REINHOLD ENVIRONMENTAL Ltd.

2017 APC & Wastewater Round Table & Expo Presentation

July 17 & 18, 2017 in Charlotte, NC / Hosted by Duke Energy

INSTALLATION OF SPRAY DRYER TECHNOLOGY FOR WET SCRUBBER BLOWDOWN EVAPORATION AT KCP&L IATAN STATION

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GE POWER - CLEAN COMBUSTION

18 July 2017

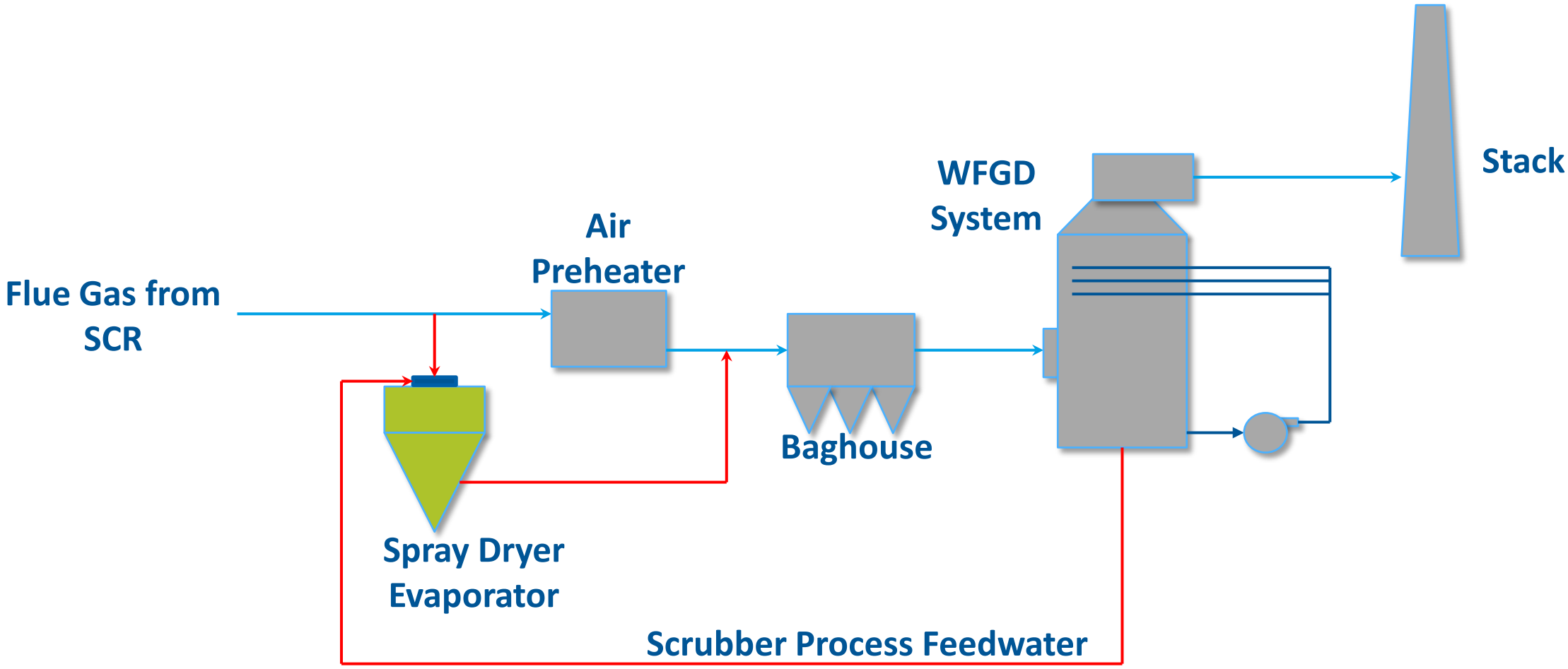
OVERVIEW

- Introduction to Station and Problem
- Technology Selection Process
- Project Structure & Front-End Engineering (Phase I)
- Construction & Commissioning (Phase II)
- Results to Date / Key Findings

- Two PRB coal-fired generating units
  - Unit 1 (700MW), 1980
  - Unit 2 (900MW), 2010
- Both units equipped with SCR, mercury control, fabric filter, and wet scrubber (Unit 1 = 2009)
- Unit 2 cooling tower blowdown = scrubber makeup
  - (Unit 1 = Once-through cooling)
- Zero Liquid Discharge (ZLD) with respect to scrubbers since 2009

- Original system: “ZLD Light”
  - Serial #1 in this arrangement
- Actual scrubber process feedwater ~5x more concentrated than design
- Minimal pretreatment
- 2012: Decision to modify or replace original treatment system

GE (ALSTOM) SDE™ SPRAY DRYER EVAPORATOR



GE (ALSTOM) SDE™ SPRAY DRYER EVAPORATOR

Background

- SDE technology uses hot flue gas for direct evaporation
- Duke-Cliffside Unit 6 in-service since 2012 (full flow)
  - Scrubber blowdown evaporation is a co-benefit

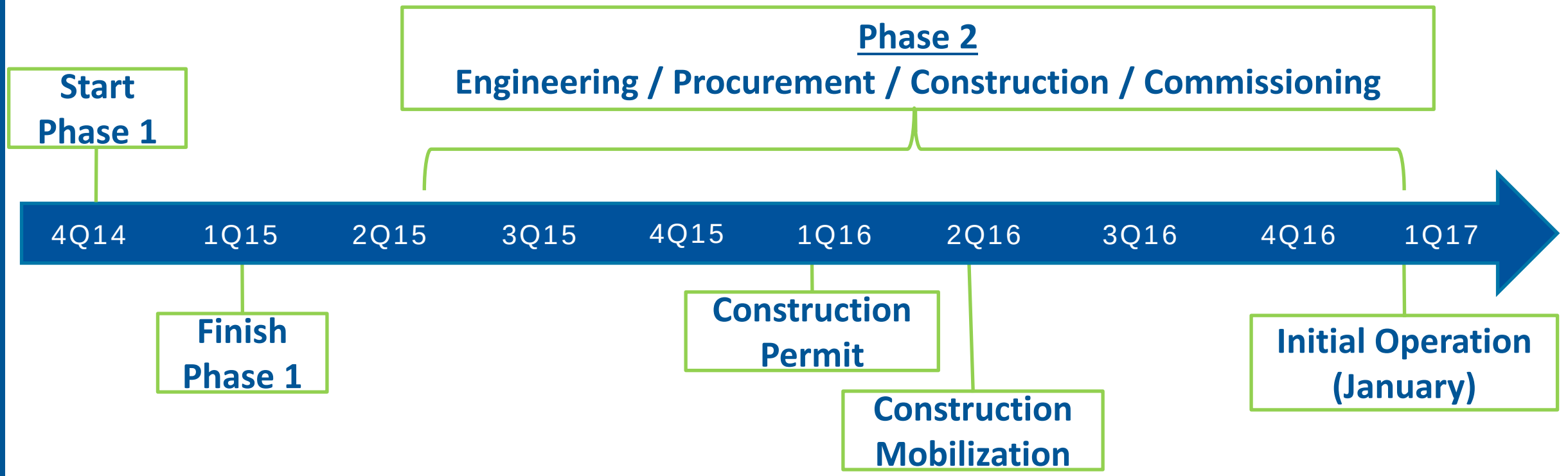
Studies

- Front-End Engineering (Phase I)

Conclusions/Recommendations

- Good fit, though first-of-its-kind in proposed configuration
- KCP&L commenced Phase I engineering in 4Q14

- Phased Approach
  - Phase 1: Scoping, technical specifications, definitive estimate
  - Phase 2: Detailed design, procurement, construction, commissioning
- Owner's Engineer – Black & Veatch
- Construction Contracting
  - General Construction (competitive bid)
  - Substructures

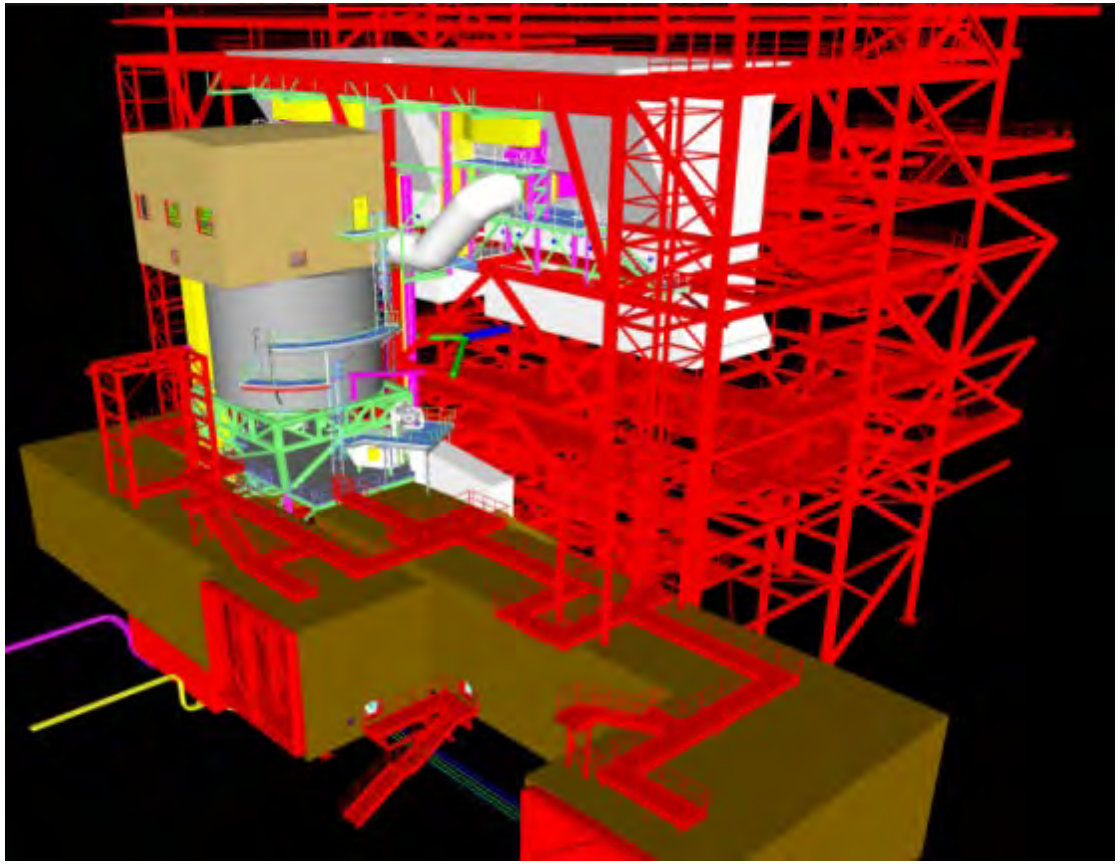

Phase 2
Engineering / Procurement / Construction / Commissioning
Start
Phase 1
4Q14
1Q15
2Q15
3Q15
4Q15
1Q16
2Q16
3Q16
4Q16
1Q17
Finish
Phase 1
Construction
Permit
Construction
Mobilization
Initial Operation
(January)

Capacity

- 18-50 gpm wastewater
  - TDS ≤ 140,000 ppm
- 2%-4% MCR flue gas rate

Atomizer

- 1 operating + 1 spare
- 200 HP



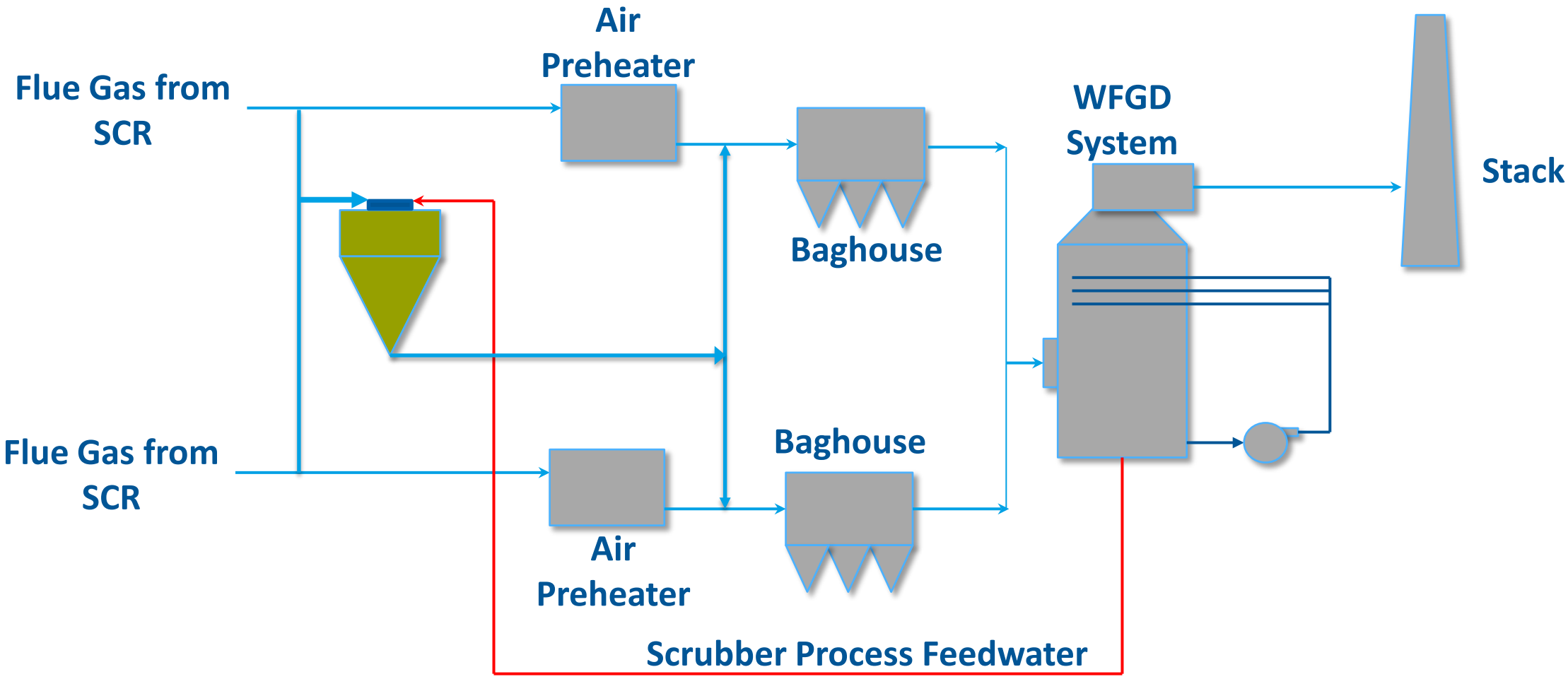
- Uniqueness of arrangement
- Elimination of softening
- Ammonia balance
- Fly ash handling
- Construction Risk

- General Constructor
  - APCom
- Construction approach
  - Ground fabrication
  - Minimal overtime
  - Familiar subcontractors
- B&V/KCP&L oversight

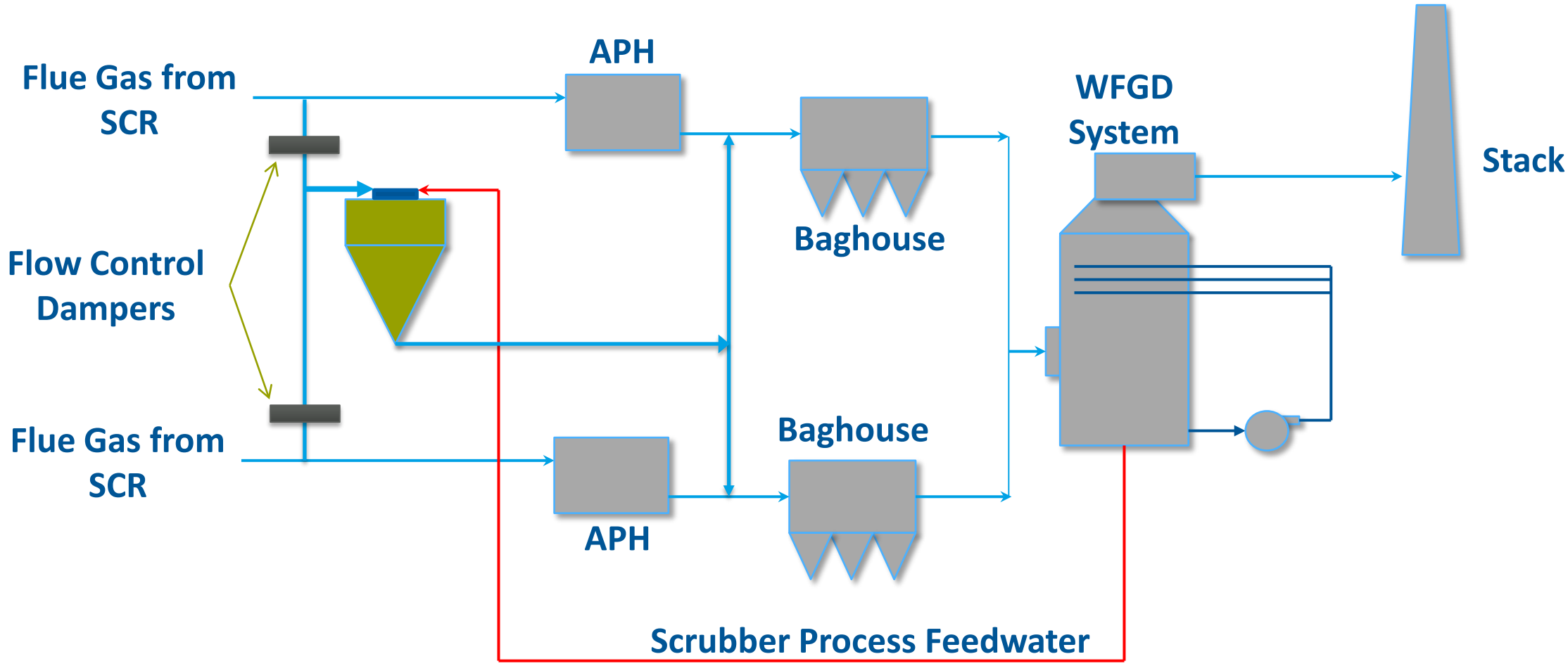
- Key Logistics
  - Crane selection/reservation
  - Substructures work
  - Space management
  - KCP&L-purchased equipment
  - Plant Operations
- Startup Ready – Nov 2016

SPRAY DRYER EVAPORATOR PROCESS FLOW DIAGRAM & CONTROL

GE POWER SDE™ SPRAY DRYER EVAPORATOR
PROCESS FLOW DIAGRAM



GE POWER SDE™ SPRAY DRYER EVAPORATOR
PROCESS CONTROL



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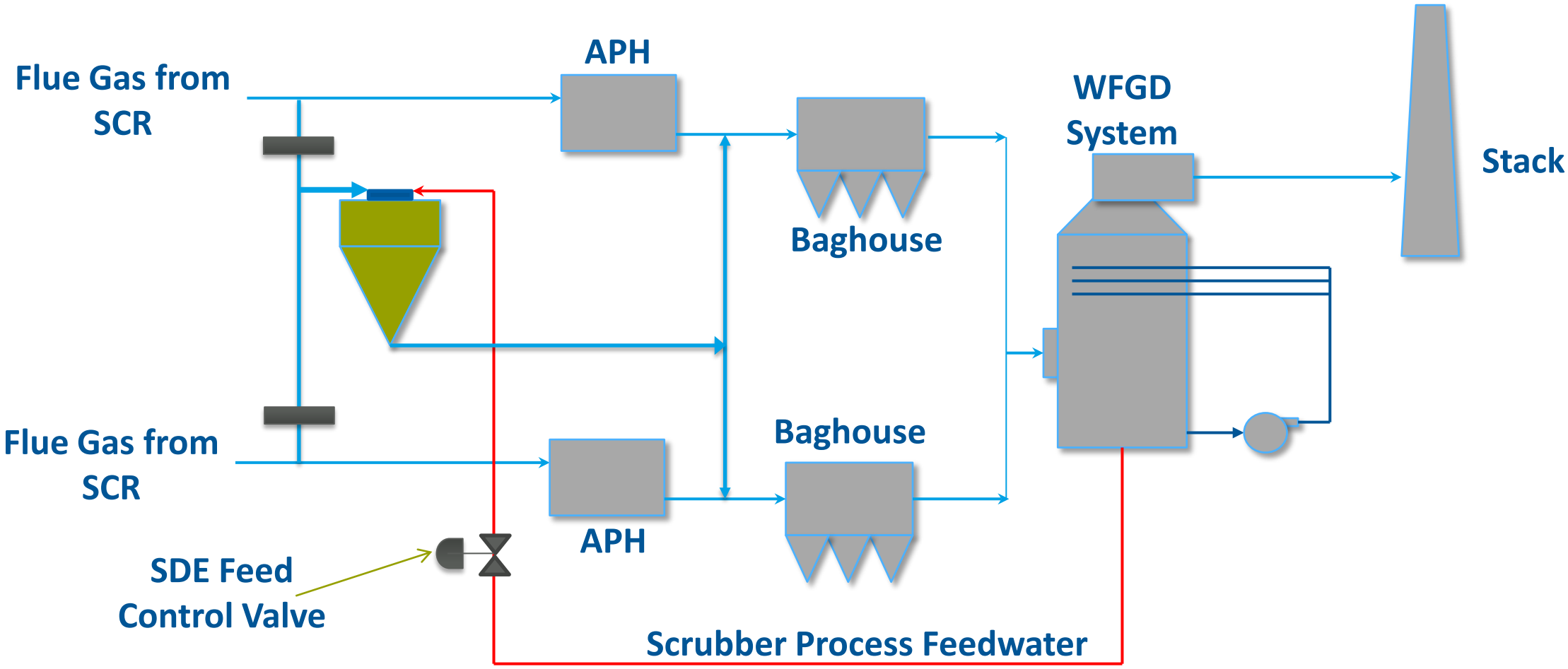

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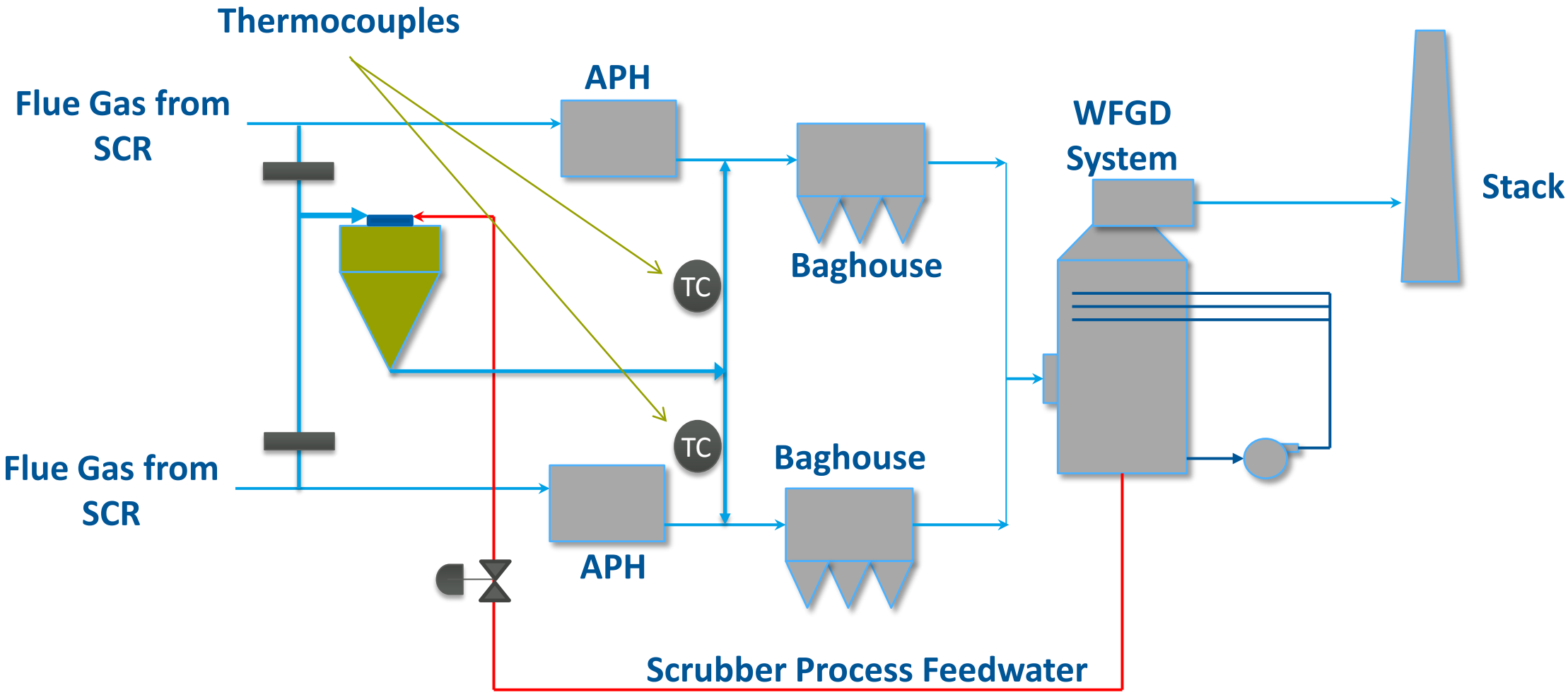

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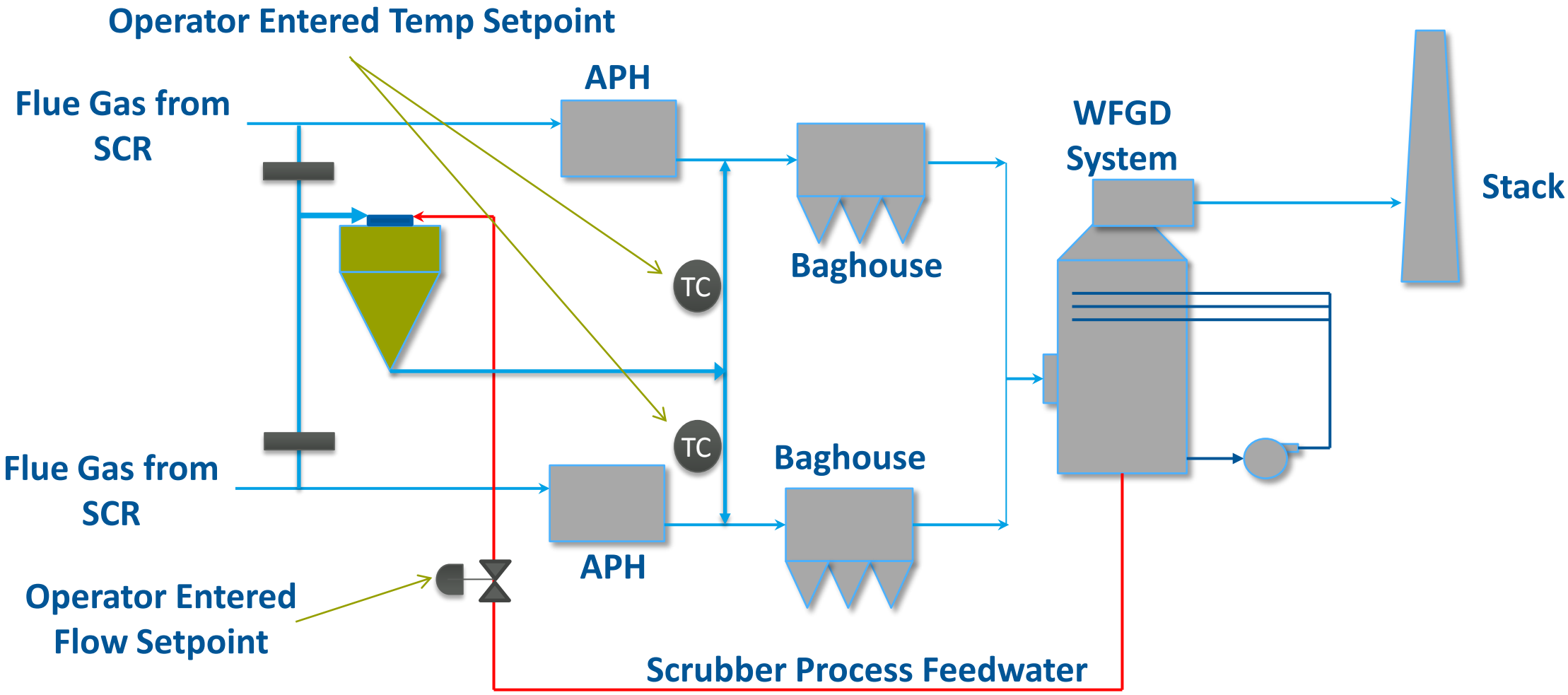

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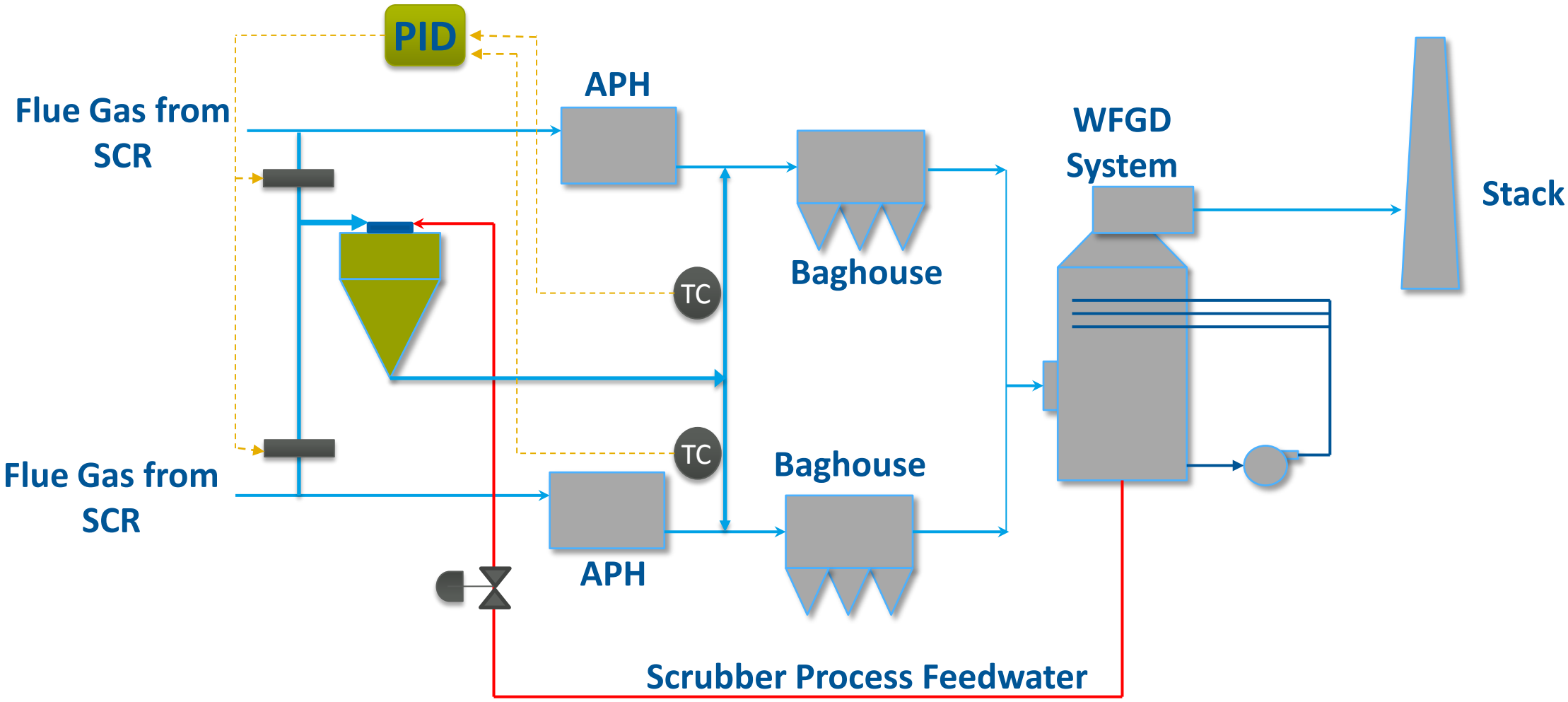

SPRAY DRYER EVAPORATOR OPERATIONAL TIMELINE & FEEDBACK

SPRAY DRYER EVAPORATOR OPERATIONAL TIMELINE

January 2017 — July 2017

Jan 3rd
First pass
Flue Gas

Jan 6th
First water spray

Jan 11th
Achieve 50 gpm
Evaporation

Feb 9th
First atomizer swap
SDE Internal Inspection

Feb 14th
SDE Testing

April 12th
Flex shaft atomizer replaced
under warranty in 1 day

May 5th – 11th
One Feed Pump Repaired
(foreign object damage)

July 6th
6 months of
Operation (>98% avail)

SPRAY DRYER EVAPORATOR
OPERATIONAL FEEDBACK

- The SDE™ is fully automated with operator entered setpoints for SDE feed flow and outlet temperature
  - Auto-start and auto-stop are also programmed
  - Operators currently start and stop in manual so they have a better understanding of the controls and sequence
- Operations has commented that the SDE™ "runs in the background" because it requires little attention
- KCP&L did not hire any additional staff for the SDE™
  - All control screens are visible on boiler control screen

SPRAY DRYER EVAPORATOR MAINTENANCE PROCEDURE

- Routine Daily Checks
  - Equipment walkdown and instrument check
- Weekly Checks
  - Lubrication levels & equipment wear
  - Rotate SDE Feed Pumps weekly
- Every 6-8 weeks
  - Atomizer swap
  - Check damper operators
  - Check accuracy of gauges and meters

BALANCE OF PLANT
BYPRODUCT HANDLING SYSTEM

- System Type
  - Vacuum or Pressure
- Supplier
  - UCC
- System Design
  - Currently sent to a landfill
  - 6-months into a 12-month study to determine sale-ability of flyash

SPRAY DRYER EVAPORATOR PERFORMANCE RESULTS

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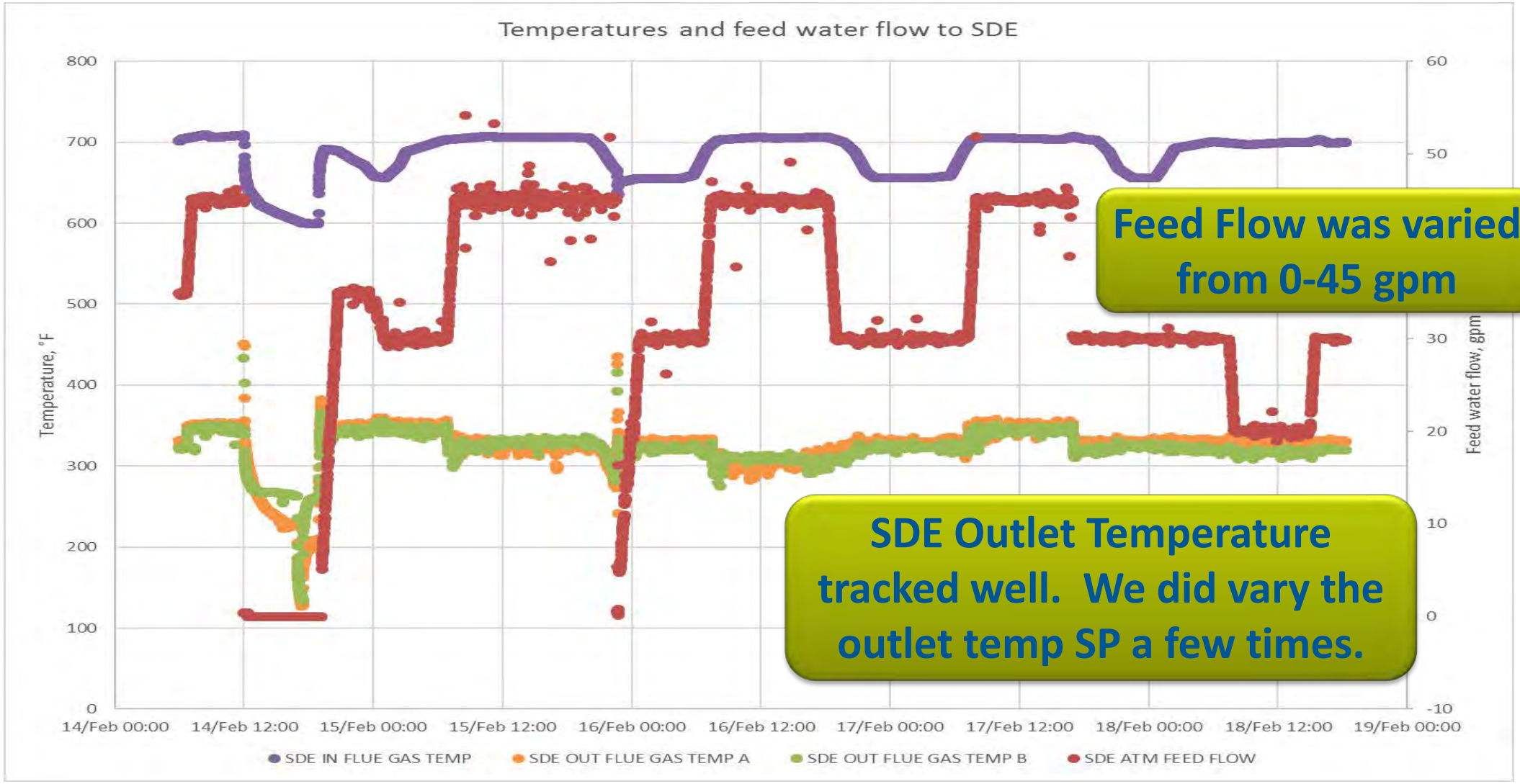
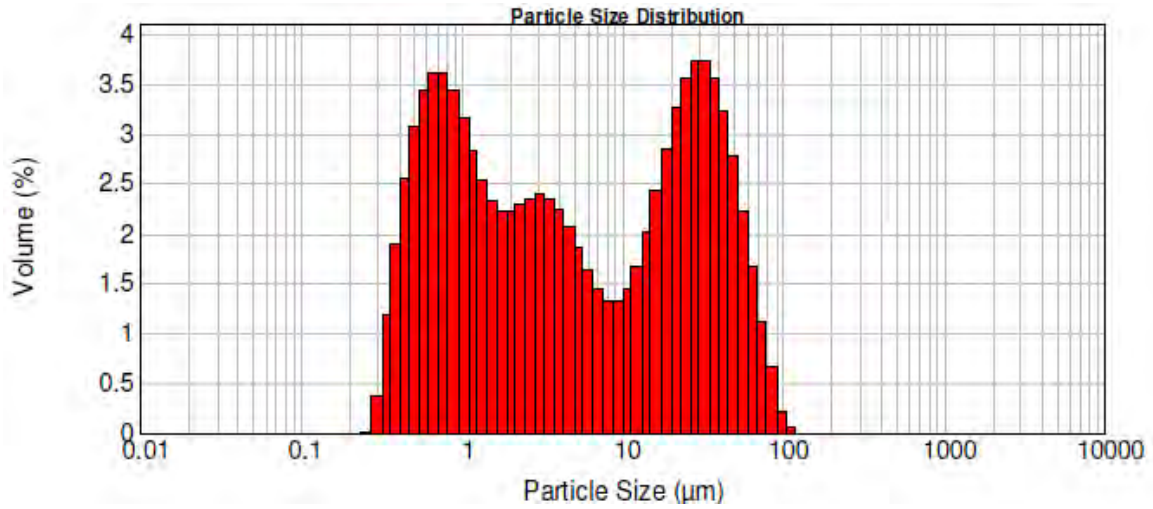


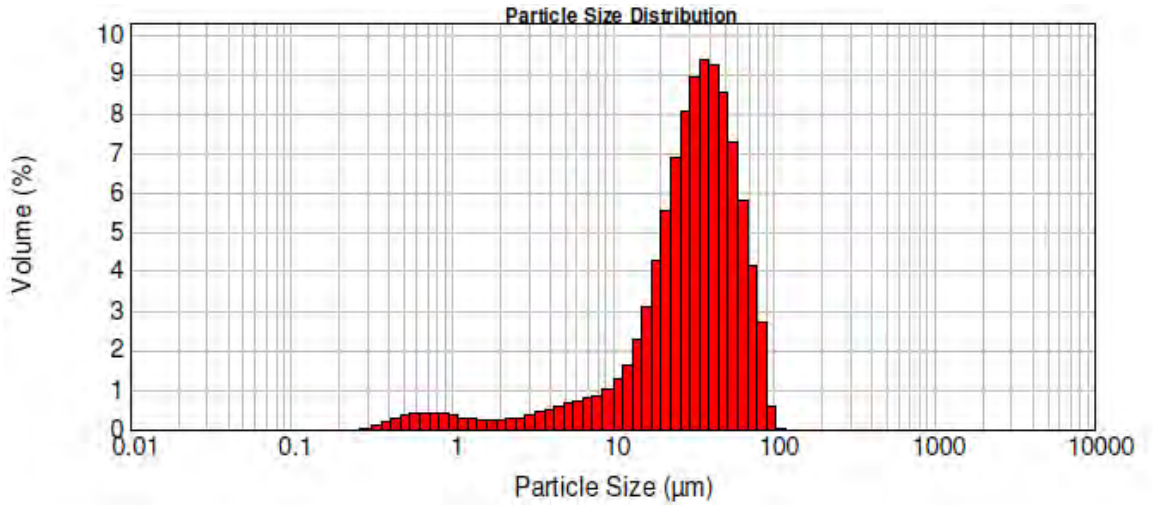
SPRAY DRYER EVAPORATOR PERFORMANCE RESULTS

- Particle Size Distribution
  - SDE byproduct ranged from 10-100 µm
  - This particle size is fabric filter friendly
  - D50 was ~35 µm

SDE inlet



SDE outlet

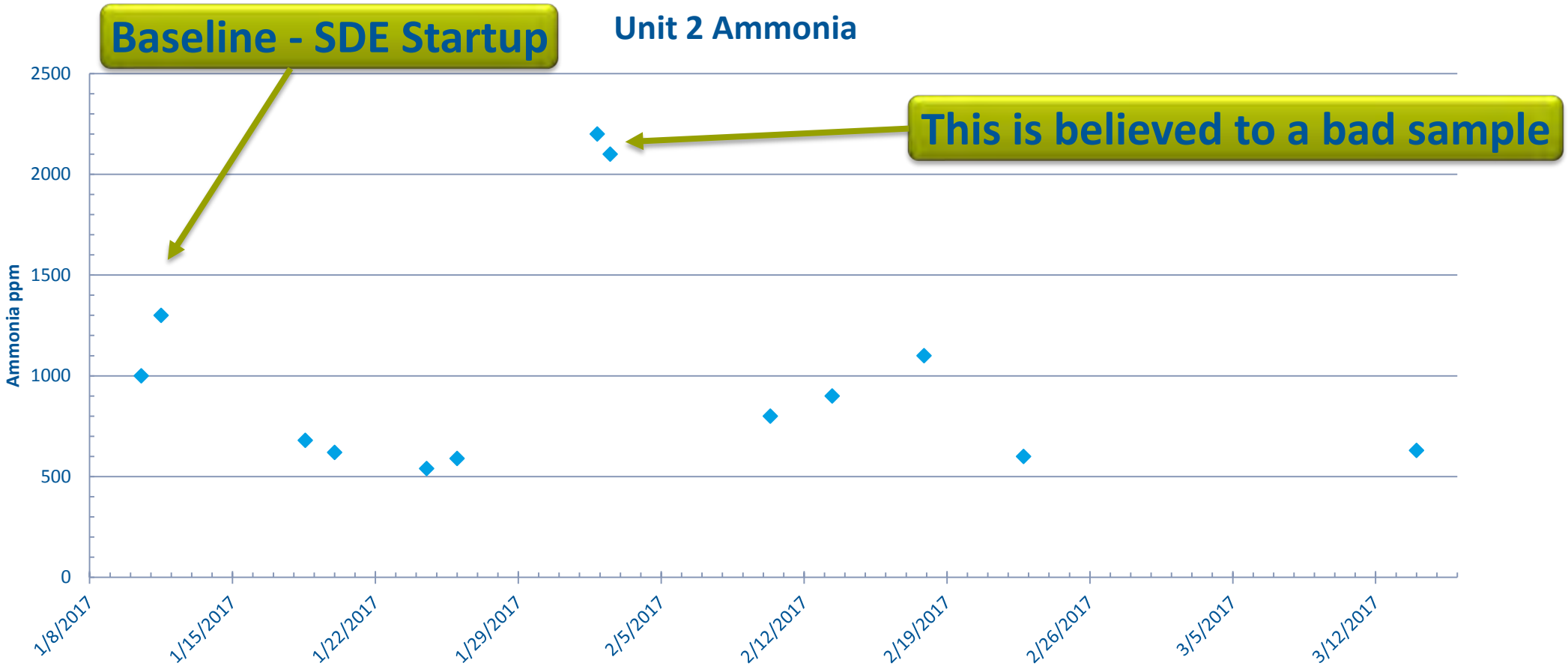


SPRAY DRYER EVAPORATOR
PERFORMANCE RESULTS

- Nitrogen Balance
  - NH4 in SDE Feed Water varied from 600-1200 mg/l
  - Nitrogen balance showed that >94% of NH4 in SDE Feed Water was collected in the FF byproduct
- Metals Balance
  - 100% of As in feed slurry was collected in dried solids
  - 100% of B in feed slurry was collected in dried solids
  - 100% of Se in feed slurry was collected in dried solids
  - ~85% of Hg in feed slurry was collected in dried solids

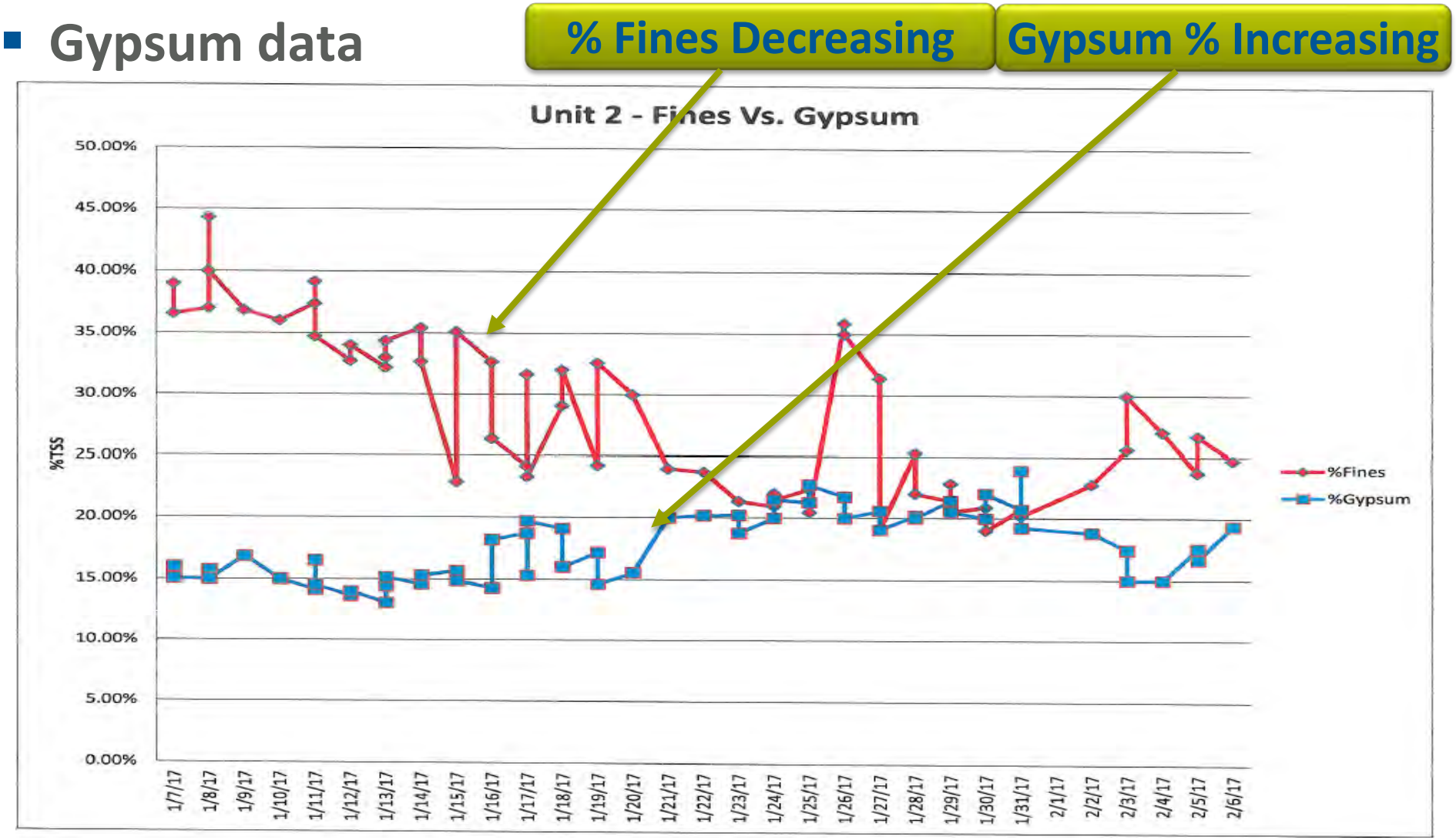
SPRAY DRYER EVAPORATOR PERFORMANCE RESULTS

- WFGD Ammonia Results

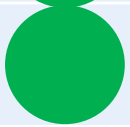


SPRAY DRYER EVAPORATOR PERFORMANCE RESULTS

- Gypsum data



INITIAL OBSERVATIONS VS KEY RISKS

Concern	Preliminary Grade	Comments
Uniqueness of Arrangement		So far, so good, but waiting on summer.
Elimination of Softening		No issues.
Ammonia Balance		Results will take several months to definitively verify.
Fly Ash Handling		Thus far, no issues with ash flowability, storability.
Corrosivity/Erosivity		Result pending internal inspection (Spring 2018).
Construction Risk		Met schedule goal with no impact on plant performance.
FGD Process Improvement		Stable chemistry and improved gypsum quality.

IATAN UNIT 2 SDE PROJECT – IN CONCLUSION

- The SDE is a “utility grade” solution for evaporating scrubber process feedwater
- Online >98% since placed into service on 7-Jan
  - “Runs in the background”, which was a key objective
- Balance of Plant impact assessment ongoing