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

Presentation Outline

- Project Overview
- Technology Description and Background
- Technical Approach
- Techno-economic Results
- Summary and Path Forward

Project Overview

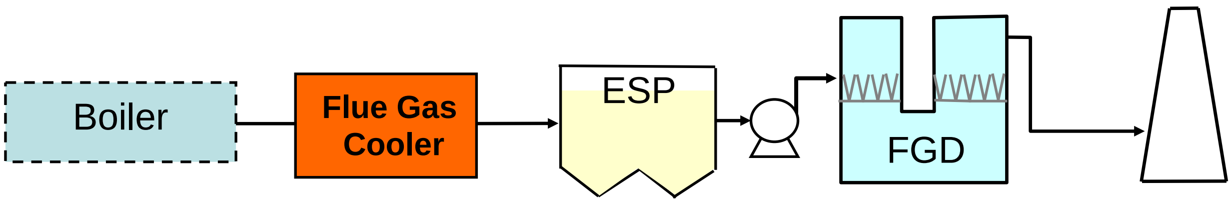
Project Scope

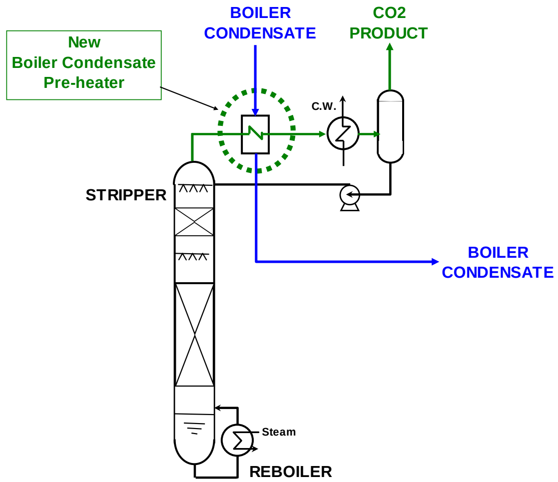
- Develop viable heat integration methods for CCS
- Integrate a waste heat recovery technology termed Mitsubishi High Efficiency System (HES) into an existing amine-based CO_2 capture process and host coal unit
- Evaluate improvements in the energy performance and emissions profile of the integrated plant

Work Plan

- A 25-MW High Efficiency System will be designed and installed to operate for 12 months in conjunction with the existing 25-MW MHI KM-CDR CCS pilot process at Southern Company’s Plant Barry.
- Waste heat in flue gas and CO_2 will be recovered to preheat a 25 MW slipstream of boiler condensate in the Plant Barry steam cycle.
- A 0.5 MW pilot ESP will be installed to test the tangential benefits of HES.

High Efficiency System





Goals

- Quantify energy efficiency improvements to the integrated process.
- Identify and resolve operational and control problems of the integrated plant.
- Assess the flue gas cooler long term deployment in an acid mist environment.
- Quantify the tangential benefits of the HES technology
  - Improved ESP performance
  - SO_3 concentration reduced 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 at the inlet

Relevance of Work

- Typical steam systems extract a significant amount of steam from the turbines to preheat boiler feed water
- 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
- Trace metals and SO_3 in flue gas result in amine solvent wastage, hazardous waste, and additional costs.

Project Budget

	DOE Share	Recipient Share	% Cost Share
BP1	$515,630	$150,558	
BP2	$8,573,466	$2,503,363	
BP3	$2,894,610	$845,196	
TOTAL	$11,983,706	$3,499,117	22.5%

Project Team

Organization	Project Manager/ Project Engineer
SCS	Nick Irvin, Todd Wall, Morgan French
MHIA	Dale Wilterdink, Takahito Yonekawa, Shintaro Honjo, Cole Maas
URS	Katherine Dombrowski
DOE-NETL	Bruce Lani

Host Site:

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

Schedule

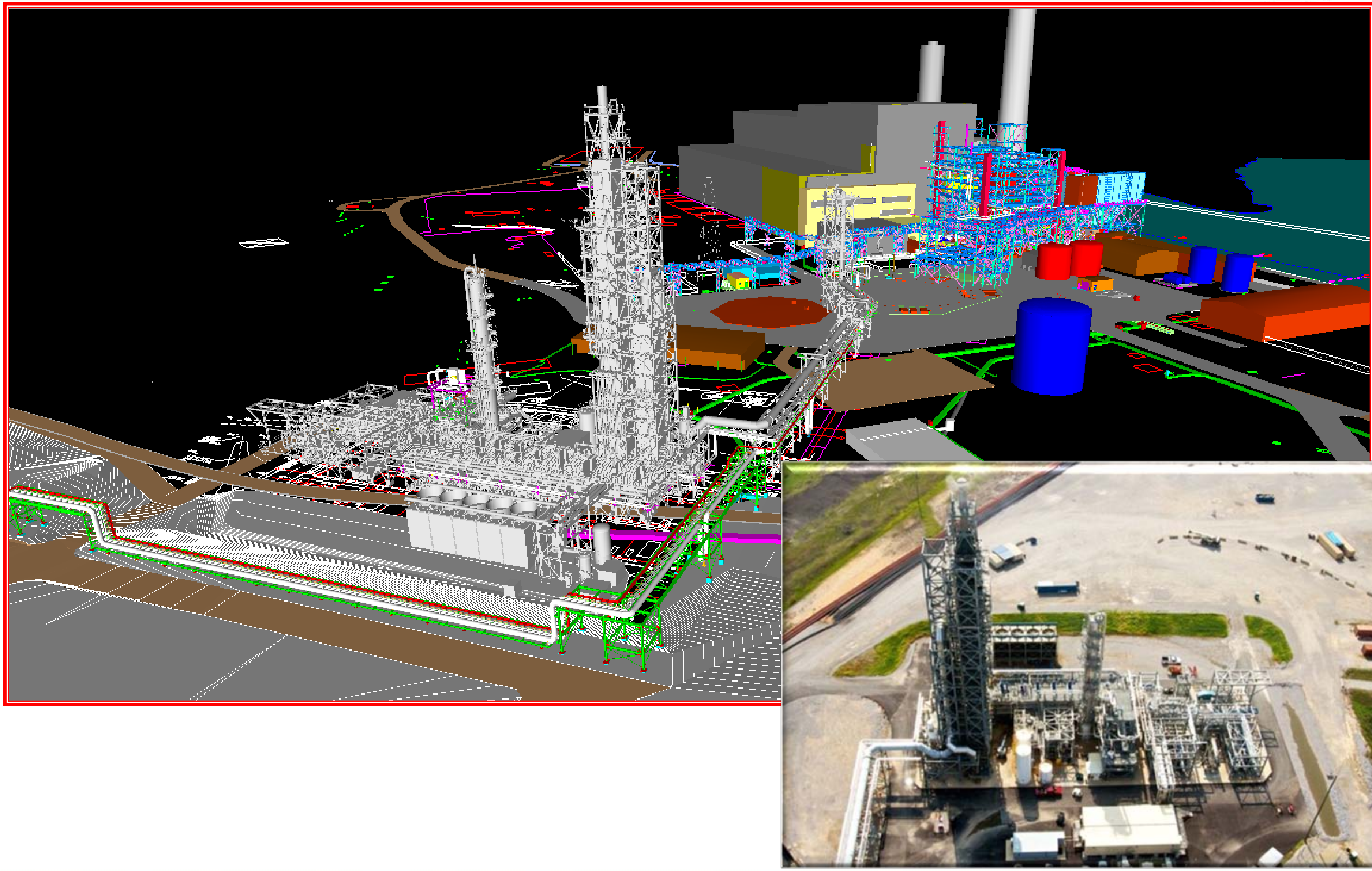
- Budget Period 1: through June 2013 (extended)
  - Task 2: Front End Design and Target Cost Estimate
  - Task 3: Permitting
- Budget Period 2: July 2013 – July 2014 (delayed)
  - Task 4: Engineering, Procurement, and Construction
- Budget Period 3: Aug 2014– February 2016 (delayed)
  - Task 5: Operations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

Completed Work in BP1: Tasks 2 and 3

- Task 2: FEED and Target Cost Estimate
  - Deliverable: Final design package with cost to build
  - Basic Engineering
    - Heat and material balances
    - General arrangement drawings (3D Model)
    - Equipment sizing and duties
    - Control system architecture
    - Process control philosophy
- Task 3: Permitting
  - Confirmed that no permits required, received approval letter from AL Department of Environmental Management

Technology Description and Background

25 MW KM-CDR at Plant Barry

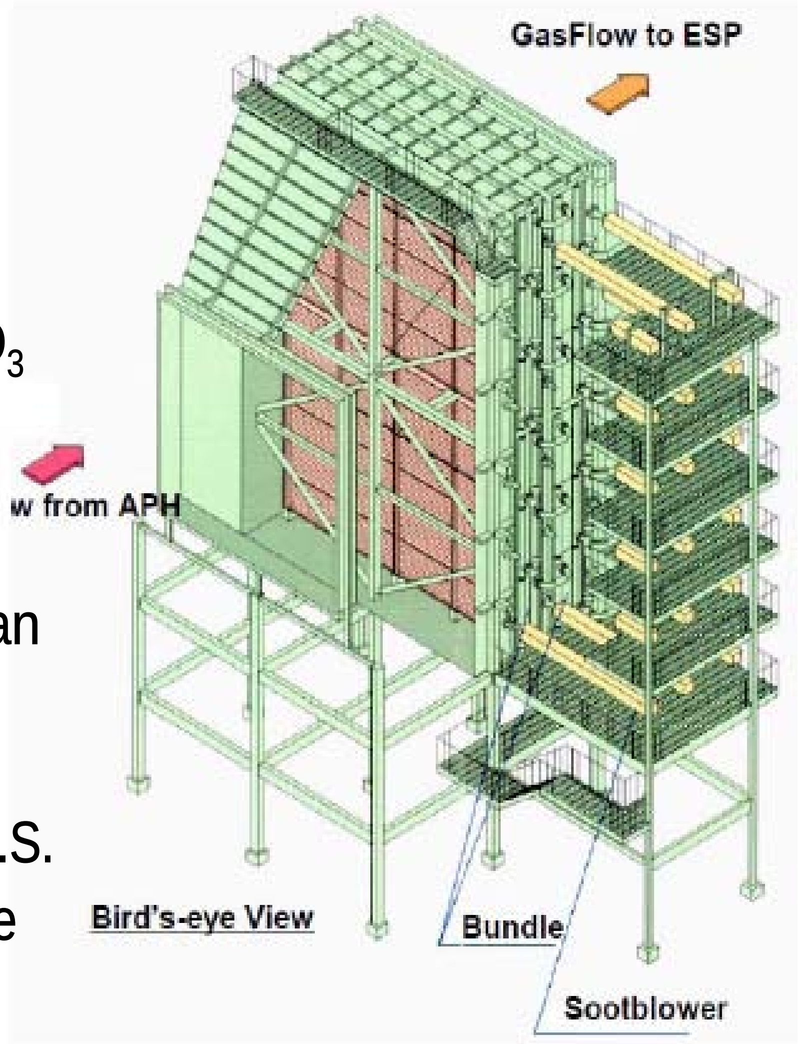


25 MW KM-CDR at Plant Barry

- Funded by an industry consortium
- Started operation: June, 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)

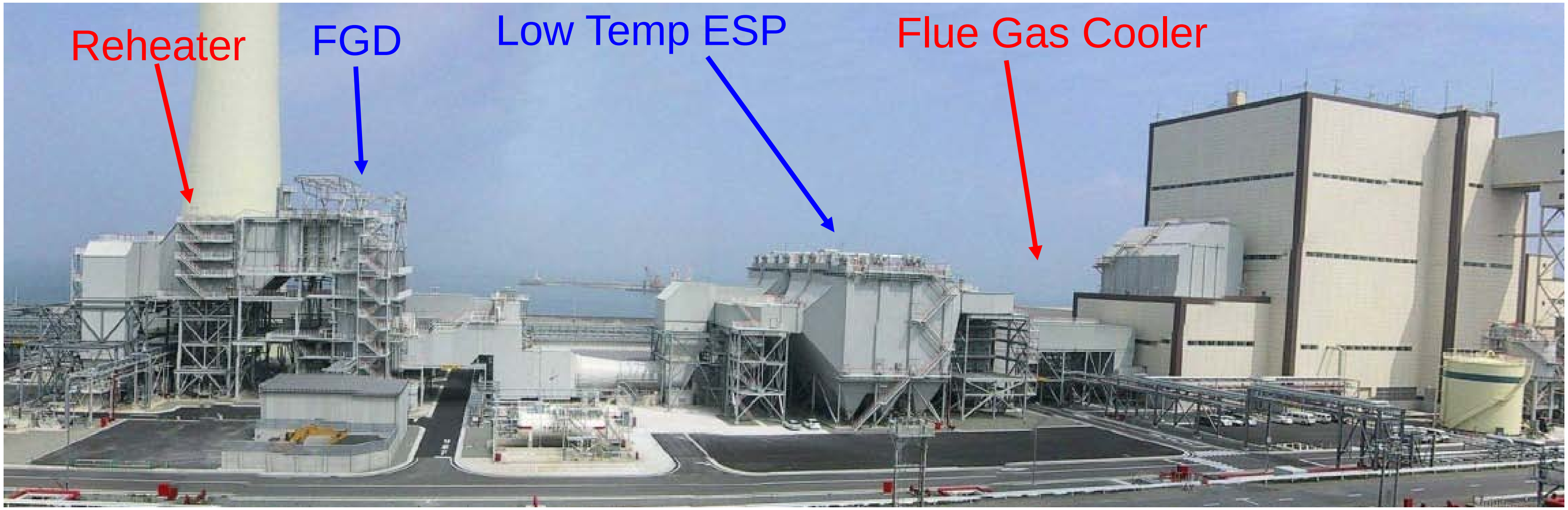
Flue Gas Cooler

- Low temperature flue gas cooler with finned tubes
- Carbon Steel construction
- Captures waste heat at APH outlet (300ºF)
- Corrosion mitigated by controlling ash to SO_3 ratio in flue gas, metal surface temperature, and SO_3 condensing onto ash
- Several installations in Japan
  - low-sulfur, coal-fired power plants in Japan
  - Re-heat scrubbed flue gas to eliminate visible plumes
- Technology has not been demonstrated in U.S.
  - Recovered heat can be used in the turbine cycle



History of Flue Gas Cooler

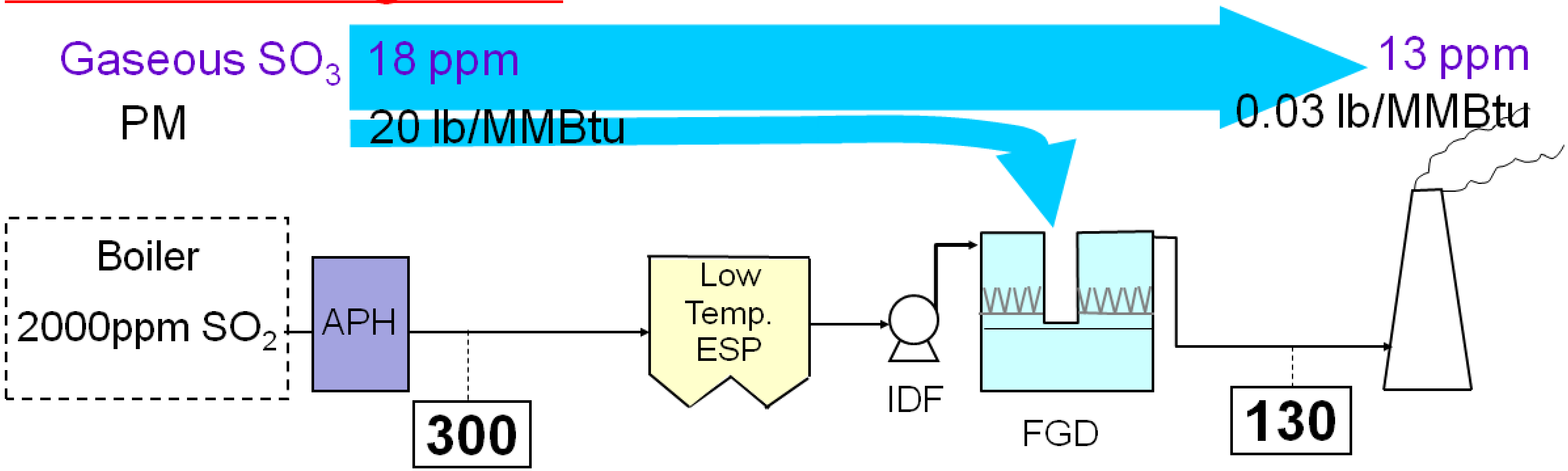
Hirono P/S Japan - 600MW



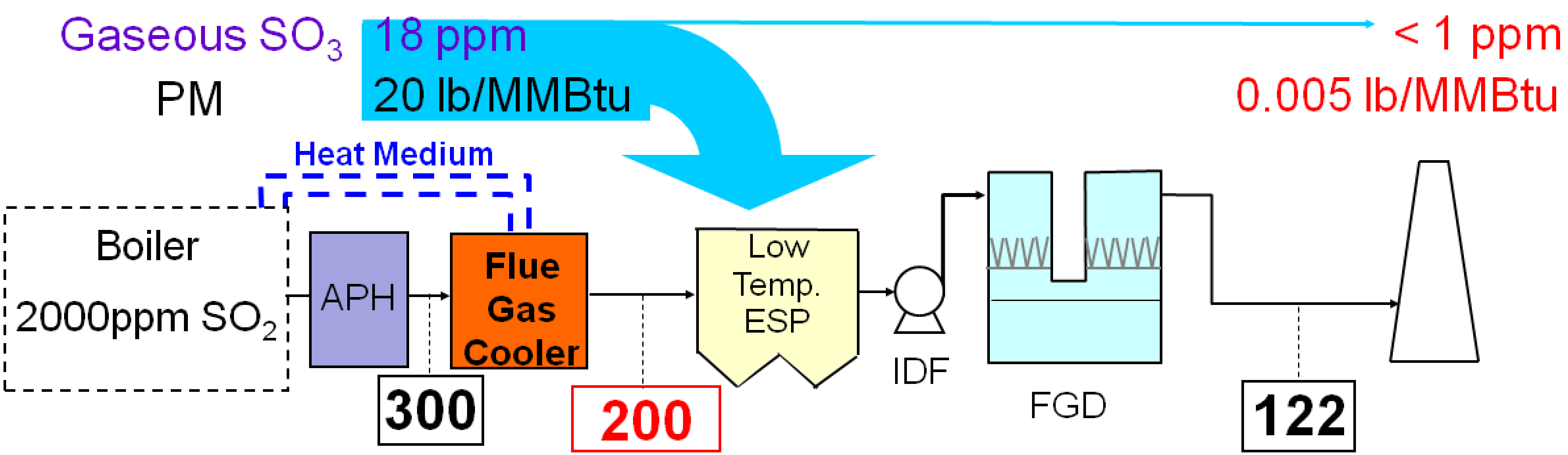
Tubes after 2 yrs operation

Outline of HES Process Flow

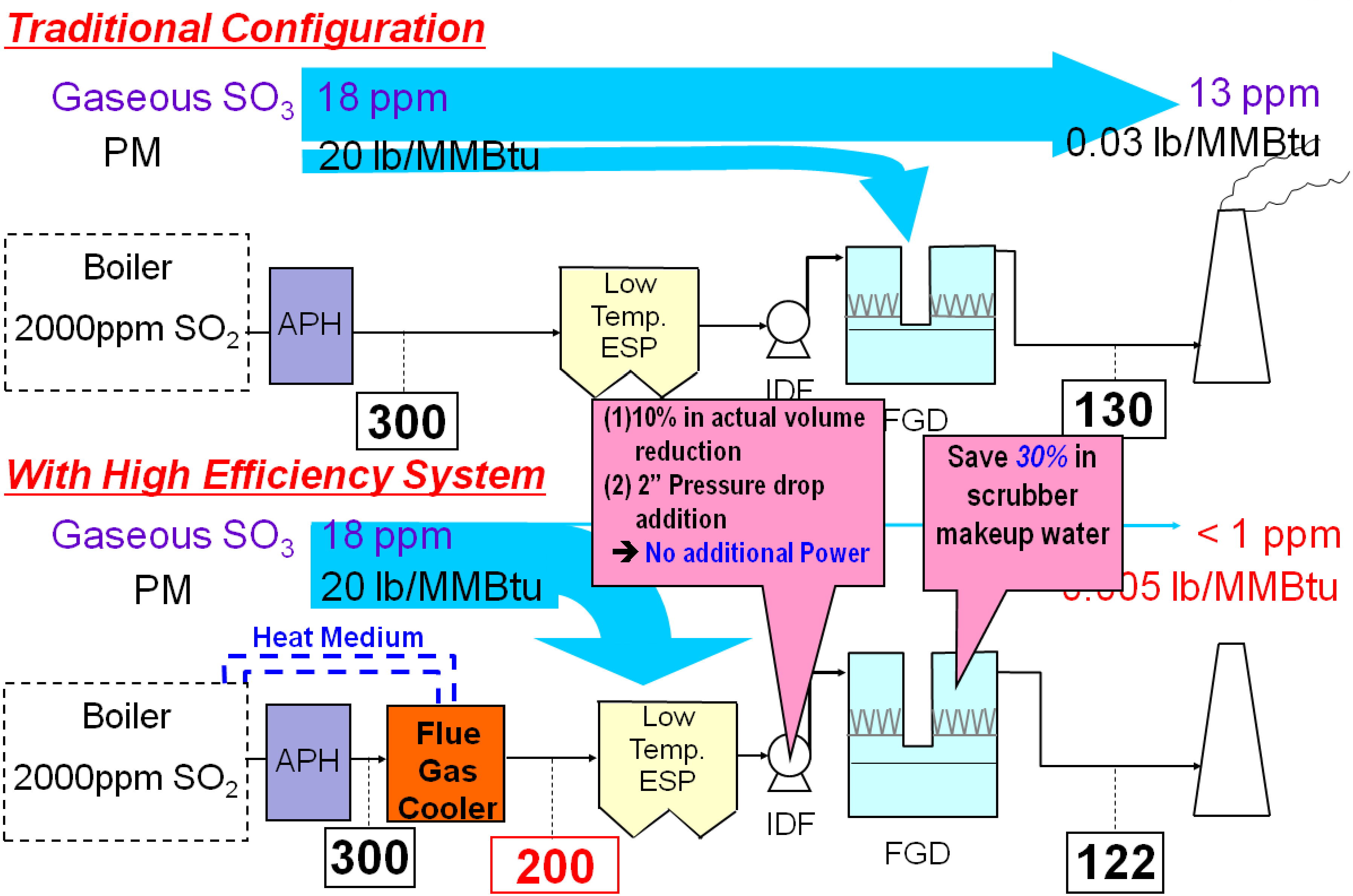
Traditional Configuration



With High Efficiency System

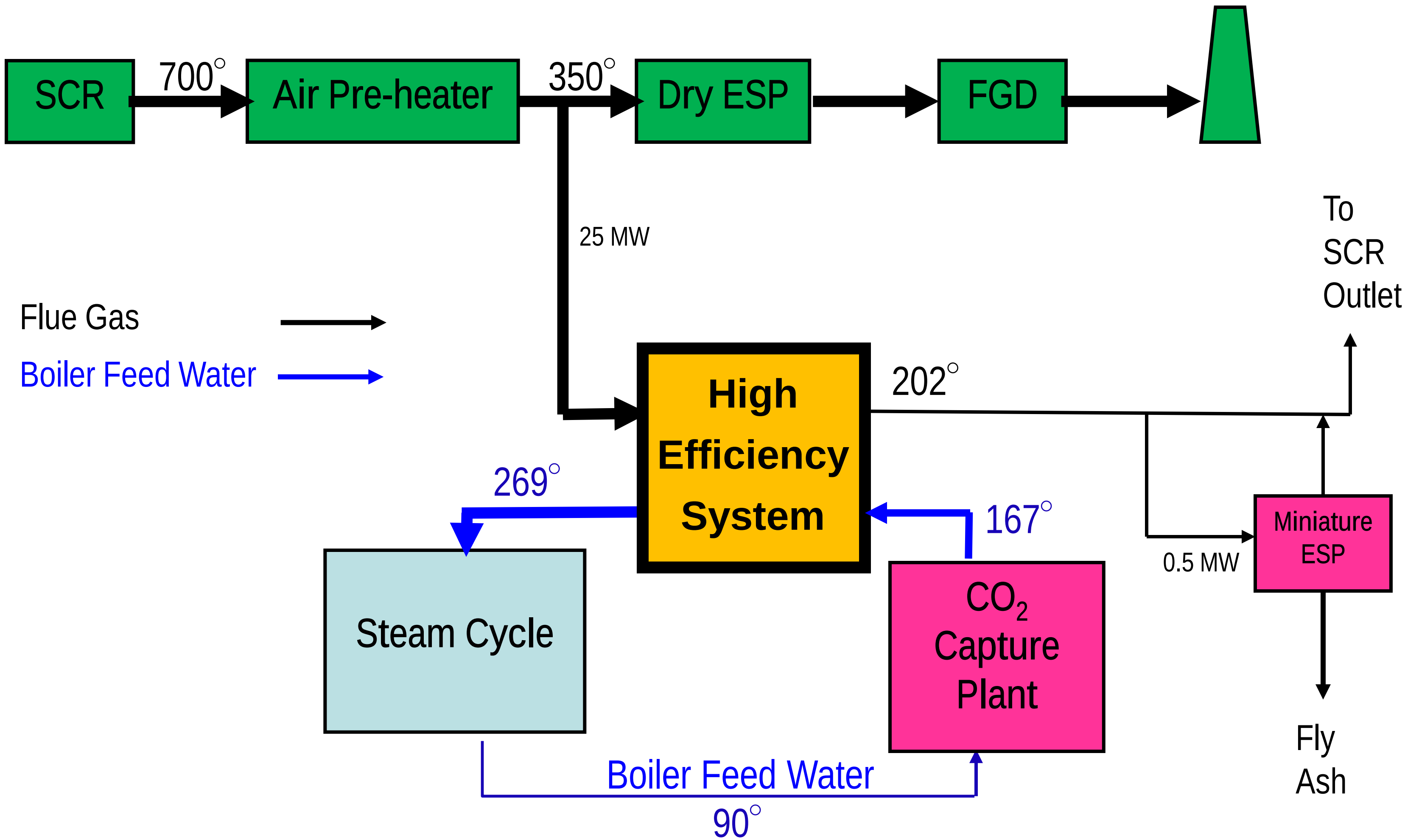


Outline of HES Process Flow



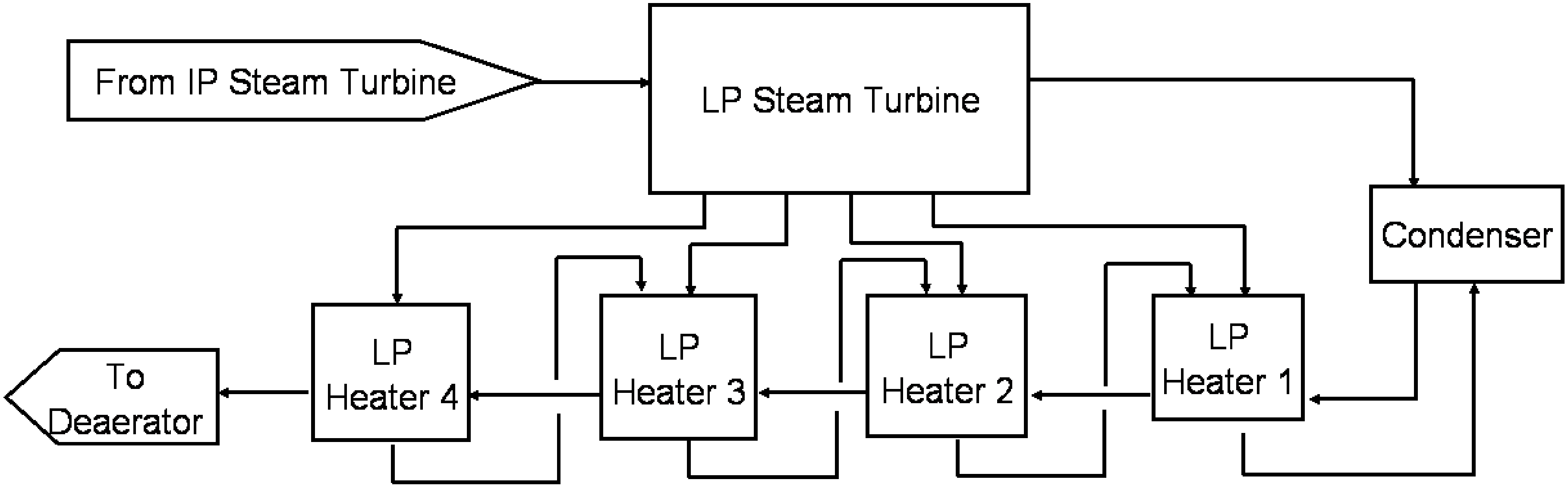
Technical Approach

Heat Integration with Power Plant

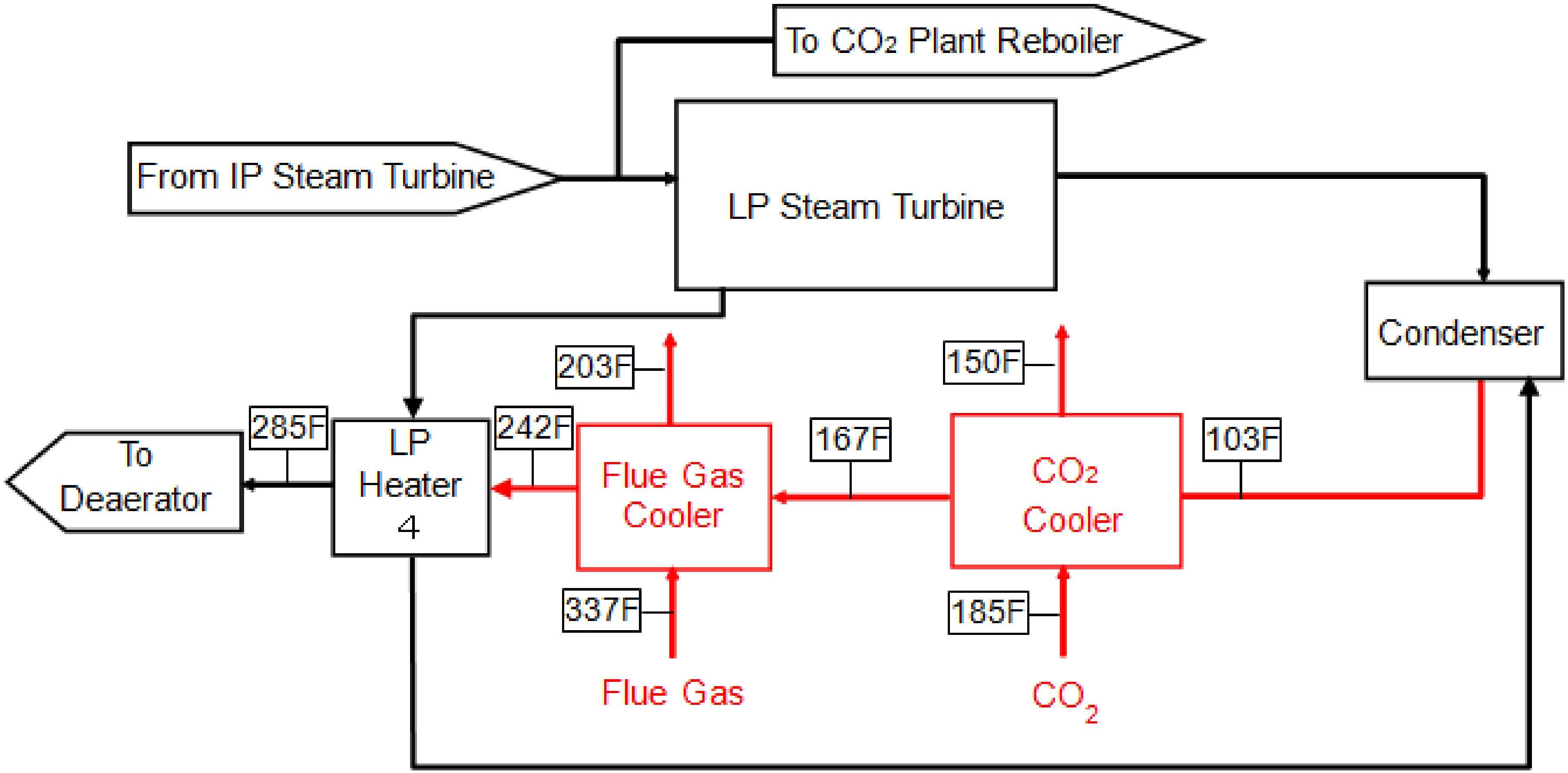


Boiler System

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

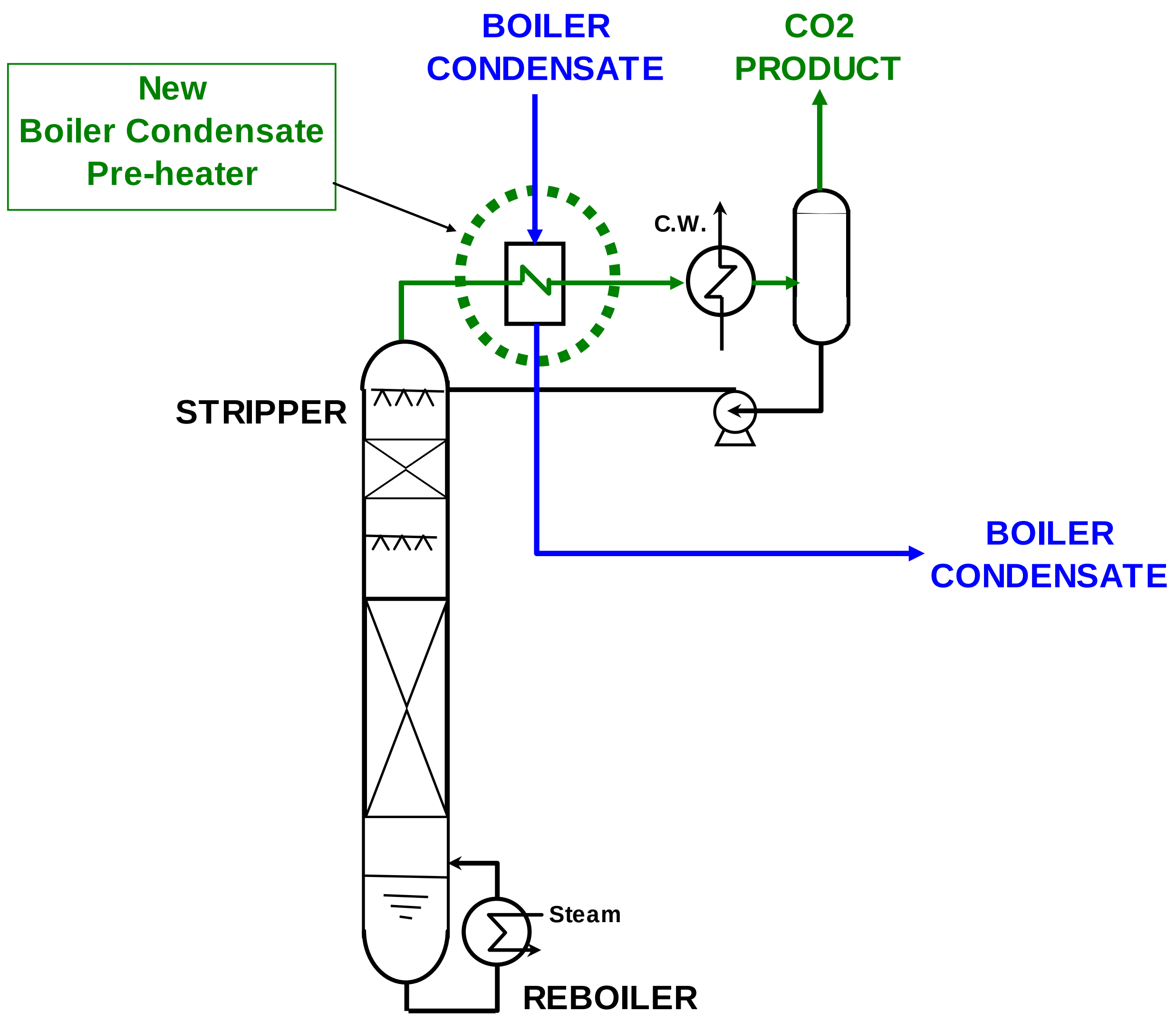


Simplified Boiler System

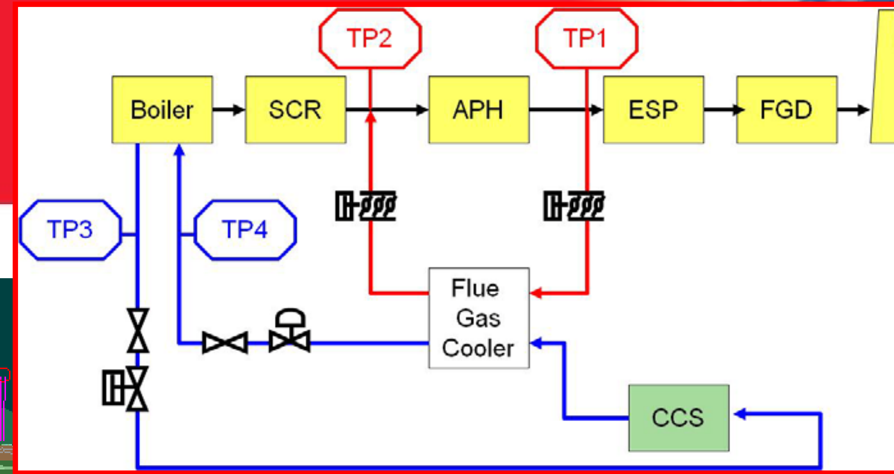


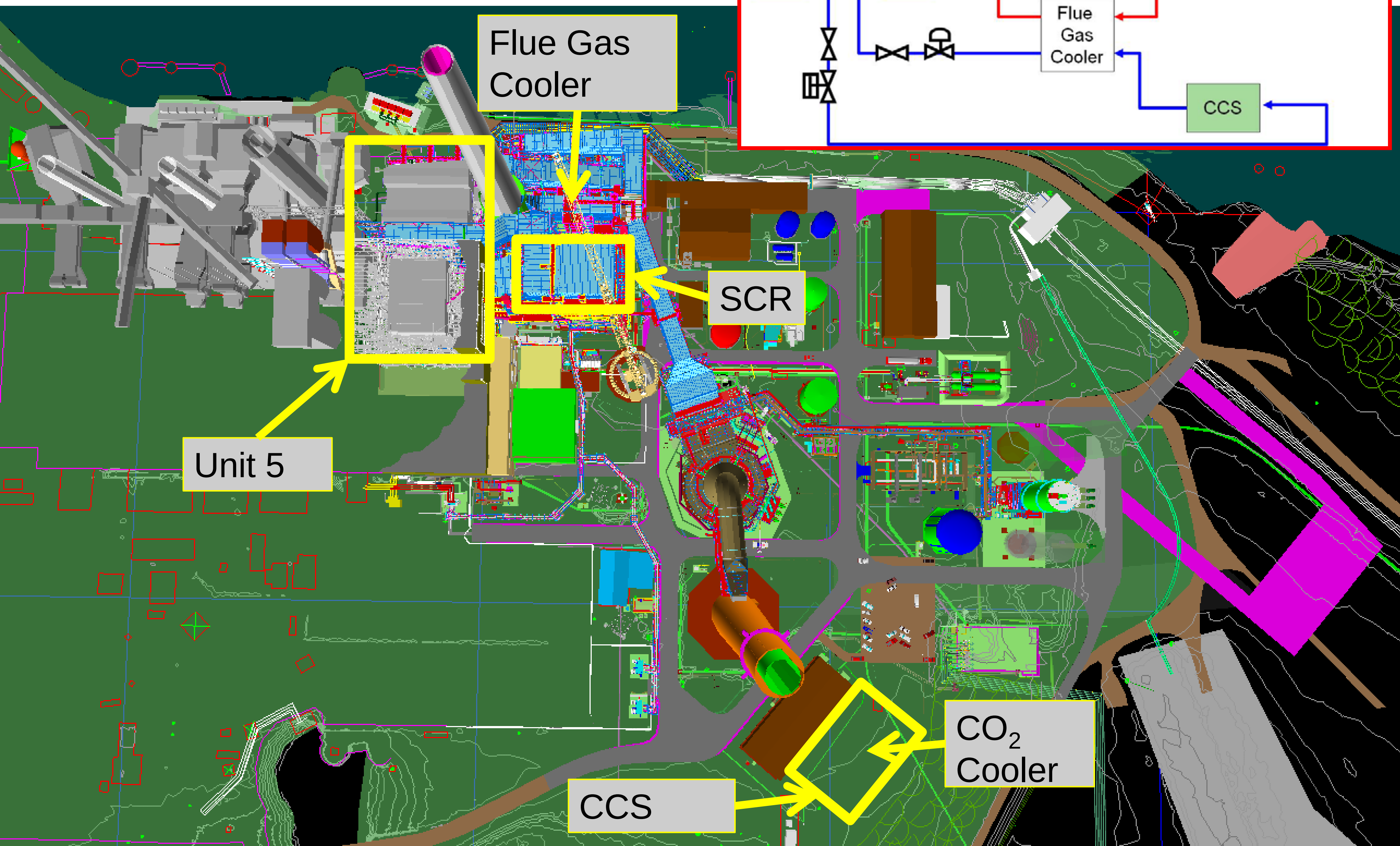
Reduce/Replace LP Feedwater Heaters

CO_2 Capture Plant Tie-in



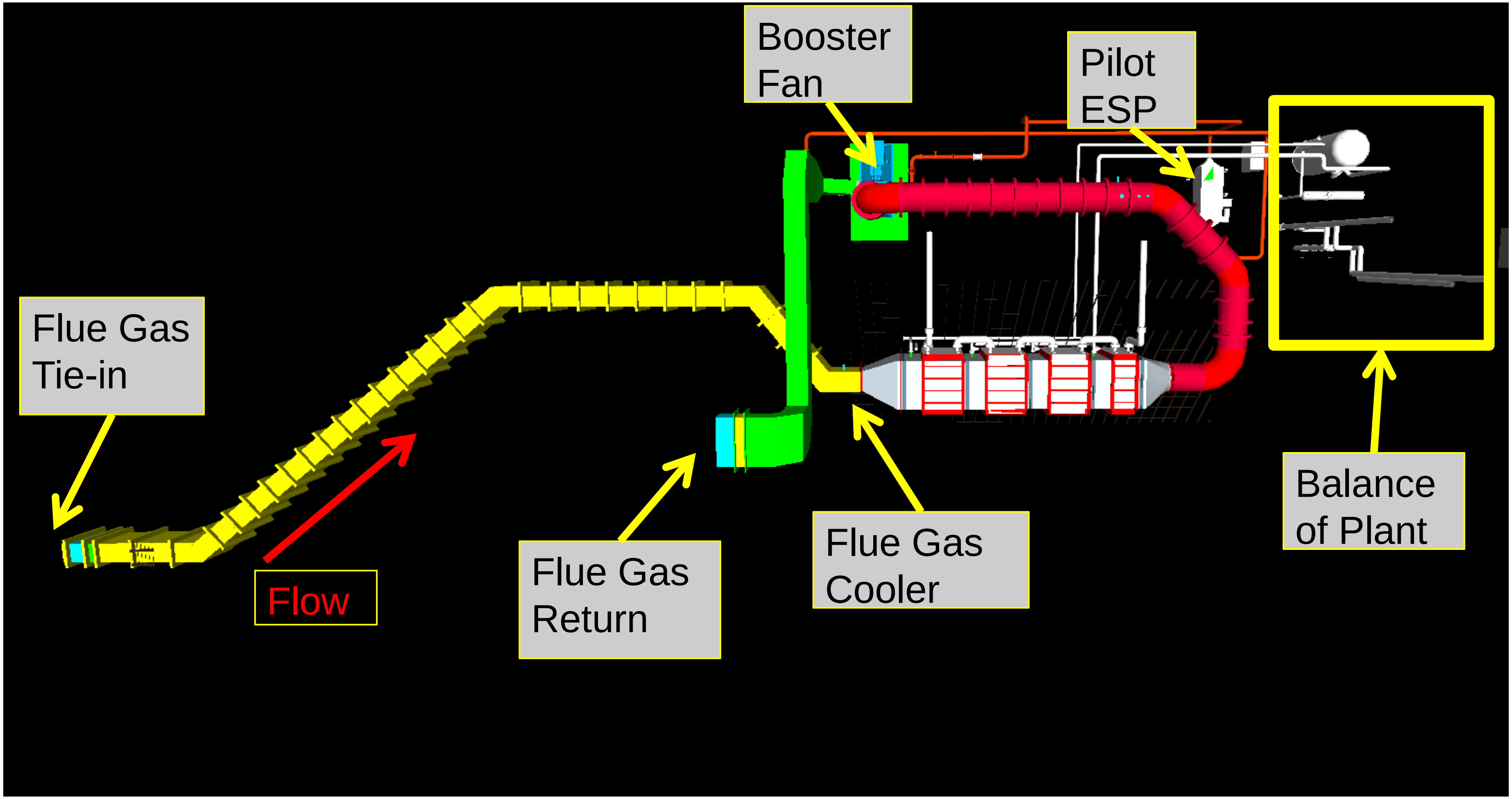
General Layout



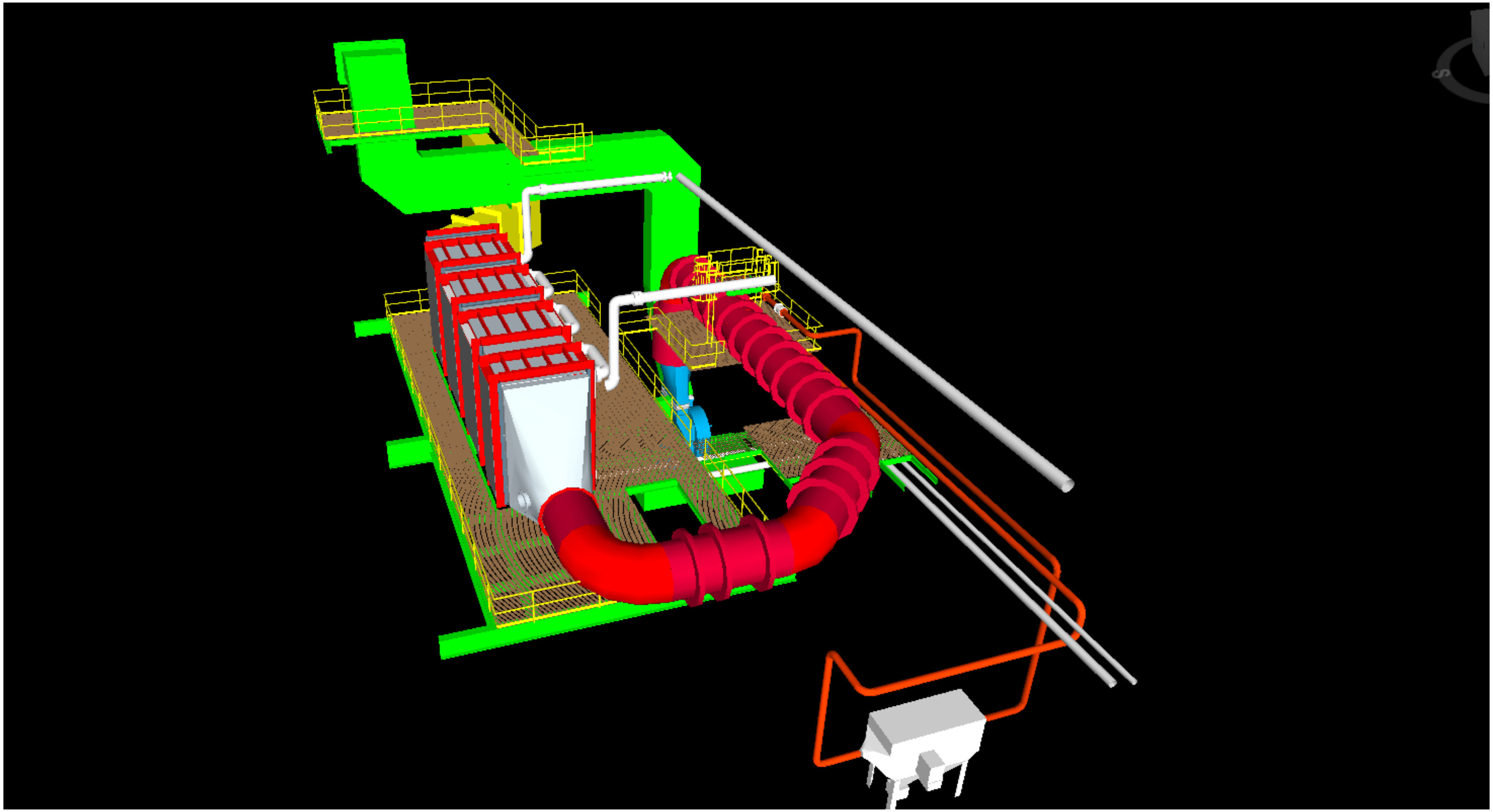


Flue Gas Cooler Area-Plan View

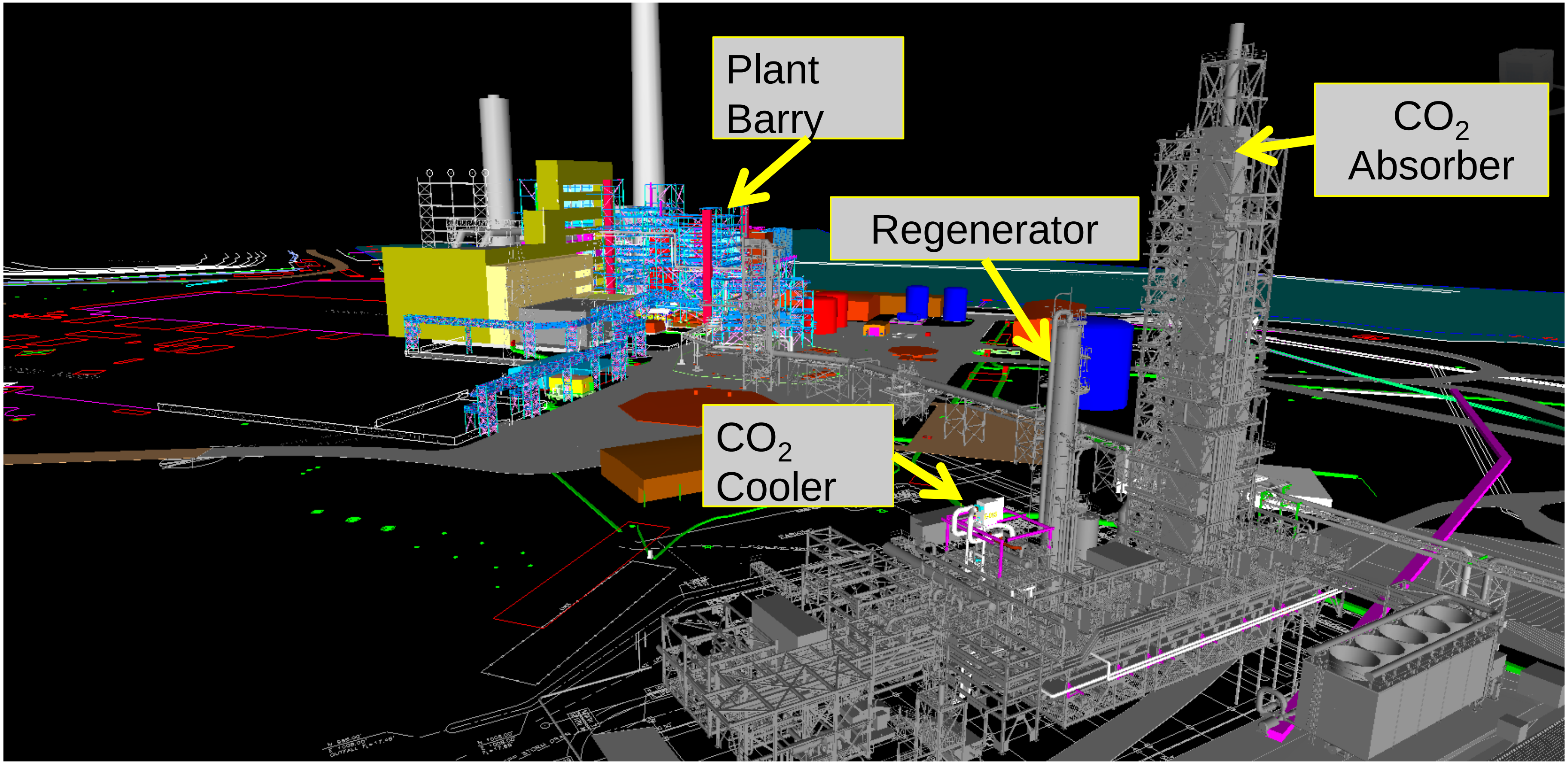
Flue Gas Cooler Area – Plan View



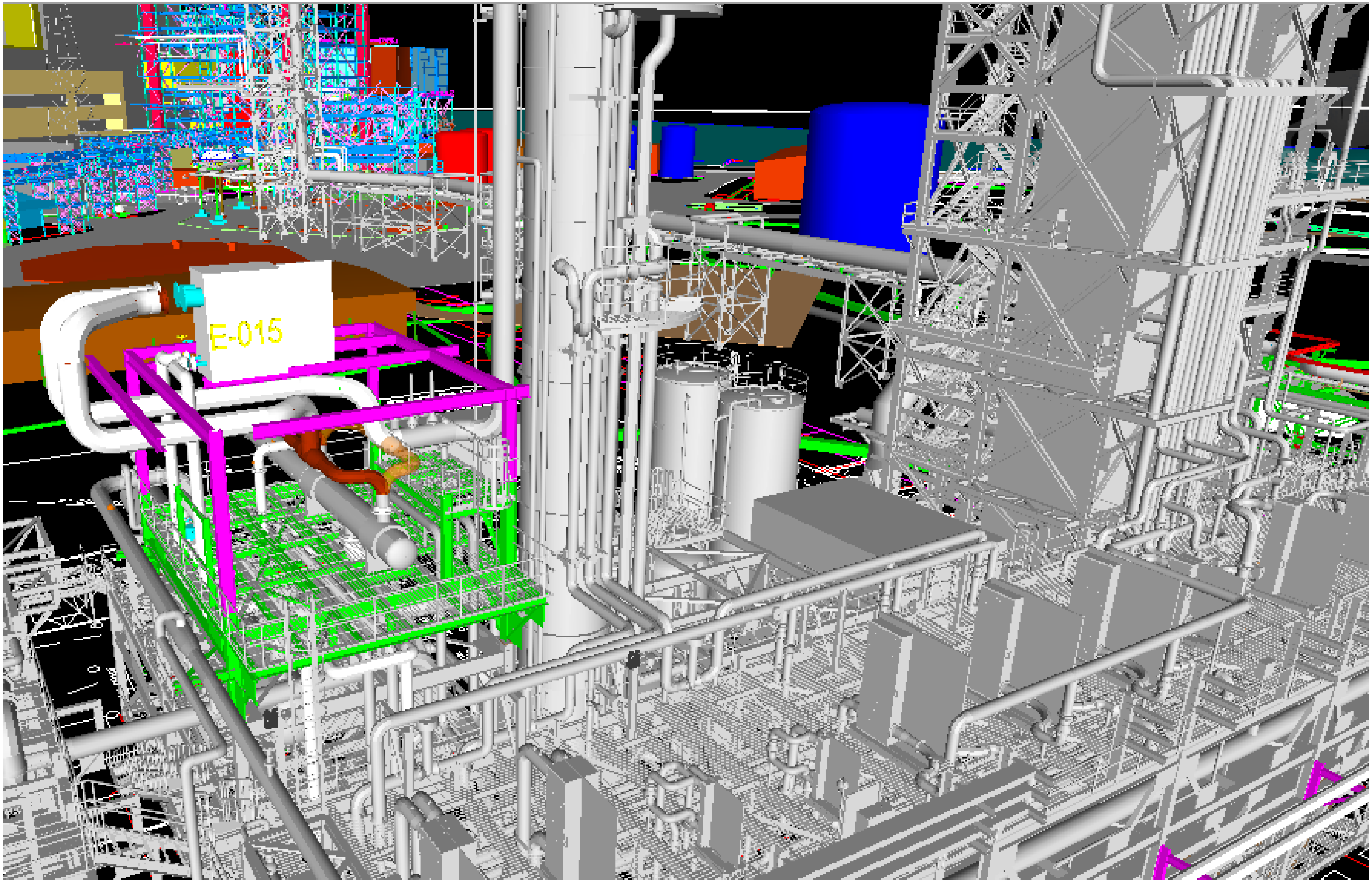
With Grating



CO_2 Cooler General Arrangement



CO_2 Cooler



Techno-Econ Snapshot

Plant Configuration		Subcrit-PC Base	w/MEA Base*	w/MHI KM-CDR*	KM-CDR & HES
Net Plant Efficiency	(HHV)	36.8%	26.2% (29% Drop)	28.9% (21% Drop)	29.7% (19% Drop)
Overnight Cost**	$MM	1,098	1,991	1,800	1,771
COE**	Mills/kWh	59.4	117.6	101.5	98
COE Ratio	-	1.0	1.98	1.71	1.65

* SBS injection (atomized sodium carbonate) for SO_3 Control

** 2007 $$

Note: Base cases outlined in Cost and Performance Baseline for Fossil Energy Plants (DOE/NETL, 2010)

Field Testing and Analysis

- Baseline Testing
- Test Campaigns
  - Corrosion and Erosion
  - Feedwater Purity 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

- Awaiting approval of continuation application for BP2
- Begin EPC phase in 2013 (BP2)
- Start operations and testing in 2014 (BP3)