Proceedings Paper:
Gibbins, J. orcid.org/0000-0003-0963-4555 (2017) UKCCSRC pact core facilities Sheffield. In: Proceedings of the Carbon Management Technology Conference, CMTC 2017. Carbon Management Technology Conference (CMTC 2017), 17-20 Jul 2017, Houston, Houston TX. AIChE , pp. 997-1010. ISBN 9781510848153

UKCCSRC PACT FACILITIES

UKCCSRC PACT CORE FACILITIES SHEFFIELD

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The UKCCSRC is supported by the Engineering and Physical Sciences Research Council as part of the Research Councils UK Energy Programme

July 2017

EPSRC
Pioneering research and skills

About UKCCSRC PACT

- **UKCCSRC P**ilot-scale **A**dvanced **C**apture **T**echnology facilities
  - Funded by: BEIS (formerly DECC) and EPSRC
  - Cranfield, Edinburgh, Imperial, Leeds, Nottingham, Sheffield
  - Member of International CCS Test Centre Network (for UK)
- **Scope:** Specialist national facilities for research in advanced fossil-fuel energy, bioenergy and carbon capture technologies
  - Comprehensive range of pilot-scale facilities
  - Supporting specialist research and analytical facilities
  - Leading academic expertise
- **Aim:** Support and catalyse industrial and academic R&D to accelerate the development and commercialisation of novel low carbon technologies
- **Objectives**
  - Bridge gap between bench-scale R&D and industrial pilot trials
  - Provide shared access to industry and academia

Department for Business, Energy & Industrial Strategy

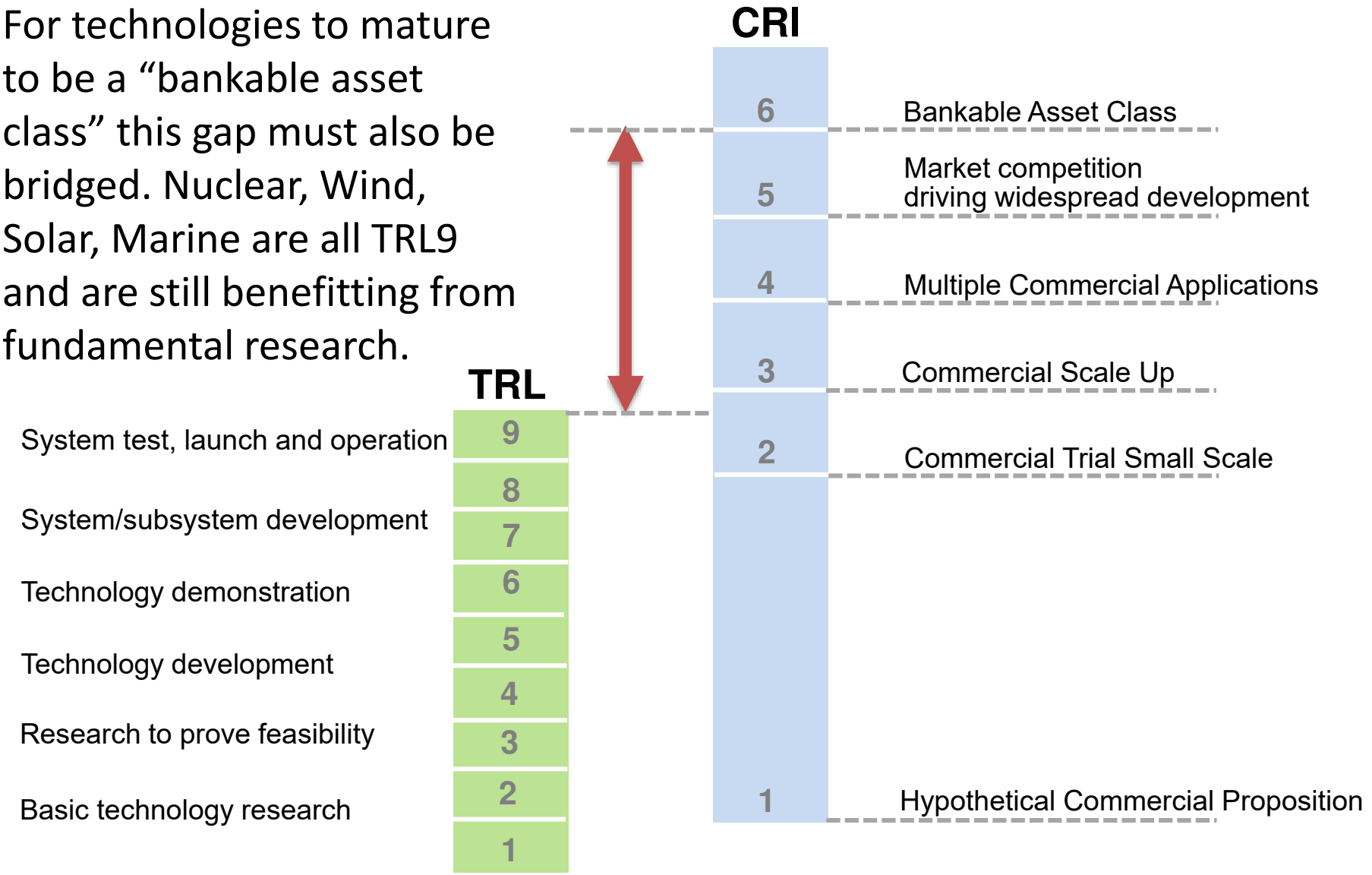
EPSRC Engineering and Physical Sciences Research Council

UKCCS RESEARCH CENTRE

Cranfield UNIVERSITY · THE UNIVERSITY of EDINBURGH · Imperial College London · UNIVERSITY OF LEEDS · The University of Nottingham · The University Of Sheffield.

Fundamental research needed to increase Commercial Readiness as well as TRL

For technologies to mature to be a “bankable asset class” this gap must also be bridged. Nuclear, Wind, Solar, Marine are all TRL9 and are still benefitting from fundamental research.



Faraday discussion, 2016, http://pubs.rsc.org/en/content/articlelanding/2016/fd/c6fd00046k#!divAbstract, based on http://arena.gov.au/files/2014/02/Commercial-Readiness-Index.pdf

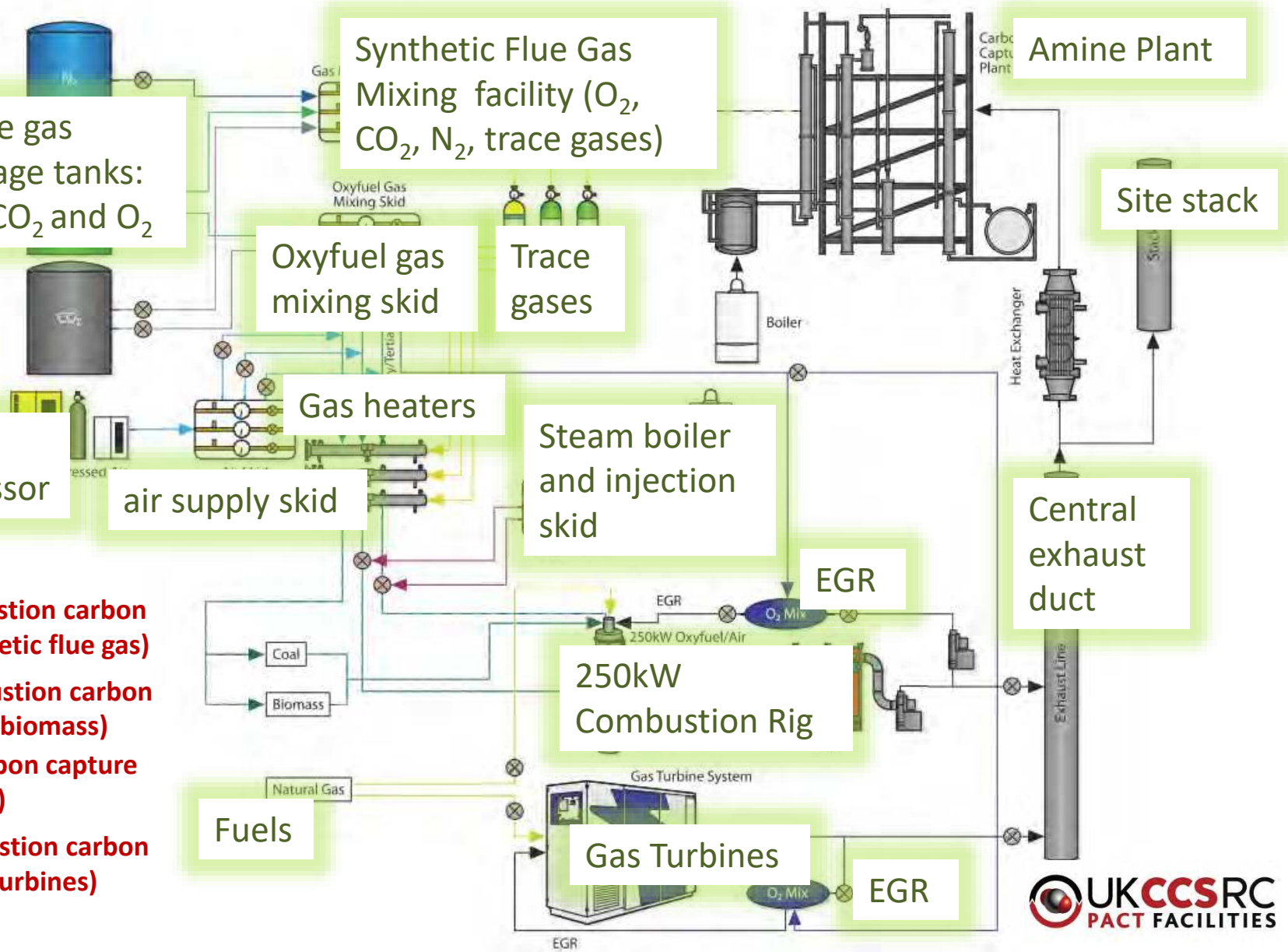
UKCCSRC PACT FACILITIES

PACT Core Facilities

Coal/Biomass, NG-CCGT , Biofuel, CO_2 Capture Plant

Large –Scale Combustion Test Facilities

PACT Core Facility: Overview



CAPABILITIES:

1. Post-combustion carbon capture (synthetic flue gas)
2. Post-combustion carbon capture (coal/biomass)
3. Oxyfuel carbon capture (coal/biomass)
4. Post-combustion carbon capture (Gas Turbines)

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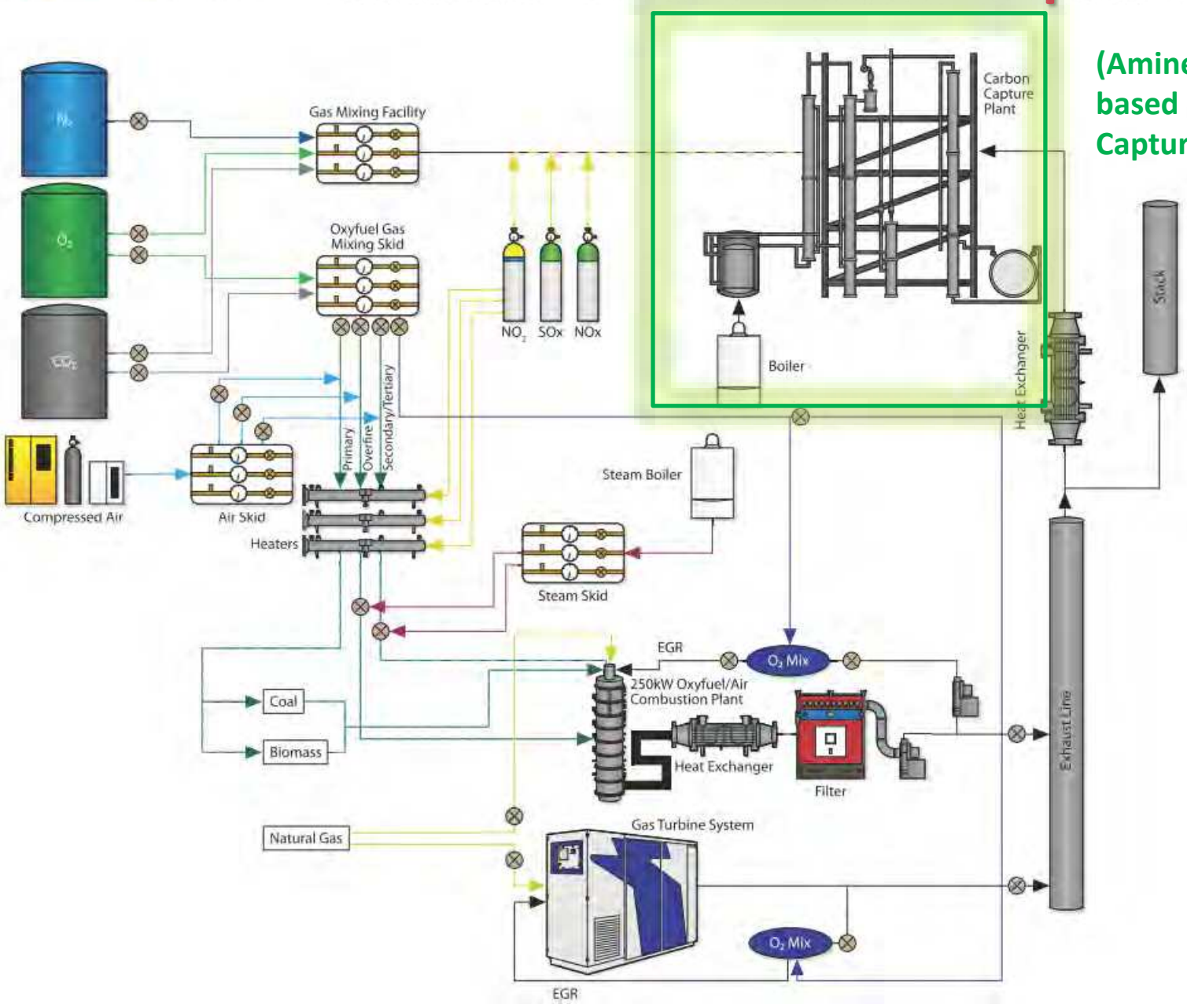
Solvent- based Carbon Capture Plant



(Amine) Solvent-based Carbon Capture Plant

Solvent- based Carbon Capture Plant

Overview

- 8m/300mm Absorber and Desorber columns
  - 2x 3m packed sections
  - Random/structured packing
- Integrated FGD (carbonate) wash system for removal of SOx from coal flue gas
- Flue gas treated: 210 Nm^3/h; eqiv. to 150kW coal flue gas
- Removes 1 tonne of CO_2 per day (MEA) with over 98% purity
- Solvent sampling on absorber and desorber
- Material corrosion testing sites
- Trace gas injection capability
- Analytical capability
  - Gas composition
  - Temperature monitoring
  - Pressure monitoring (e.g. foaming)

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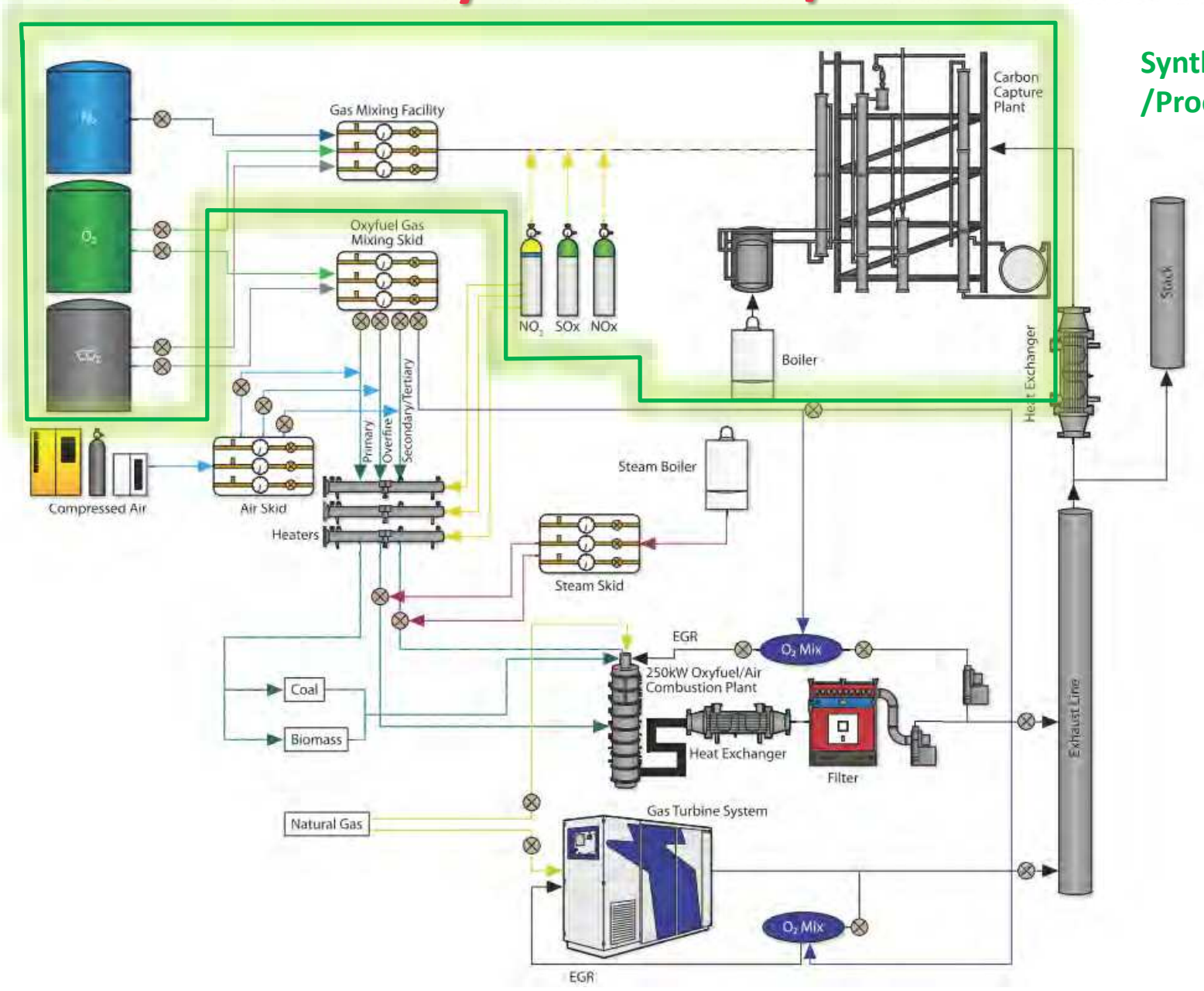
Synthetic Flue/Process Gas Facility

Synthetic Flue /Process Gas System



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Synthetic Flue/Process Gas Facility

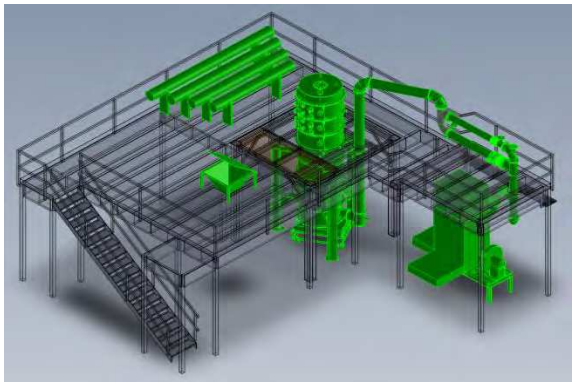
Overview

- Three **gas metering and mixing** lines, fed from O_2, CO_2 and N_2 storage tanks
- Complemented by **trace gas injection** NOx and SOx, other trace gasses
- Generate simulated flue/process gases
- Connected directly to the **Solvent-based Carbon Capture Plant**

250kW Air Combustion Plant

Overview

- ~250kWth, 4.5m high; 0.9m radius, cylindrical, down-fired rig with 8 sections
- Fuel: Coal, Biomass, Co-firing, Gas (primarily preheating)
- 2 x (interchangeable) coal/biomass burners - scaled from Doosan Power Systems commercial low-NOx burners
- Dedicated, high precession air metering skid
- Flue gas candle filter (>99% ash removal);
- Furnace pressure (negative) balanced by exhaust fan
- Temperature and flow monitored water cooling system for the combustion rig, flue gas duct and heat exchanger.
- SCADA operating system with internet monitoring



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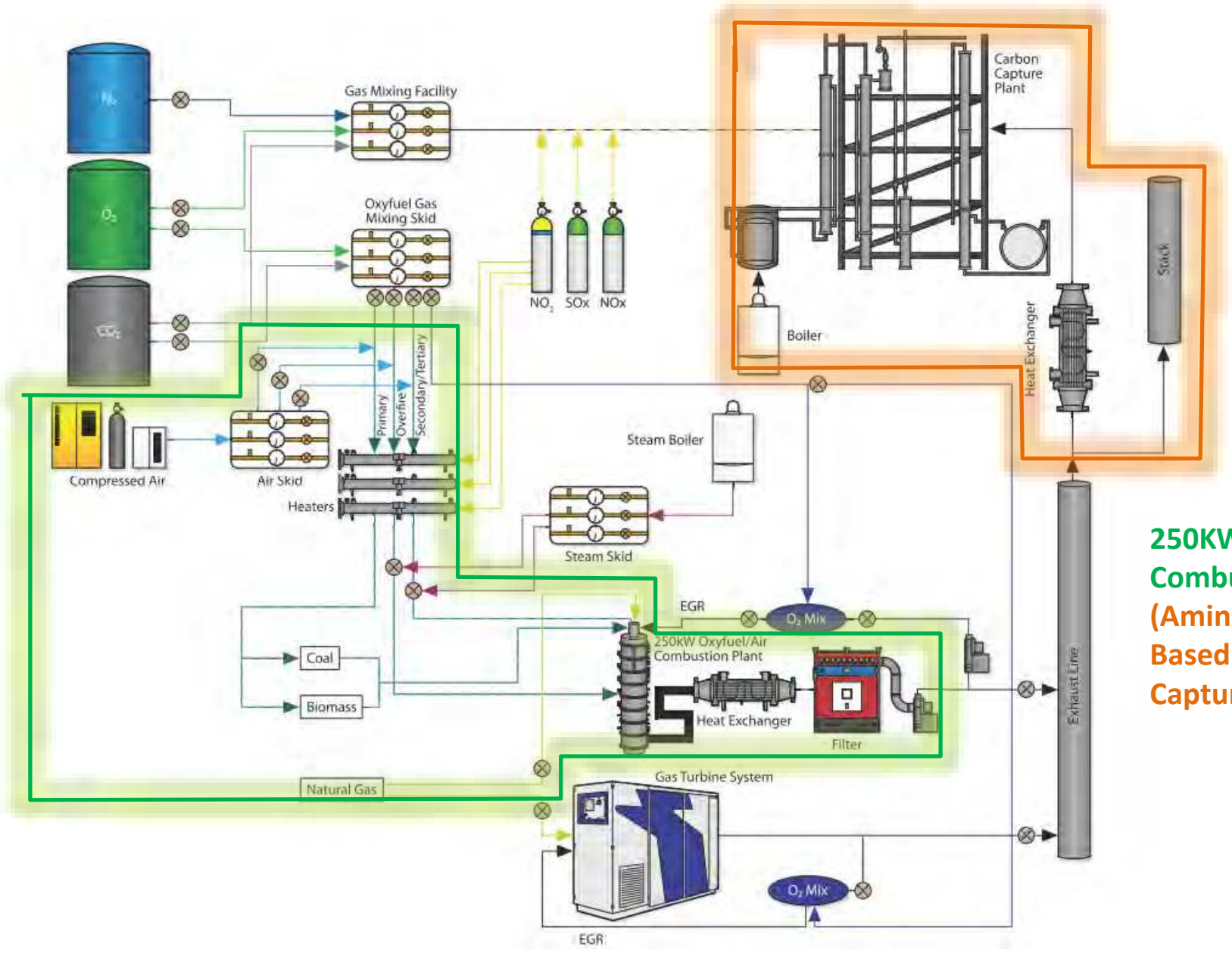
PACT Core Facility: Layout



250KW Air Combustion Plant + (Amine) Solvent Based Carbon Capture Plant =

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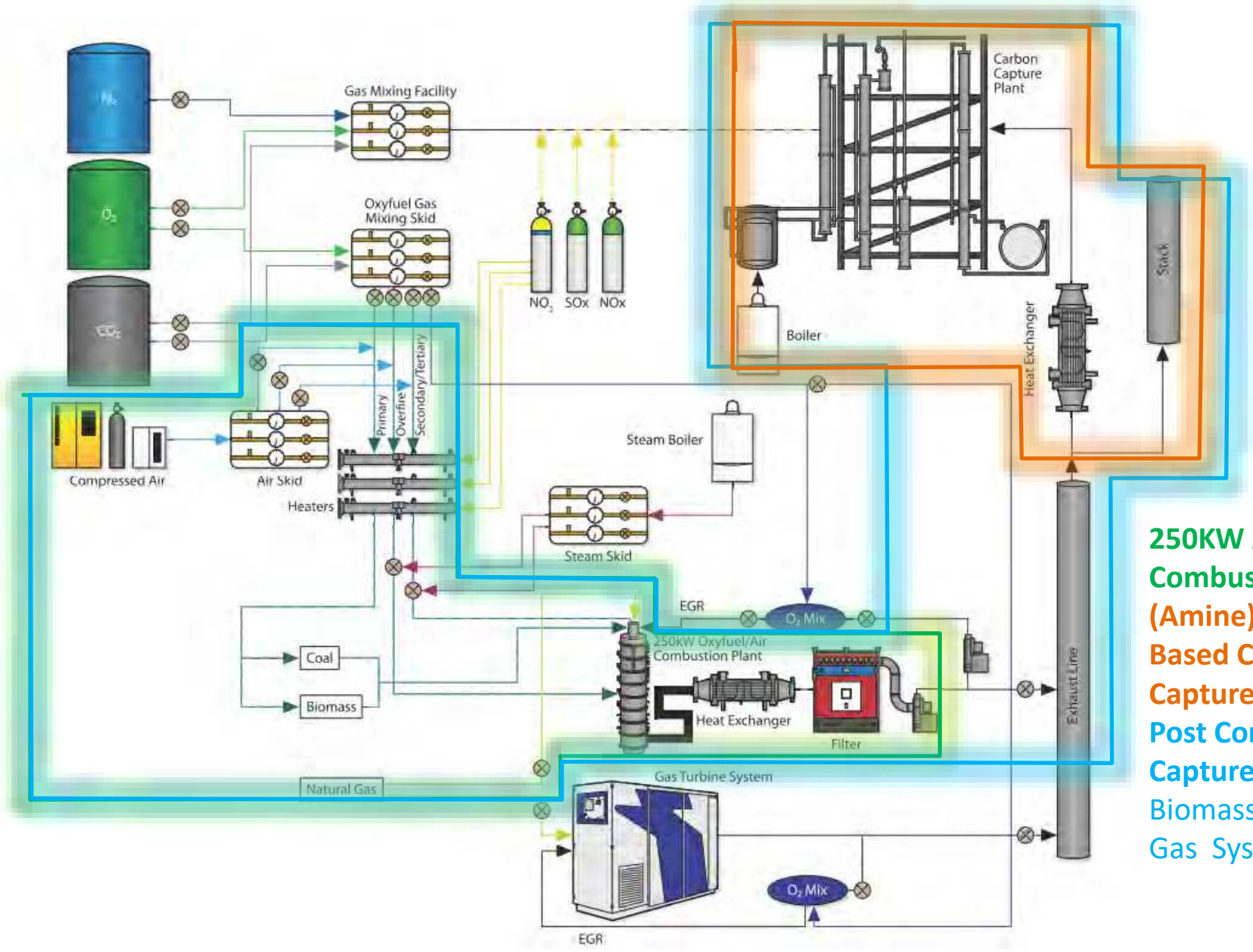
PACT Core Facility: Layout



250KW Air Combustion Plant + (Amine) Solvent Based Carbon Capture Plant = Post Combustion Capture from Coal, Biomass, Co-firing, Gas Systems:

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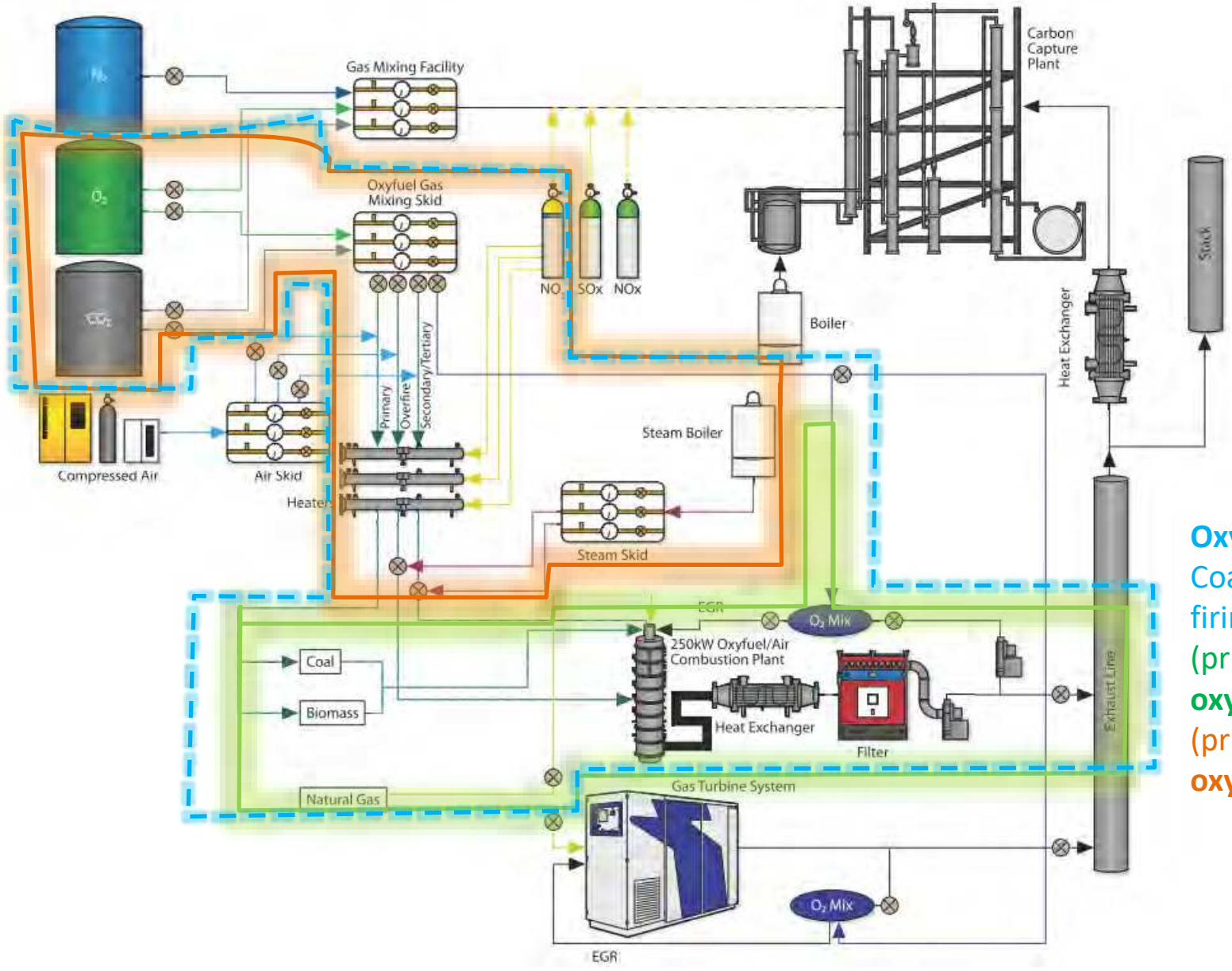
250kW Oxyfuel Combustion Plant



Oxyfuel capture from Coal, Biomass, Co-firing, Gas systems**:** (primarily) **Real oxyfuel mode+** (primarily) **Synthetic oxyfuel mode**

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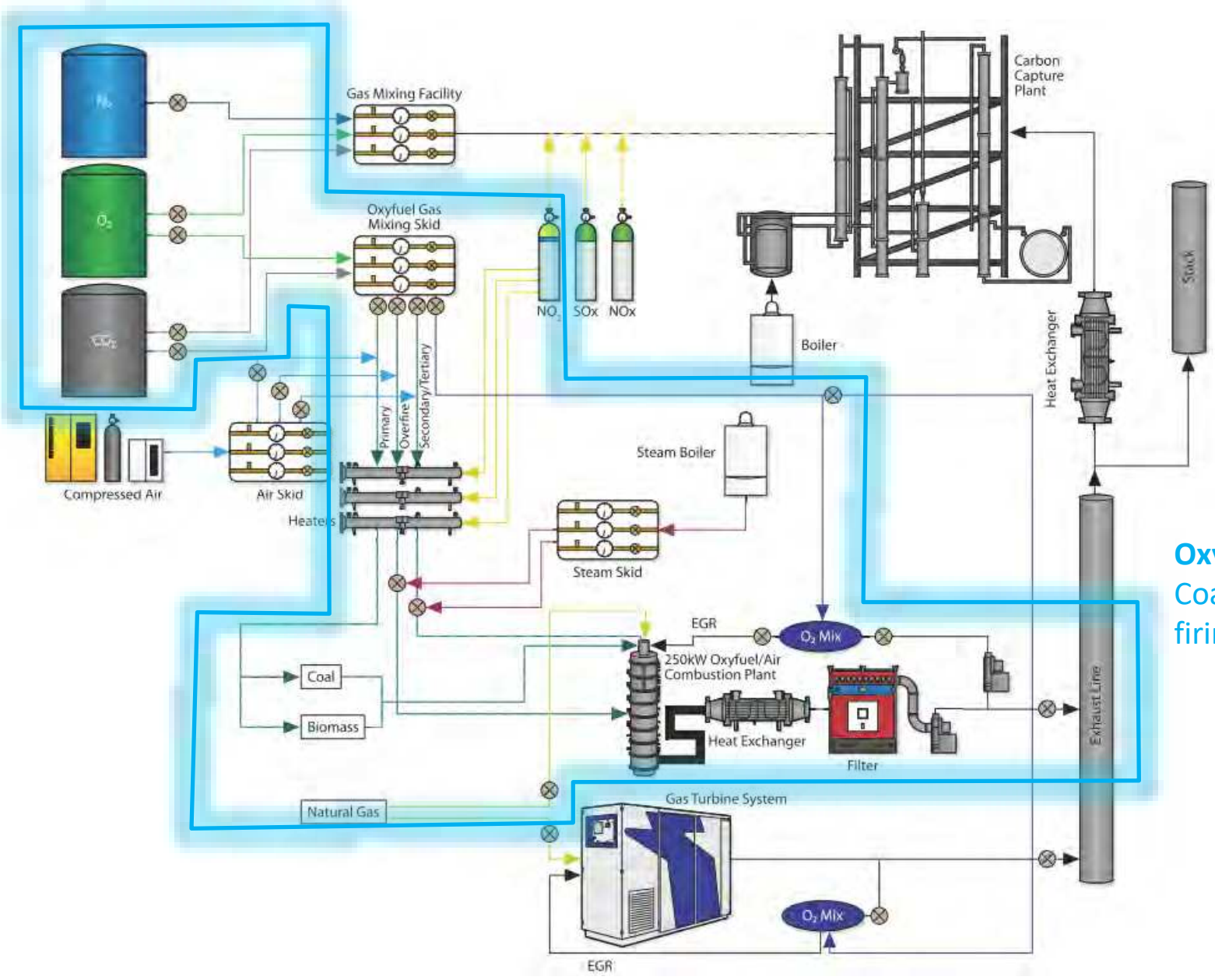
250kW Oxyfuel Combustion Plant



Oxyfuel capture from Coal, Biomass, Co-firing, Gas systems**:**

250kW Oxyfuel Combustion Plant

Example Applications

- Oxyfuel combustion R&D for coal, biomass or co-firing using a synthetic mixture of dry or wet CO_2/O_2 or wet flue gas recycle
- Fuel and process testing and optimisation;
- Integrated system modelling, for optimising Air Separation Unit (ASU) operation, combustion system control, and simulating the effect of different fuels on the combustion process
- System modelling and optimisation for flame visualisation and analysis, and latest modelling software for combustion system design, development and optimisation.

Pilot-Scale Integrated Experimental Facilities for BIO-Cap Project

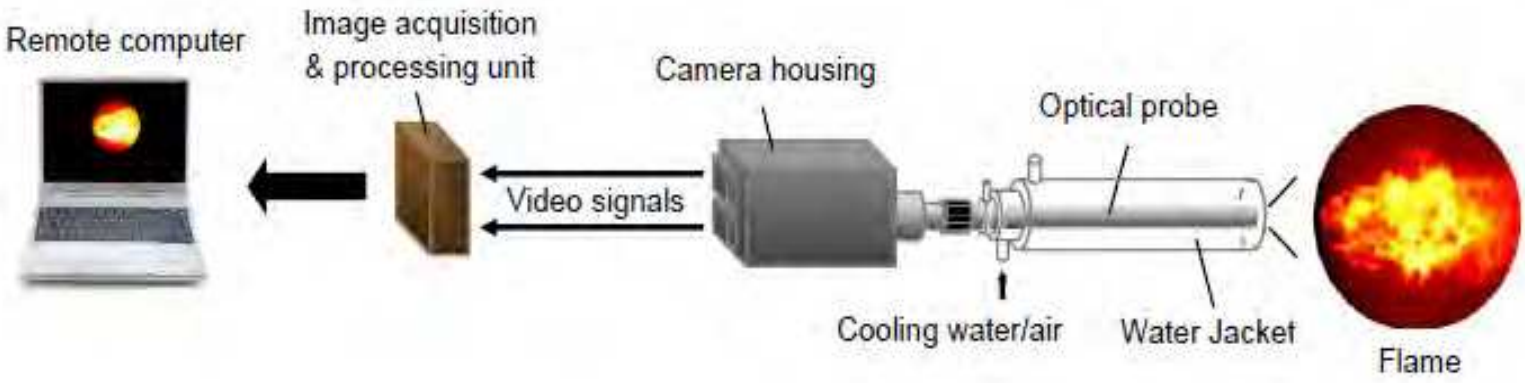
Gas Mixing Facilities

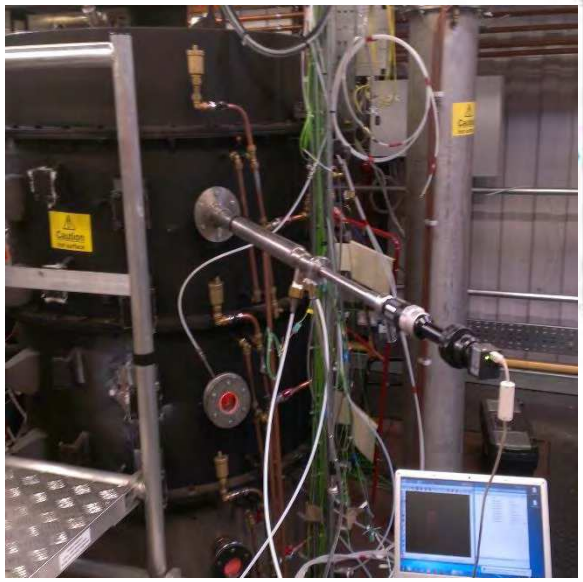
250kW Air/Oxy Rig

ICP-OES & DMS 500

Carbon Capture Plant

Flame Imaging System





Flame characteristics

- Size/shape, Ignition point
- Luminous intensity, Uniformity
- Temperature
- Oscillation frequency

Flame assessment

Fuel/air inputs

Emissions

Other data

Computational modelling

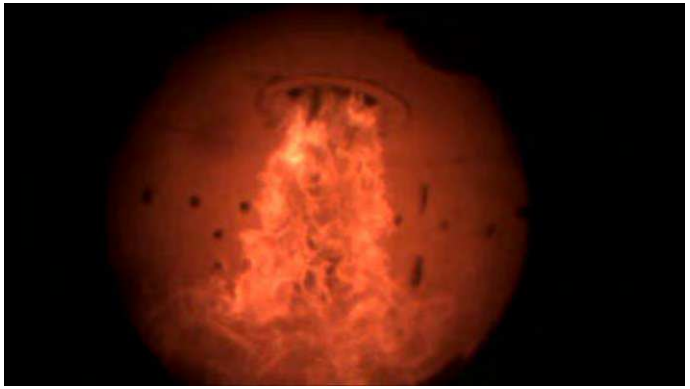
Recommendation to Combustion optimisation

Imaging system has been developed by the University of Kent (Dr Gang Lu & Prof Yong Yan)

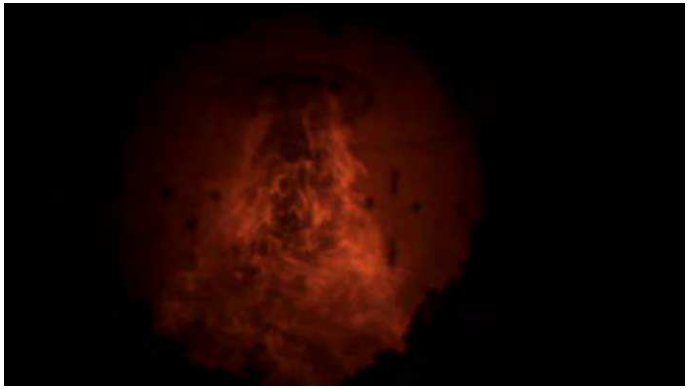
Results

Experimental calculation of the oscillation frequency - COAL

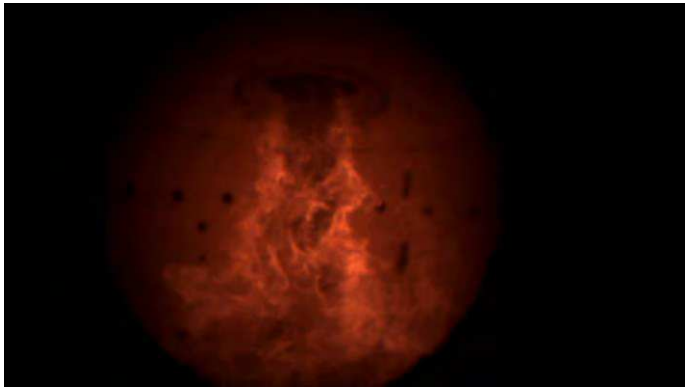
Original videos



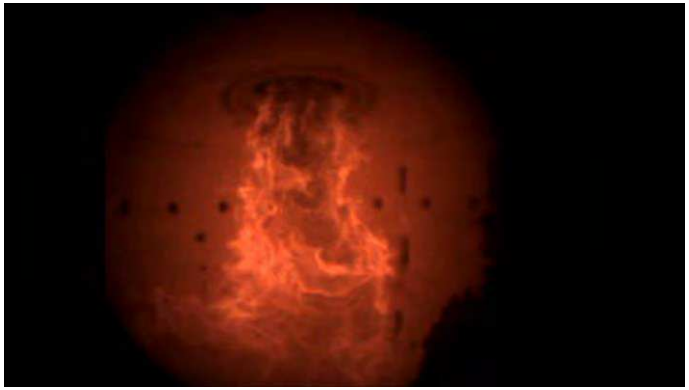
Air



Oxy24



Oxy27

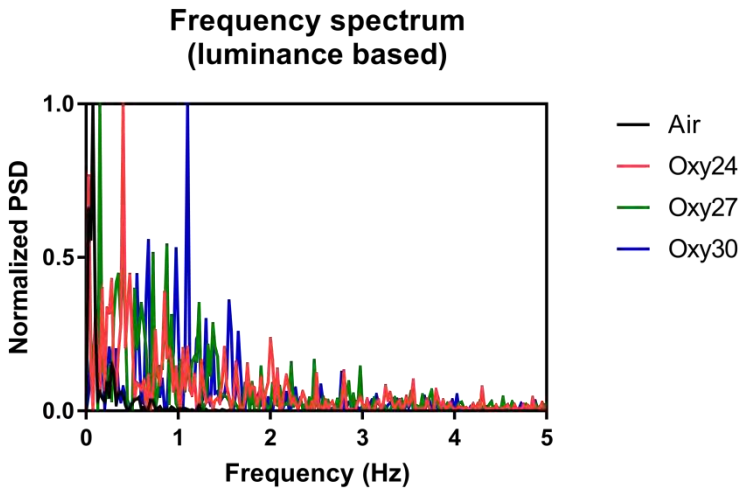


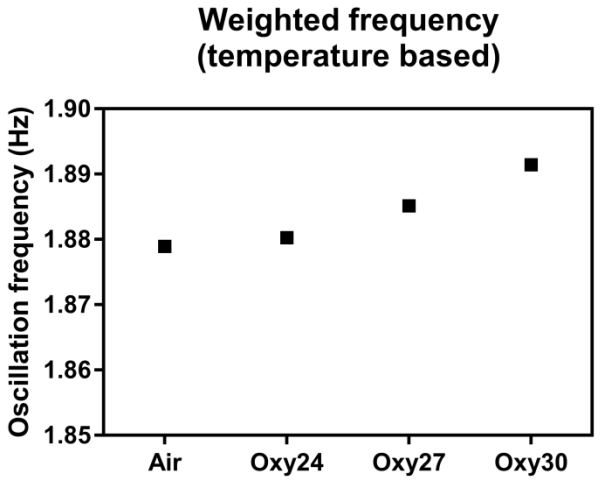
Oxy30

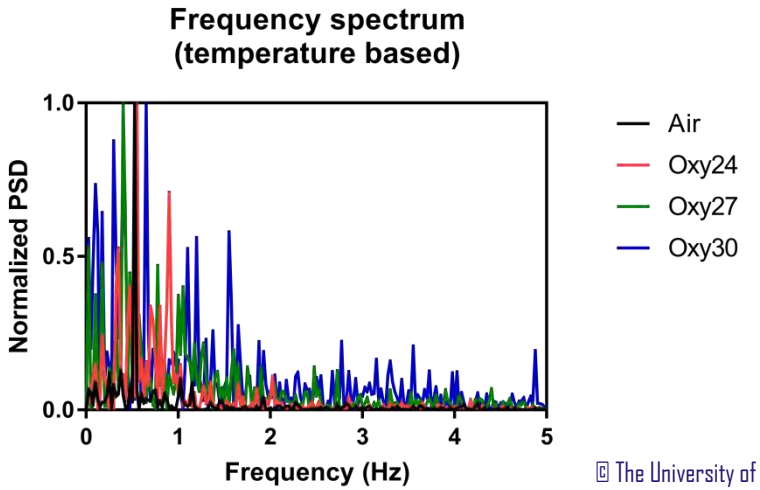
Results

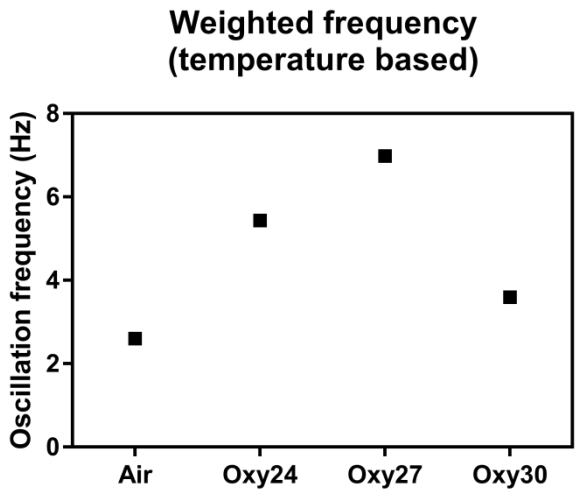
Experimental calculation of the oscillation frequency

COAL





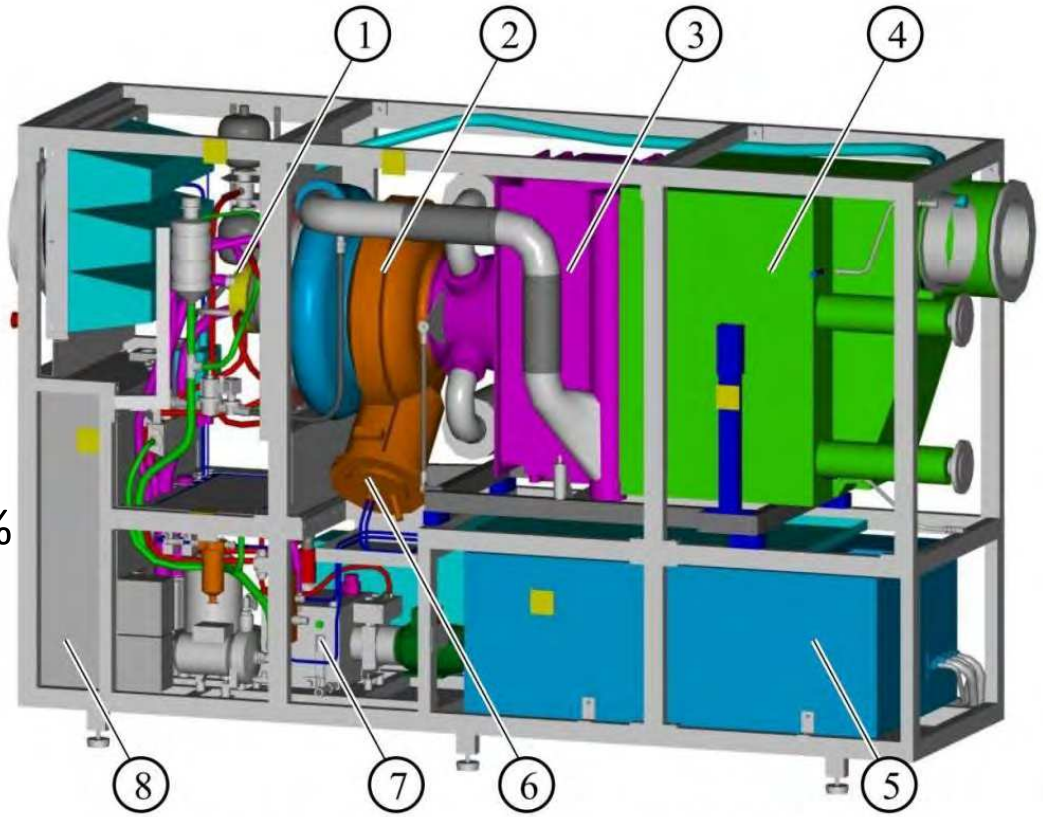




Gas Turbine System

Overview

- Two Turbec T100 Microturbines
- Consume 330kW of Natural gas
- Fuel: Natural gas, biogas, syngas, diesel, kerosene, methanol, LPC
- Generation 100kWe and 150kWth
- Overall efficiency up to 77% (33% electrical)

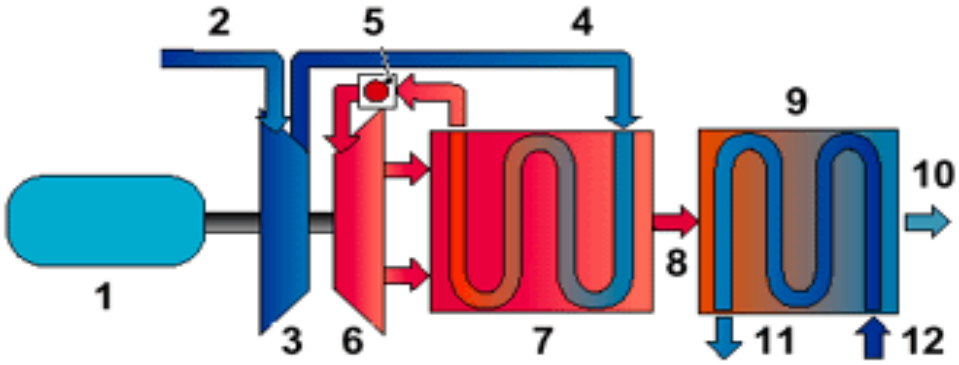


1. Electrical Generator
2. Gas Turbine Engine
3. Recuperator
4. Heat Exchanger
5. Power Electronics
6. Combustion Chamber
7. Auxiliary Systems
8. Control System

Gas Turbine System

System description

- **compressor** – radial centrifugal compressor compresses ambient air before sending to recuperator
- **recuperator** – preheats the compressed combustion air with the heat from the flue gases
- **combustor** – a lean combustion environment ensures low NOx, CO and hydrocarbon emissions
- **Turbine** – the hot, pressurised gas expands through the turbine to drive the turbine and the compressor and generator, which are all on the same shaft
- **Flue gas heat exchanger** – uses the hot flue gas to heat water

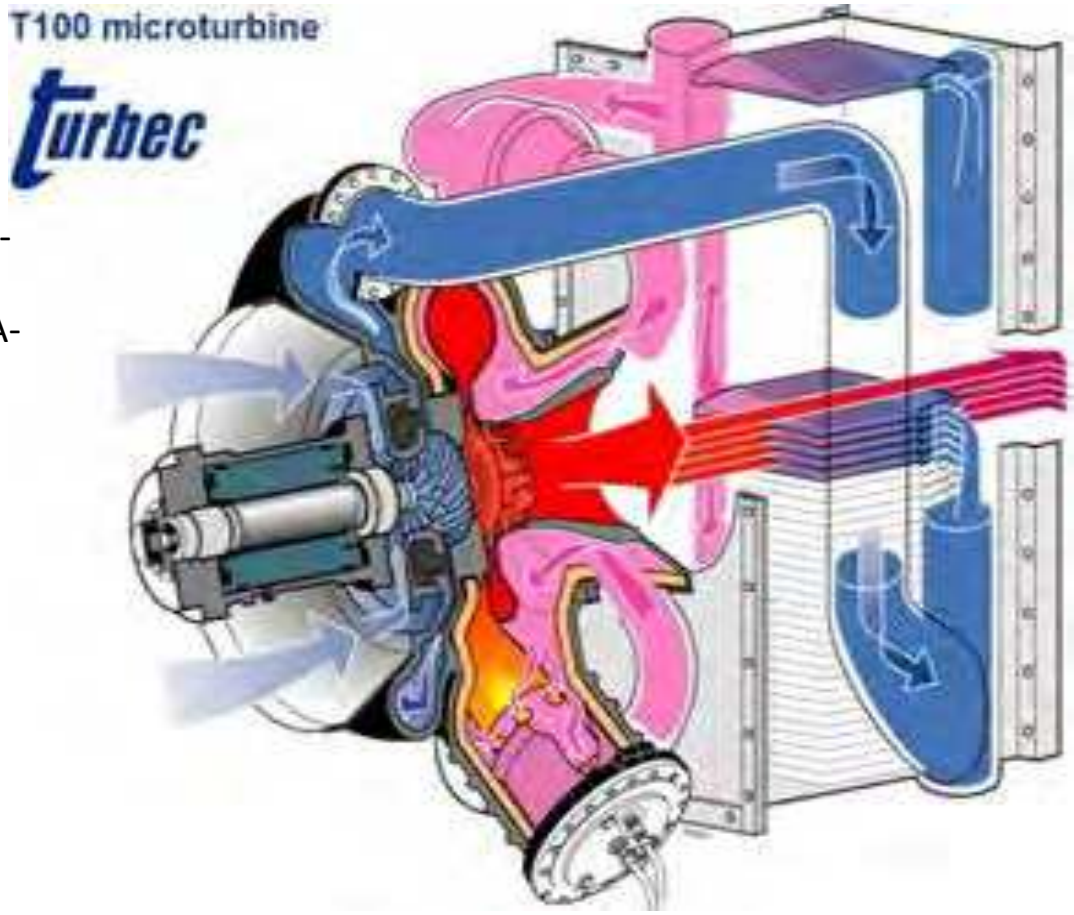


1. Generator
2. Air inlet
3. Compressor
4. Air to recuperator
5. Combustion chamber
6. Turbine
7. Recuperator
8. Exhaust gases
9. Heat exchanger
10. Exhaust gas outlet
11. Hot water outlet
12. Water inlet

Gas Turbine System

Analytical Facilities

- Flow rates, temperatures, dew points and pressure measurements throughout the system.
- Electrical and thermal power measurement
- Combustion Gas Analysis
  - Horiba VA-3000 Analyser I: Model VA-3002 for CO and NOx analysis
  - Horiba VA-3000 Analyser II: Model VA-3113 for CO2, O2 and SO2 analysis
  - Signal 3000HM Heated FID for total hydrocarbon analysis
- Particulate Spectrometer (Cambustion DMS500 Fast Particulate Spectrometer)
  - Classification by particle electrical mobility
  - Online analysis of particle mass, number and size spectra
  - range (5 – 1000nm)



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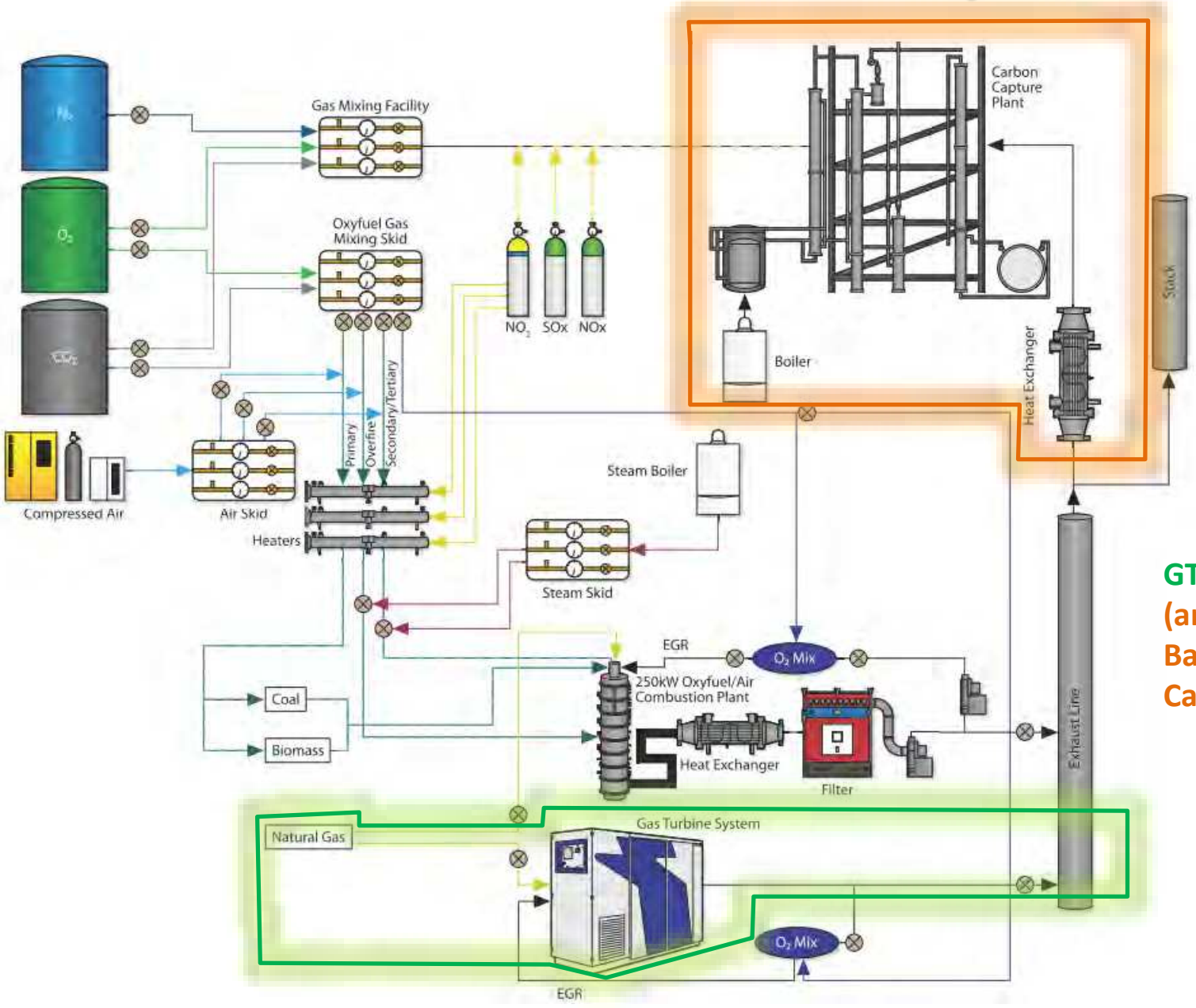
Gas Turbine System



GT + (amine) Solvent Based Carbon Capture Plant =

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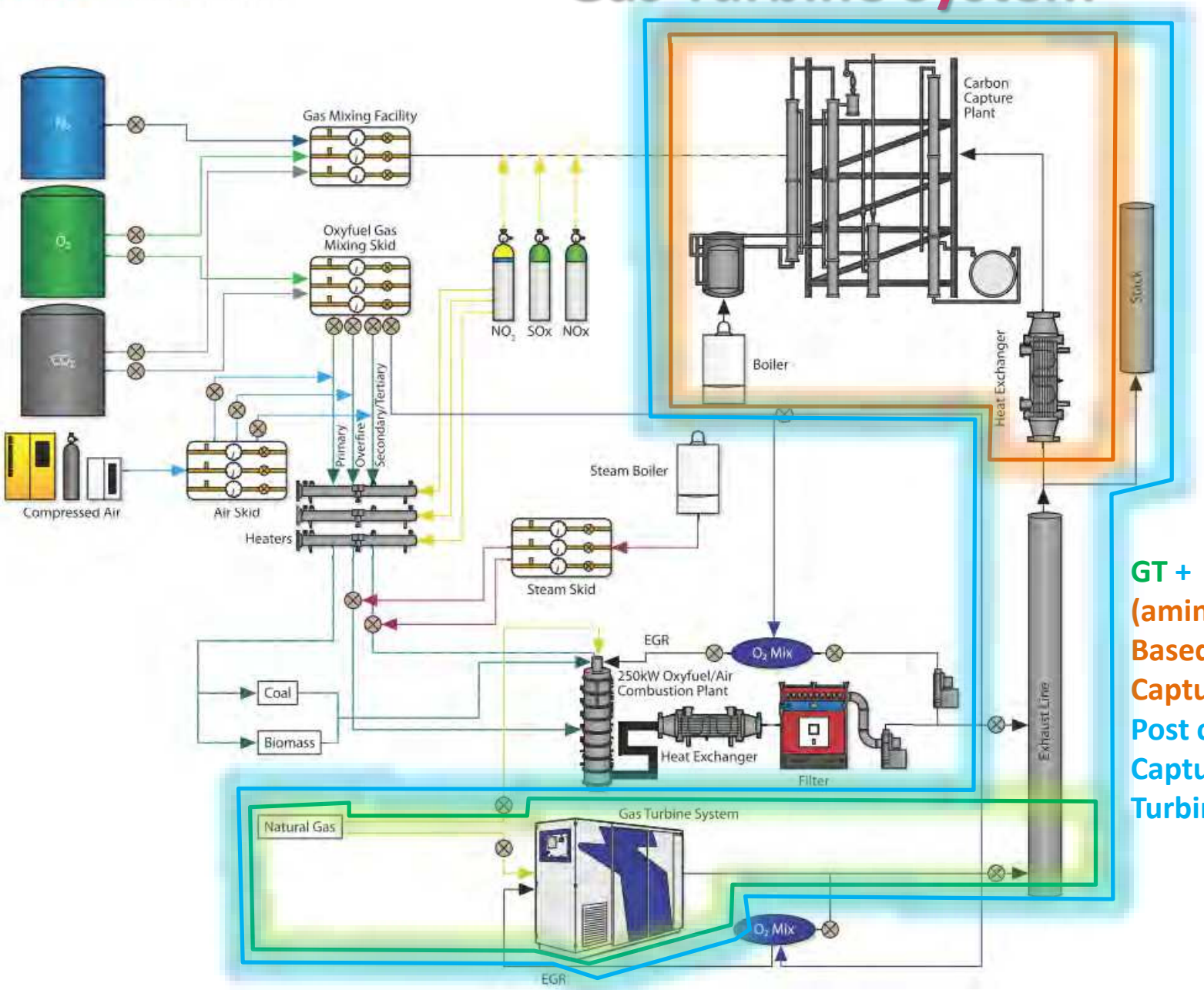
Gas Turbine System



GT + (amine) Solvent Based Carbon Capture Plant = Post combustion Capture from Gas Turbine System

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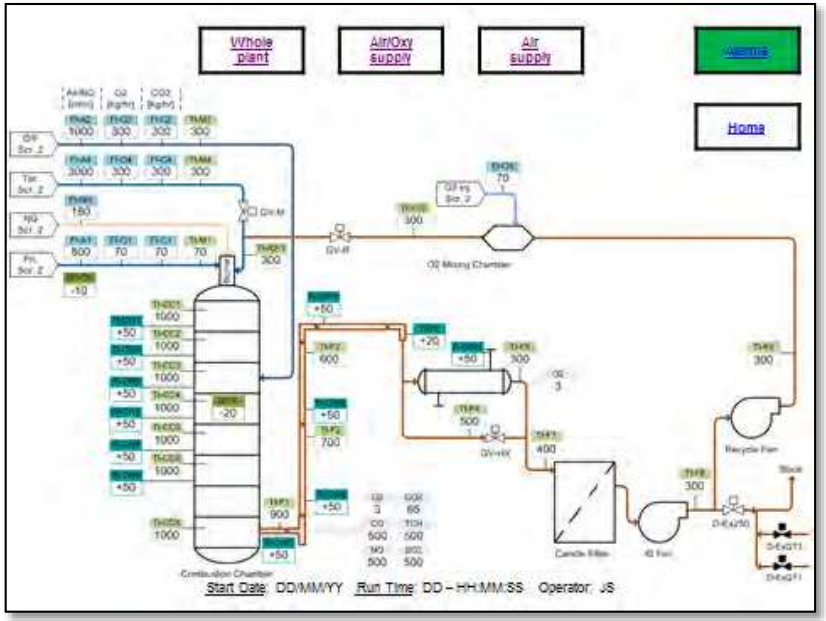
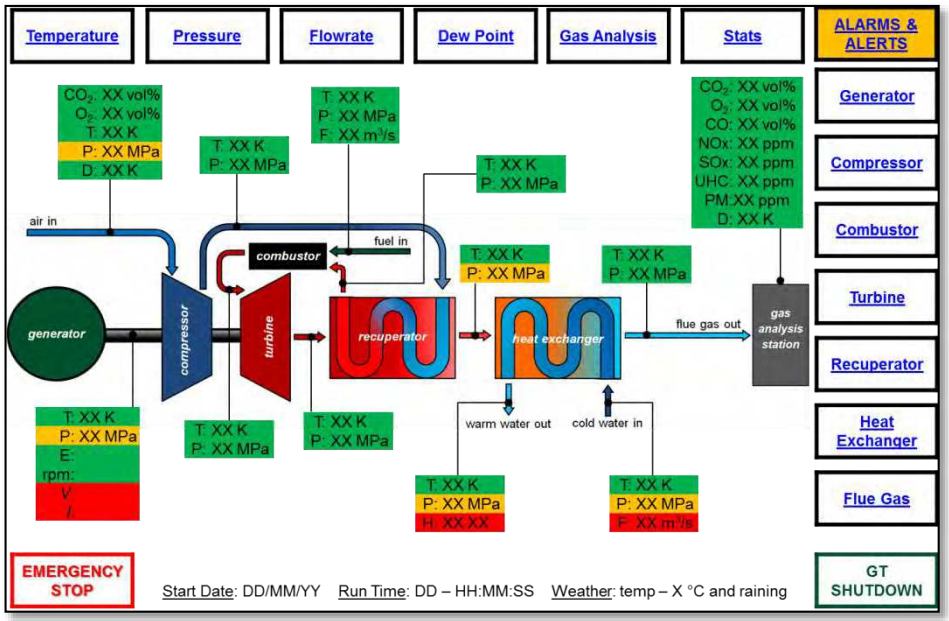
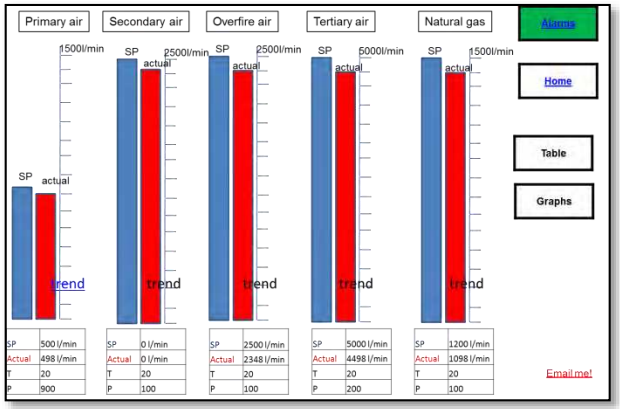
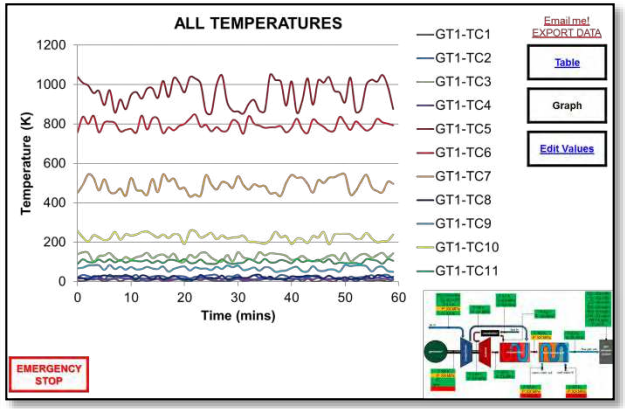
250 kW plant

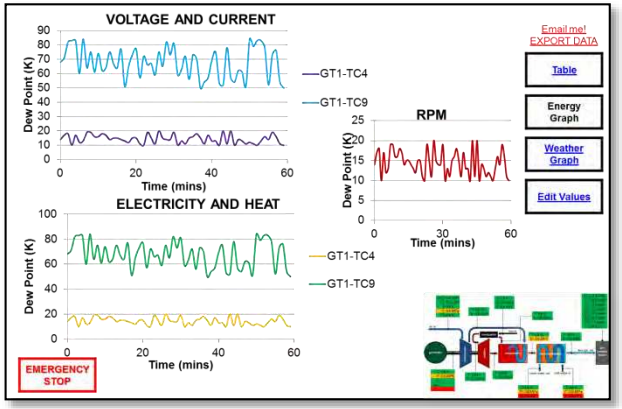


Gas Turbine









Analytical Facilities: Labs

Analytical labs

- Unique CEM mobile laboratory for solid-state detector based ICP-OES (SUWIC)
- Cambustion DMS500 Fast particulate analyser
- CHNS/O Elemental Analyser
- GC MS and TG-MS
- Thermogravimetric Analyser and TG-MS
- FT-IR and TG-IR
- Portable SERVOFLEX MiniMP gas analysers (CO_2 and O_2)

Analytical Facilities: online monitoring

- Gas analysis systems for both 250kW plant and the gas turbine.
- Particle size analyser
- Continuous Emissions Monitoring Laboratory (CEML) mobile laboratory, (Inductively Coupled Plasma) for monitoring metallic emissions from thermal processes;
  - Real-time, online diagnostics
  - Simultaneous multi-metal analysis

Summary

- Comprehensive research capability and support
- Consolidating a wide range of facilities and supporting expertise
- Maximising equipment utilisation through shared access to industry and academia
- Services
  - R&D Services
    - Collaborative research
    - Contract research
  - Analytical services
  - Technical consultancy
  - Training

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