

REINHOLD ENVIRONMENTAL Ltd.



## **2019 NO<sub>x</sub>-Combustion-CCR Round Table Presentation**

February 11 & 12, 2019, in Salt Lake City, Utah / Hosted by PacifiCorp

All presentations posted on this website are copyrighted by Reinhold Environmental, Ltd (RE). Any unauthorized downloading, attempts to modify or to incorporate into other presentations, link to other websites, or obtain copies for any other uses than the training of attendees to RE's Conferences is expressly prohibited, unless approved in writing by RE or the original presenter. RE does not assume any liability for the accuracy or contents of any materials contained in this library which were presented and/or created by persons who were not employees of RE.

# Duke Energy Gas Co-Firing

*The Why, The Where and The How*



Brad Rudolph – PE  
Dual Fuel Program Manager







Room Safety Awareness

Hotel Safety





## What is DFO / Co-firing?

Dual Fuel Optionality (DFO) is the ability to generate electricity using 1 of 2 fuels.

- For this program we are using Coal and Natural Gas

The DFO Program is taking existing coal generating sites and adding the capability of using Natural Gas to generate electricity without changing the ability to utilize Coal to generate

Dual Fuel Optionality and Gas Co-firing are used interchangeably



## Why Gas Co-firing at Duke Energy



Increase fleet flexibility to adapt to renewables

- Lowered Unit Minimum Load
- Increased Unit Ramp Rates



Deliver savings to our customers

- Option to utilize lowest cost fuel on a daily basis
- Drive competition

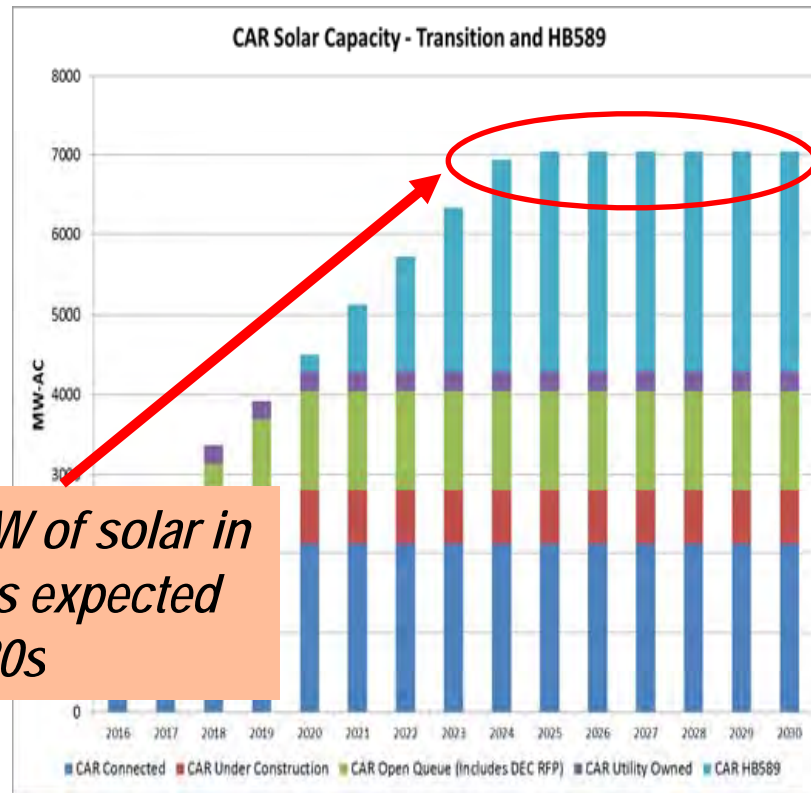
Reduce environmental footprint

- Reduced CO<sub>2</sub>
- Reduced NO<sub>x</sub>, SO<sub>x</sub>, Hg
- Reduction in Fuel Oil usage and handling





## Carolinas Solar Growth Forecast



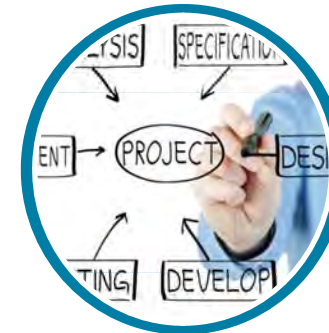
*Over 7GW of solar in Carolinas expected by mid-20s*

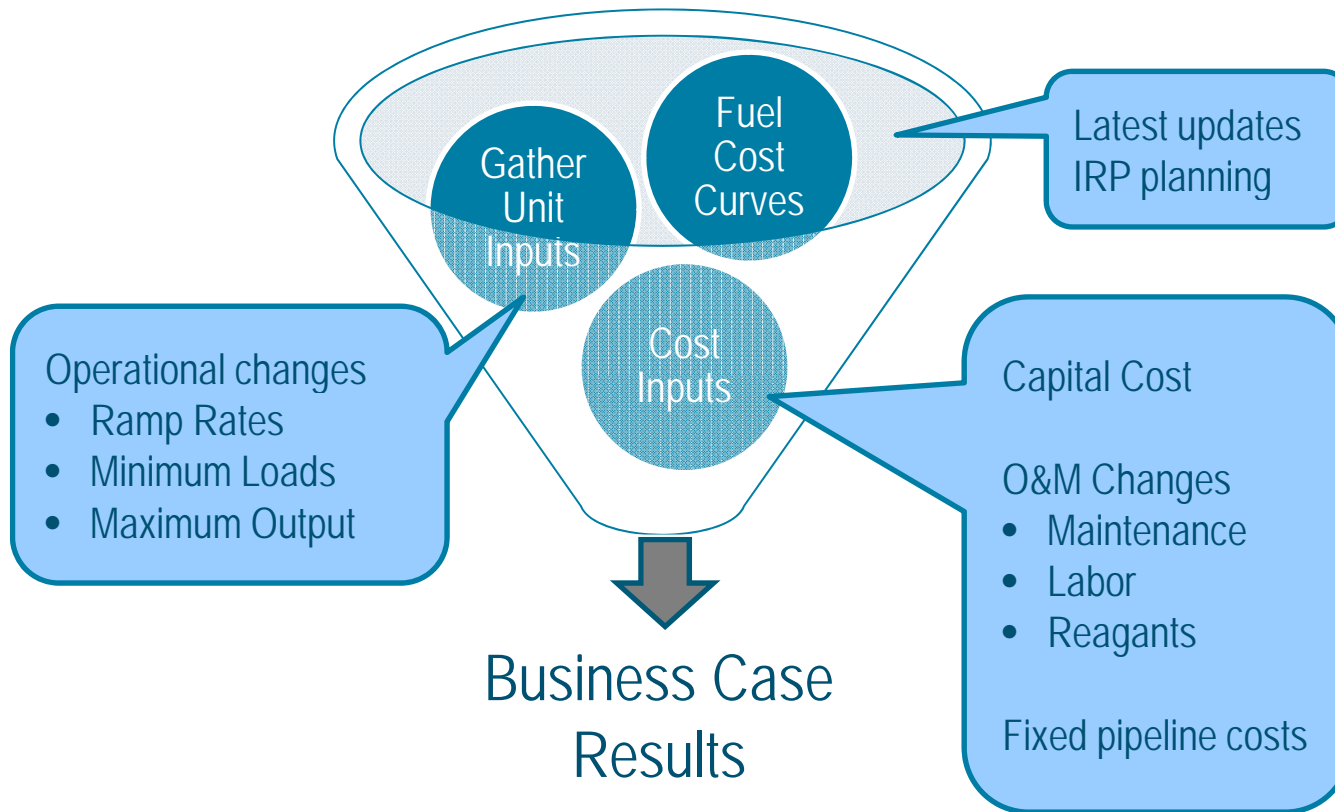
- New MW from NC HB 589 (07/2017)
- Pending MW
- Connected MW



## Project Development Approach

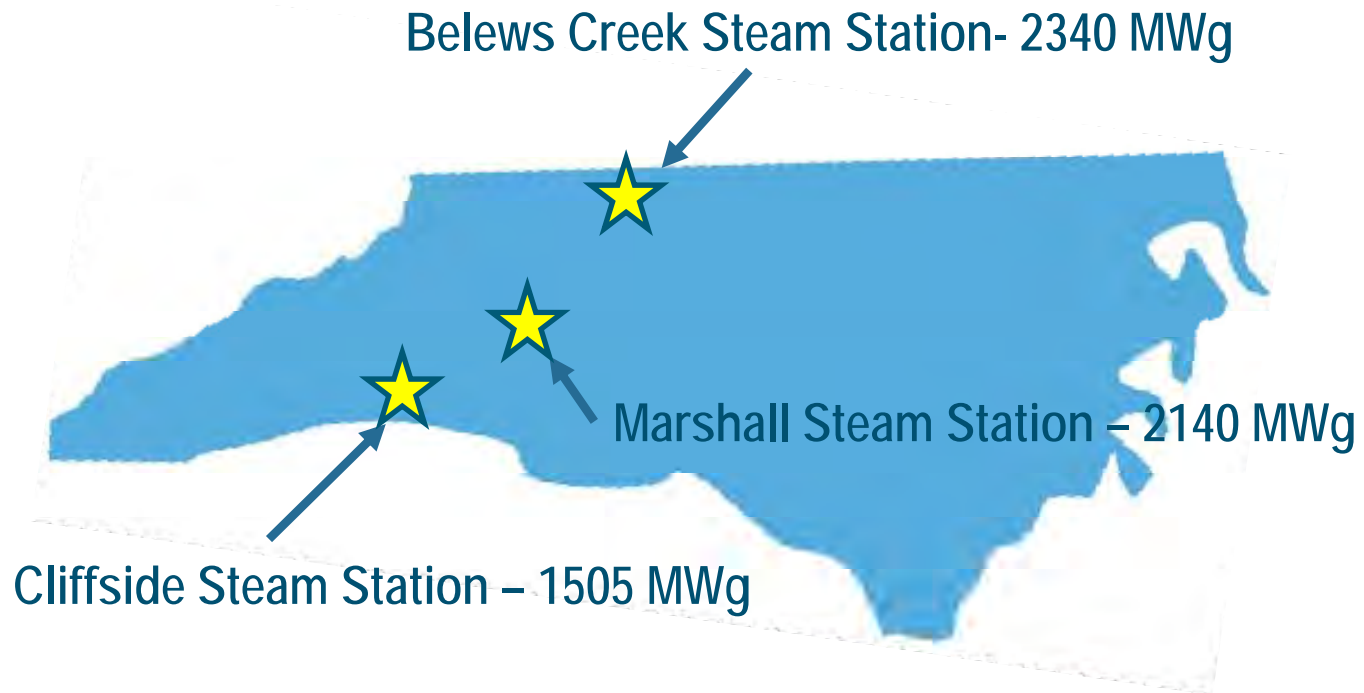
- Concept
  - What is the Co-fire ratio?
  - Technology approach
- Feasibility review
  - Boiler combustion and Heat Transfer
  - BOP Design Considerations
- Industry benchmarking
  - Anyone done this on a similar boiler?
- Internal economic analysis
  - Value to Duke and to our Customers







## Where Gas Co-firing at Duke Energy



Still evaluating additional sites per strategic and systems needs

#### Cliffside 5

- Combustion Engineering – 600 MWg
- 4 Corner Tilting Tangential boiler
- Sub-Critical operation

#### Cliffside 6

- Hitachi – 905 MWg
- Opposed Wall Fired, Spiral Furnace
- Super-Critical operation

#### Belews Creek 1 & 2

- Babcock and Wilcox - 1170 MWg ea
- Opposed Wall Fired boiler
- Super-Critical operation

#### Marshall Units 1 & 2

- Combustion Engineering – 370 MWg ea
- 8 Corner Tilting Tangential boiler
- Sub-Critical operation

#### Marshall Unit 3 & 4

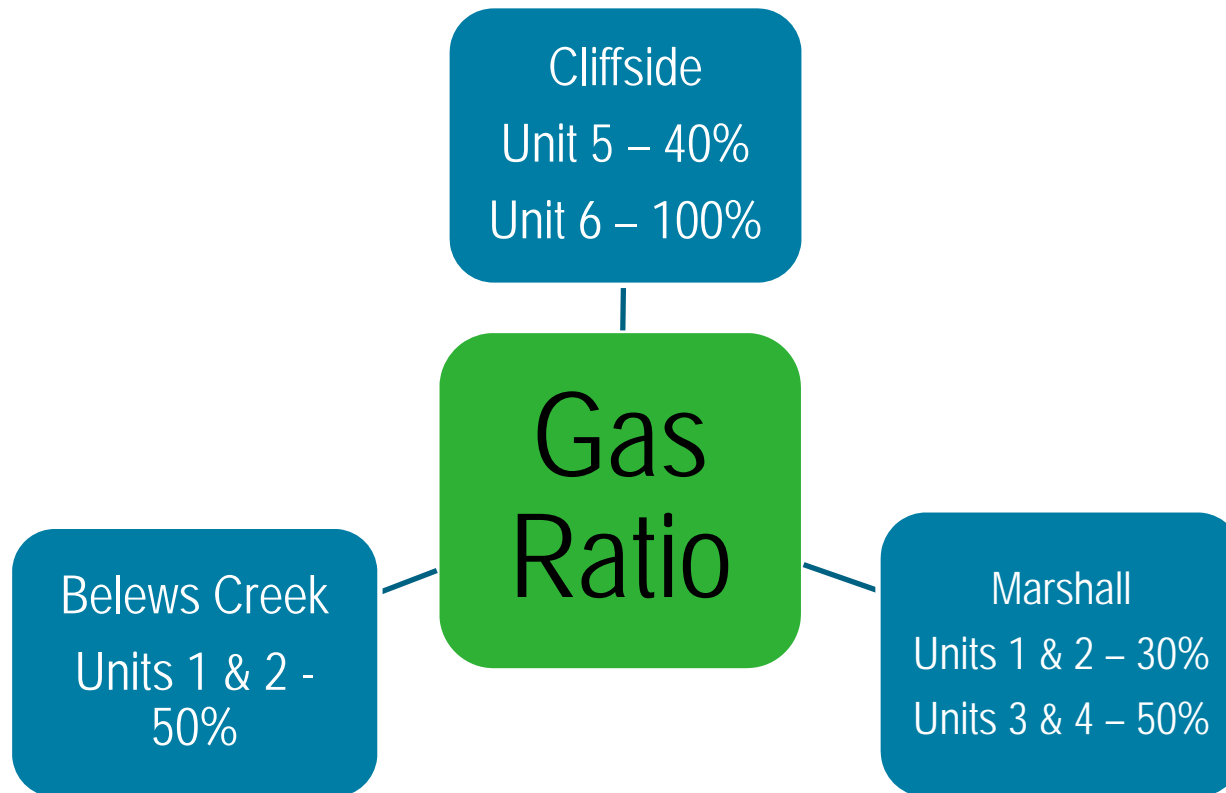
- Combustion Engineering – 700 MWg ea
- 8 Corner Tilting Tangential boiler
- Super-Critical operation



- Cliffside Steam Station
  - Unit 5 and Unit 6 in Service Q4 2018
  
- Marshall Steam Station
  - Engineering complete Q1 2019
  - Construction to start late Q2 2019
  - First unit target in service Q3 2020
  
- Belews Creek Steam Station
  - Engineering complete Q4 2018
  - Construction to start early Q2 2019
  - First unit target in service Q1 2020

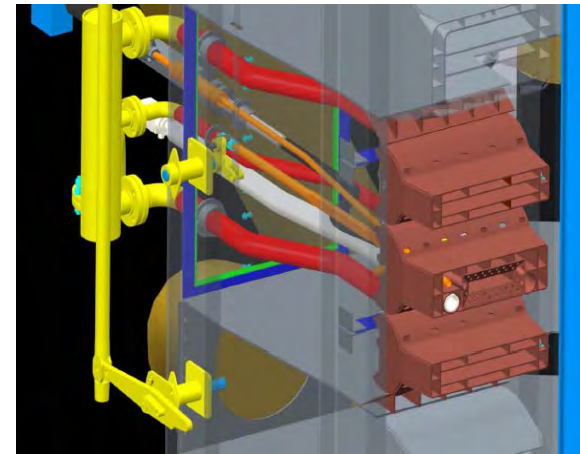






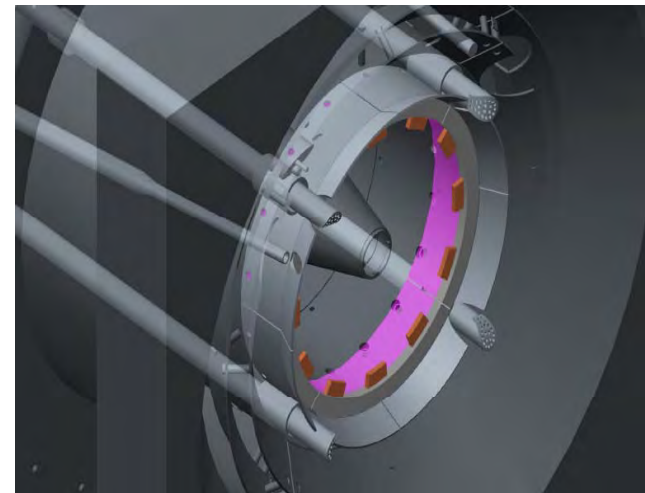
### Gas System Design

- Burner Supplier: Riley Power (Patent Pending)
- Wafer Style Tilting Gas Burners
  - Located in Auxiliary Air Ports
- 1 Level of Wafer Style Ignitor for LOFIR level
  - Located in Auxiliary Air Port
- Class III Special Ignitor
  - Direct High Energy Spark Ignition (HESI)
- Number of Gas Pressure Control Skids dependent upon unit tiering
  - High tier units have 1 Control Skid per burner level
  - Lower tier units have 1 Control Skid per 2 burner levels



### Gas System Design

- Burner Supplier – Riley Power (Patent Pending)
- Cane style gas burner located in Secondary Air Plenum of existing coal burners
- Retractable Cane Design
- Class III Special Ignitor
  - Direct HESI ignition
- 1 Gas Pressure Control Skid per burner level



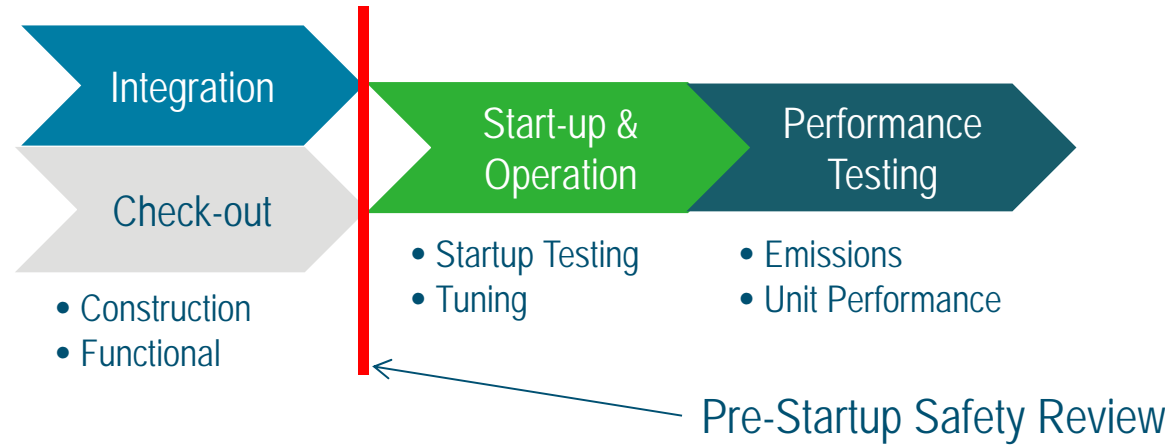


## Cliffside operational lessons to date





# Project Commissioning



*Integration:* Getting the **People** and **Processes** ready to operate the equipment

*Check-out:* Getting the **Equipment** ready to be operated

1. Gas Light Off Testing
  - Testing ignition of a single gas burner, flame scanner tuning. Group Start Testing
2. Initial Loading Plan
  - Build boiler pressure, gas valve tuning, Sync to grid on gas, load to max gas capacity with tuning
3. Gas Run Back Testing
4. Coal Start-up with Gas Ignition Testing
  - Typical unit start with coal but using gas for ignition not fuel oil
5. Co-firing Run Back Testing
6. Gas Minimum Load Testing
  - Testing of new unit minimum with tuning
7. Co-firing Ratio Testing
  - Testing with different coal to gas ratios, ramping and tuning.
8. Fuel Swap Testing
9. Ramp Rate Testing



### Unit Design

- Commercial in 1972
- 600 MWg
- Combustion Engineering Boiler
- 4 Corner T-Fired
- 24 coal burners
- 2400 psig (Sub-Critical)
- 1005 F SH / RH
- 100% MCR Heat Release 5910 mmBTU/hr
  
- SOFA
- CCOFA
- LOFIR

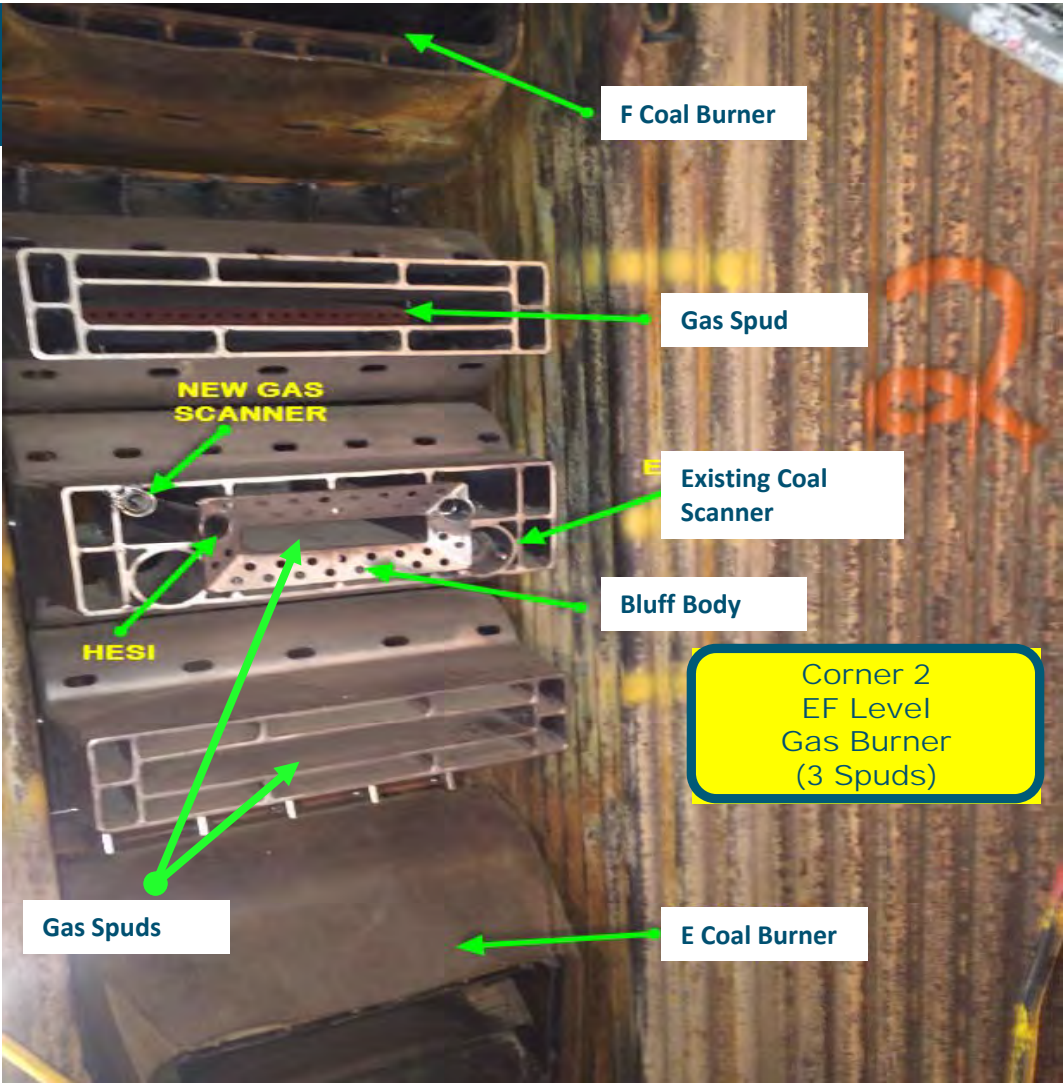
Environmental Controls include

- Selective Catalytic Reduction (SCR)
- Electrostatic Precipitator
- Wet Flue Gas Desulfurization (WFGD)



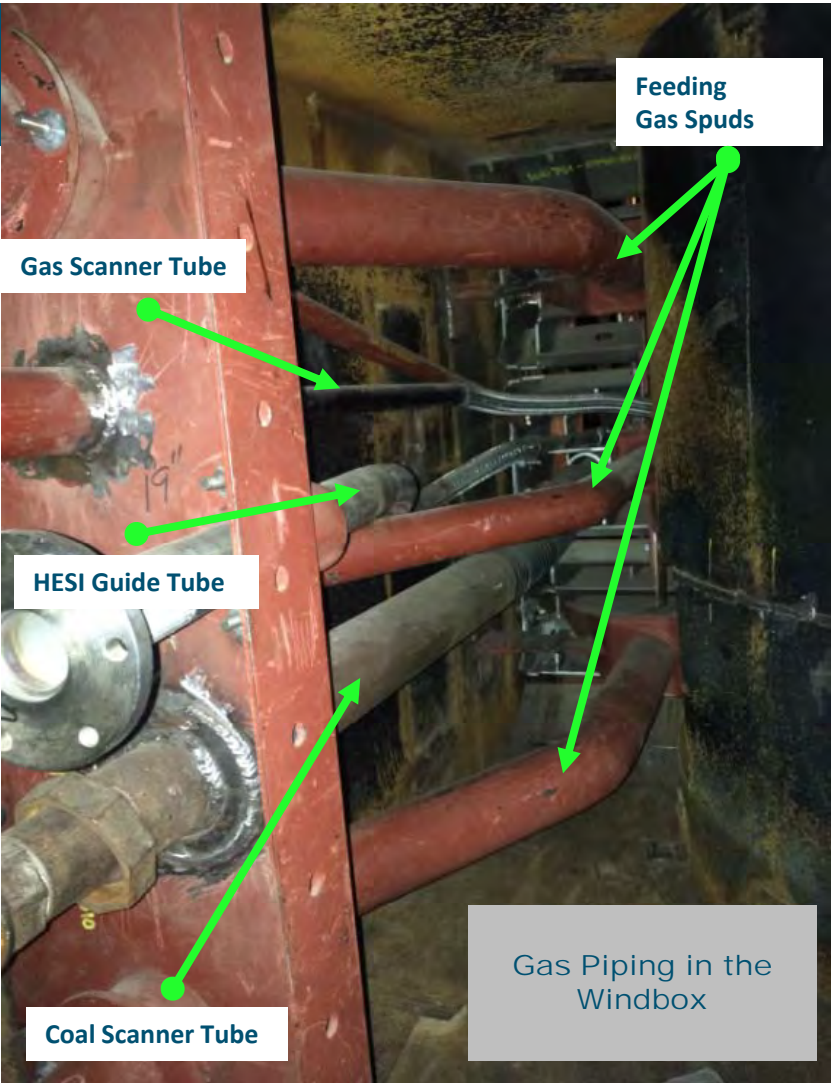


Cliffside 5



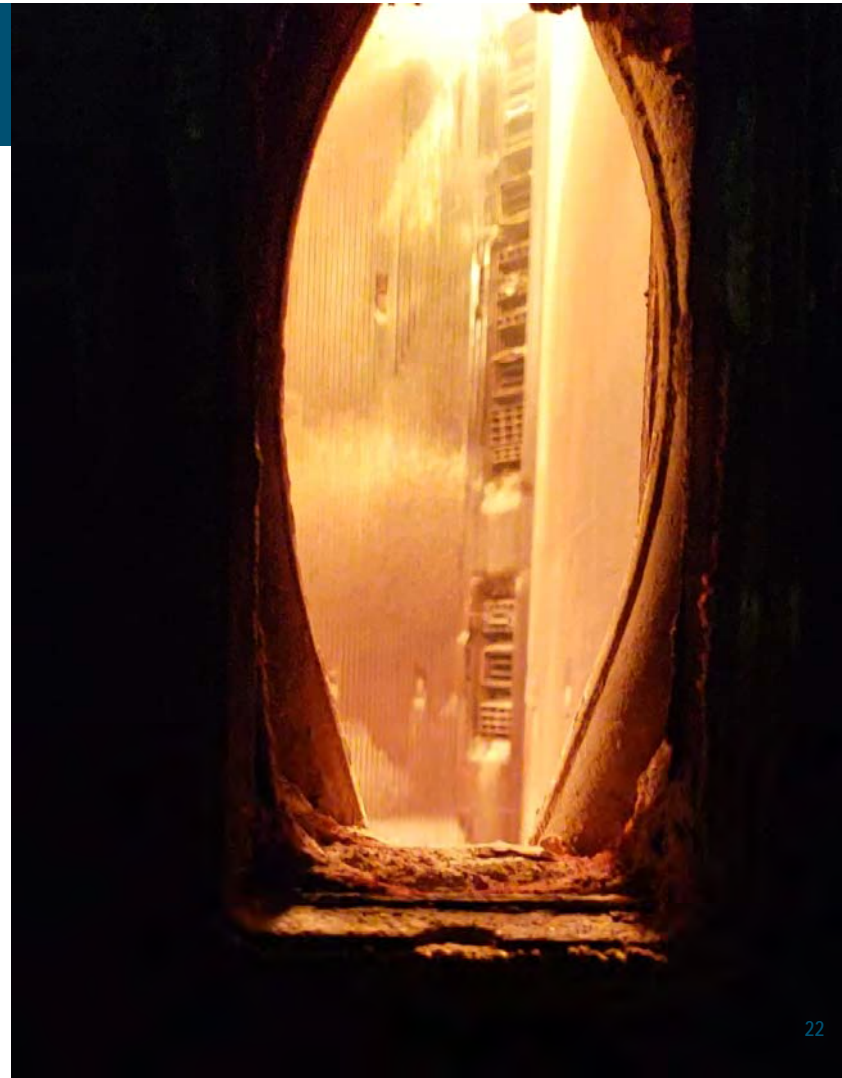


Cliffside 5



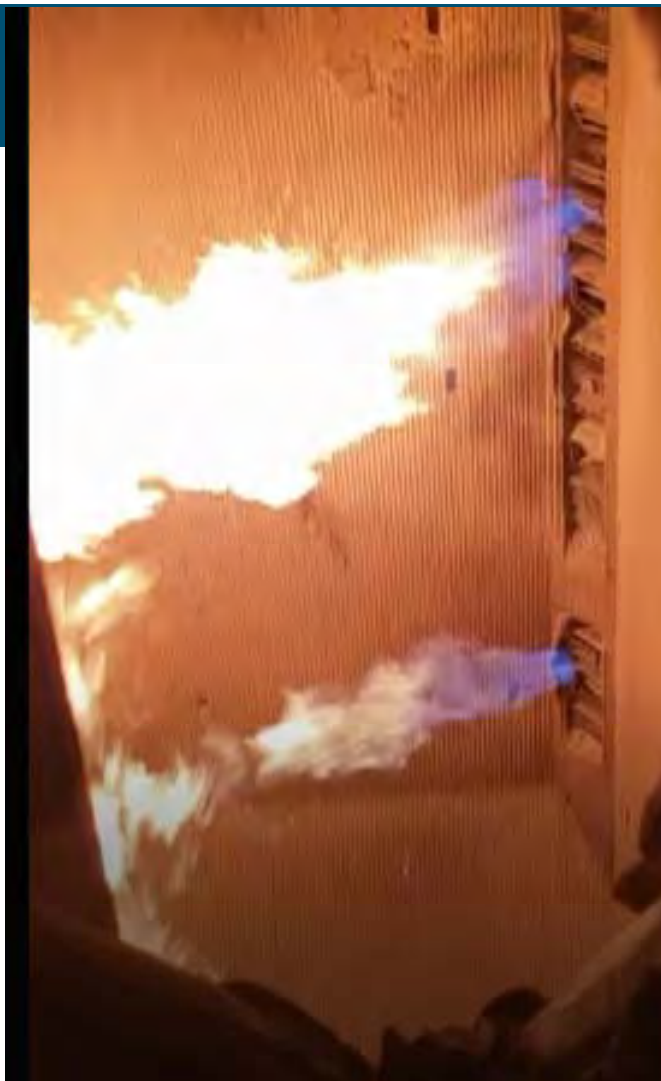


Cliffside 5  
Early Ignition Testing on  
LOFIR Gas Ignitor





Cliffside 5

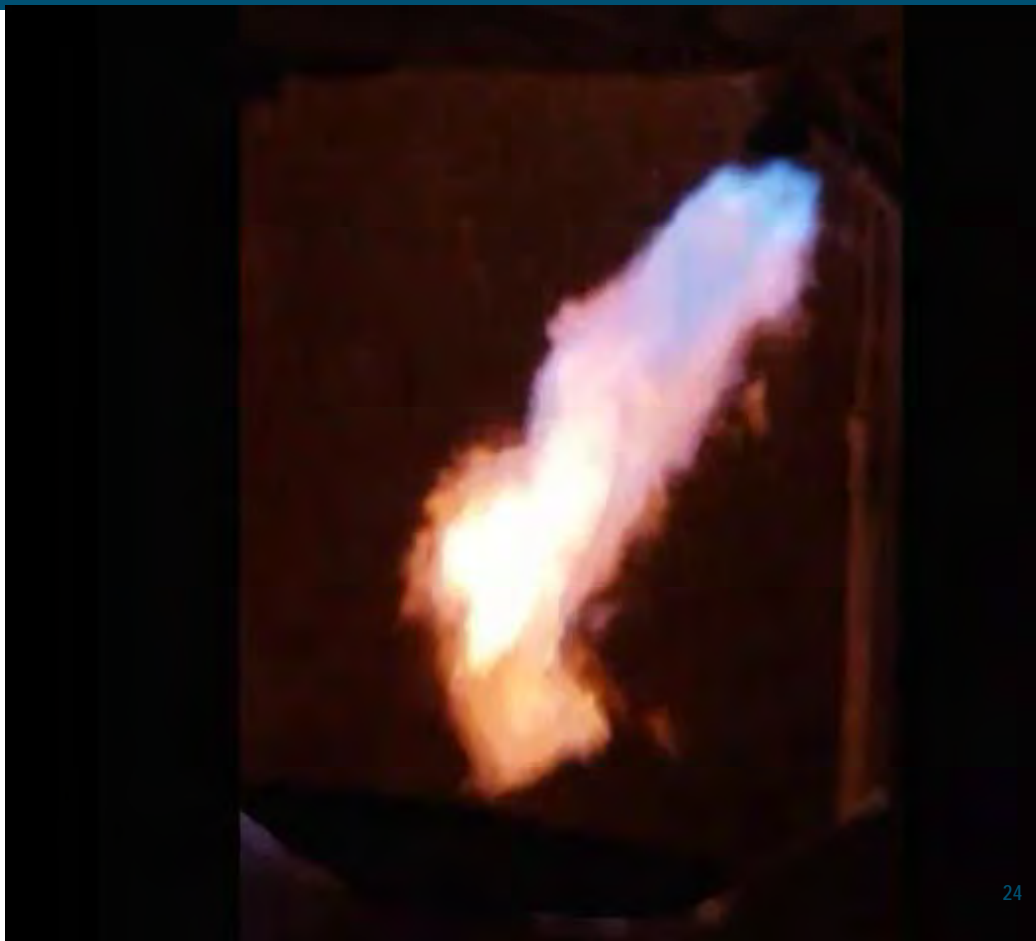


Main Gas Burner

LOFIR Gas Ignitor

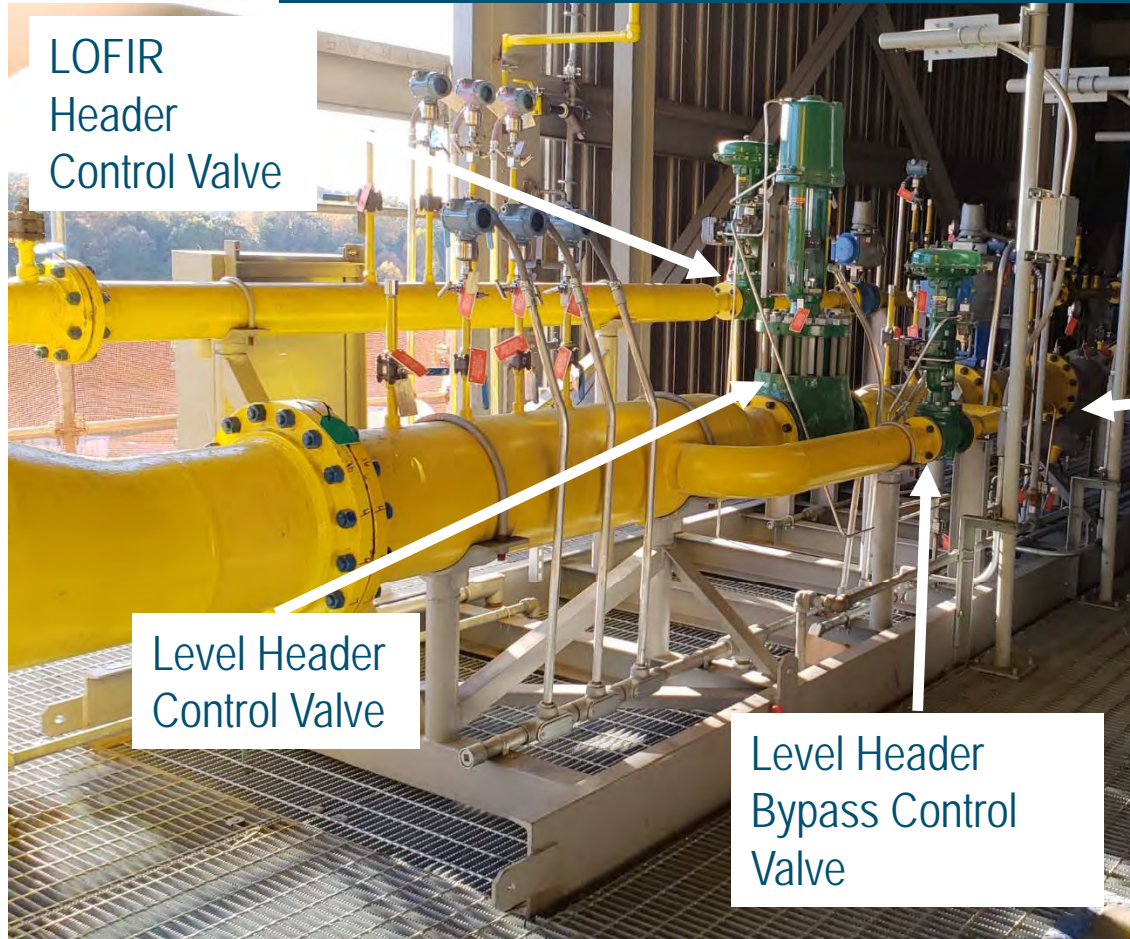


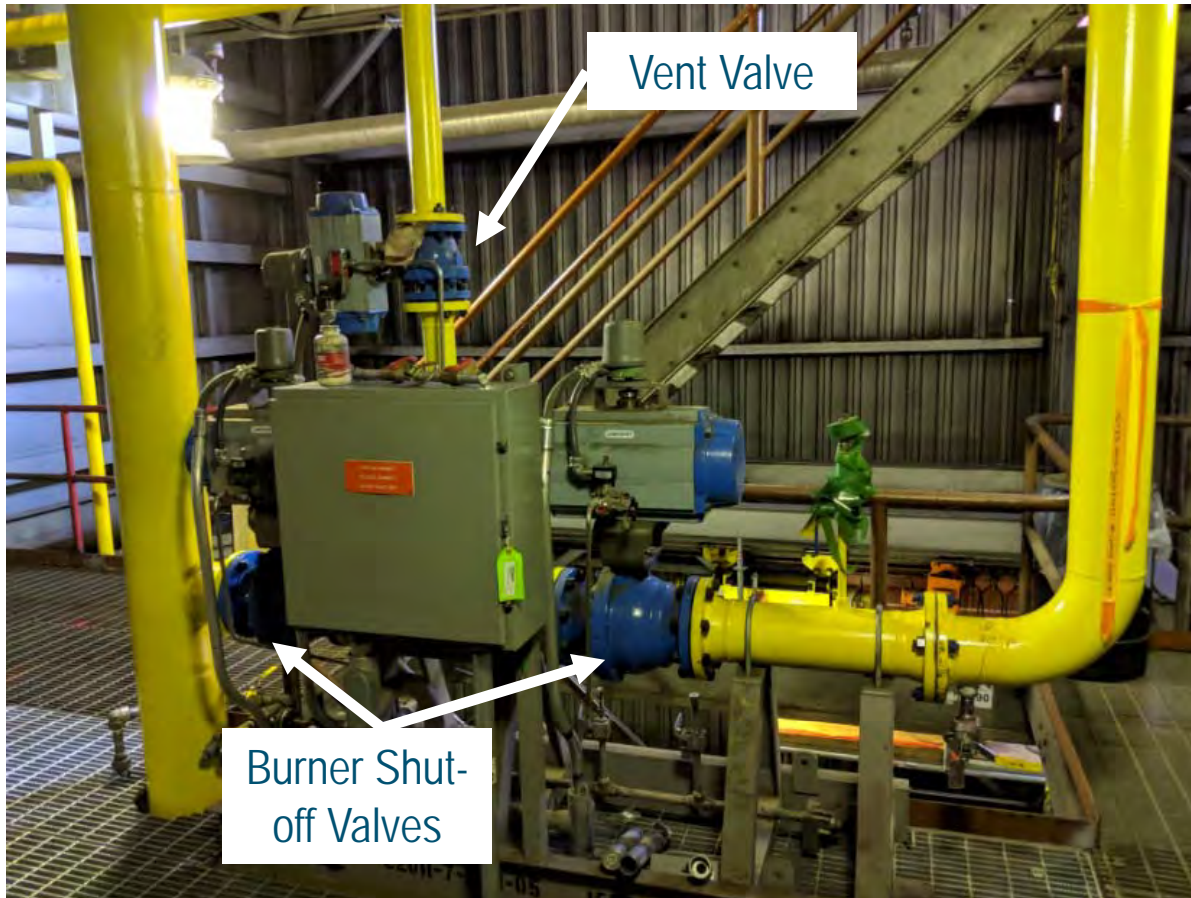
Cliffside 5  
Main Gas Burner  
Overhead View





## Cliffside Unit 5 Fuel Control Skid







## Cliffside 5 – Preliminary Results

### POSITIVES

Burner design output achieved

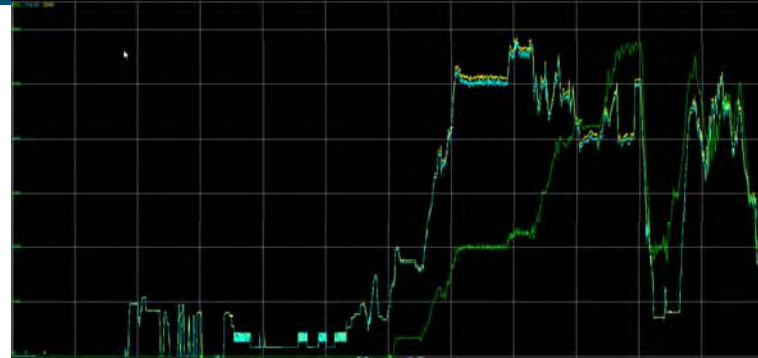
Steam temperatures maintained

FGD operations impacted as expected

- Slurry temp increased with higher gas ratio

Improved unit startup for operations

Excellent operations support and moral with the change



### CHALLENGES

Flame stability at low gas pressures

- Line of sight

Turbine start-up – differential expansion



## Cliffside 5 – Preliminary Results

Emissions (no tuning done to date)

- CO – No samples pulled to date
- SCR Inlet NOx
  - 40% Co-Fire: ~ 20% Reduction

Min Load – 50 MWg reduction from Coal to Gas operation

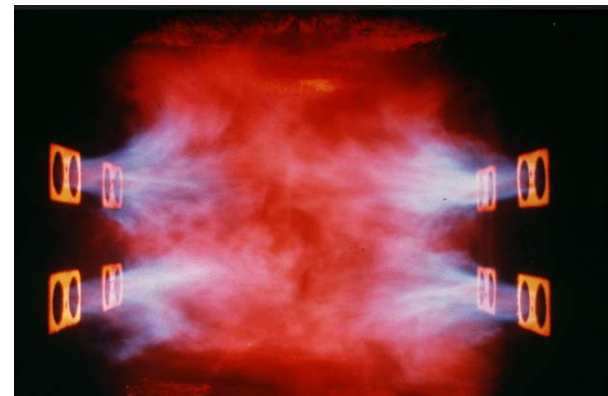


## Unit Design

- Commercial in 2012
- 905 MWg
- Hitachi Boiler
- Opposed Wall Fired Spiral Furnace
- 30 coal burners / 3 Elevations per Wall
  - Full load on 25 burners
- 3700 psig (Super-Critical)
- 1055 F SH / 1075 F RH
- Each Burner Heat Release = 320 mmBTU/hr
  
- OFA
- Side Air Ports

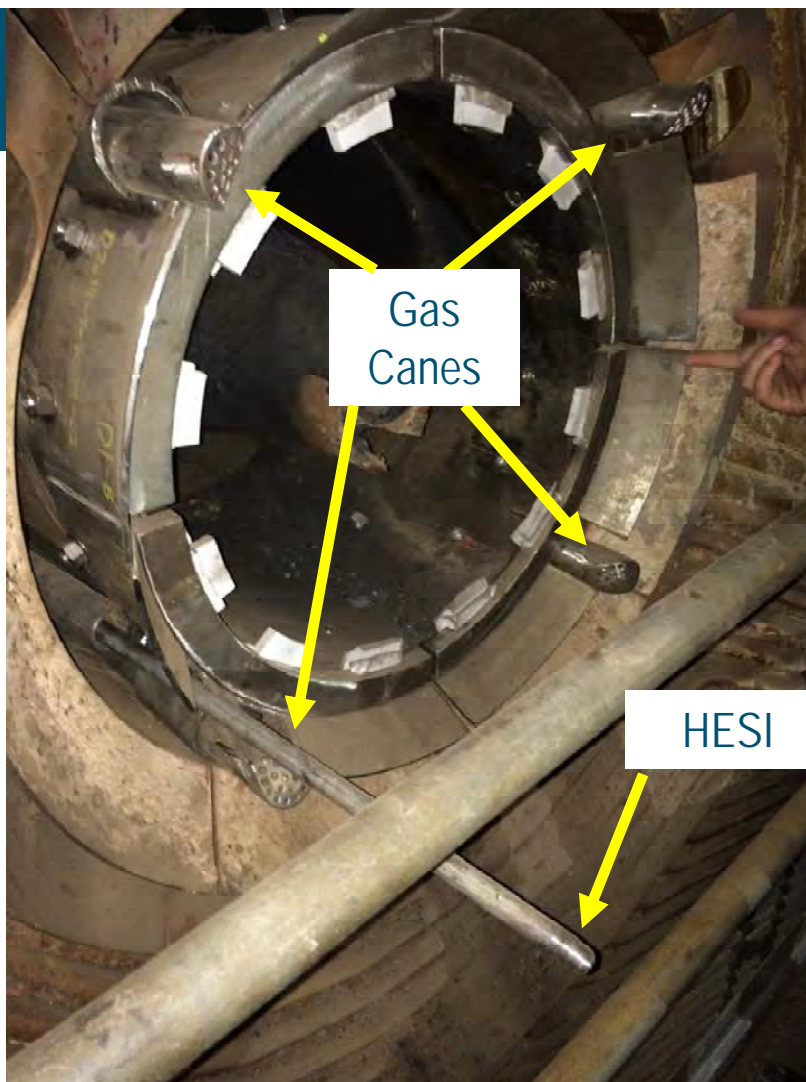
Environmental Controls include

- Selective Catalytic Reduction (SCR)
- Spray Dryer Absorber (SDA)
- Fabric Filter
- Wet Flue Gas Desulfurization (WFGD)





Cliffside 6





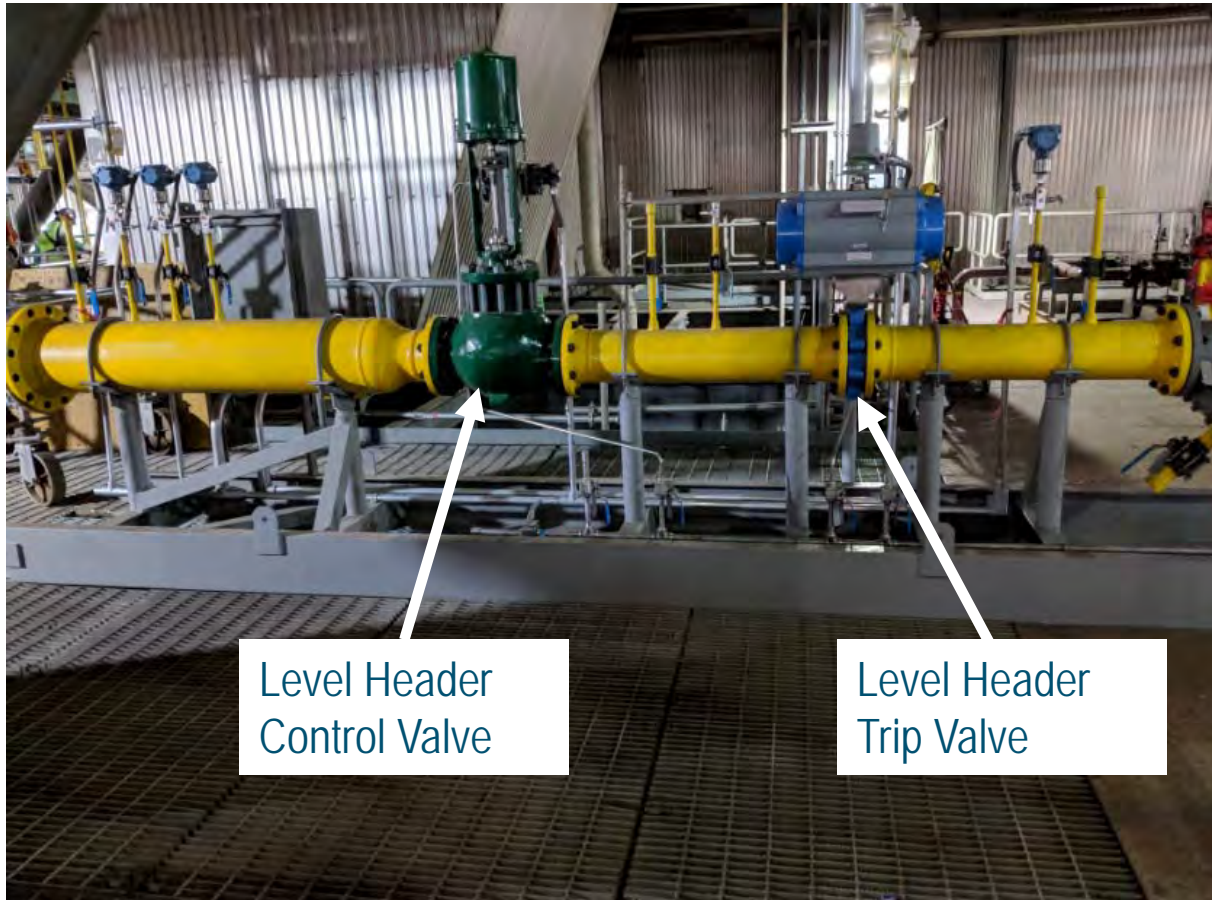
Cliffside 6

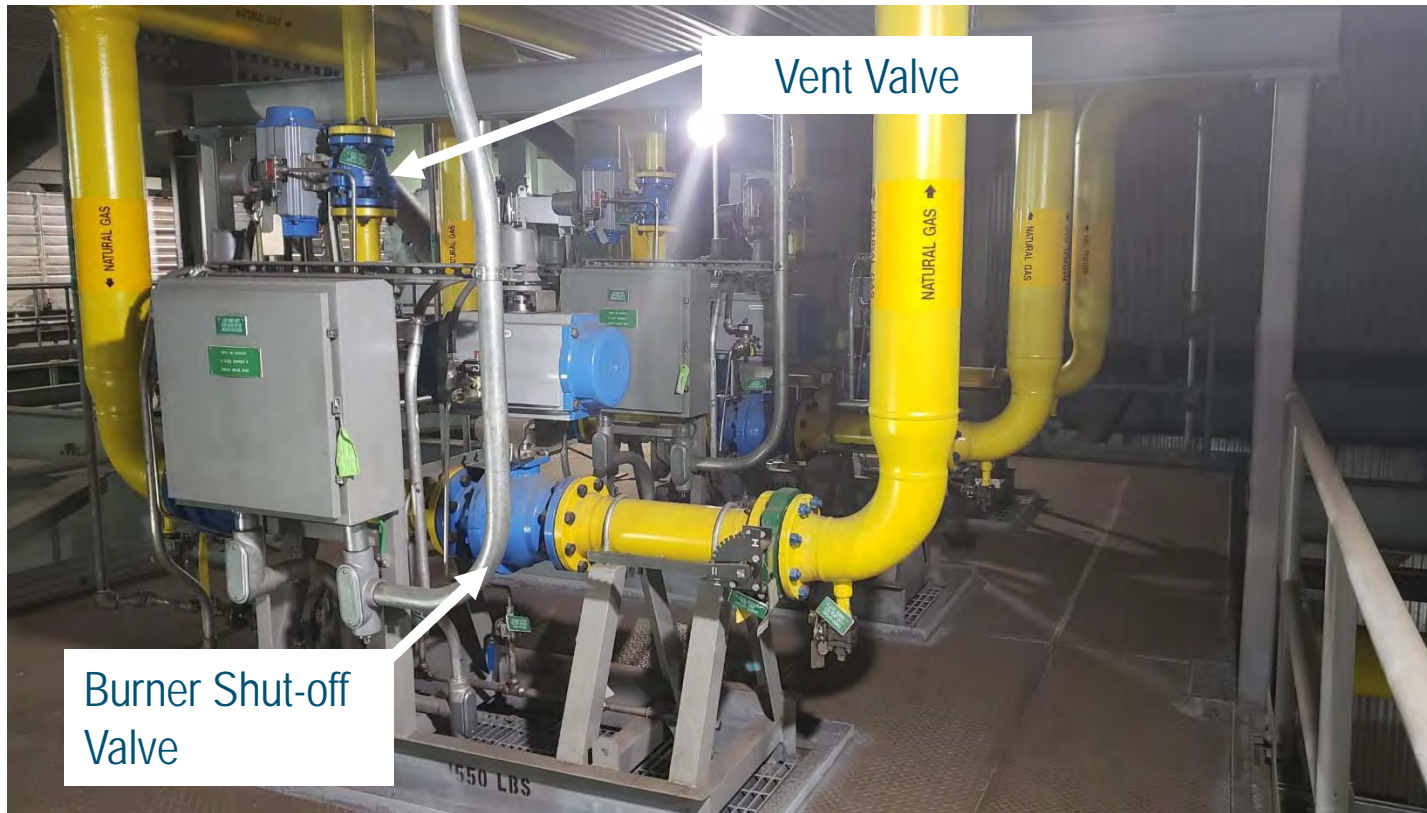




Cliffside 6  
Main Gas Burner  
Low Output















## Cliffside 6 – Preliminary Results

### POSITIVES

Burner design output achieved

Maintained design steam temperatures

- More tuning needed to maintain during ramps

Improved unit startup for operations

Less impact to some AQCS systems than expected

- SDA
- SCR

~ 11 MW reduction in Auxiliaries on 100% Gas

Excellent operations support and moral with the change

### CHALLENGES

Flame stability at low gas pressures

- Line of sight

Turbine start-up – differential expansion

Baghouse operation during startup



## Emissions (no tuning done to date)

- CO – well under target depending on Excess Air
  - SCR Inlet CO ~ 2000 ppm with 10-12% Excess Air
  - SCR Inlet CO 0 ppm with 15% Excess Air
- SCR Inlet NOx
  - 100% Gas: ~ 40% reduction from Coal at 12% Excess Air (CO issue)
  - 50% Co-Fire: No change at this point – running 18% Excess Air
    - OFA Damper Control Issue

Boiler Excess Air  
~ 18% on Coal  
At 100% MCR

## Min Load – 120 MWg reduction from Coal to Gas operation

- Unit Dry to Wet transfer is the limiting factor at this point
- Previously min load based on stable pulverizer operation
- SCR temps above 475 F at new lower min load

## Ramp Rate

- Increase from 10 MW/min (Coal) to 20 MW/min (Gas)

### Cliffside 5 and 6

- Continue to diagnose and develop options for correcting flame stability / line of sight issues
- Continue to research and evaluate start-up conditions at the turbine and develop countermeasures to improve
- Continue to gather operational learnings that lead to additional opportunities to improve
- Emissions tuning and optimization

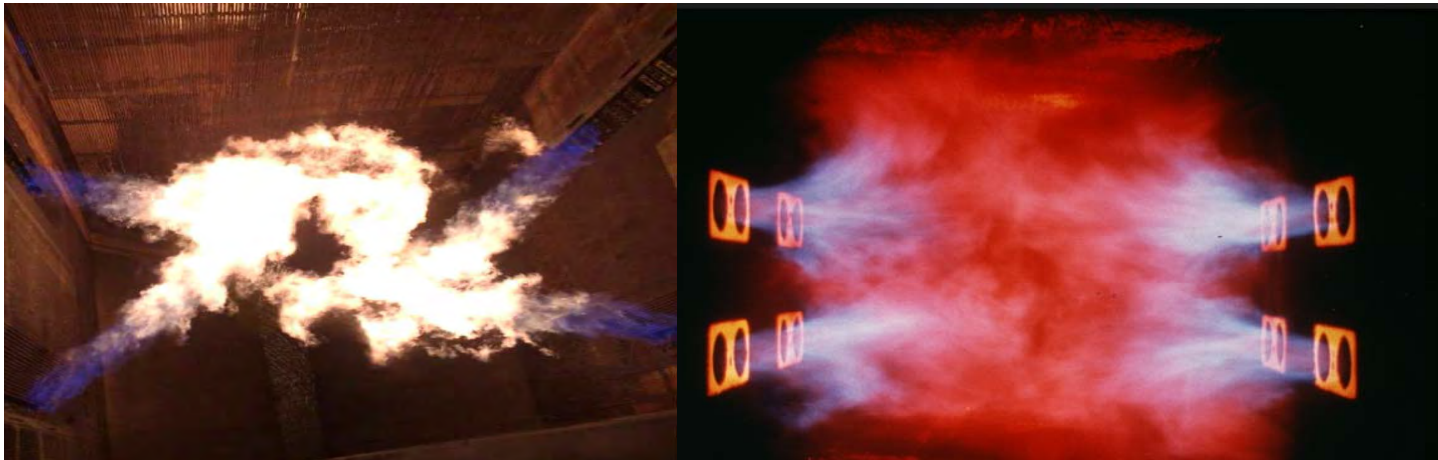
### Cliffside 6

- Finish unit optimization and ramp rate tuning





# Questions ??





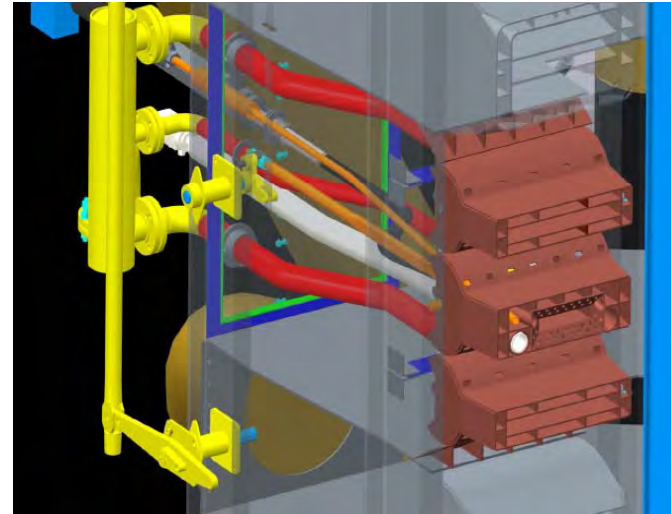




## Appendix – additional pictures and site info

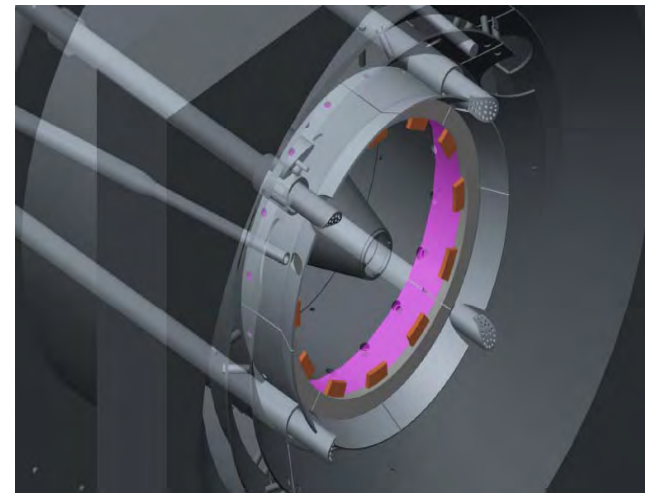
### Gas System Design

- Burner Supplier: Riley Power
- 40% Gas Capacity
- 2 Levels of Wafer Style Gas Burners – 8 Burners
  - Located in Auxiliary Air Ports
- Each Burner Heat Release = 271 mm BTU/hr
- 1 Level of Wafer Style Ignitor for LOFIR level
  - Located in Auxiliary Air Port
- Each Ignitor Heat Release = 40 mmBTU/hr



### Gas System Design

- Burner Supplier – Riley Power
- 100% Gas Capacity
- 30 Gas Burners / 3 Elevations per Wall
  - All 30 gas burners needed for full load
- Each Burner Heat Release = 263 mmBTU/hr
  
- Cane style gas burner located in Secondary Air Plenum of existing coal burners
- 1 Gas Pressure Control Skid per burner level (Qty 6)





## Belews Creek Units 1 & 2

### Unit Design

- 1170 MWg
- Babcock and Wilcox Boiler
- Opposed Wall Fired
- 80 coal burners / 4 Elevations per Wall
  - Full load on 72 burners
- 3500 psig (Super-Critical)
- 1005 F SH / RH
- 100% MCR Heat Release = 10,590 mmBTU/hr
  
- OFA

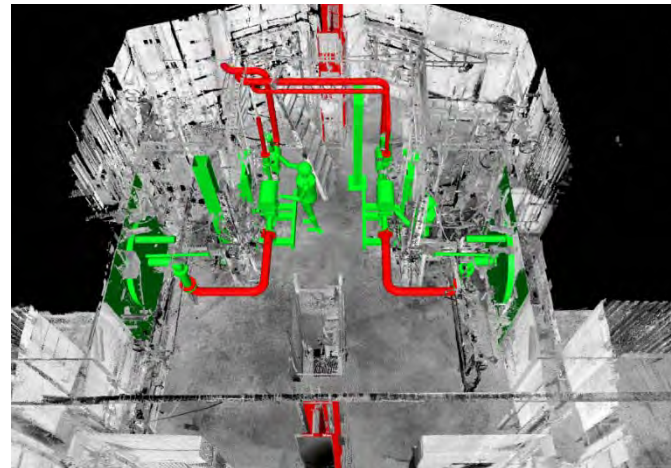
### Environmental Controls include

- Selective Catalytic Reduction (SCR)
- Electrostatic Precipitator
- Wet Flue Gas Desulfurization (WFGD)



### Gas System Design

- 50% Gas Capacity (~70% with ignitors)
- 32 Gas Burners / 2 Elevations per Wall
- Each Burner Heat Release = 171 mmBTU/hr
- Cane style gas burner located in Secondary Air Plenum
- 1 Gas Pressure Control Skid per burner level (Qty 4)
- Goal is to operate with 4 gas levels and 4 pulverizer burner sets in service at full load
- Replacing fuel oil ignitors with natural gas ignitors on remaining 48 burners = 50 mmBTU/hr



### Unit Design

- 370 MWg
- Combustion Engineering Boiler
- 8 Corner T-Fired
- 40 coal burners
- 2400 psig (Sub-Critical)
- 1050 F SH / 1000 F RH
- 100% MCR Heat Release = 3885 mmBTU/hr
  
- SOFA
- CCOFA
- LOFIR

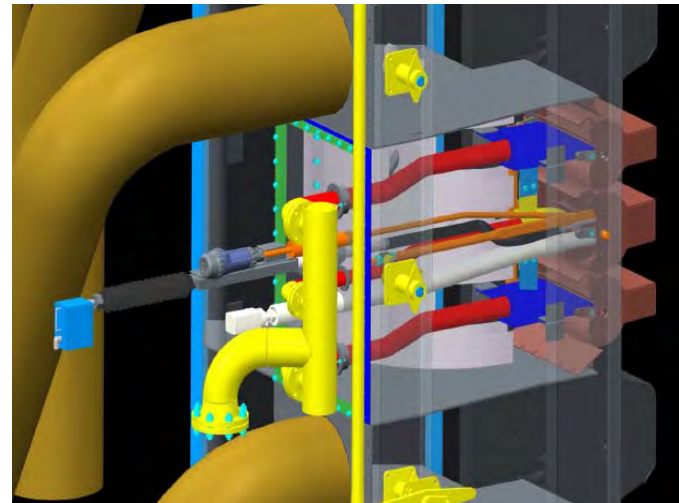
### Environmental Controls include

- Selective Non-Catalytic Reduction (SNCR)
- Electrostatic Precipitator
- Wet Flue Gas Desulfurization (WFGD)



### Gas System Design

- 30% Gas Capacity
- 2 Levels of Wafer Style Gas Burners
  - Located in Auxiliary Air Ports
- Each Burner Heat Release = 90 mmBTU/hr
- 1 Gas Pressure Control Skid per unit
- 1 Level of Wafer Style Ignitor for LOFIR level
  - 18 mmBTU
  - Located in Auxiliary Air Port
- When Units 3 & 4 are utilizing maximum gas only 10% available for use on 1 & 2
- 30% capacity provides flexibility for times when 3 & 4 are at reduced load or possibly offline





## Marshall Units 3 & 4

### Unit Design

- 700 MWg
- Combustion Engineering Boiler
- 8 Corner T-Fired
- 48 coal burners
- 3500 psig (Super-Critical)
- 1007 F SH / 1000 F RH
- 100% MCR Heat Release = 6930 mmBTU/hr
  
- SOFA
- CCOFA
- LOFIR

### Environmental Controls include

- Selective Catalytic Reduction (SCR) – Unit 3
- Selective Non-Catalytic Reduction (SNCR) – Unit 4
- Electrostatic Precipitator
- Wet Flue Gas Desulfurization (WFGD)



### Gas System Design

- 50% Gas Capacity
- 2 Levels of Wafer Style Gas Burners
  - Located in Auxiliary Air Ports
- Each Burner Heat Release = 212 mmBTU/hr
- 1 Gas Pressure Control Skid per burner level (2)
- 1 Level of Wafer Style Ignitor for LOFIR level
  - 42 mmBTU/hr
  - Located in Auxiliary Air Port

