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EUtech Scientific Engineering

HRL Technology Group

Automatic control of FEGT using EUflame Technology: Case study for CCGT / HRSG system

apa

17th November 2022 - ABHUG

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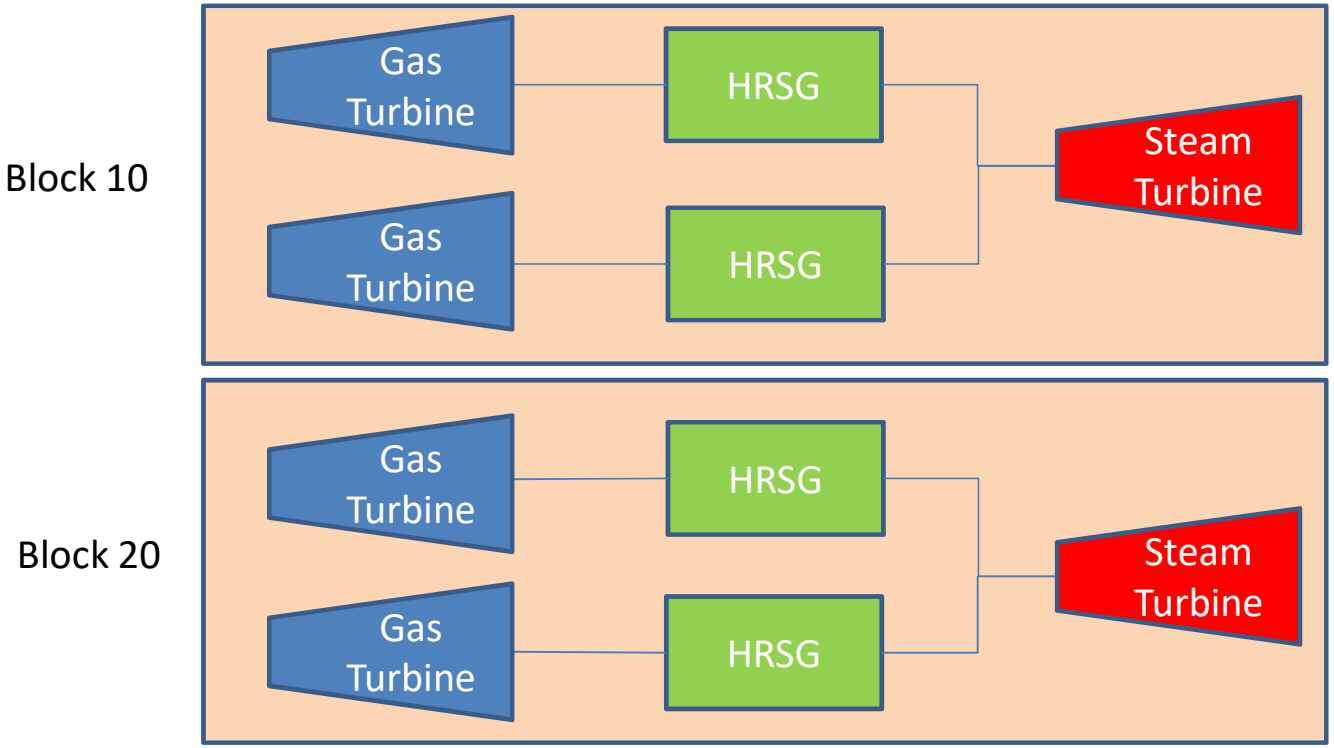
Presentation Outline

- Project background
- Improvement objectives
- Need for advanced temperature measurement
- EUflame 2D technology overview
- APA Diamantina PS Application
- Benefits of Technology for DPS

Diamantina Power Station

- Total of 230MW on an isolated grid in Mt Isa
- 4 GTs, 4 HRSGs, 2 STs
- Operated as two individual blocks
- Plant not achieving maximum output
- Supplementary firing was not in operation



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Improvement Opportunities

- HRL worked with APA to identify and implement improvement opportunities with key objectives of:
  - Maximising plant output
  - Improving operational flexibility
- Approach
  - Develop overall plant thermodynamic model
  - Compare plant operation to design
  - Model a wide range of operating scenarios
  - Identify improvement opportunities
  - Design and implementation of solutions

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Improvement Opportunities

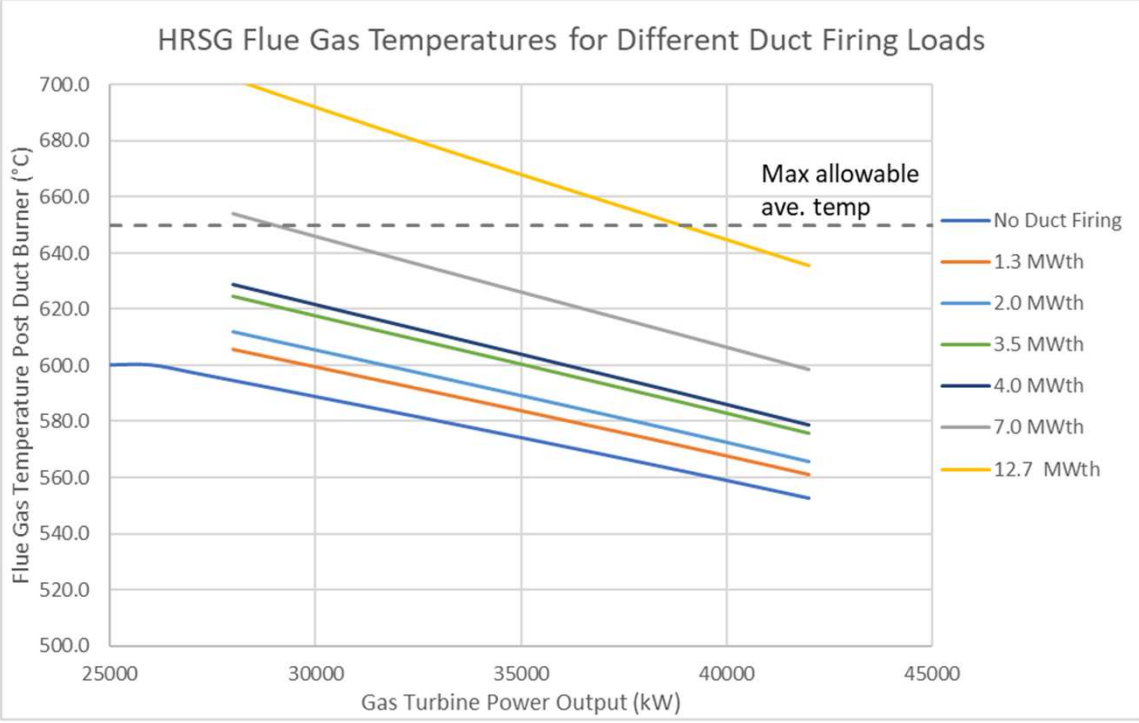
- Key factors limiting output and flexibility
  - STs only achieving 36MW versus design of 40MW
    - High HRSG gas exhaust temperatures
    - ST degradation
    - Other factors
  - Supplementary firing not in operation
  - Supplementary firing designed for on/off control
  - Two blocks operated in isolation

Key Improvement Objectives

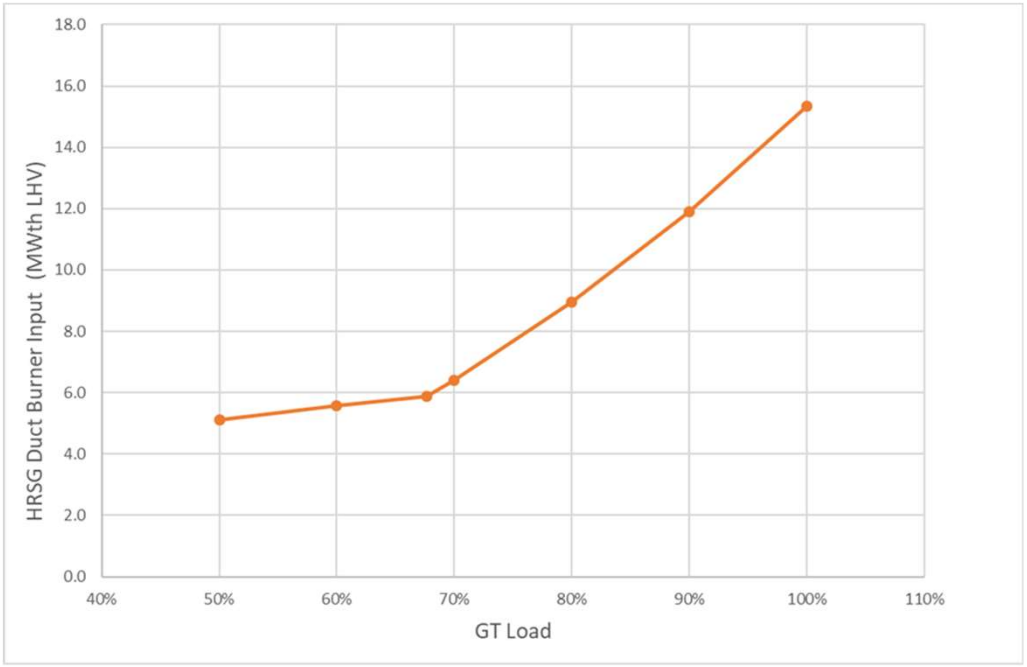
- Maximise ST output through supplementary firing
- Maintain consistent ST output for varying GT loads by modulation of supplementary firing
- Implement steam range in combination with supplementary firing to achieve full capacity for both STs when only 3 GTs/HRSGs are operating

Supplementary Firing Control Requirement

- Need to prevent exceeding maximum allowable average flue gas temperature (650°C) for different GT loads (70 to 100%)
- Effective control of duct firing rate and gas temperature is required for safe and effective operation and to prevent overheating of the final superheater

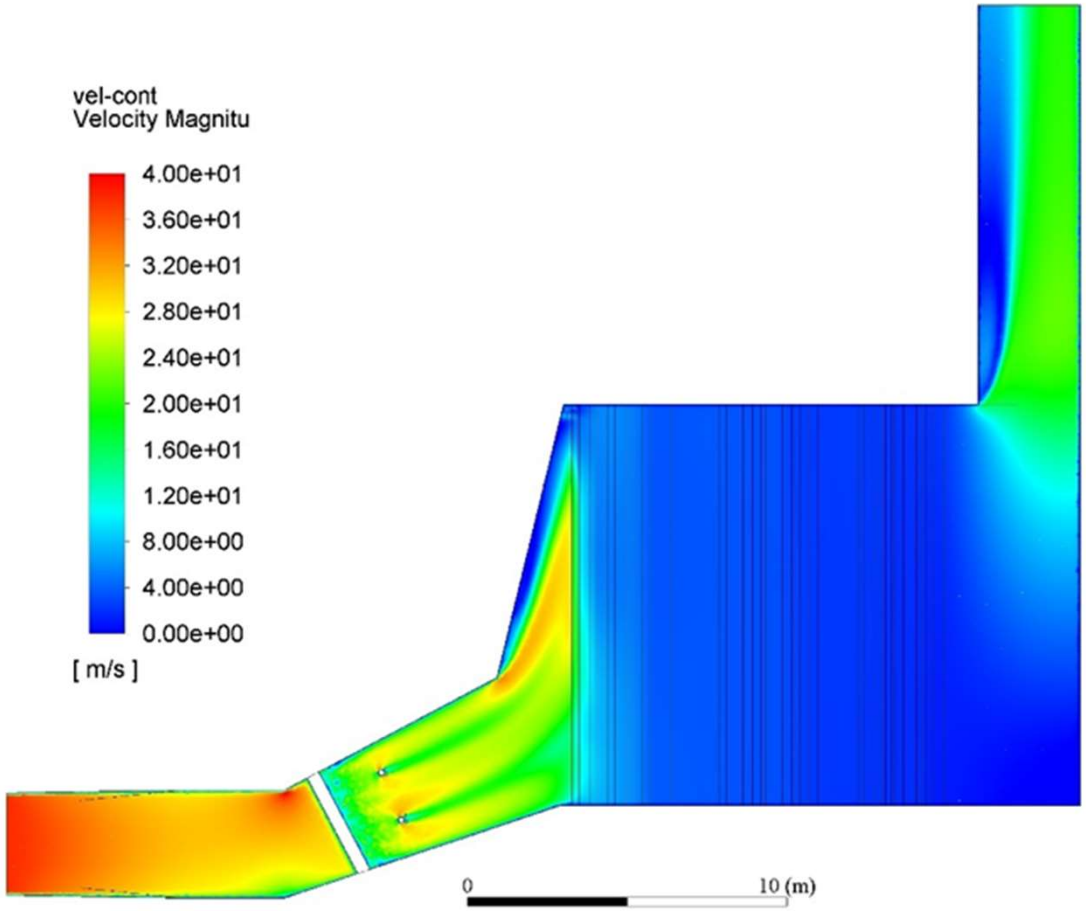


Duct Burner Input to Reach 650°C versus GT Load

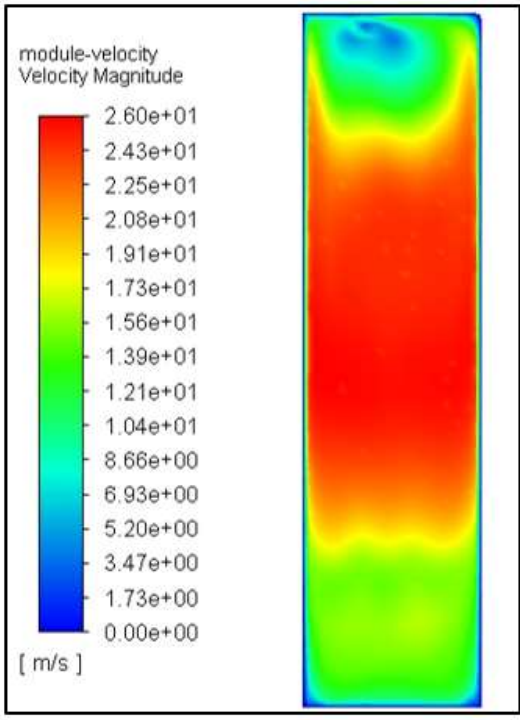


Challenges for Temperature Measurement

- Variable gas velocity distribution to superheater tube bank



Velocity profile



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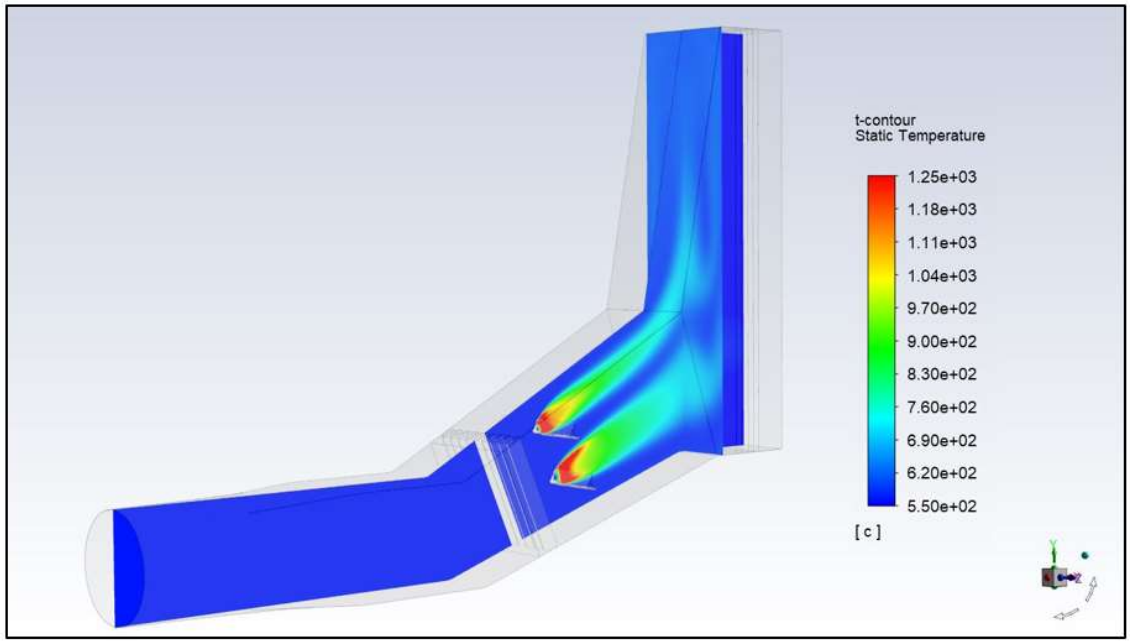
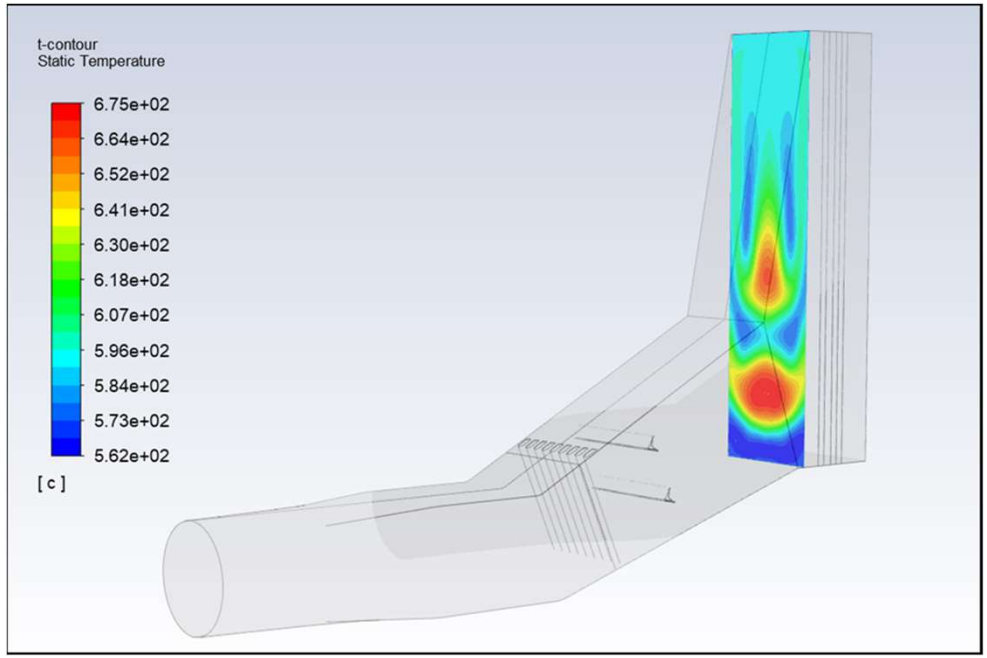
Challenges for Temperature Measurement

- Variable gas temperatures to superheater tube bank
- Effectiveness of thermocouples is limited for such variability
- Advanced temperature measurement approach required



Temperature profile for supplementary firing



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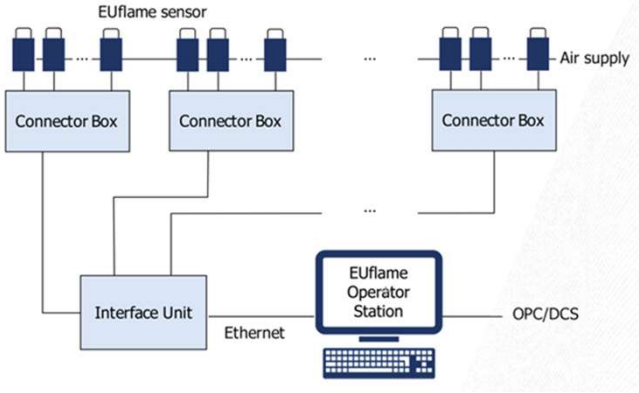
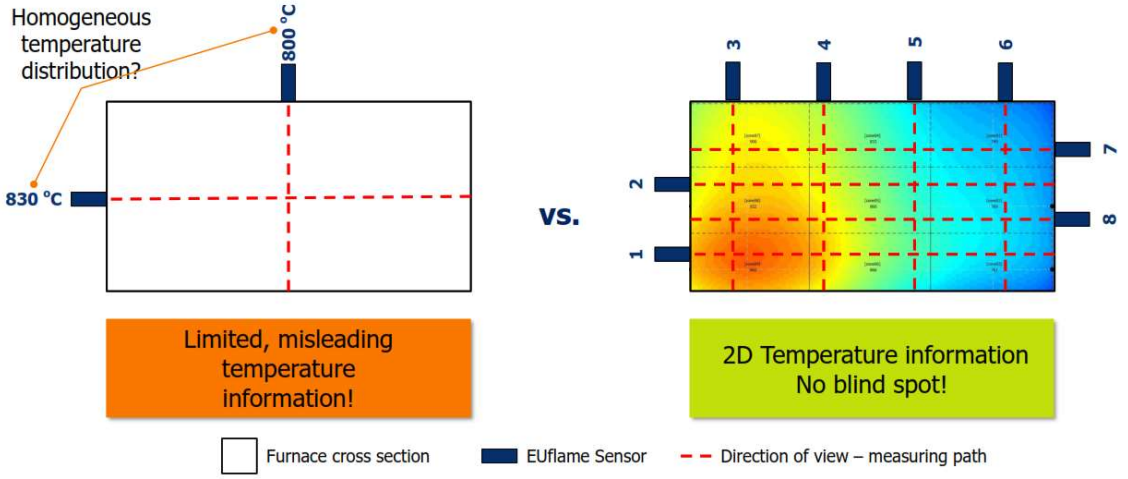
EUflame Optical Pyrometry Technology

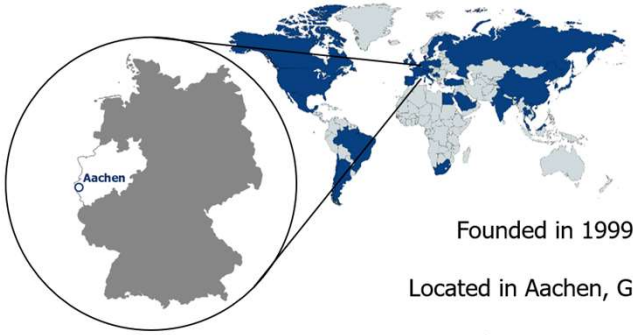
- Based on optical measuring technique –thermal radiation of CO/CO_2 used to measure temperature
- Temperature measurement from 400 to 2000°C
- Single point and 2D/3D measurements by use of multiple sensors
- Stationary or mobile system
- Digital output for integration with plant DCS
- Easy installation and turnkey system
- Robust with long service life
- Also offered as a flame temperature and carbon burnout system – for solid fuel applications





EUtech Overview

- HRL is Australian EUtech Product Agent
- EUflame technology well proven



Founded in 1999 (1995)

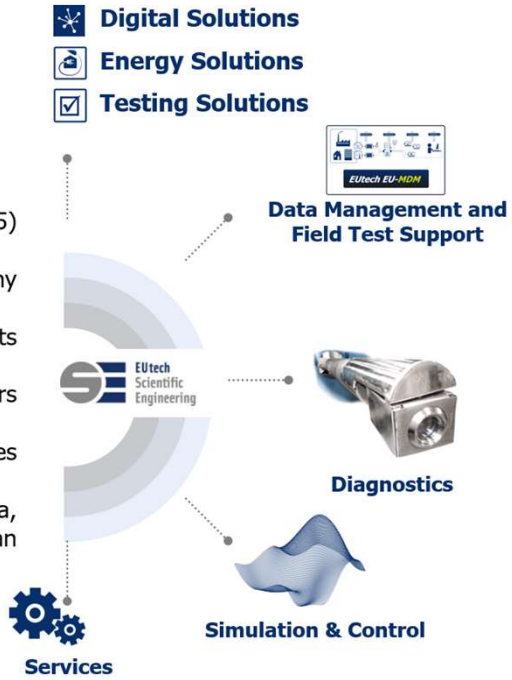
Located in Aachen, Germany

1000+ executed engineering projects

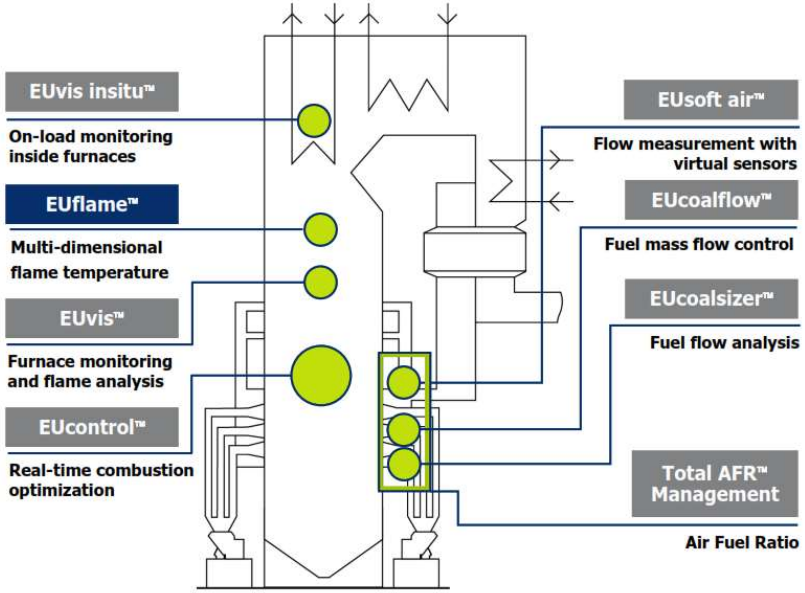
International teams of highly qualified engineers

Global customer base from various industries

Regional engineering partners in Australia, USA, China, India, Europe, Brazil, Korea and Japan

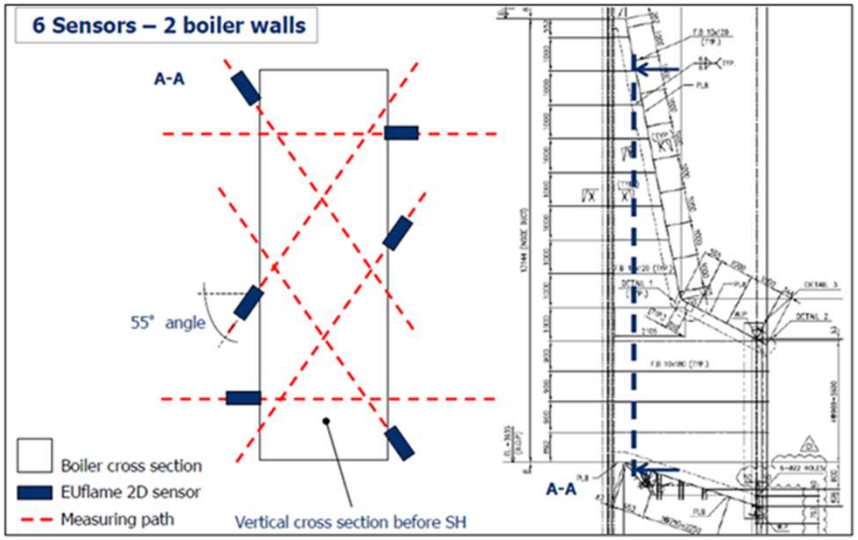


Products and Solutions



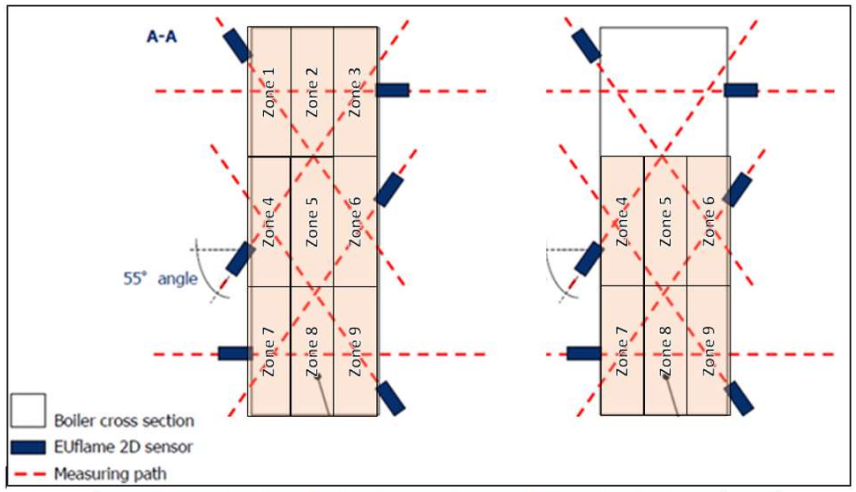
Application of EUflame Technology at DPS

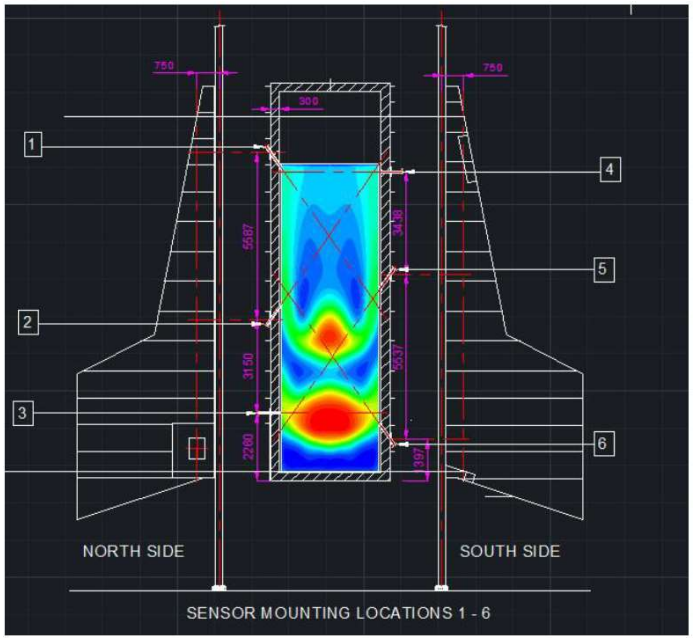
- On-line determination of gas temperature across a plane upstream of the first superheater
- System designed by HRL/EUtech based on plant configuration
- 6 ports and sensors per HRSG
- Installed and commissioned by HRL in co-operation with APA
- Digital output integrated with plant DCS for control of modulated supplementary firing



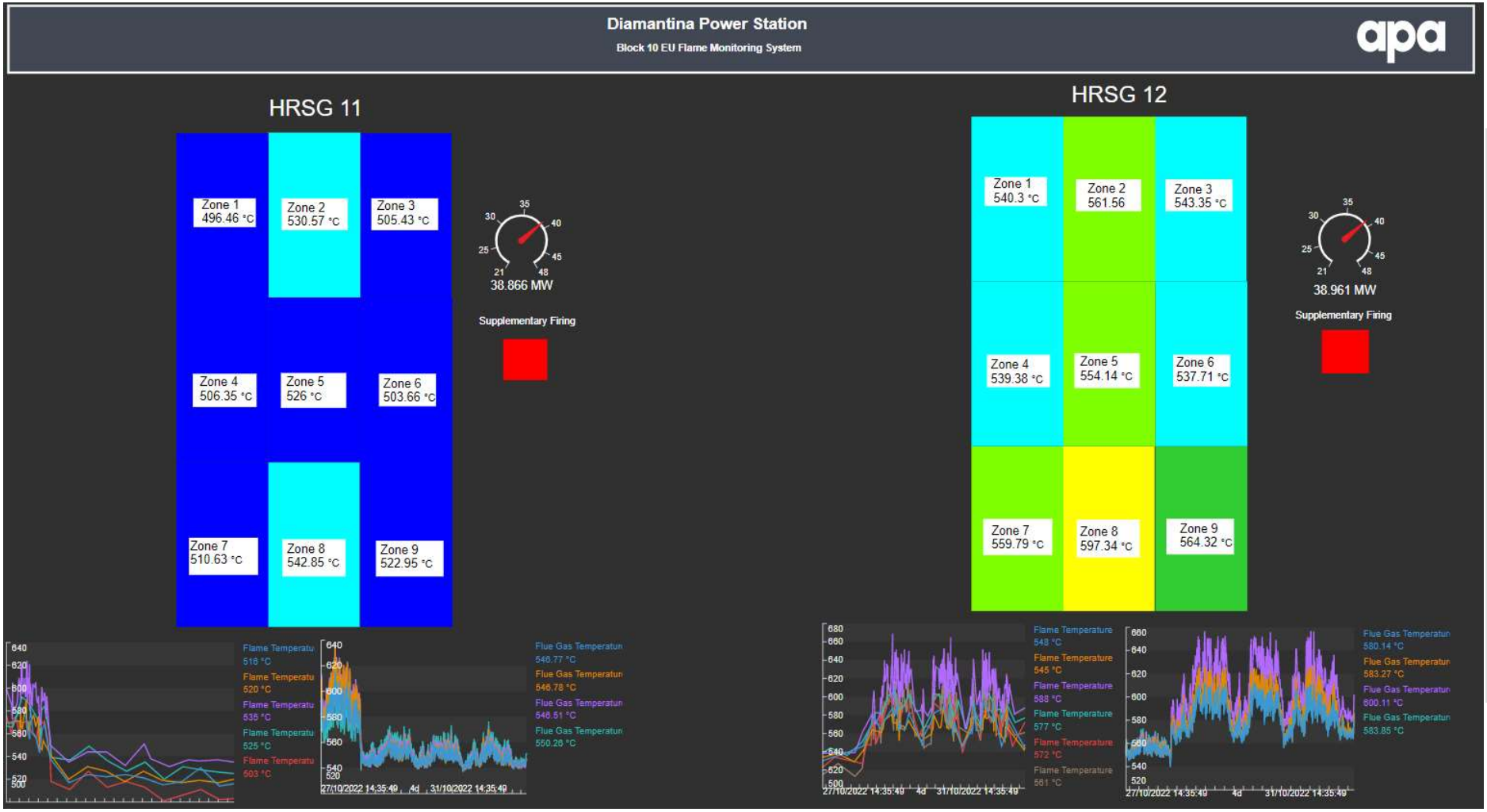
Selection of Sensor Number and Locations

- Number of sensors selected to provide 2D output and output with 1 or 2 burners per HRSG in operation
- Locations determined based on consideration of CFD results
- Use of 6 sensors allows a 2D temperature distribution to be continuously determined
  - Fluctuations across the plane and hotspots can be identified
  - Measurement of average and maximum temperature in 9 zones and across duct





Plant DCS Output



■	≤	691
■	≤	675
■	≤	652
■	≤	630
■	≤	618
■	≤	596
■	≤	584
■	≤	562
■	≤	548
■	≤	528
■	≤	480
	≥	400

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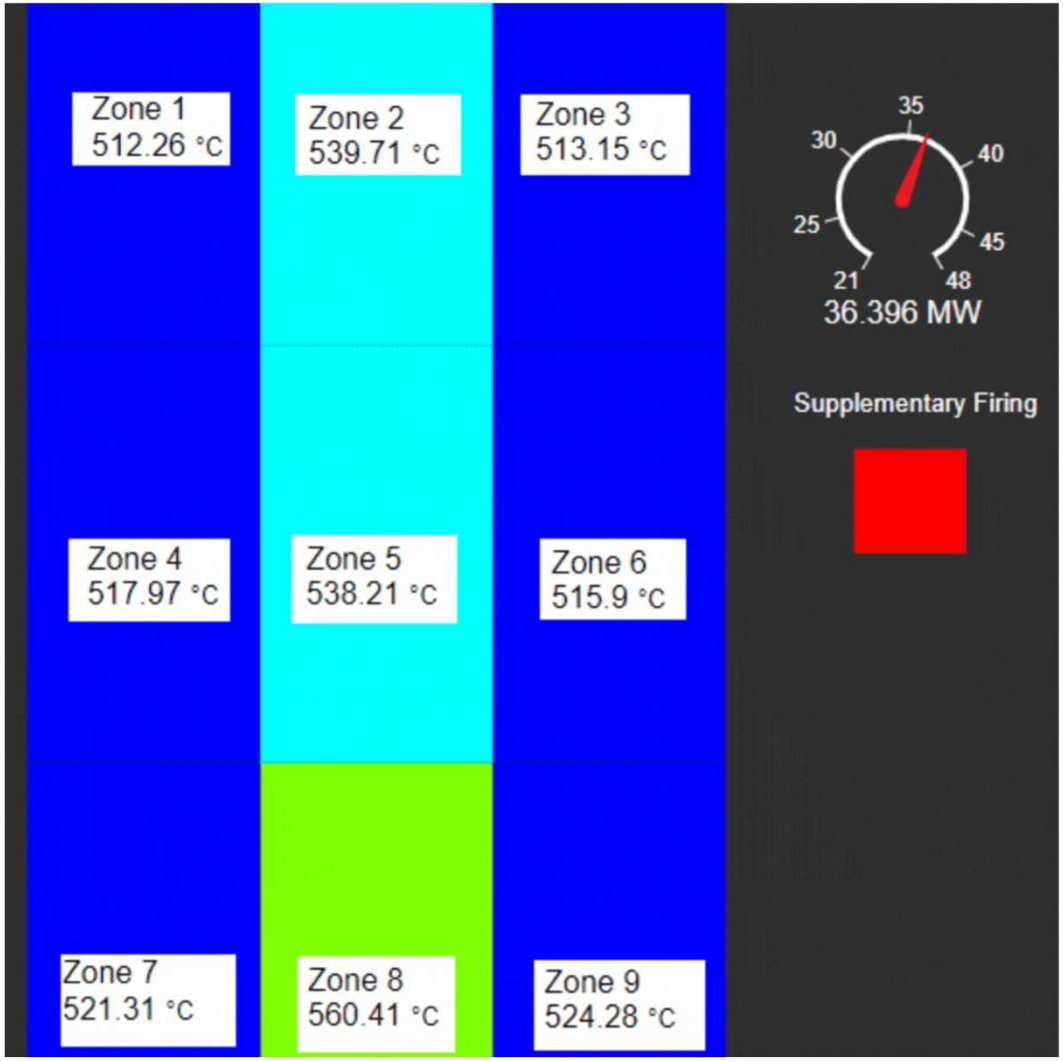
Time Lapse for DCS Output



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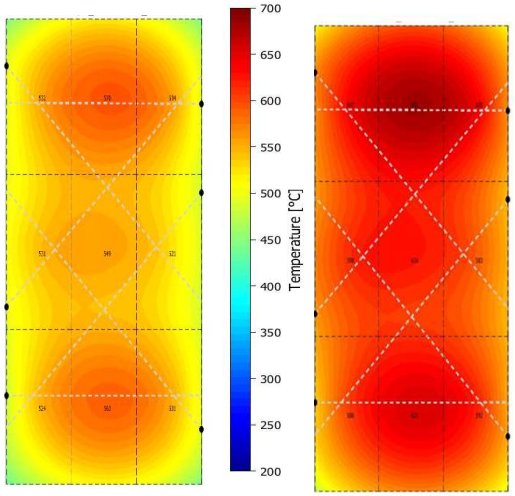
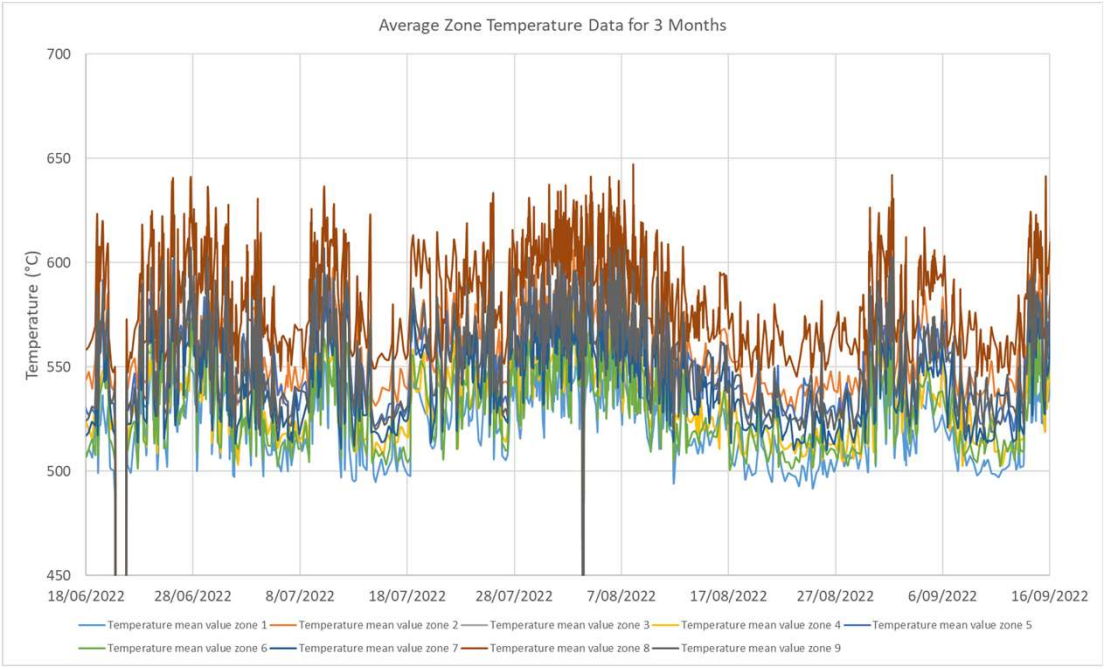
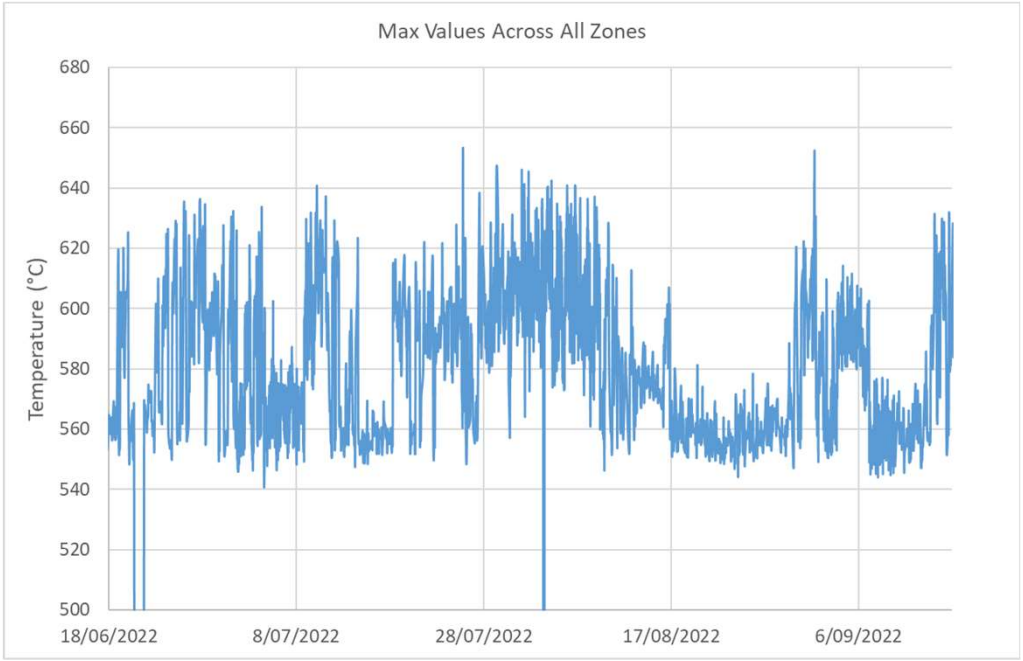
Three Months Data for One HRSG

- Data for each zone below max of 650°C
- Maximum values across all zones also below 650°C
- Consistent trends by zone
- Demonstrates effective system control of supplementary firing and temperatures

Example of profiles with and without supplementary firing







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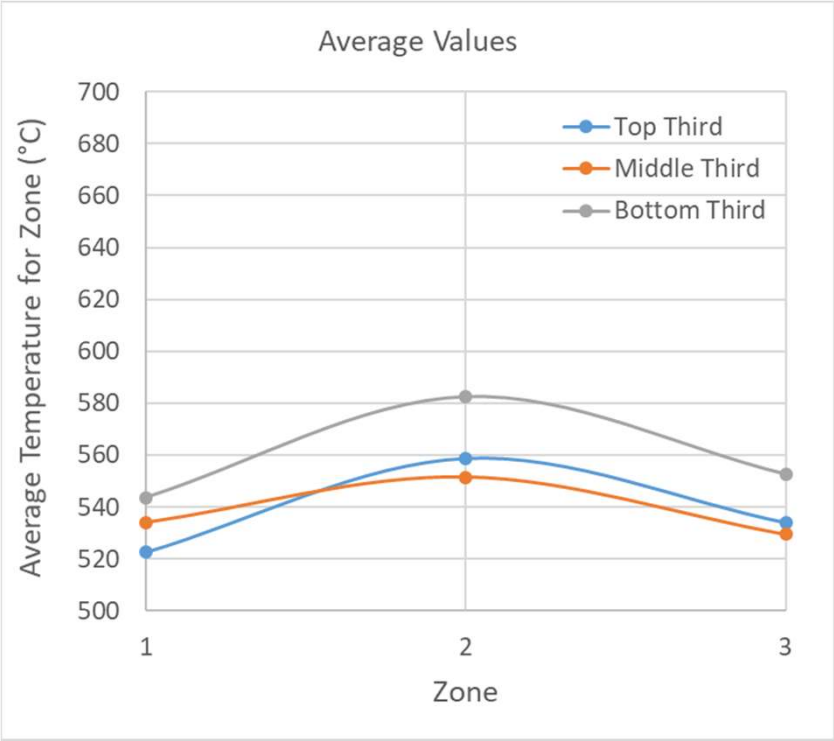
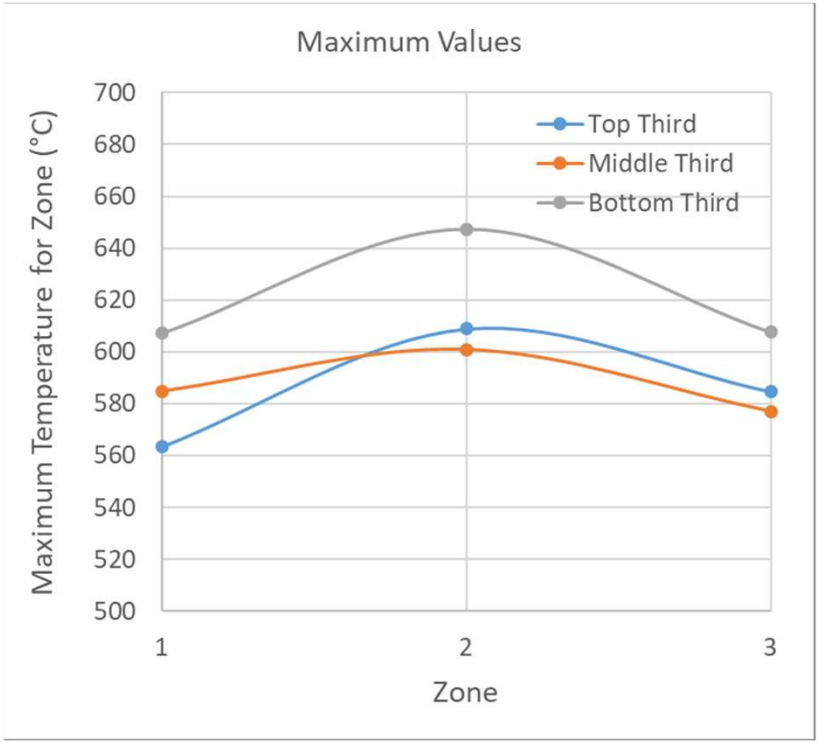
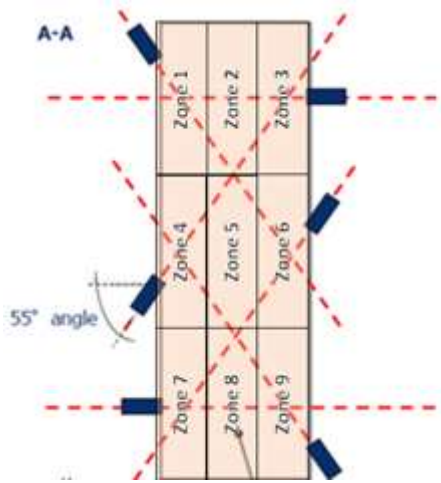
Trends Across Zones

- Highest temperatures in bottom third of HRSG (zones 7-9)
- Higher temperatures in central third of HRSG







Benefits to DPS of Advanced Temperature Monitoring

- Safe and effective operation of the SF systems across 4 HRSGs
- Allows operation near maximum temperature limits without exceeding maximum allowable gas temperatures
  - Protects superheater
- Allows maximum ST load and thus maximum plant load to be achieved
- Allows operation of STs at steady load with operating flexibility achievable through GT load and SF load modulation

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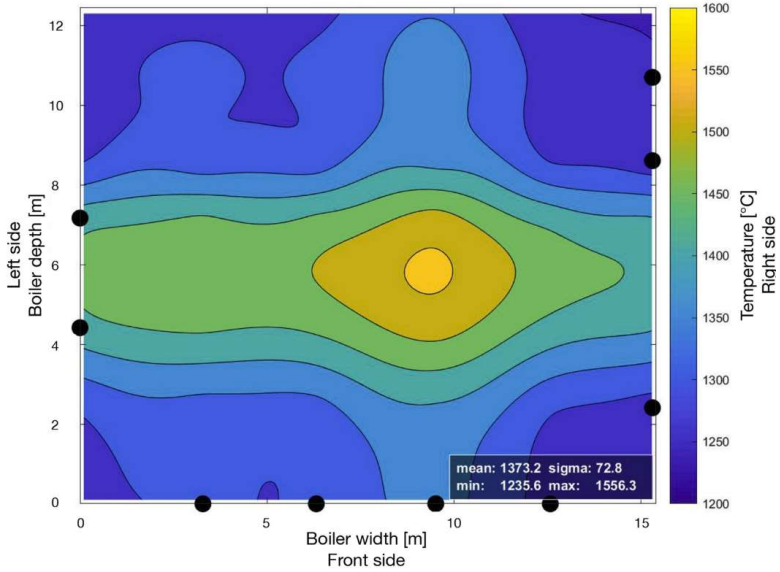
Next Steps/Challenges

- Implement steam range to allow transfer of steam from one block to the other block
  - Key benefit will be the ability to achieve full plant load with one GT/HRSG out of service
- Operate plant in more flexible mode given implementation of solar farms in Mt Isa
  - Implementation of 88MW of solar capacity reported

Application of Advanced Pyrometry for Coal Fired Plant

- Uneven spatial distribution of FEGT across boiler can lead to variable heat flux, hot spots and tube leaks
- Ideal case is centred temperature peak and even distribution
- Advanced pyrometry facilitates on-line determination of 2D profile, identification of hot spots and deviation from target distribution
- Assists monitoring and optimisation of combustion in real time across variable load conditions



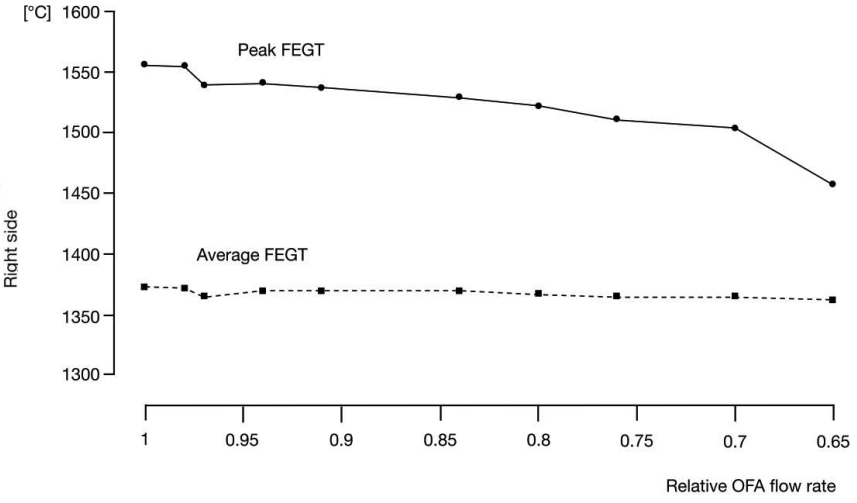


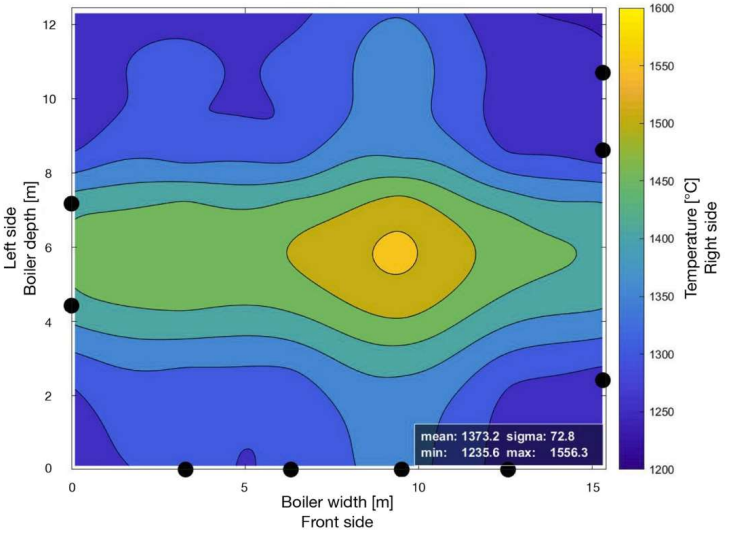
Fig. 4. Peak and average FEGT vs. relative OFA flow rate.

Example initial distribution for 1500MWth boiler
- Max 1556°C
- Ave 1373°C
- Min 1236°C

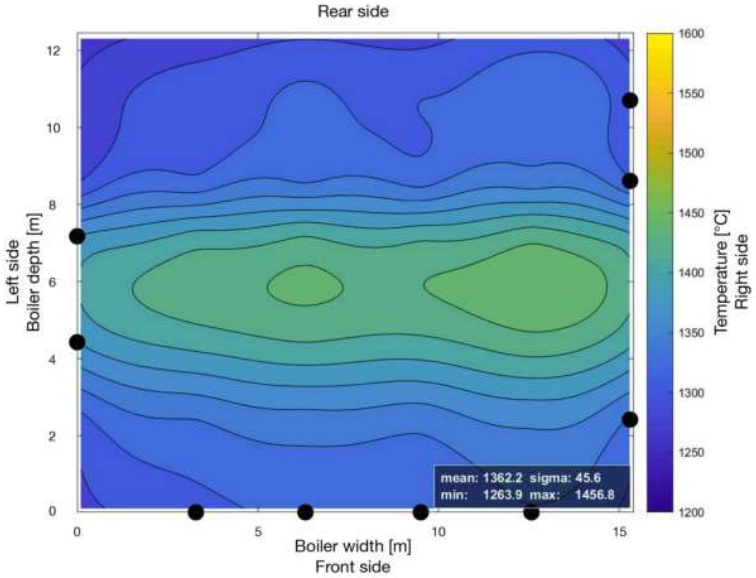
Optimisation of Temperature Distribution

- Initial distribution highlights high peak temperature and significant temperature variability
- Distribution optimised by adjusting the combustion air distribution
- Peak temperature reduced by ~100°C, flame centred

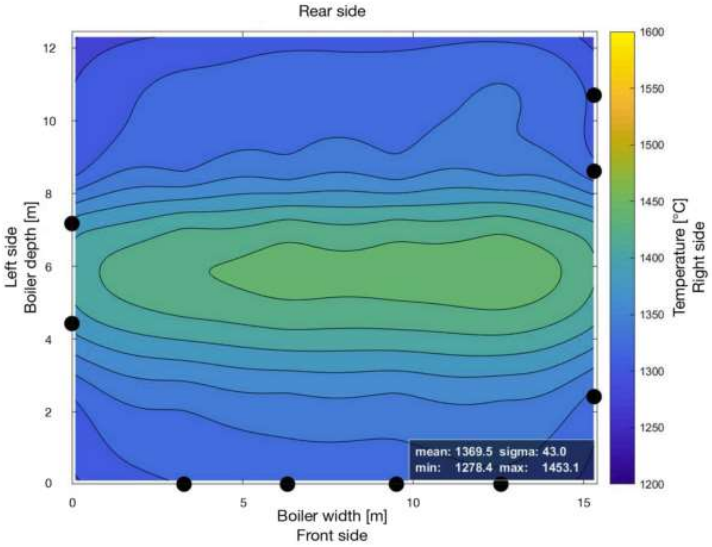
Initial	Optimised
- Max 1556°C	- Max 1457°C
- Ave 1373°C	- Ave 1362°C
- Min 1236°C	- Min 1264°C



Initial Distribution



Decreased overfire air



Detailed adjustment of overfire air

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Summary

- Advanced infrared pyrometry provides an accurate and efficient way to monitor FEGT and provide 2D spatial distribution
- Standard equipment cannot provide such information
- Application at DPS in combination with supplementary firing has allowed full load ST operation and improved operational flexibility
- Applied in coal fired plant to minimise peak temperatures and centre fireball, and facilitate combustion optimisation
- Accurate FEGT monitoring assists flexible operation whilst minimising impacts on plant integrity

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