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UKCCSRC PACT CORE FACILITIES SHEFFIELD

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EPSRC
Pioneering research
and skills

- **UKCCSRC Pilot-scale Advanced Capture Technology 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

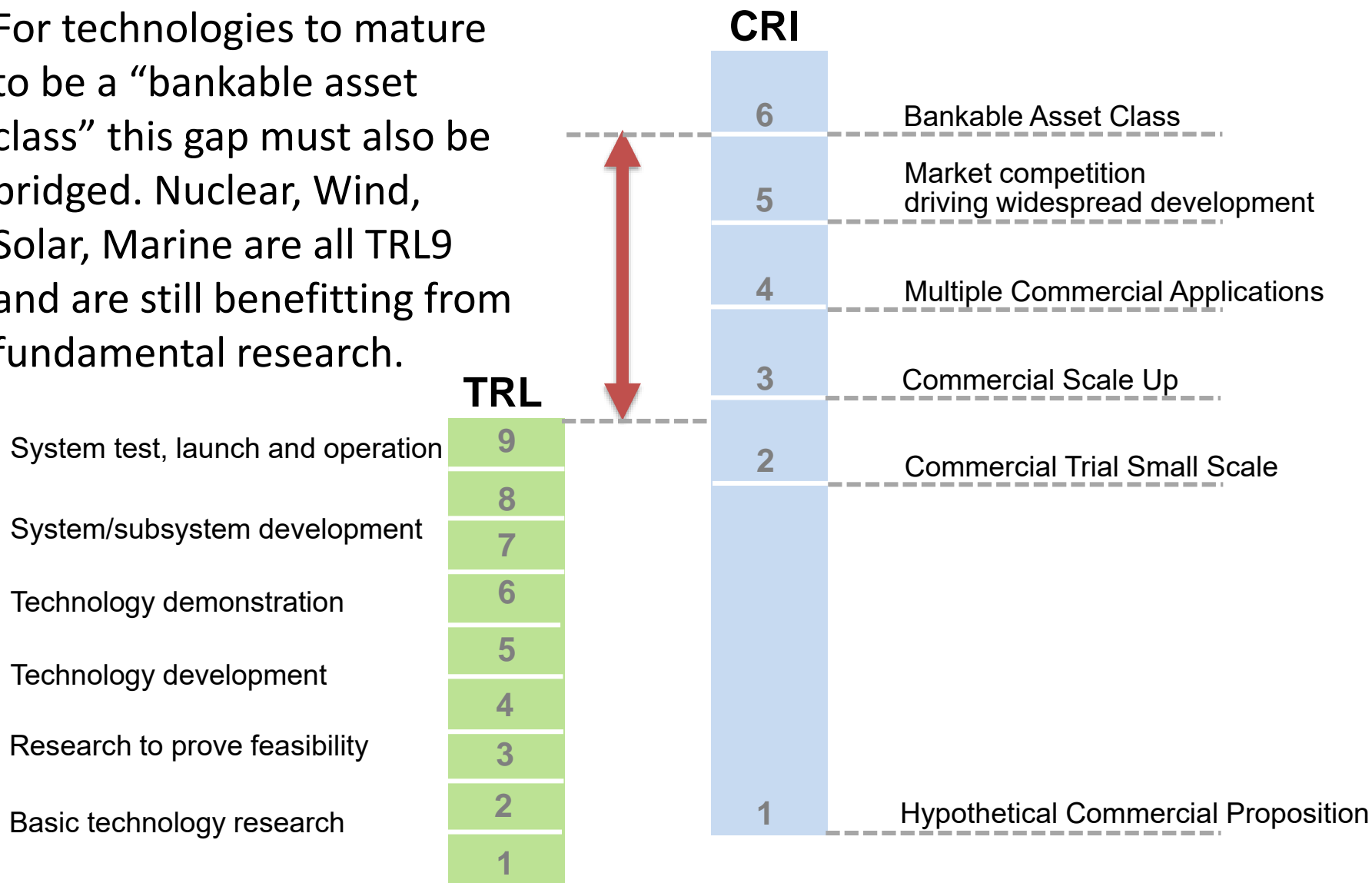
EPSRC

Engineering and Physical Sciences
Research Council



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.

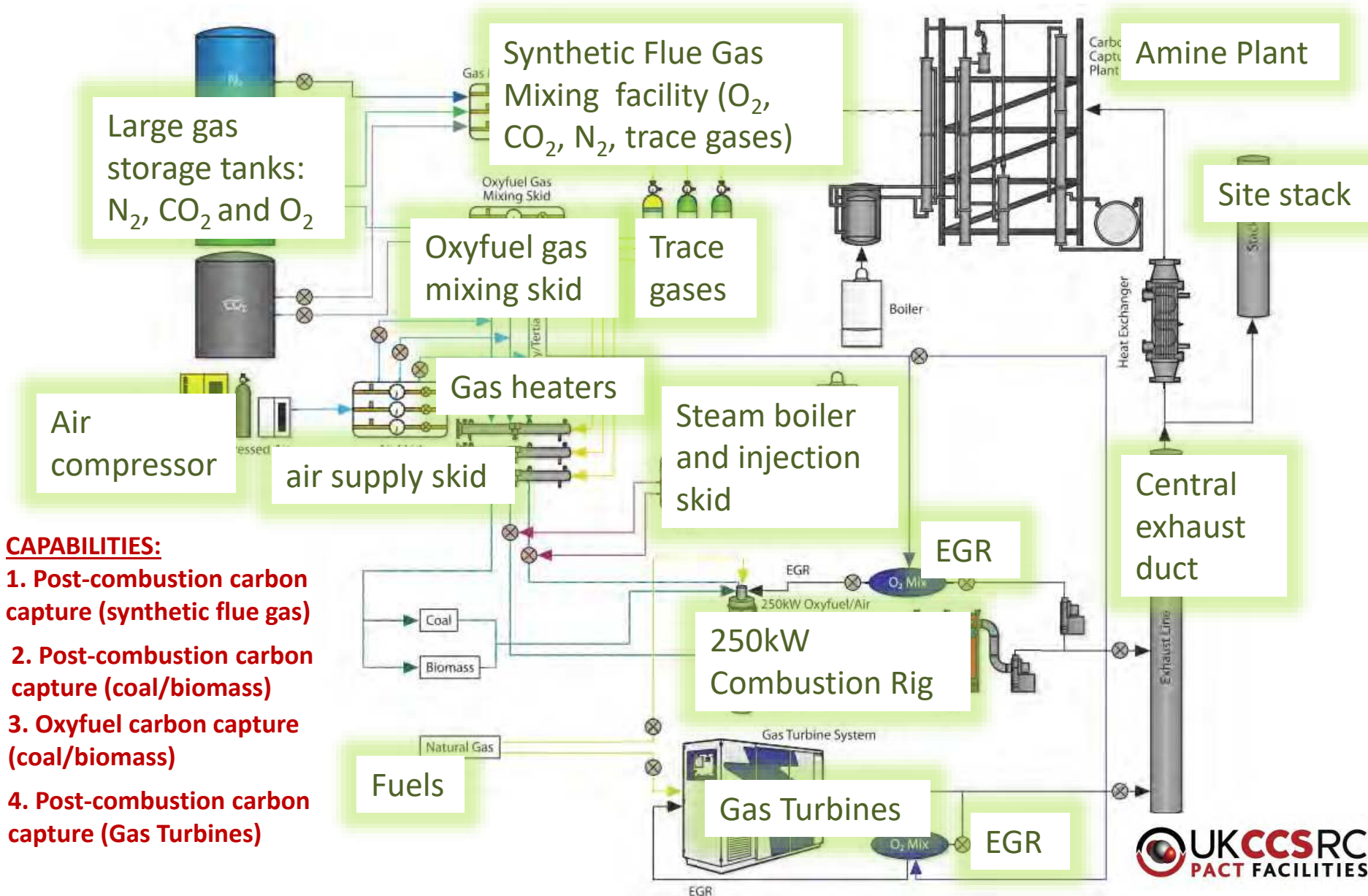


PACT Core Facilities

**Coal/Biomass, NG-CCGT , Biofuel, CO₂
Capture Plant**

**Large –Scale Combustion Test
Facilities**

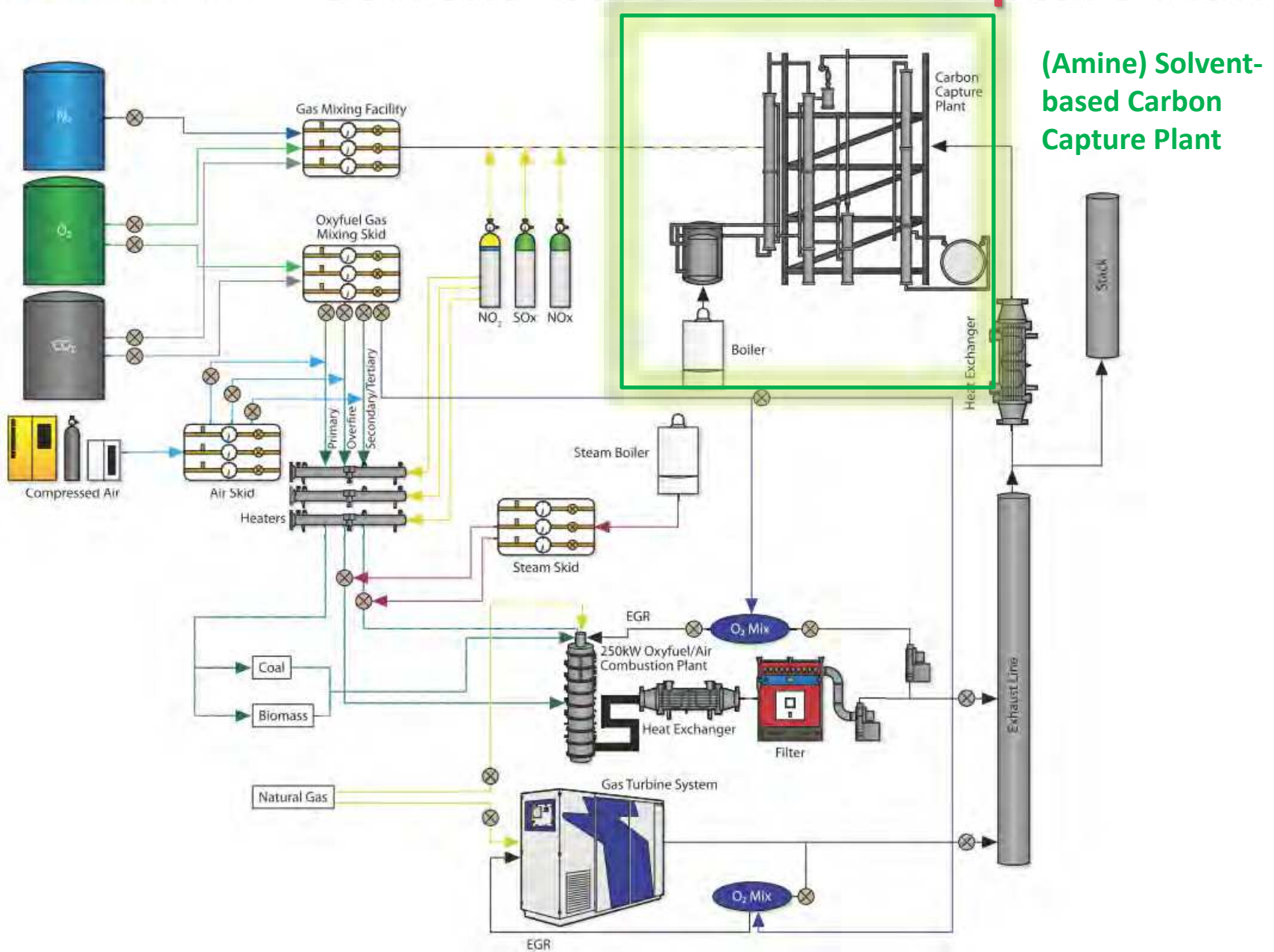
PACT Core Facility: Overview



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)

Solvent-based Carbon Capture Plant



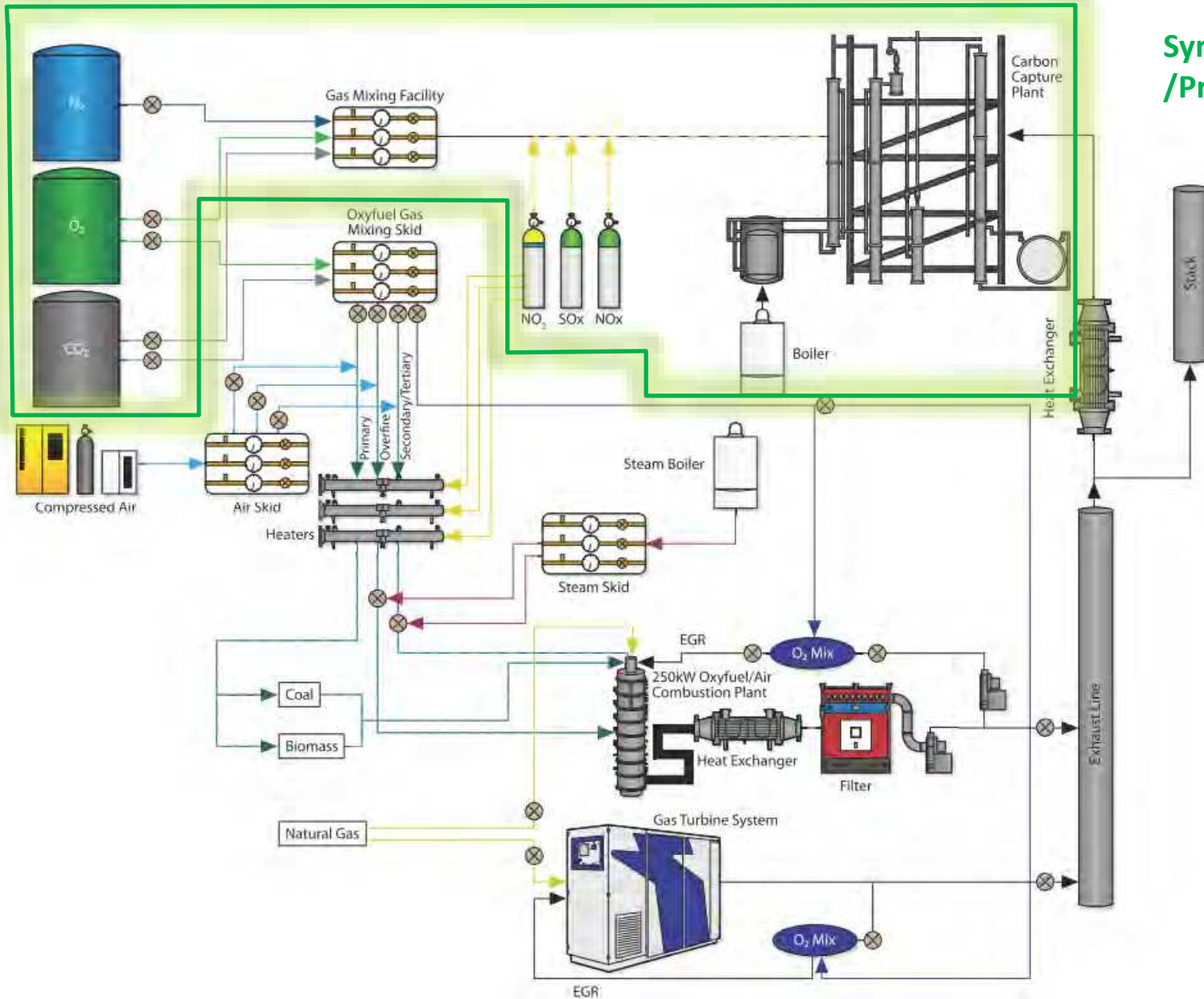
Overview

- 8m/300mm Absorber and Desorber columns
 - 2x 3m packed sections
 - Random/structured packing
- Integrated FGD (carbonate) wash system for removal of SO_x from coal flue gas
- Flue gas treated: 210 Nm³/h; equiv. to 150kW coal flue gas
- Removes 1 tonne of CO₂ 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)



Synthetic Flue/Process Gas Facility

Synthetic Flue
/Process Gas System



Synthetic Flue/Process Gas Facility

Overview

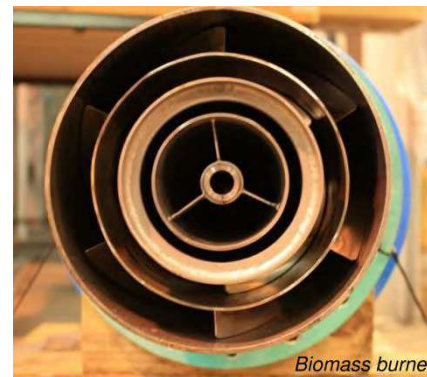
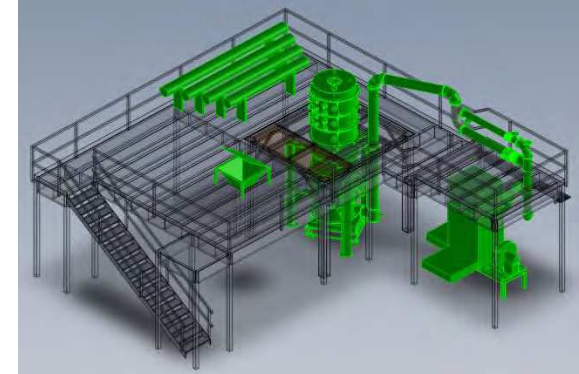
- Three **gas metering and mixing** lines, fed from O₂, CO₂ and N₂ storage tanks
- Complemented by **trace gas injection** NO_x and SO_x, other trace gasses
- Generate simulated flue/process gases
- Connected directly to the **Solvent-based Carbon Capture Plant**



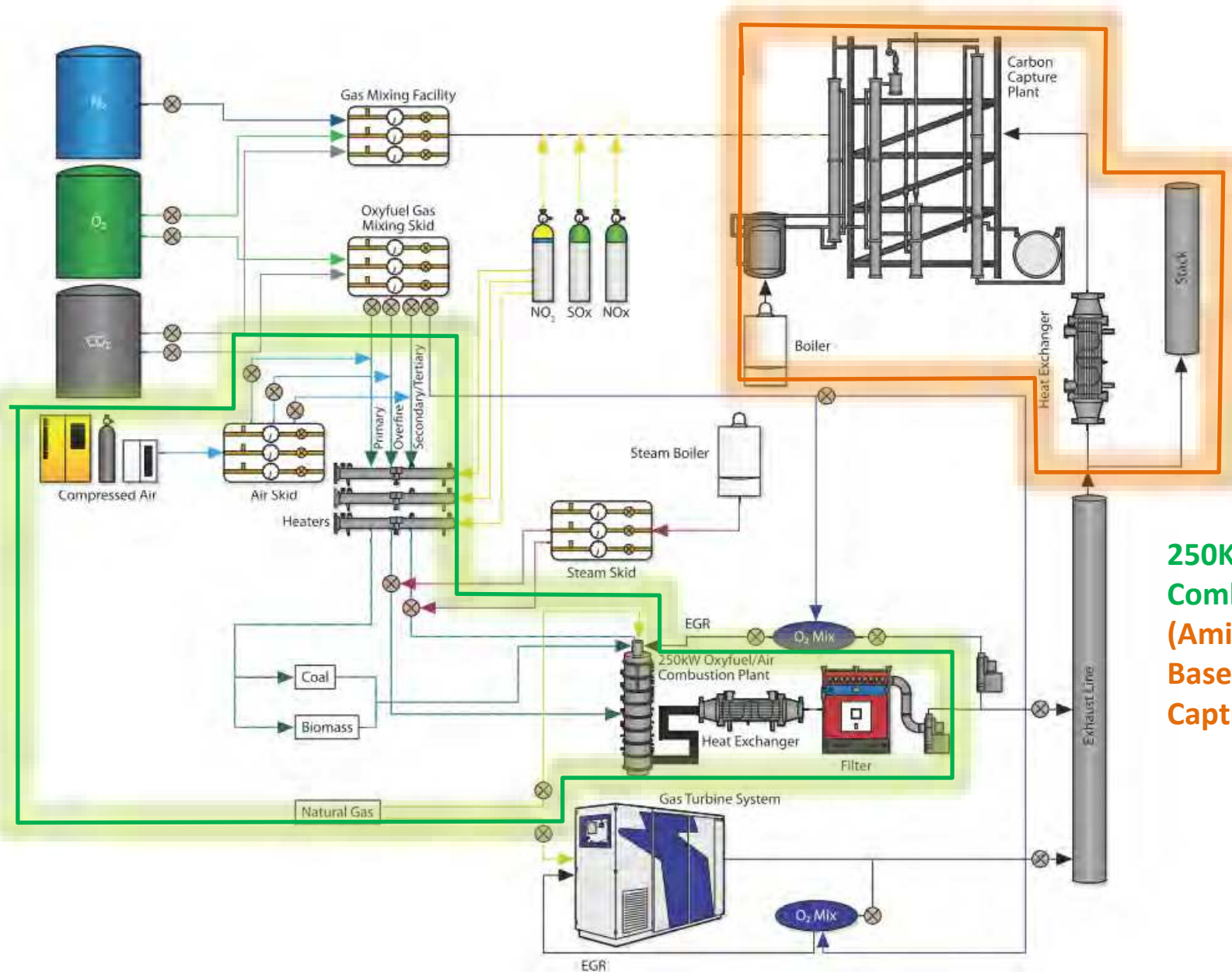
250kW Air Combustion Plant

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-NO_x burners
- Dedicated, high precision 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

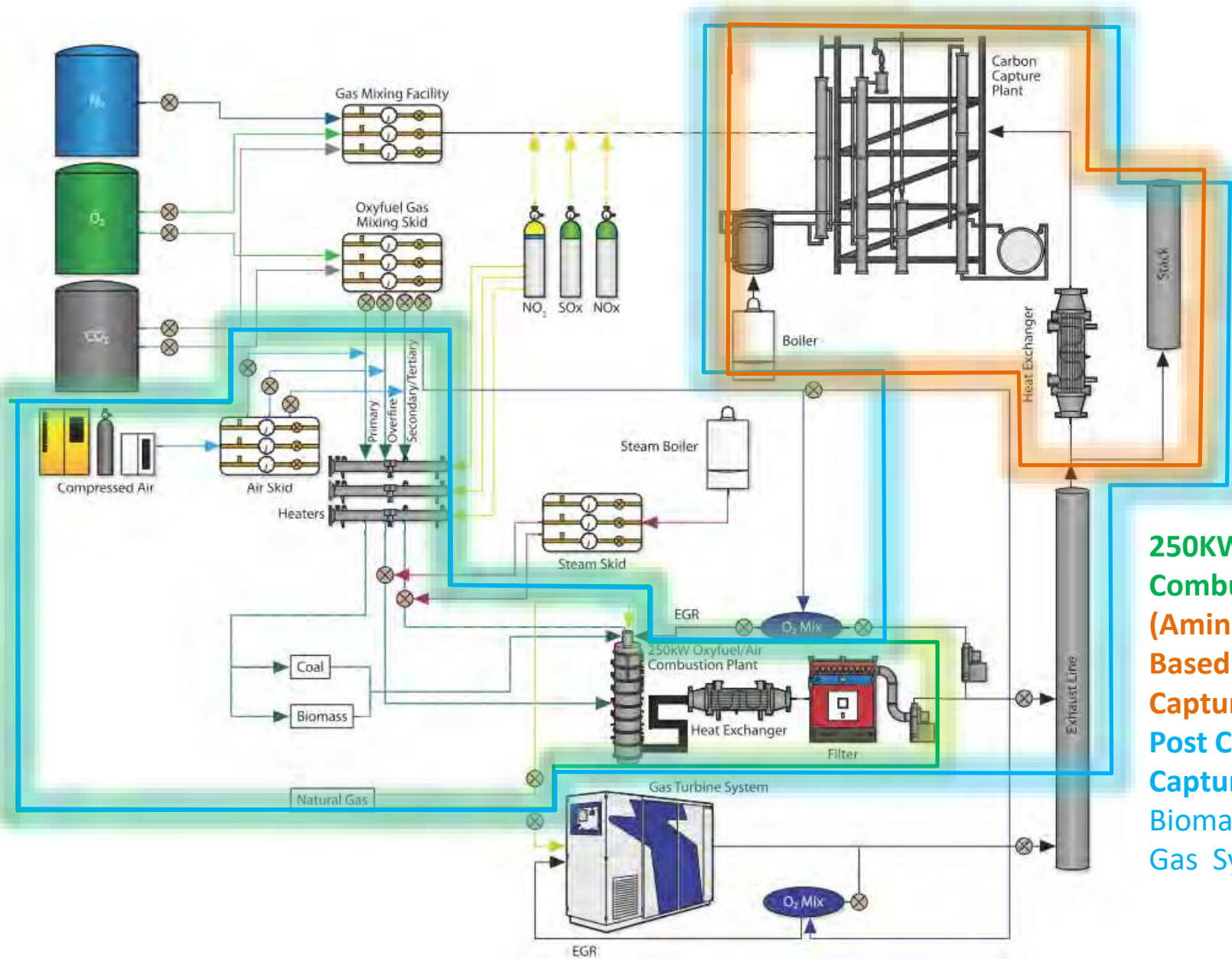


PACT Core Facility: Layout



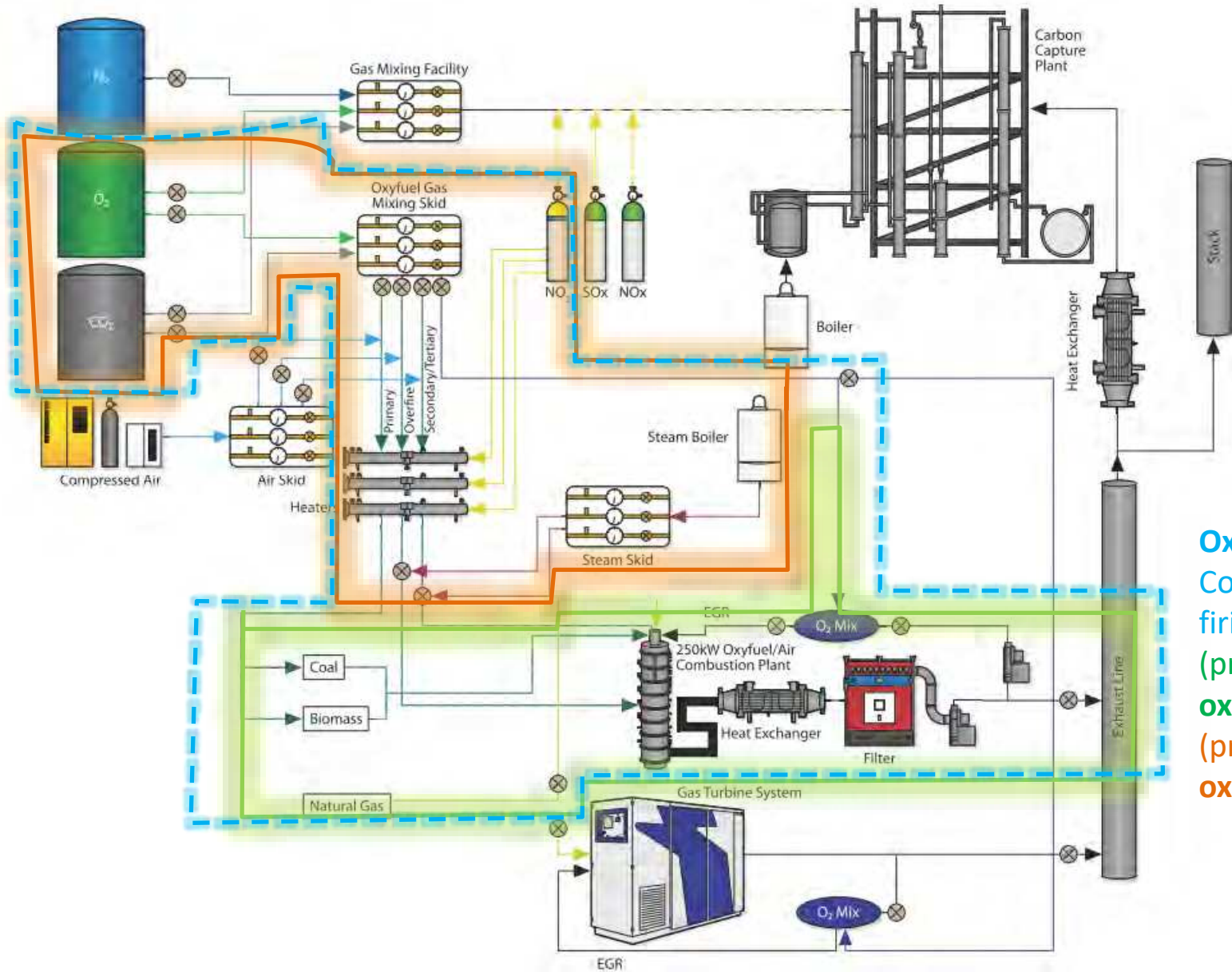
**250KW Air
Combustion Plant +
(Amine) Solvent
Based Carbon
Capture Plant =**

PACT Core Facility: Layout



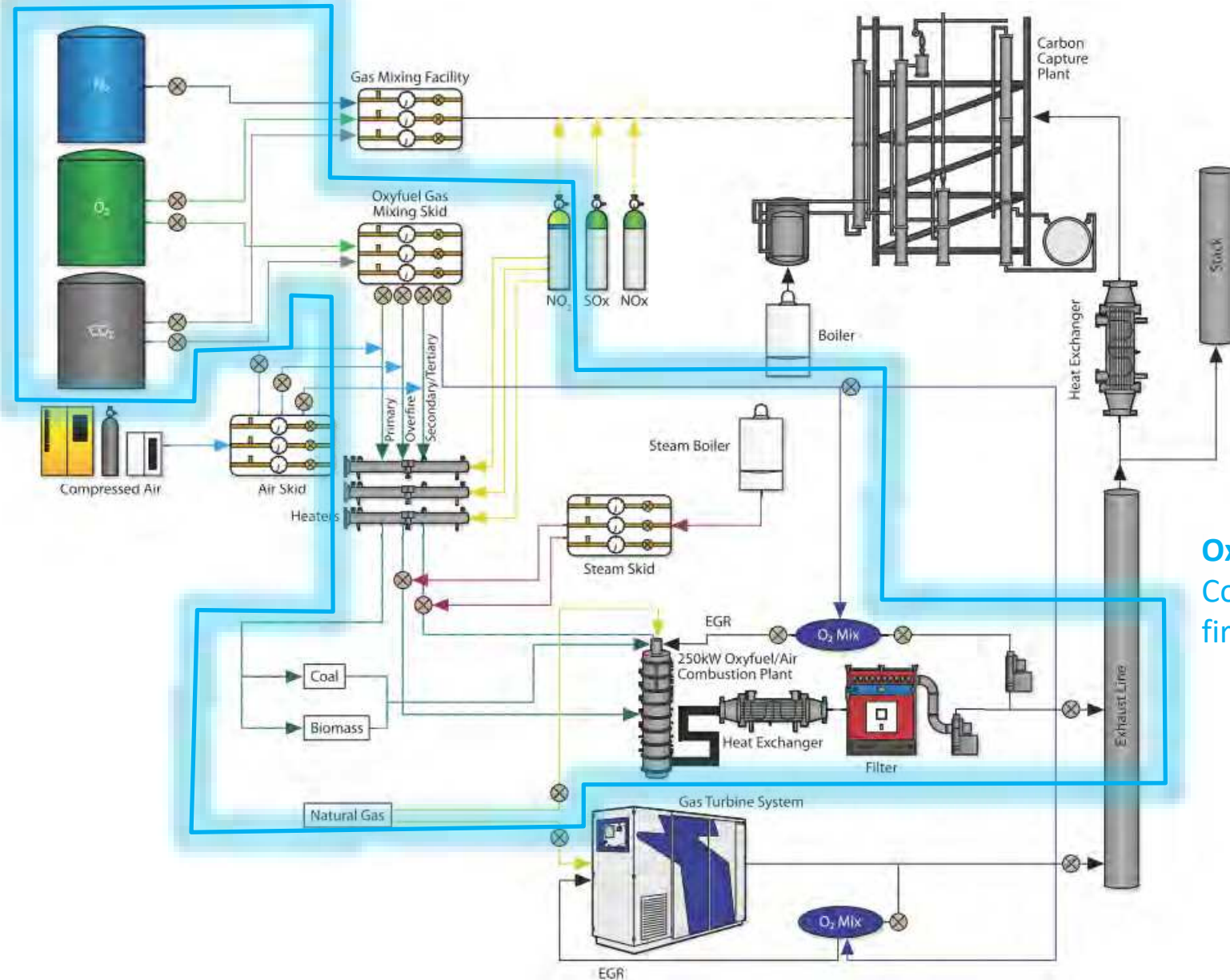
**250KW Air
Combustion Plant +
(Amine) Solvent
Based Carbon
Capture Plant =
Post Combustion
Capture from Coal,
Biomass, Co-firing,
Gas Systems:**

250kW Oxyfuel Combustion Plant



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

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

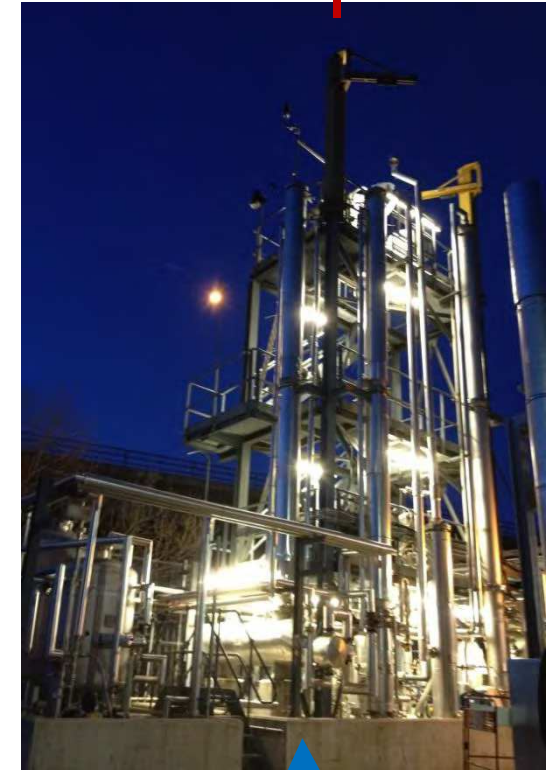
Gas Mixing Facilities



250kW Air/Oxy Rig

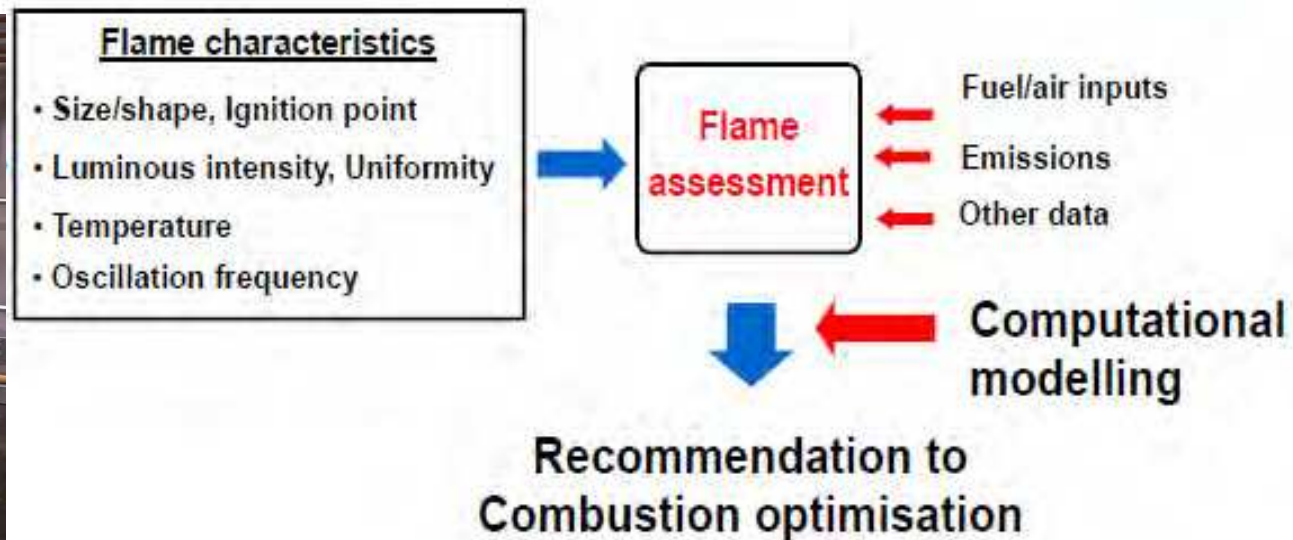
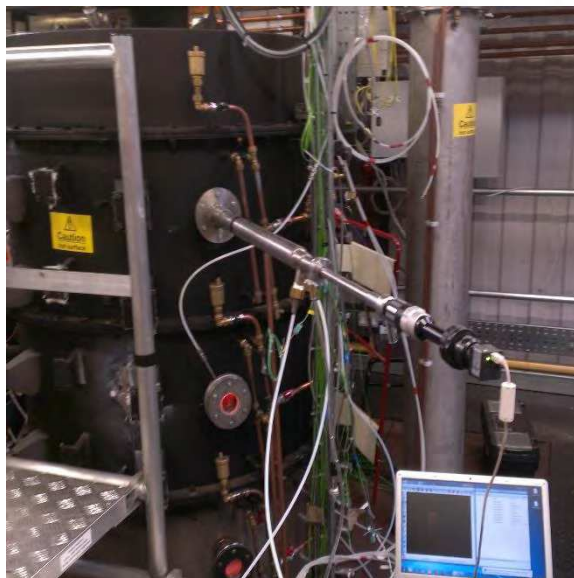
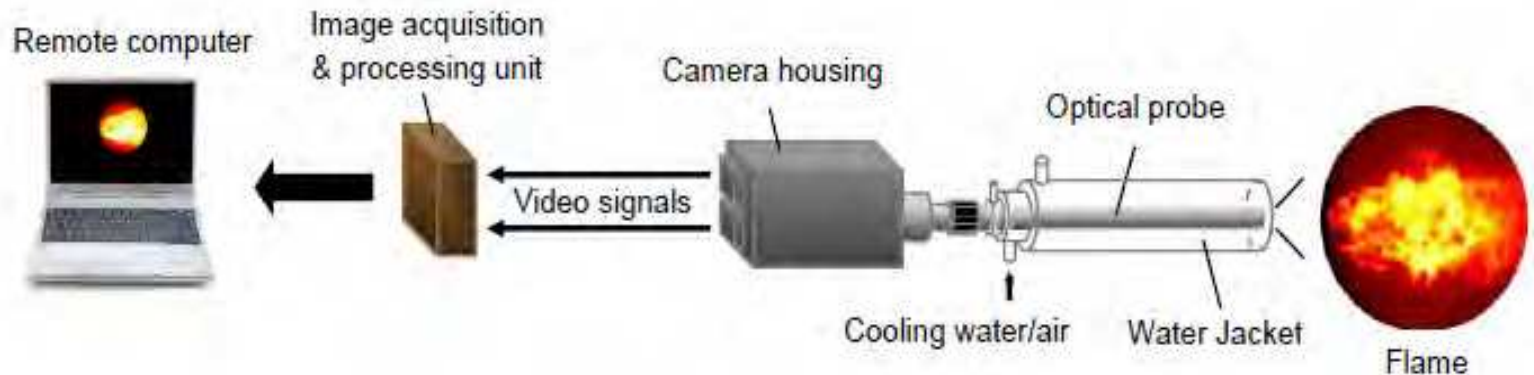


ICP-OES & DMS 500



Carbon Capture Plant

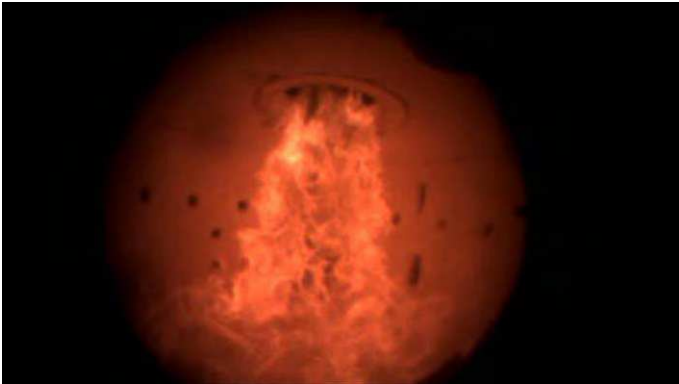
Flame Imaging System



Results

Experimental calculation of the oscillation frequency - COAL

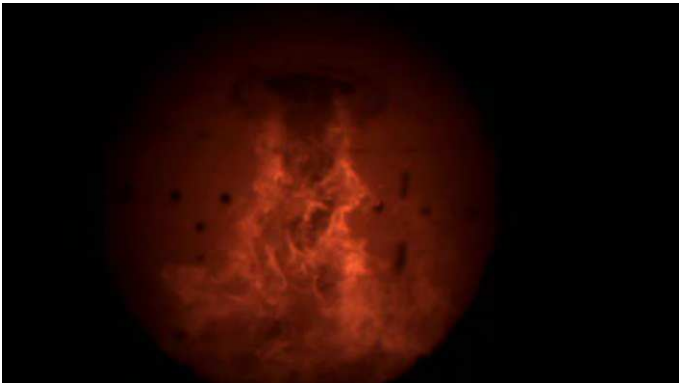
Original videos



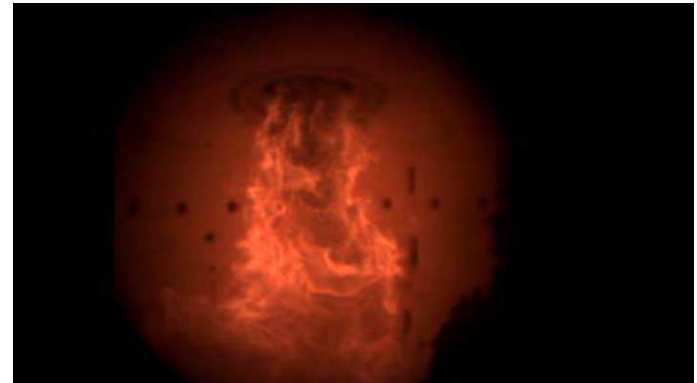
Air



Oxy24



Oxy27



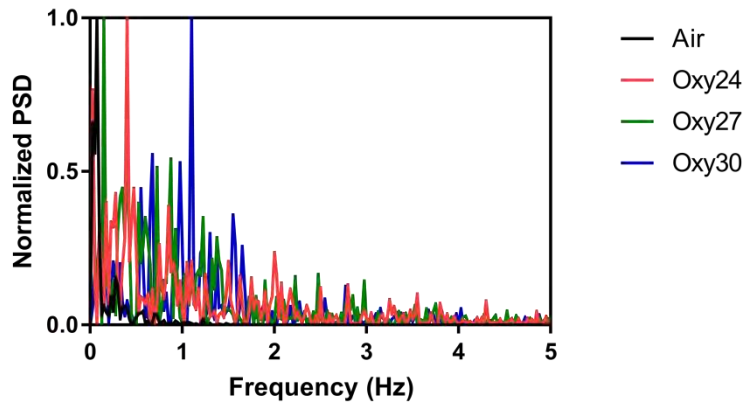
Oxy30

Results

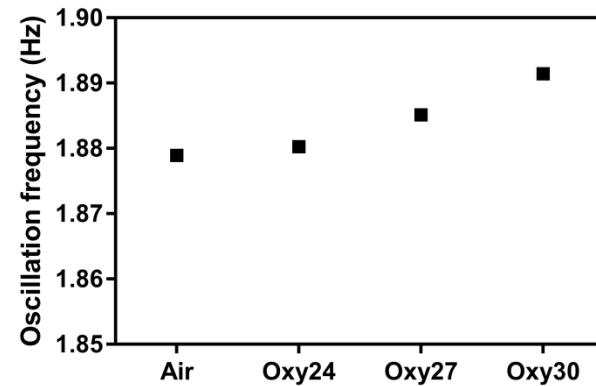
Experimental calculation of the oscillation frequency

COAL

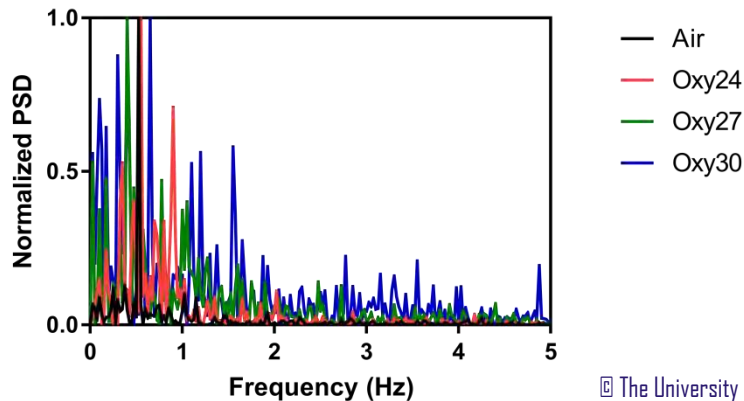
Frequency spectrum
(luminance based)



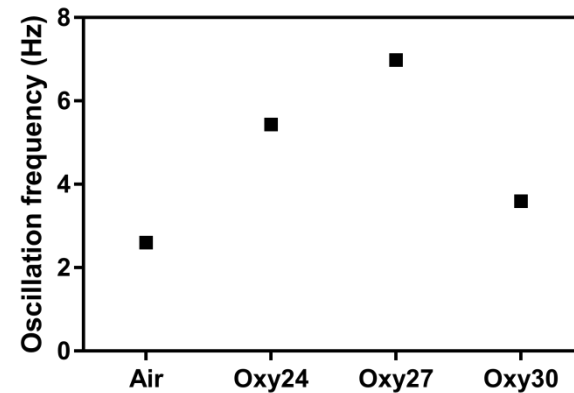
Weighted frequency
(temperature based)



Frequency spectrum
(temperature based)



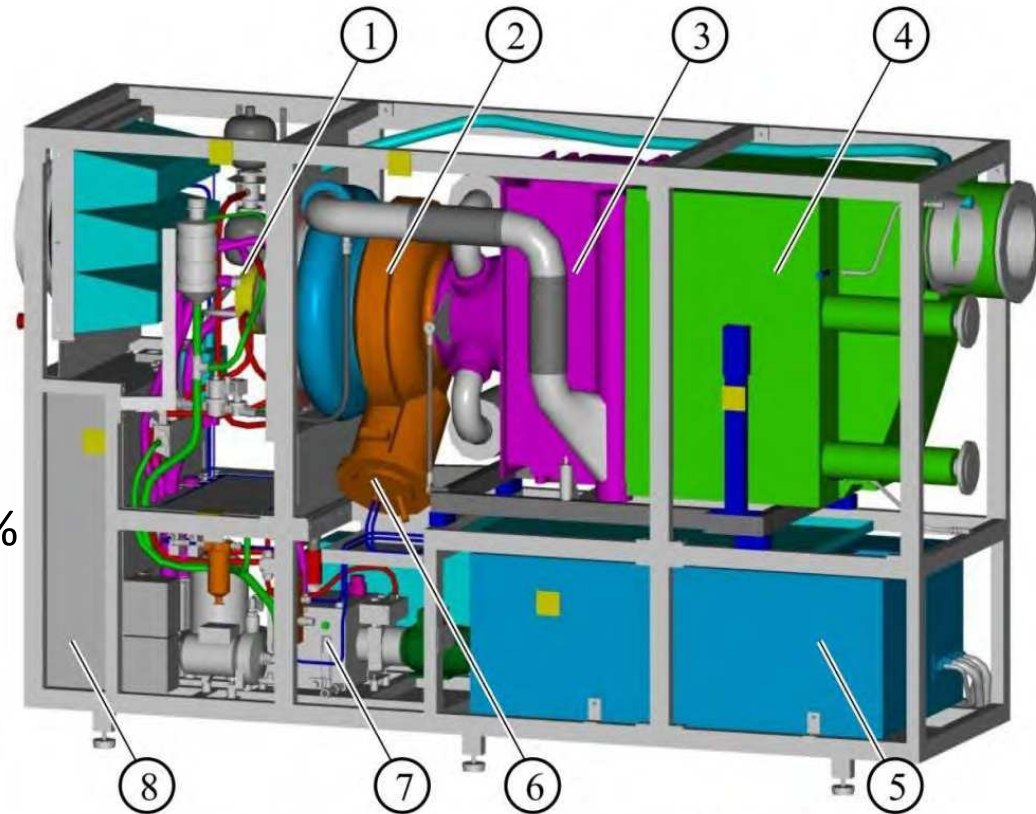
Weighted frequency
(temperature based)



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)



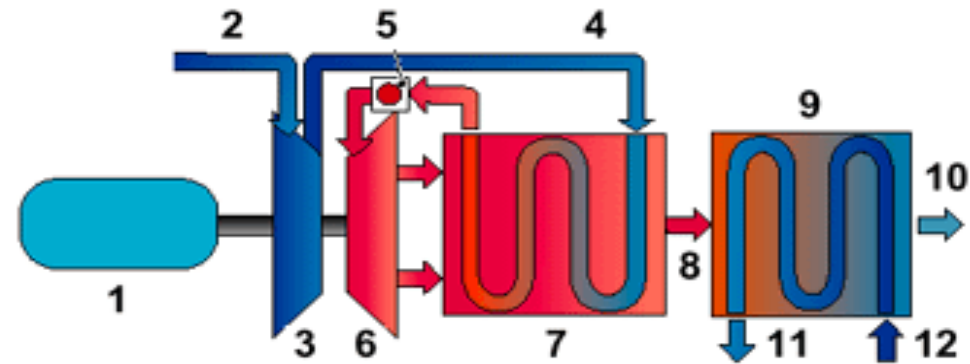
1. Electrical Generator
2. Gas Turbine Engine
3. Recuperator
4. Heat Exchanger

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 NO_x, 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



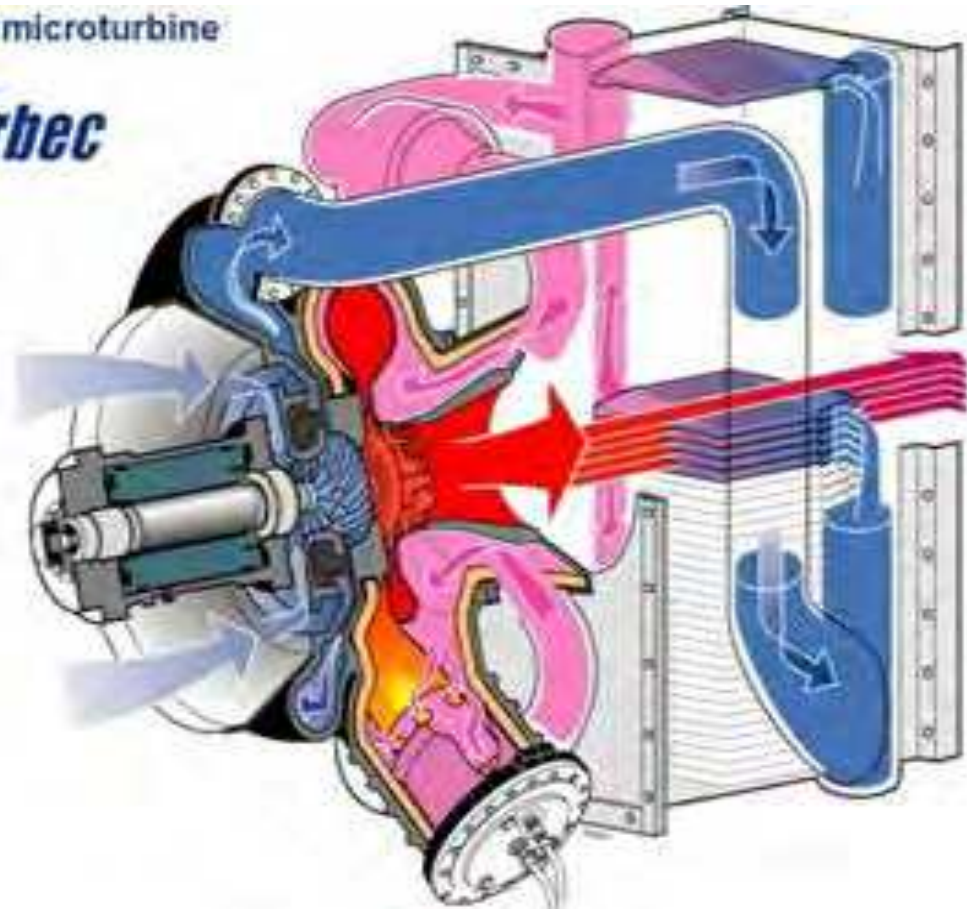
- | | |
|-----------------------|------------------------|
| 1. Generator | 7. Recuperator |
| 2. Air inlet | 8. Exhaust gases |
| 3. Compressor | 9. Heat exchanger |
| 4. Air to recuperator | 10. Exhaust gas outlet |
| 5. Combustion chamber | 11. Hot water outlet |
| 6. Turbine | 12. Water inlet |

Gas Turbine System

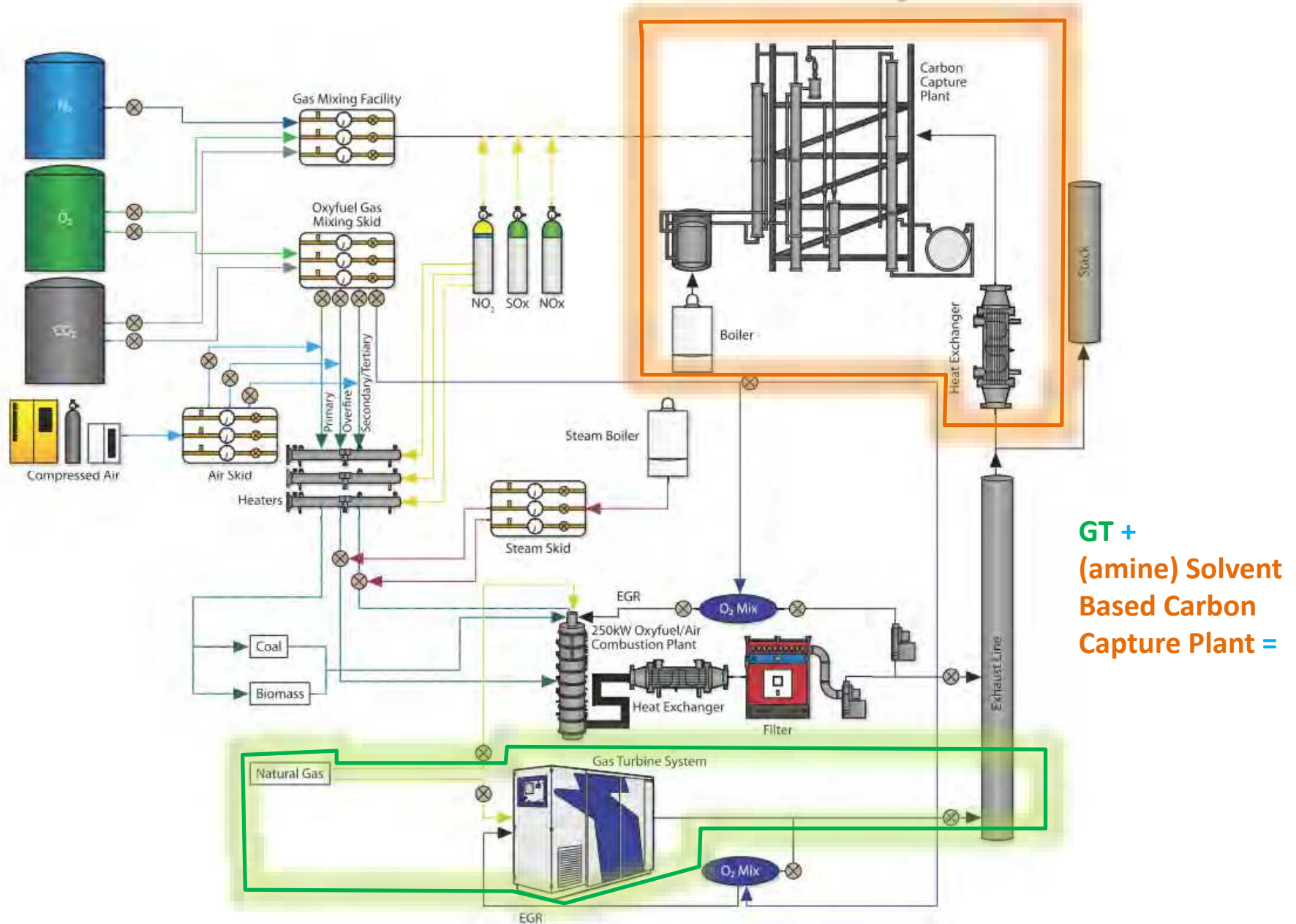
Analytical Facilities

- ❑ 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)

T100 microturbine
turbec

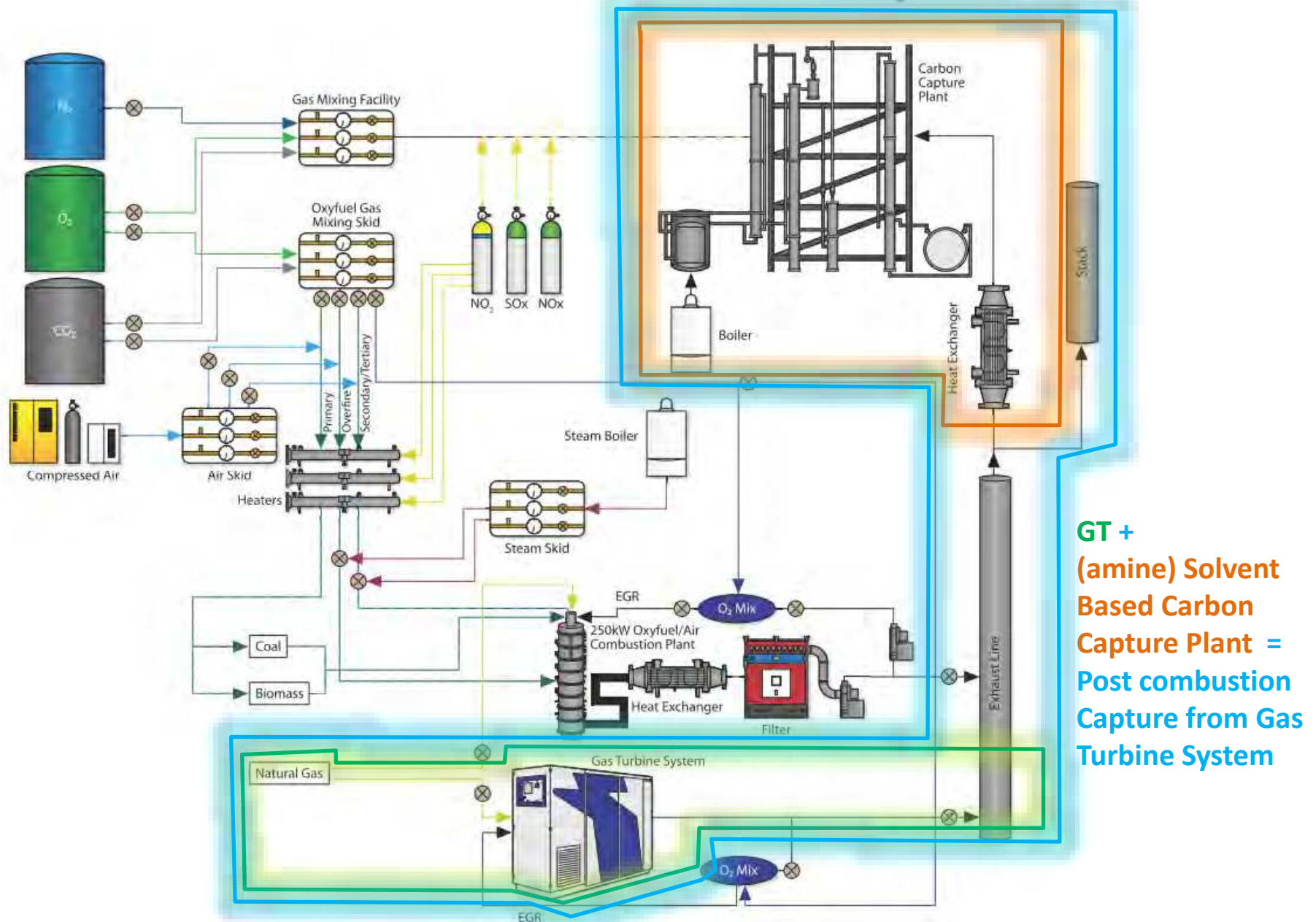


Gas Turbine System



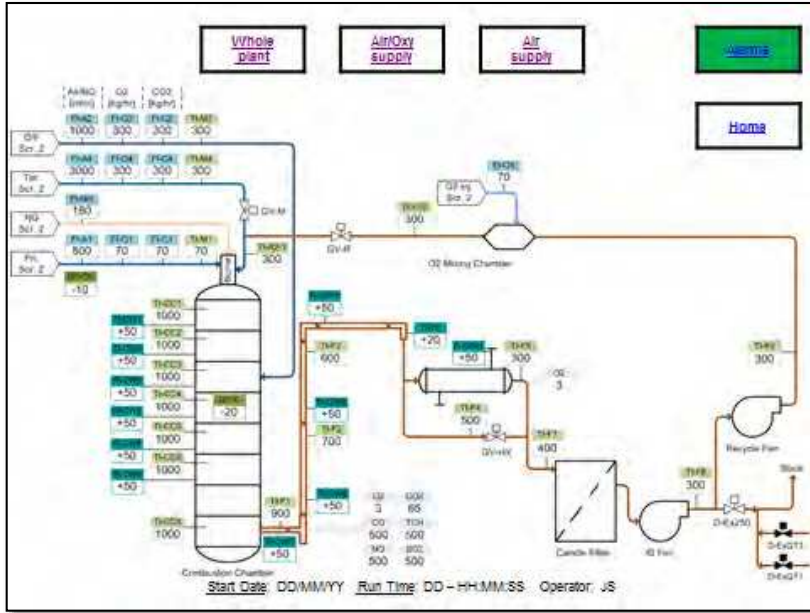
GT +
(amine) Solvent
Based Carbon
Capture Plant =

Gas Turbine System

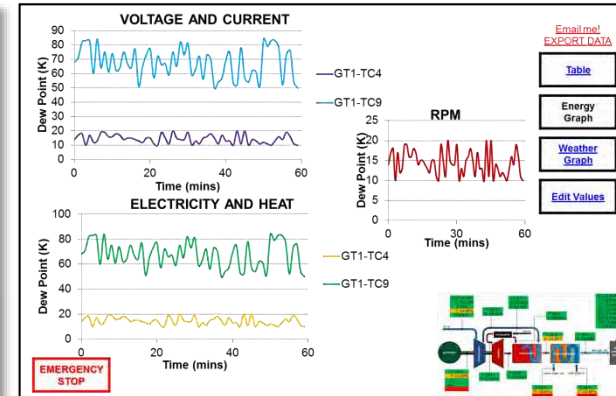
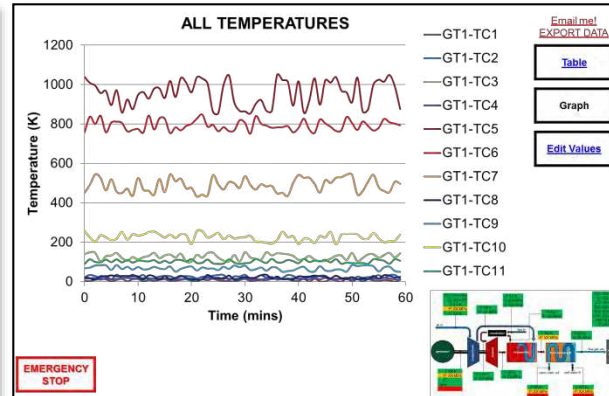
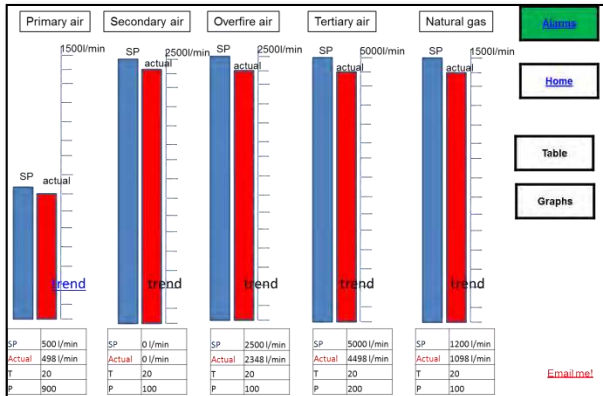
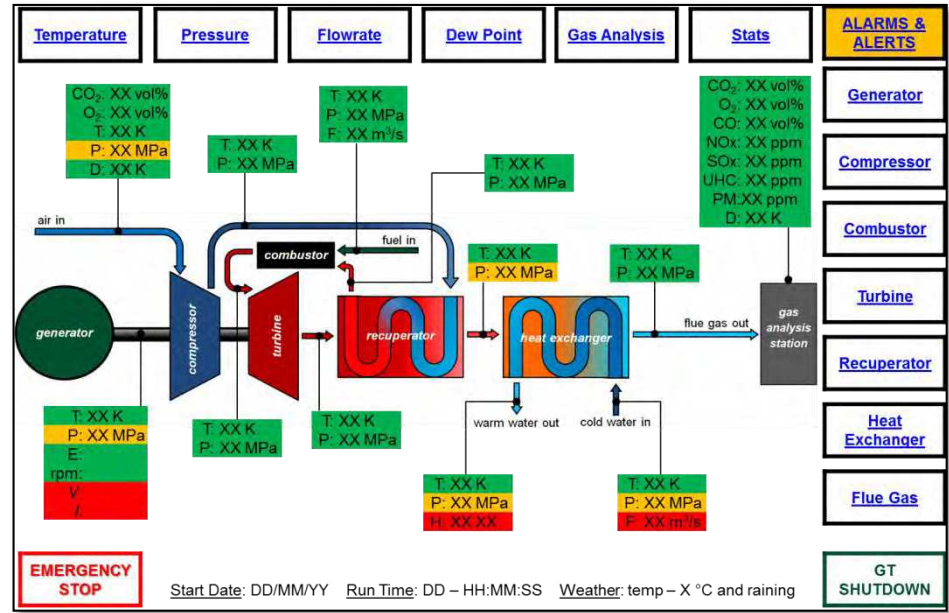


**GT +
(amine) Solvent
Based Carbon
Capture Plant =
Post combustion
Capture from Gas
Turbine System**

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 SERVOMEX MiniMP gas analysers (CO₂ and O₂)



- 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

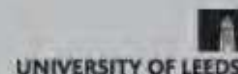
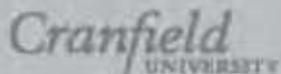
Summary

- 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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