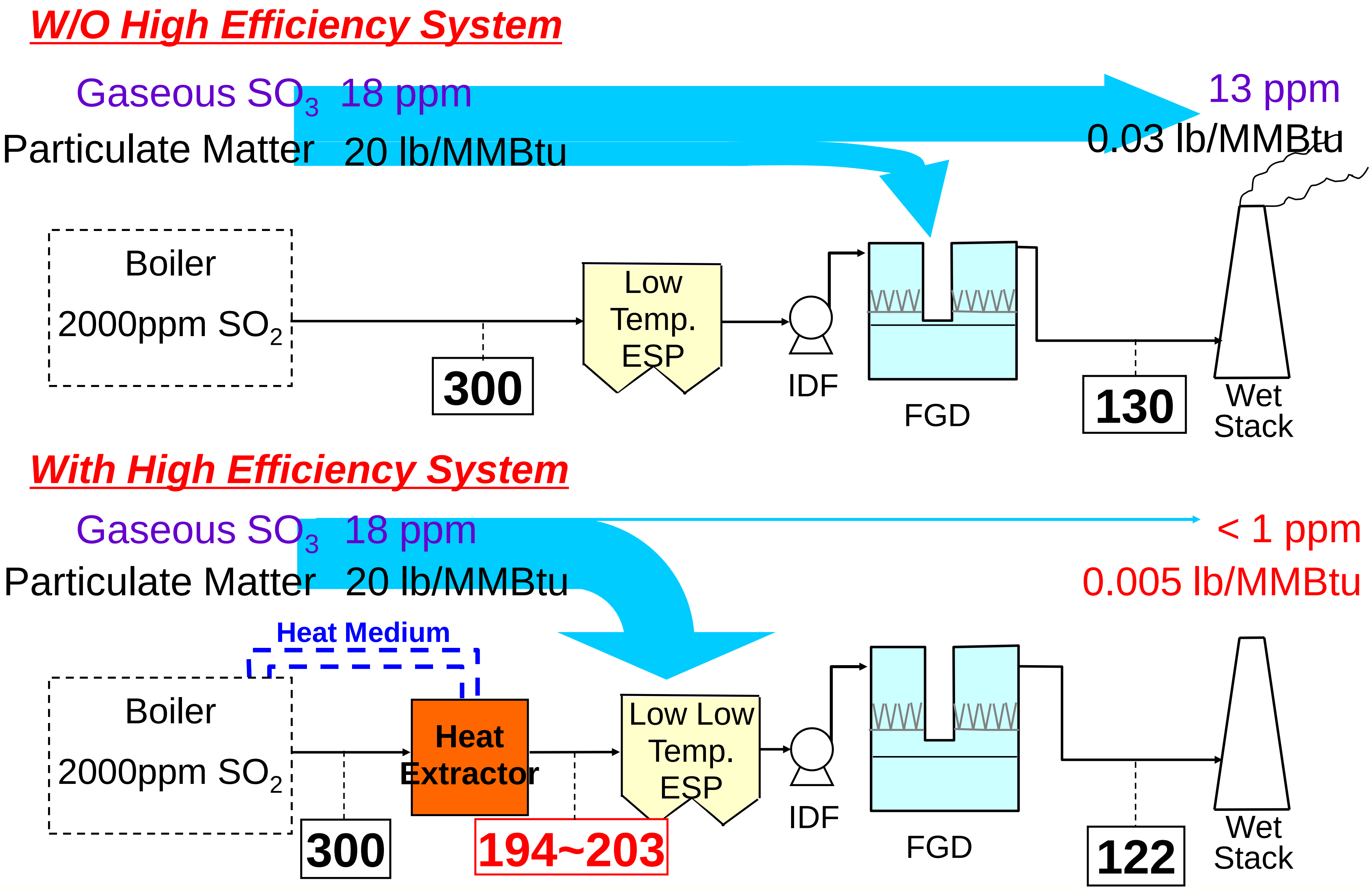


High Efficiency System (HES)

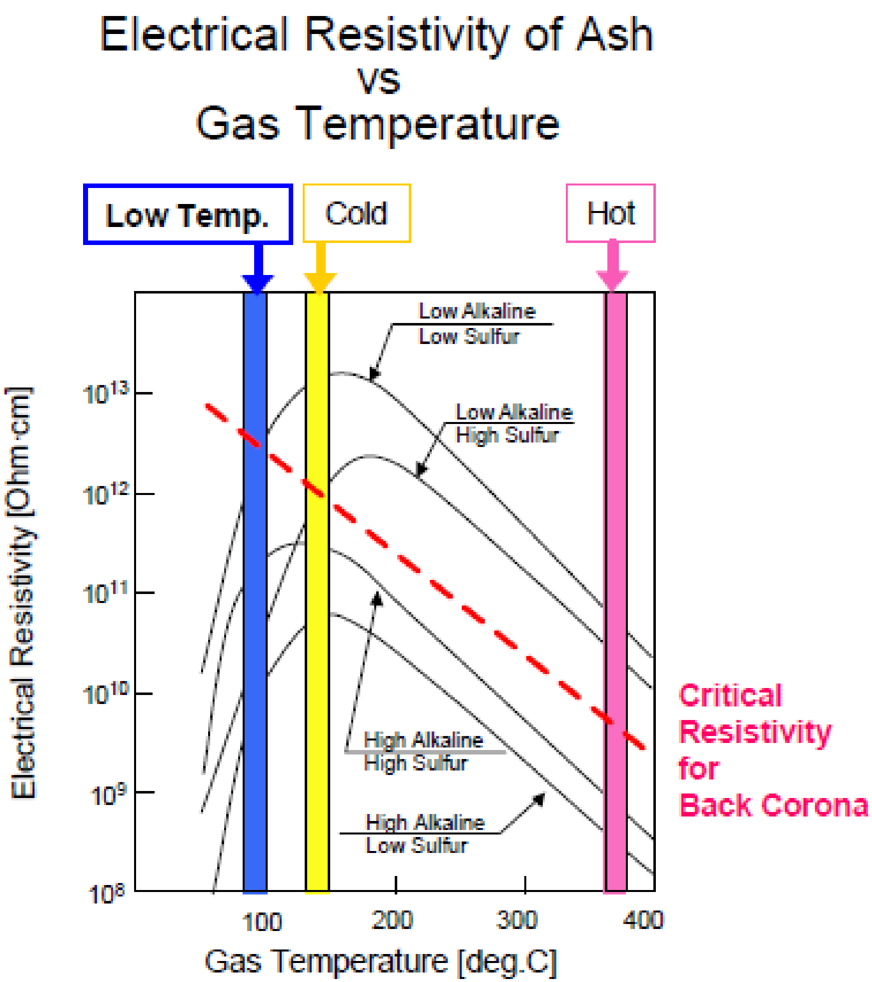
- Low temperature flue gas cooler with finned tubes
- Several installations in Japan
  - low-sulfur, coal-fired power plants in Japan
  - Re-heat scrubbed flue gas to eliminate visible plumes
- HES has not been demonstrated in U.S.
  - Recovered heat can be used in the boiler/steam turbine

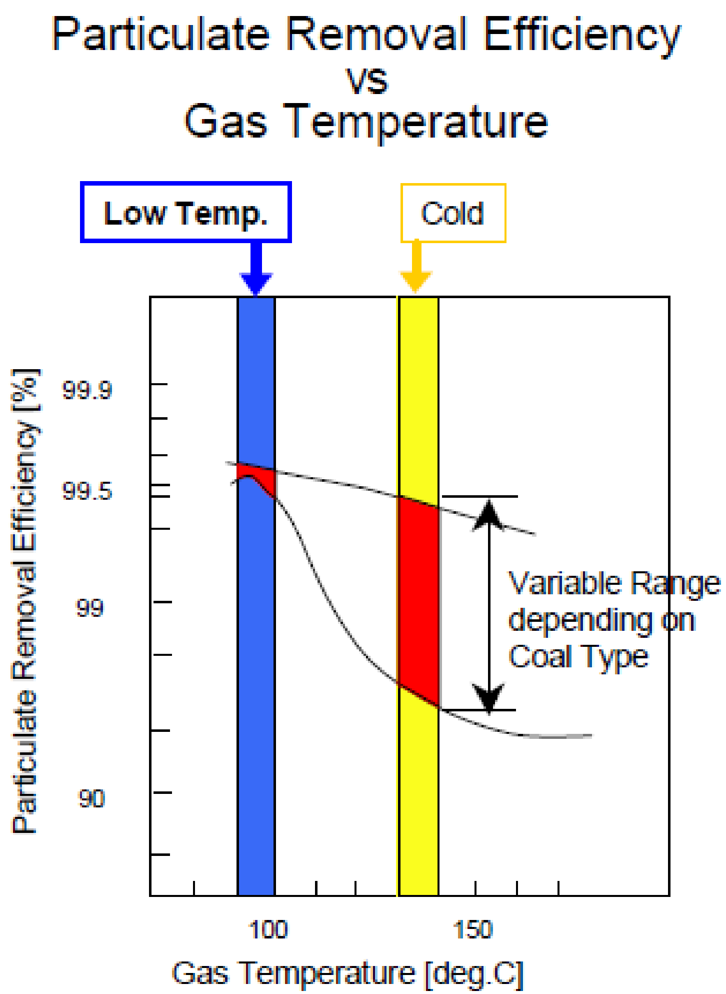


Outline of HES Process Flow

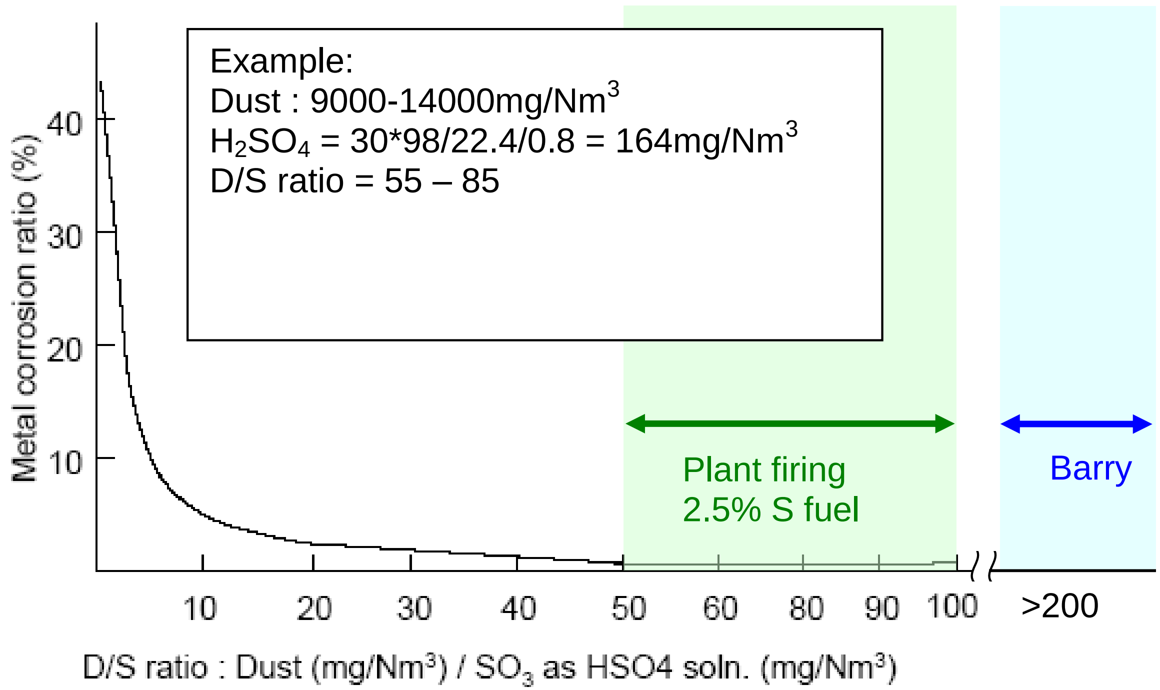


ESP Performance with HES





HES Requires High D/S Ratio



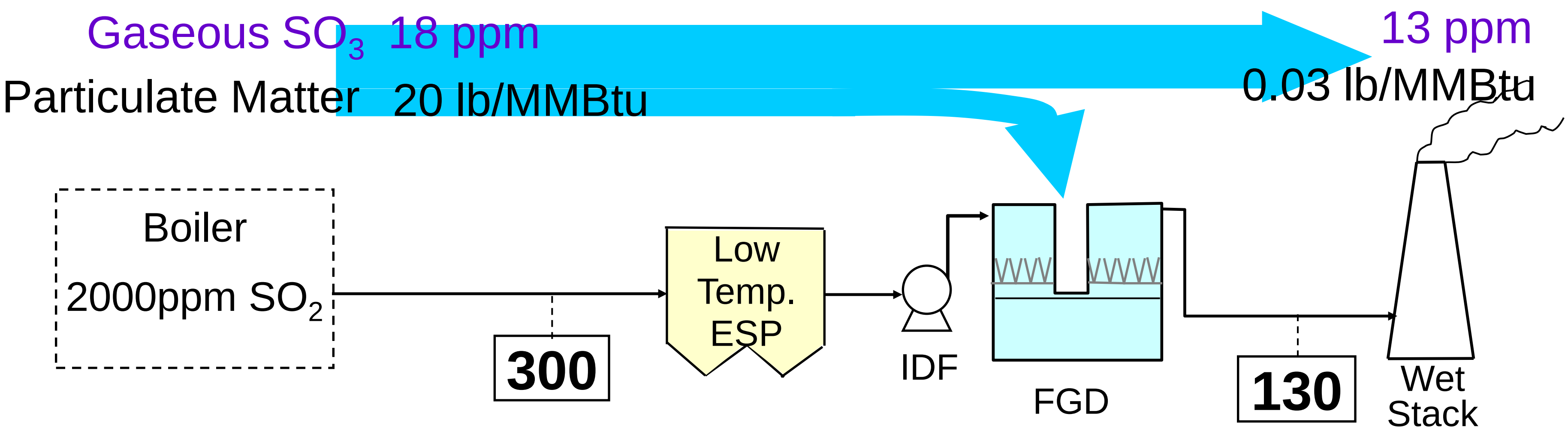
- Flue gas dust to sulfur ratio must be within an appropriate range
- SO_3 is condensed on the fly ash as the flue gas cools in the HES
  - Corrosion due to acid mist is avoided
  - Carbon steel can be used for plant equipment downstream of the air heater, except the FGD system

Material of Construction

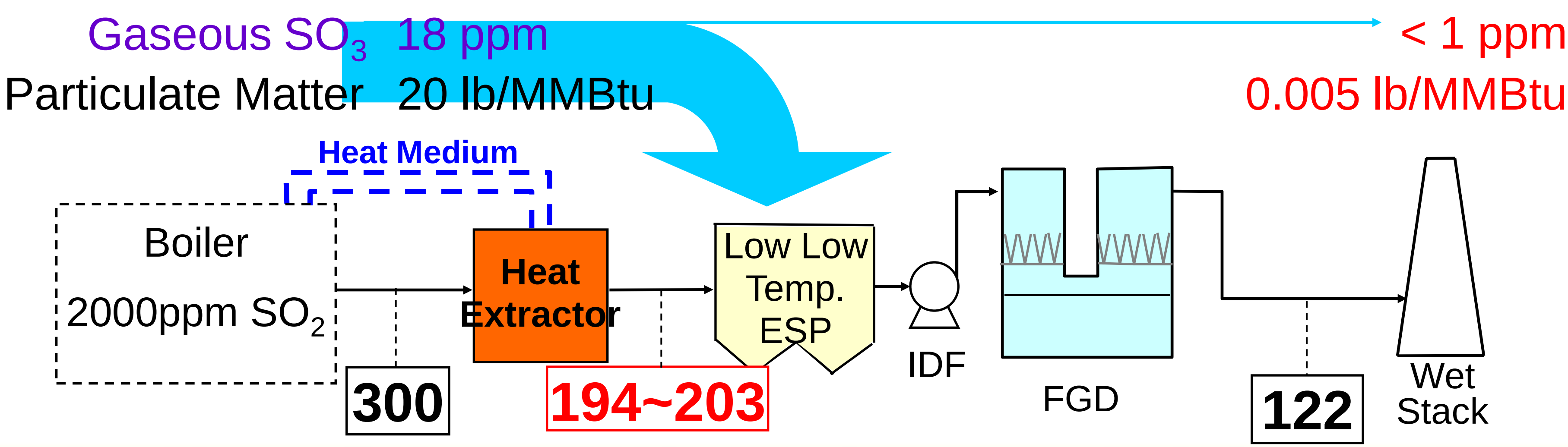
Carbon steel tube condition after 2 years operation at Tomatoh-atsuma #4

Outline of HES Process Flow

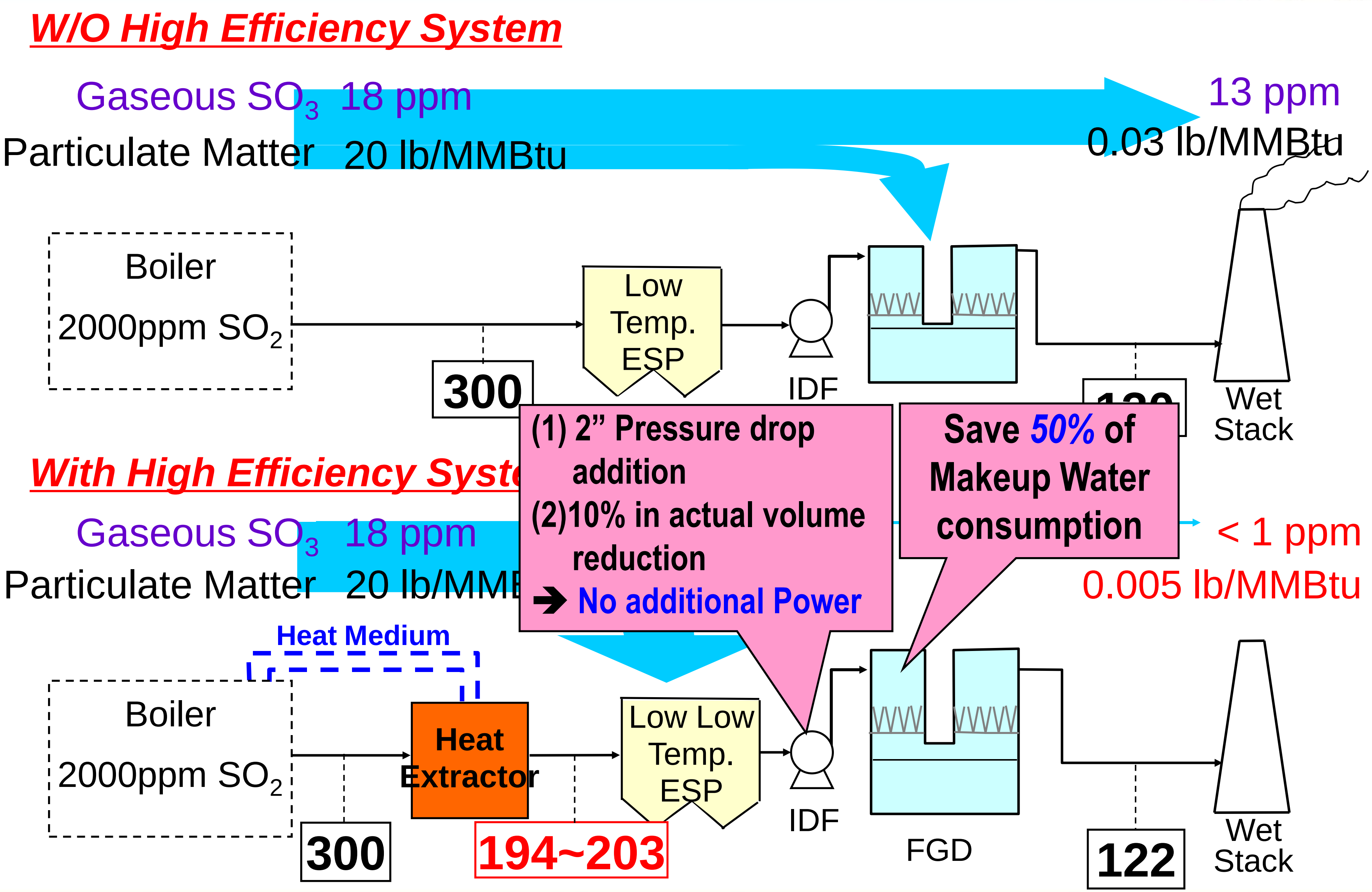
W/O High Efficiency System



With High Efficiency System

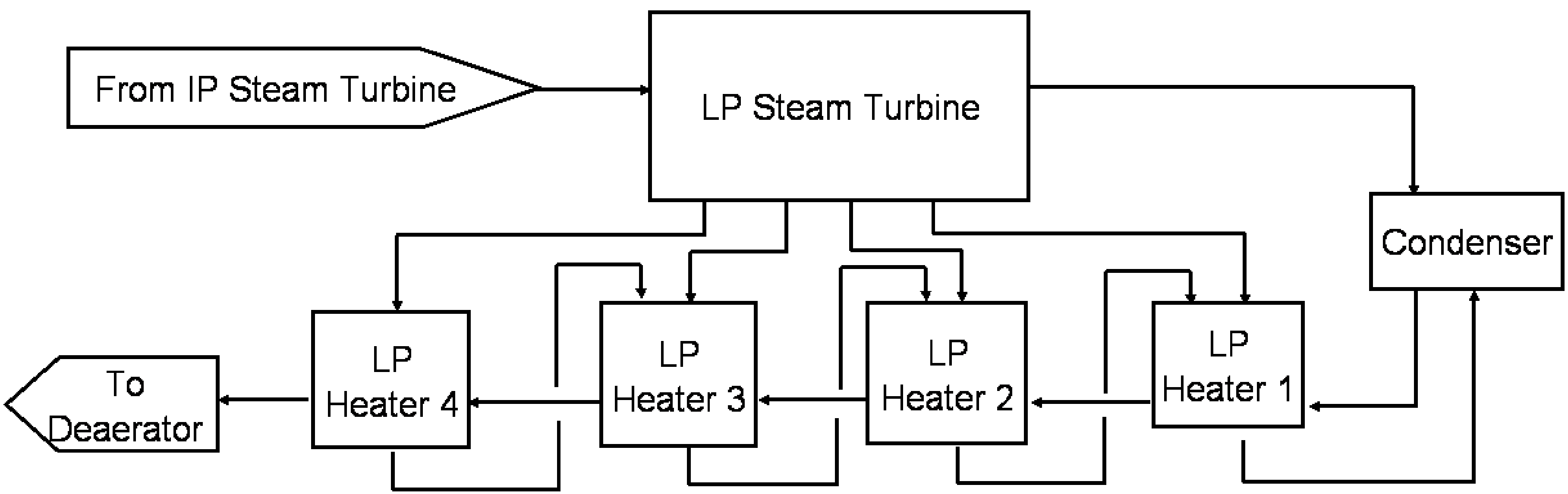


Outline of HES Process Flow

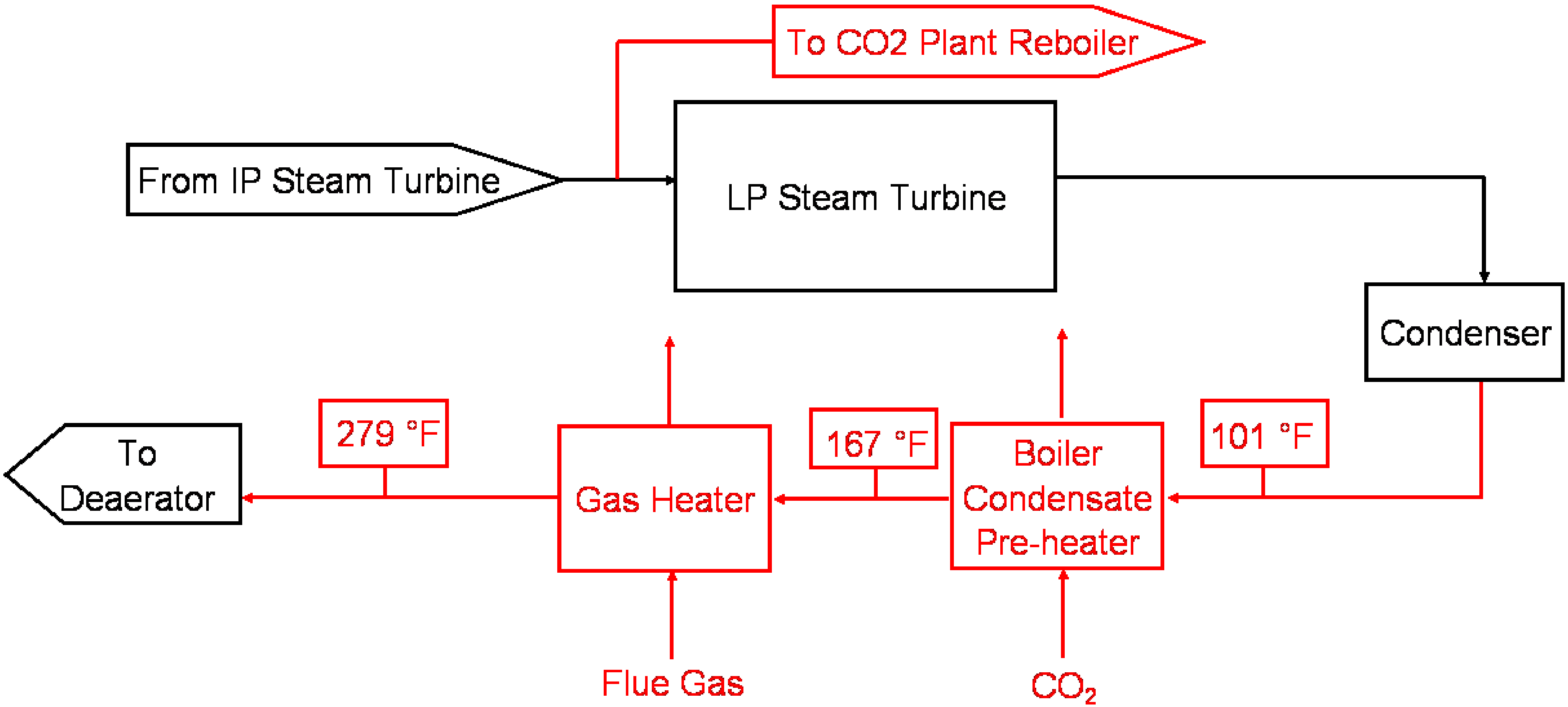


Boiler System

- Highly integrated heat recovery system can simplify the LP steam cycle



Simplified Boiler System



Economic Analysis

- Preliminary economics calculated per 2007 DOE Cost and Performance Baseline
- % increase in LCOE over no CO_2 capture plant
  - KM-CDR: 69%
  - KM-CDR + HES + CCS Heat Integration: 62%
- Revised analysis in progress, per 2010 methodology

Summary of HES Benefits

- Improve removal of hazardous air toxics (Hg, Se, SO_3) across the ESP
- Reduce AQCS cost
  - Improve ESP performance
  - Improve FGD performance
  - Improve CCS performance
- Potential to simplify boiler/steam turbine cycles
- Reduce total energy penalty of CCS plant by 26%

Challenges

- Highly integrated systems incorporating waste heat recovery have yet to be demonstrated at any scale
- Process control challenges, specifically during process dynamics which are typical in power plant operations
- Removal performance of specific impurities not yet quantified for varying operating conditions
- Uncertainty around the reliability of the system with higher sulfur fuels (> 1% S)

Field Testing and Analysis

- Baseline Testing
- Test Campaigns
  - Corrosion and Erosion
  - Water quality testing
  - SO_3 and Trace Metal Removal Performance
- Data Analysis
  - Verification of heat integration effect
  - Heat recovery for boiler feedwater
  - Reduction of FGD water consumption

Future Plans

- Complete FEED and TCE at the beginning of next year
- Begin EPC phase in 2013
- Start operations and testing in 2014