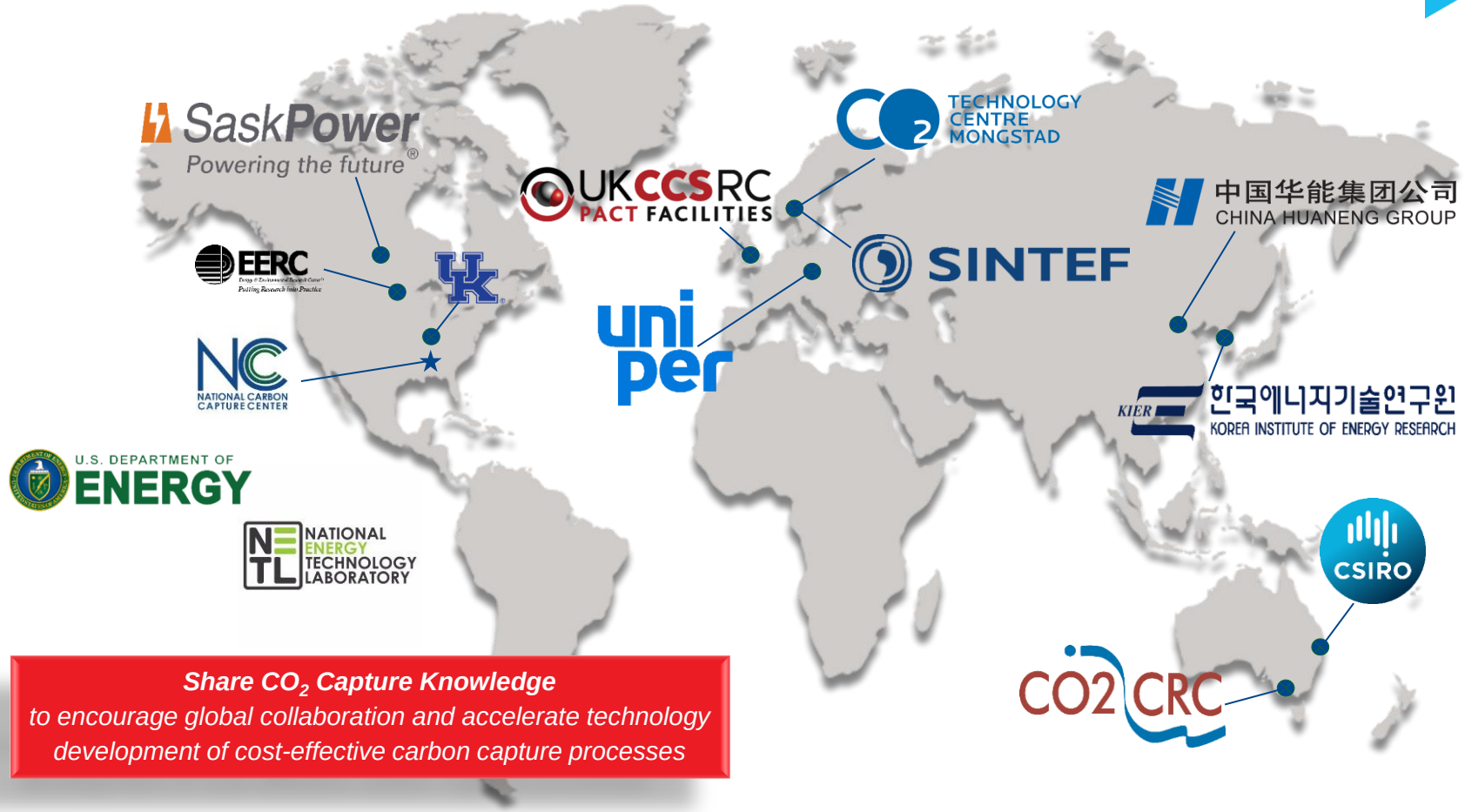
International Test Center Network

- 13 Members
- Share pubic knowledge with carbon capture test facilities.
  - Facility operations
  - Facility funding
  - Safety
  - Analytical techniques
- Collaborate on one technical item per year.
  - Amine carry-over and measurement techniques
  - Support advanced simulations and model development with a focus on reducing capital and operating cost and minimizing scale-up risks

Share CO_2 Capture Knowledge
to encourage global collaboration and accelerate technology development of cost-effective carbon capture processes

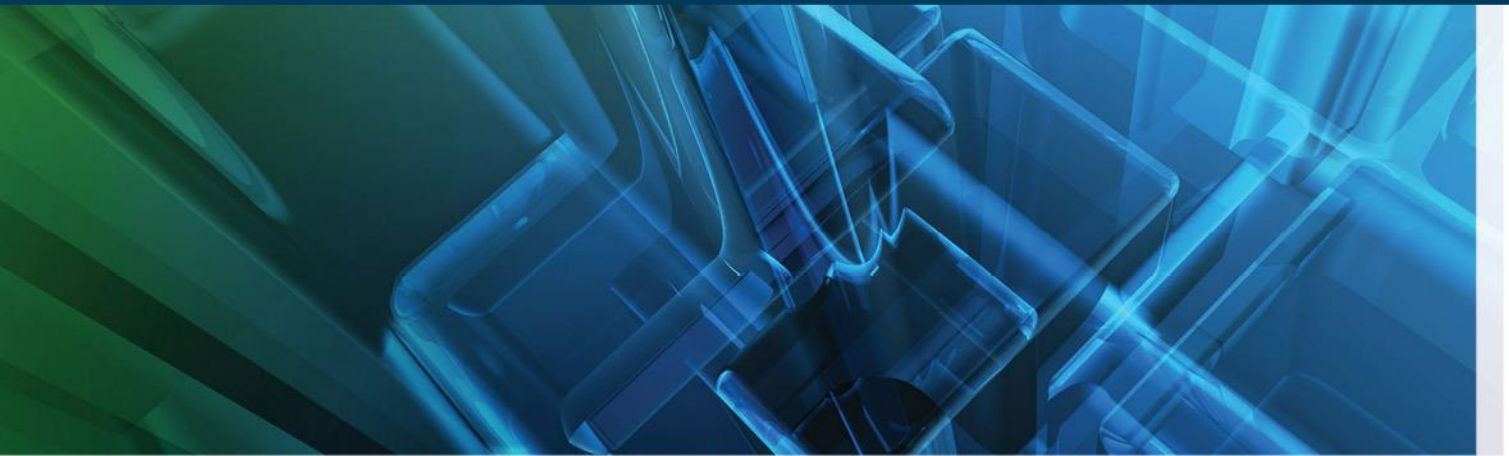
International Test Center Network Members



Share CO_2 Capture Knowledge
to encourage global collaboration and accelerate technology development of cost-effective carbon capture processes

National Carbon Capture Center Overview

Frank Morton – Director Technology Development



NATIONAL CARBON CAPTURE CENTER

National Carbon Capture Center

*Offering a **world-class neutral test** facility and highly specialized staff to **accelerate the commercialization** of advanced technologies and enable coal-based power plants to achieve **near-zero emissions (low-cost CO_2)**.*

- Over **97,000 test hours** since founding in 2008
- Technology developers from **U.S. and six other countries**
- **First coal-derived gas testing** of solid oxide fuel cells and certain solvents, membranes and enzymes
- On-site **scale-ups** and **process enhancements** for 10 technologies
  - Scale-ups for testing at larger sites for five solvents
  - Scale-up to commercial operation for one solvent

Timeline: June 1, 2014 – May 31, 2019

U.S. DEPARTMENT OF ENERGY

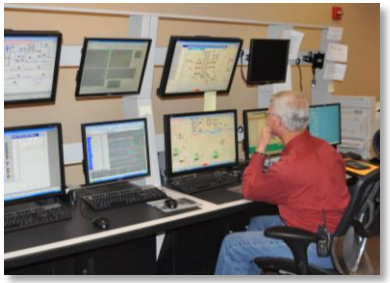
NATIONAL ENERGY TECHNOLOGY LABORATORY

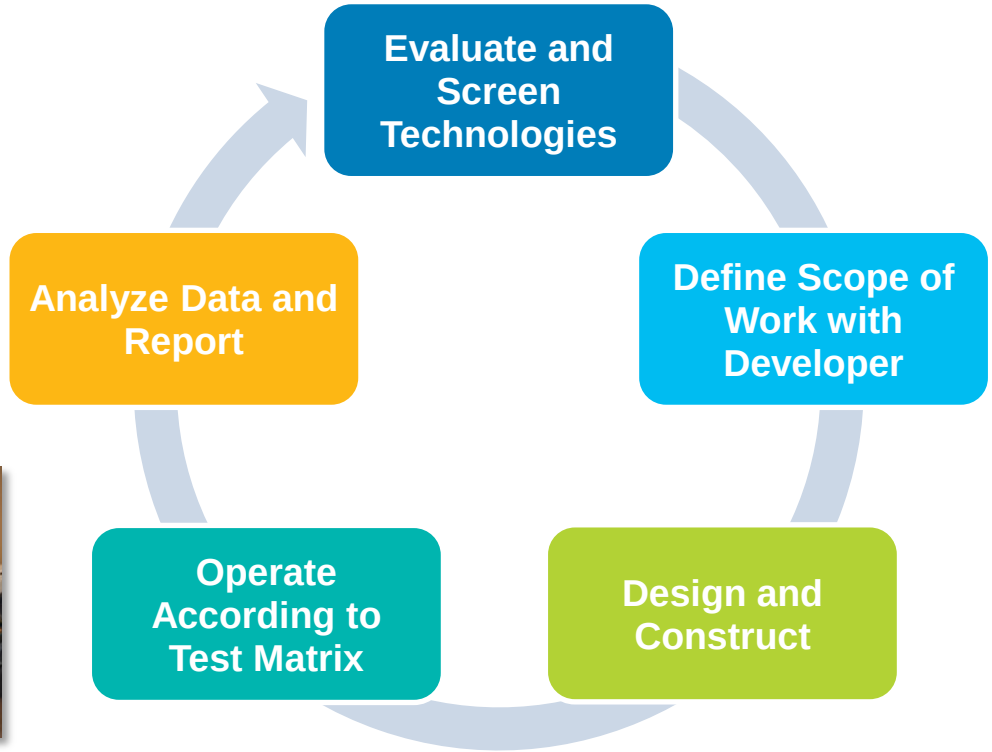
AEP AMERICAN ELECTRIC POWER · DUKE ENERGY · CLOUD PEAK ENERGY · EPRI ELECTRIC POWER RESEARCH INSTITUTE · Southern Company

What the Project Provides

- **Cost-efficient test site** with **infrastructure** for numerous technology developers
- **Real-world conditions** with coal-derived flue gas and syngas
- Flexible capability for testing at **multiple scales** and **on-site scale-ups**
- Expert **technical staff for** design, installation and testing support
- High-quality **data acquisition** and gas/liquid **sampling and analysis**

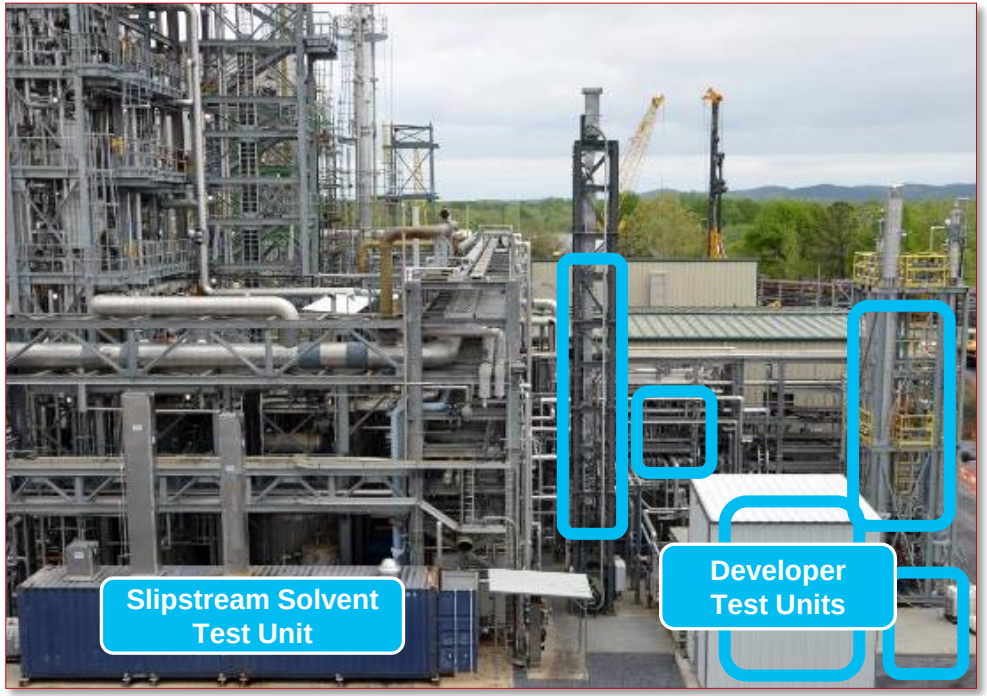
Technology Development Process





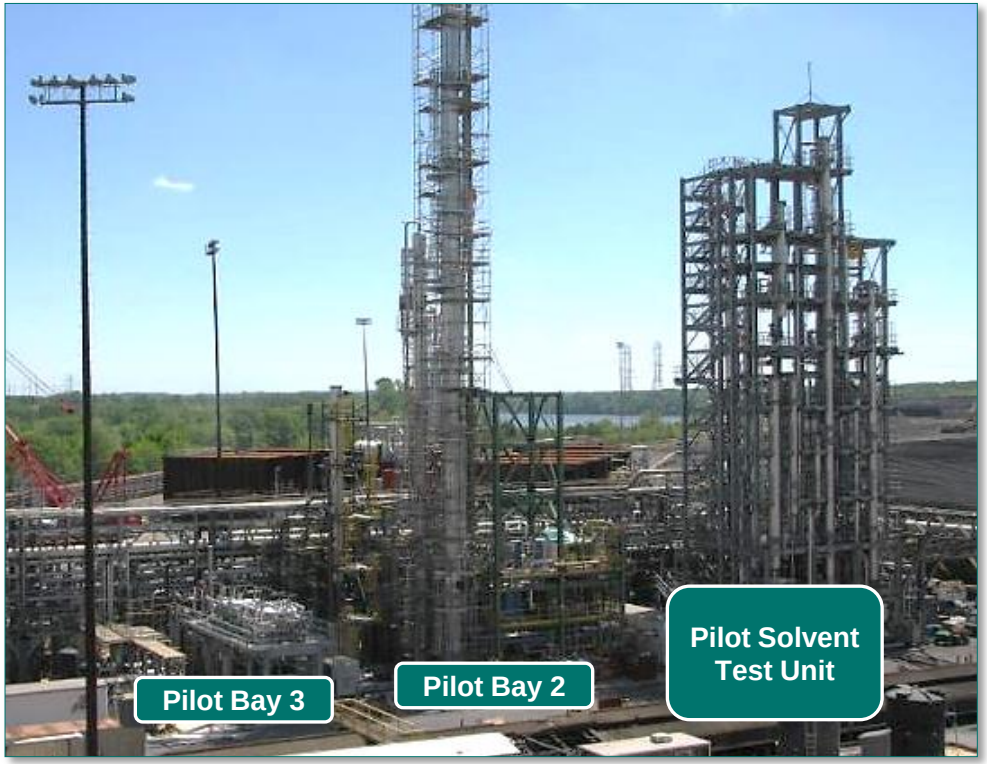
PC4 Bench-Scale

- Simultaneous operation of up to five developers' test units
- Slipstream Solvent Test Unit (SSTU) for solvents in early development
- SSTU also used for solvent emissions studies and emission mitigation processes
- Flue gas/utilities and gas analysis systems operating independently of PC4 pilot-scale area

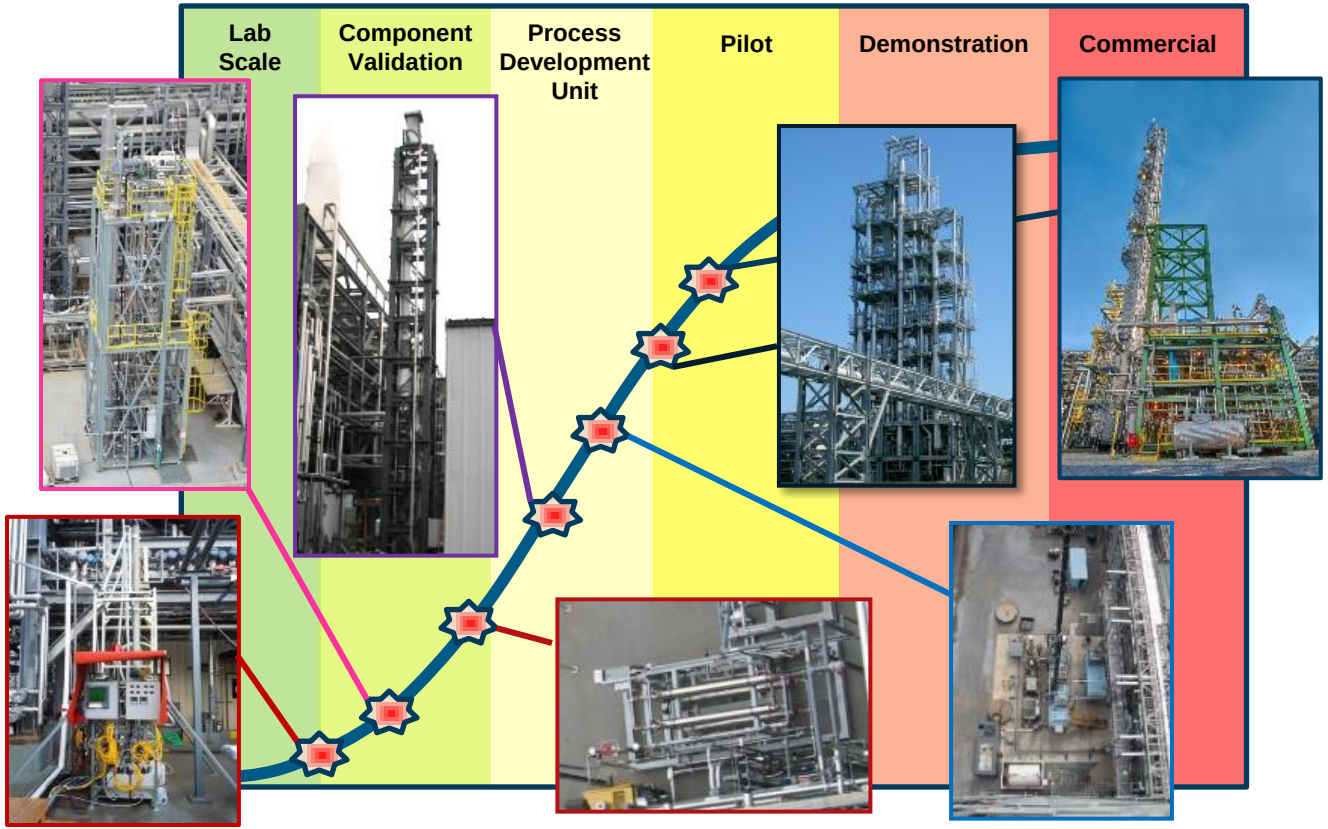


PC4 Pilot-Scale

- Simultaneous operation of developer test units and Pilot Solvent Test Unit (PSTU)
- PSTU offers flexible operation to match developers' planned commercial configuration
- PSTU also supports solvent emissions and degradation studies



Successful Testing and Partnerships



NCCC International Collaboration

- Test facility – extensive support at no charge
- Co-funding partner – active participation in R&D
- Facilitate test partnerships
- International Collaboration – testing from 7 countries and ITCN
- Policy support – Organizations attempting to influence policy and improve carbon capture messaging need technical substance





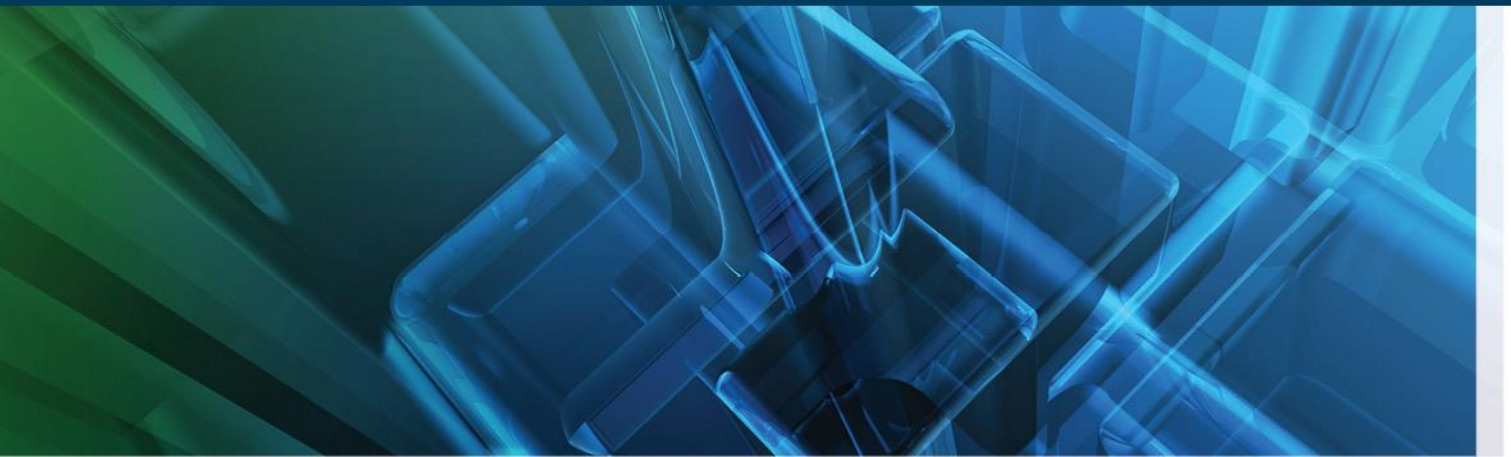


NATIONAL CARBON CAPTURE CENTER

More information

www.nationalcarboncapturecenter.com

https://twitter.com/NCarbonCaptureC



UKCCSRC PACT CORE FACILITIES SHEFFIELD

Jon Gibbins
Director, UK CCS Research Centre
Professor of Power Plant Engineering and Carbon Capture
University of Sheffield
www.ukccsrc.ac.uk
www.pact.ac.uk
j.gibbins@sheffield.ac.uk

Mohamed Pourkashanian
Director UKCCSRC PACT
Director University of Sheffield Energy 2050

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

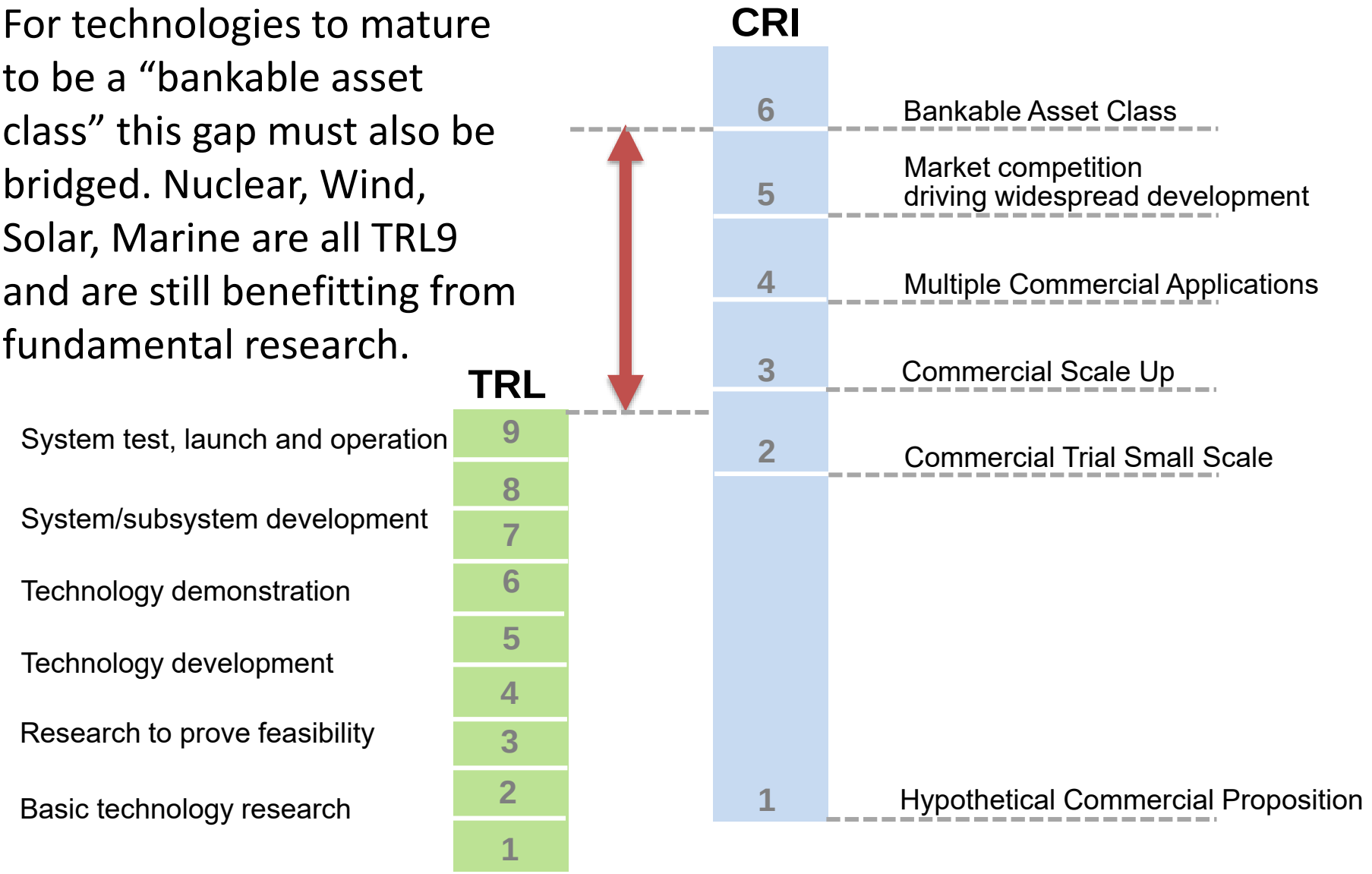
EPSRC Engineering and Physical Sciences Research Council

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

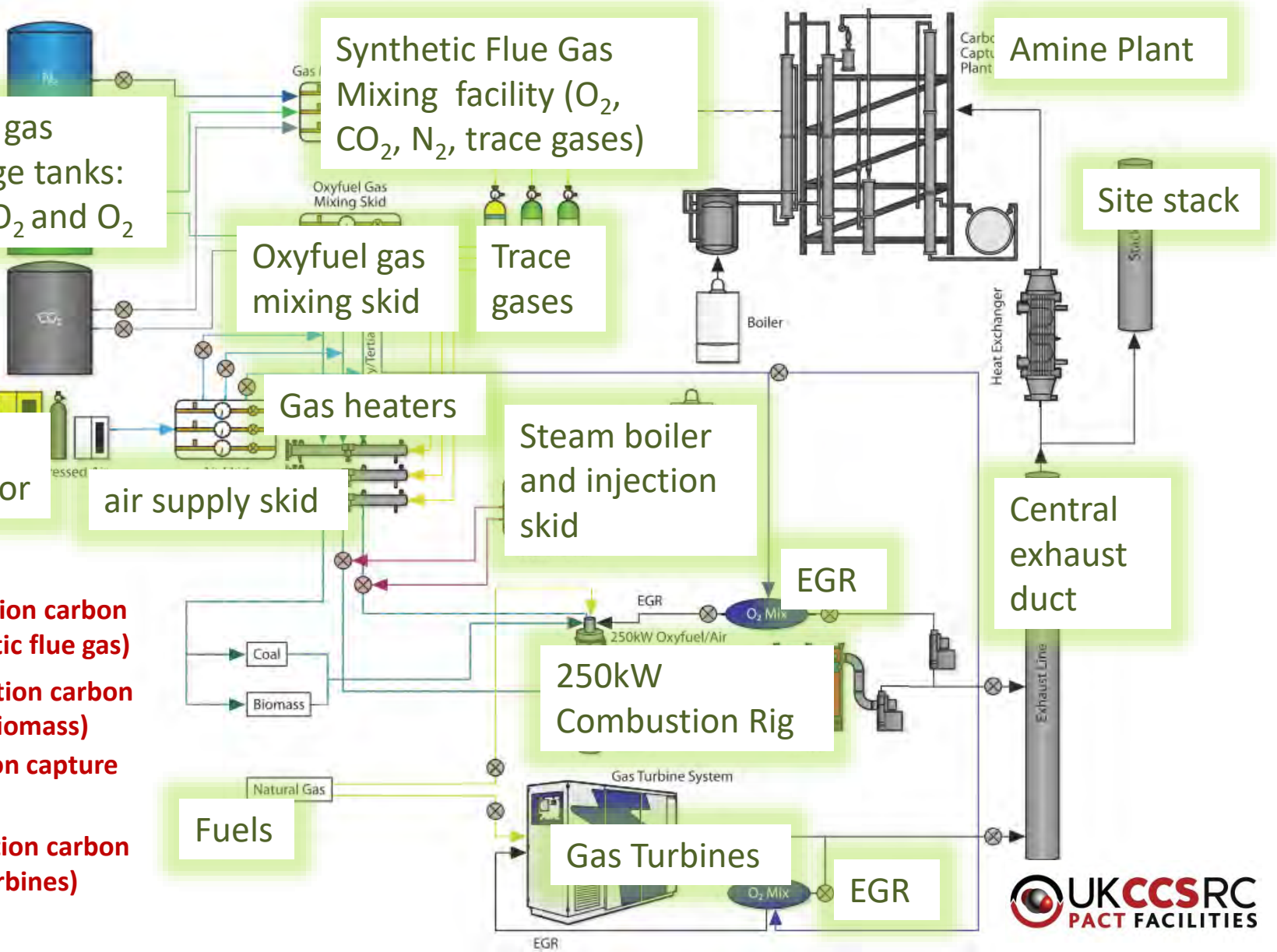
UKCCSRC PACT FACILITIES

PACT Core Facilities

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

Large –Scale Combustion Test Facilities

PACT Core Facility: Overview

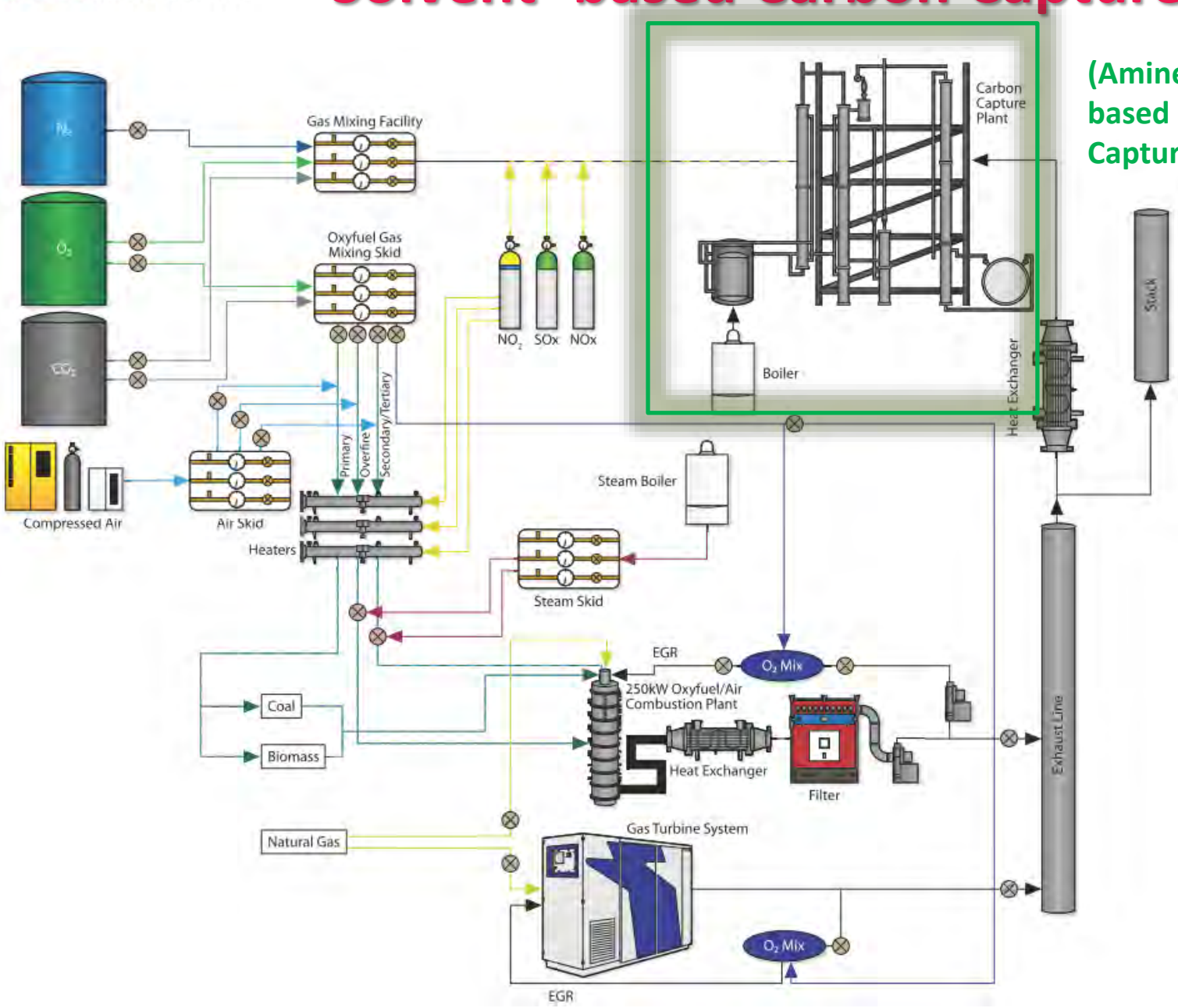


CAPABILITIES:

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)

UKCCSRC PACT FACILITIES

Solvent- based Carbon Capture Plant



(Amine) Solvent-based Carbon Capture Plant

Solvent- based Carbon Capture Plant

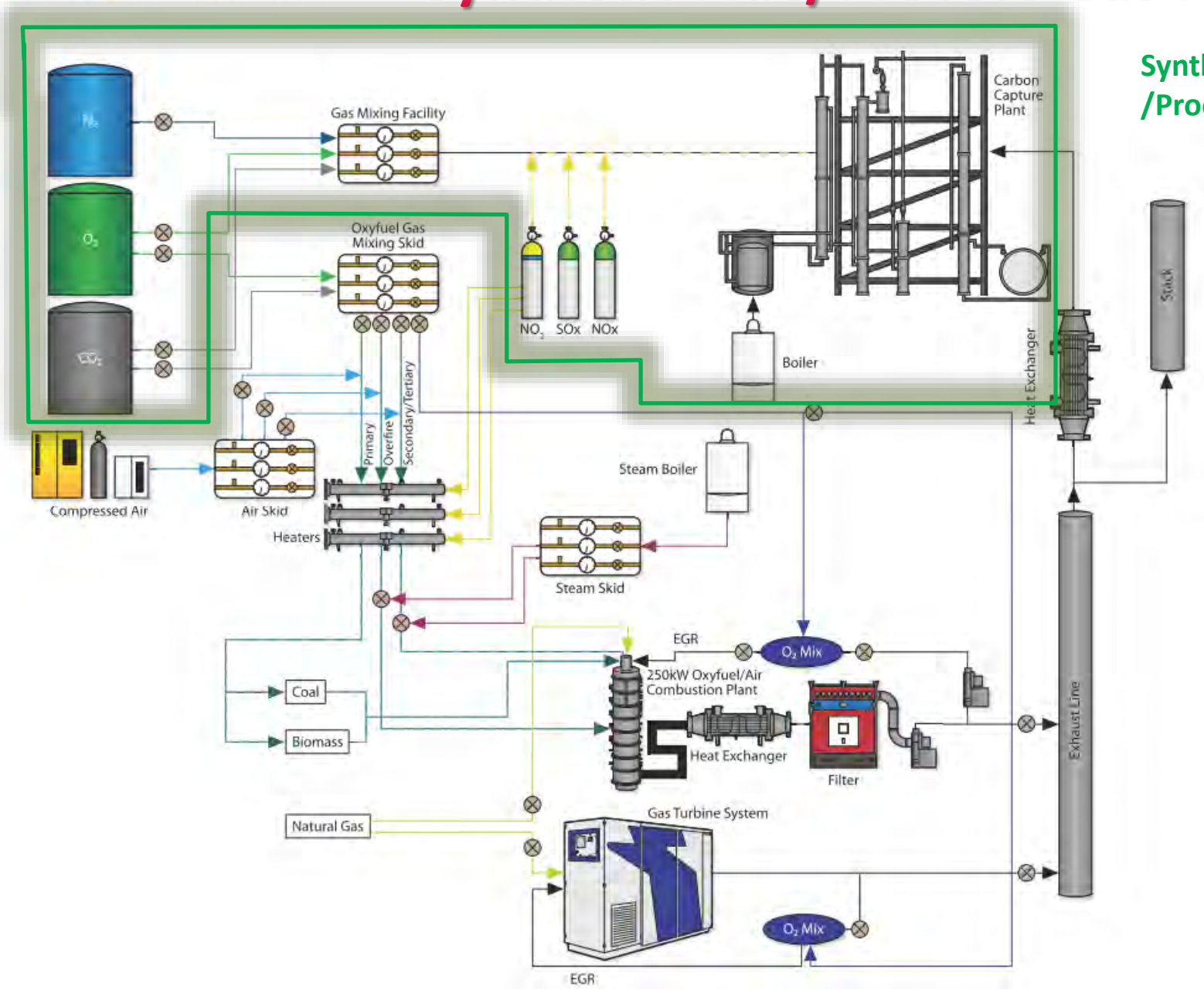
Overview

- 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)

UKCCSRC PACT FACILITIES

Synthetic Flue/Process Gas Facility

Synthetic Flue /Process Gas System



UKCCSRC PACT FACILITIES

Synthetic Flue/Process Gas Facility

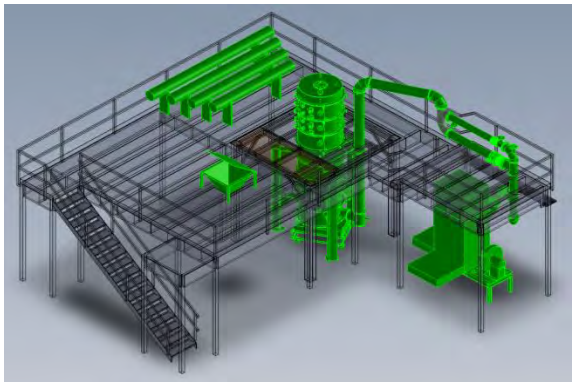
Overview

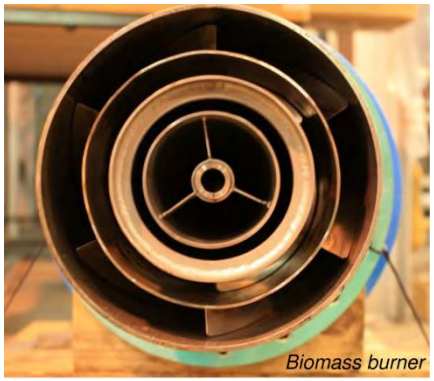
- Three **gas metering and mixing** lines, fed from O_2, CO_2 and N_2 storage tanks
- Complemented by **trace gas injection** NOx and SOx, other trace gasses
- Generate simulated flue/process gases
- Connected directly to the **Solvent-based Carbon Capture Plant**

250kW Air Combustion Plant

Overview

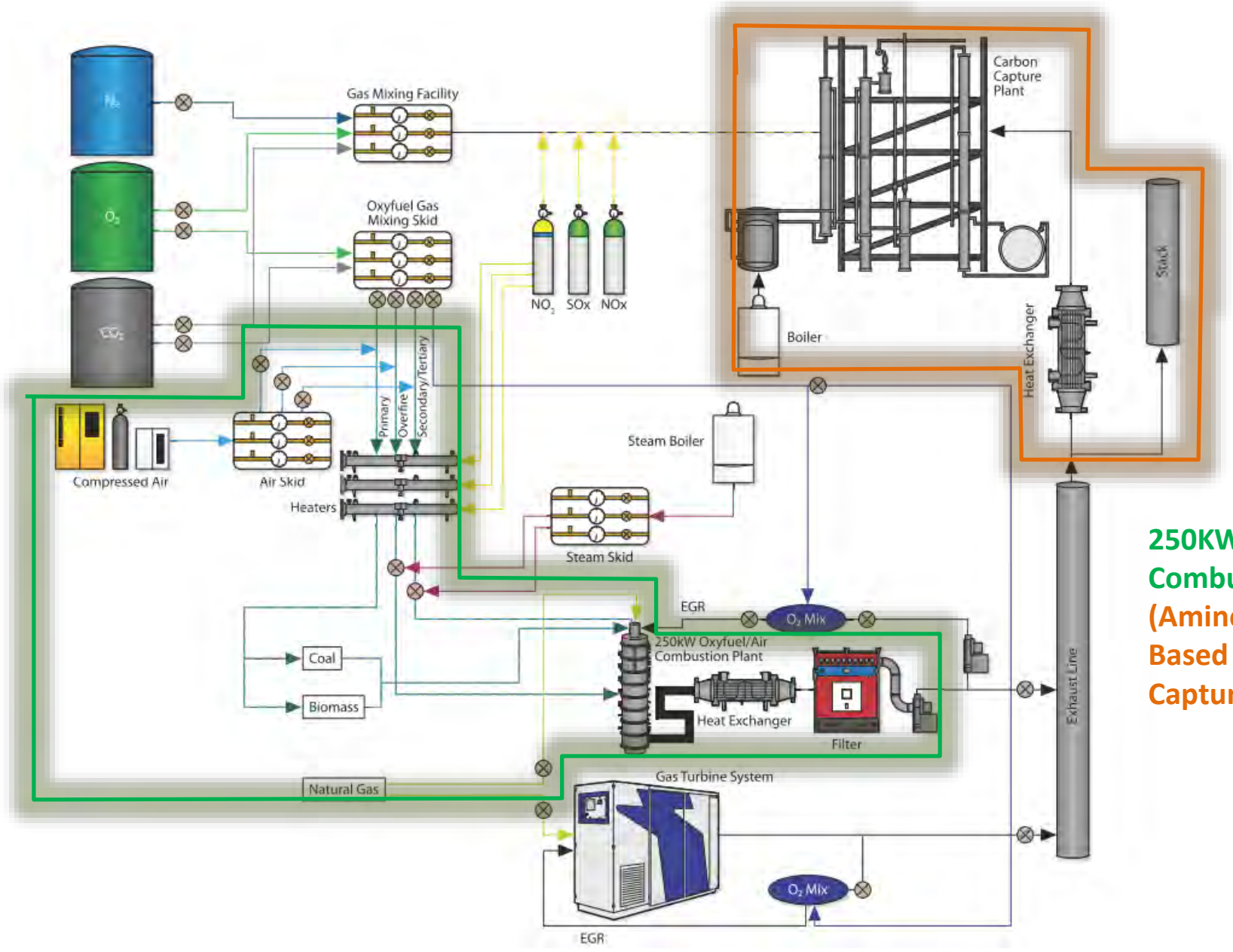
- ~250kWth, 4.5m high; 0.9m radius, cylindrical, down-fired rig with 8 sections
- Fuel: Coal, Biomass, Co-firing, Gas (primarily preheating)
- 2 x (interchangeable) coal/biomass burners - scaled from Doosan Power Systems commercial low-NOx burners
- Dedicated, high precession air metering skid
- Flue 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





UKCCSRC PACT FACILITIES

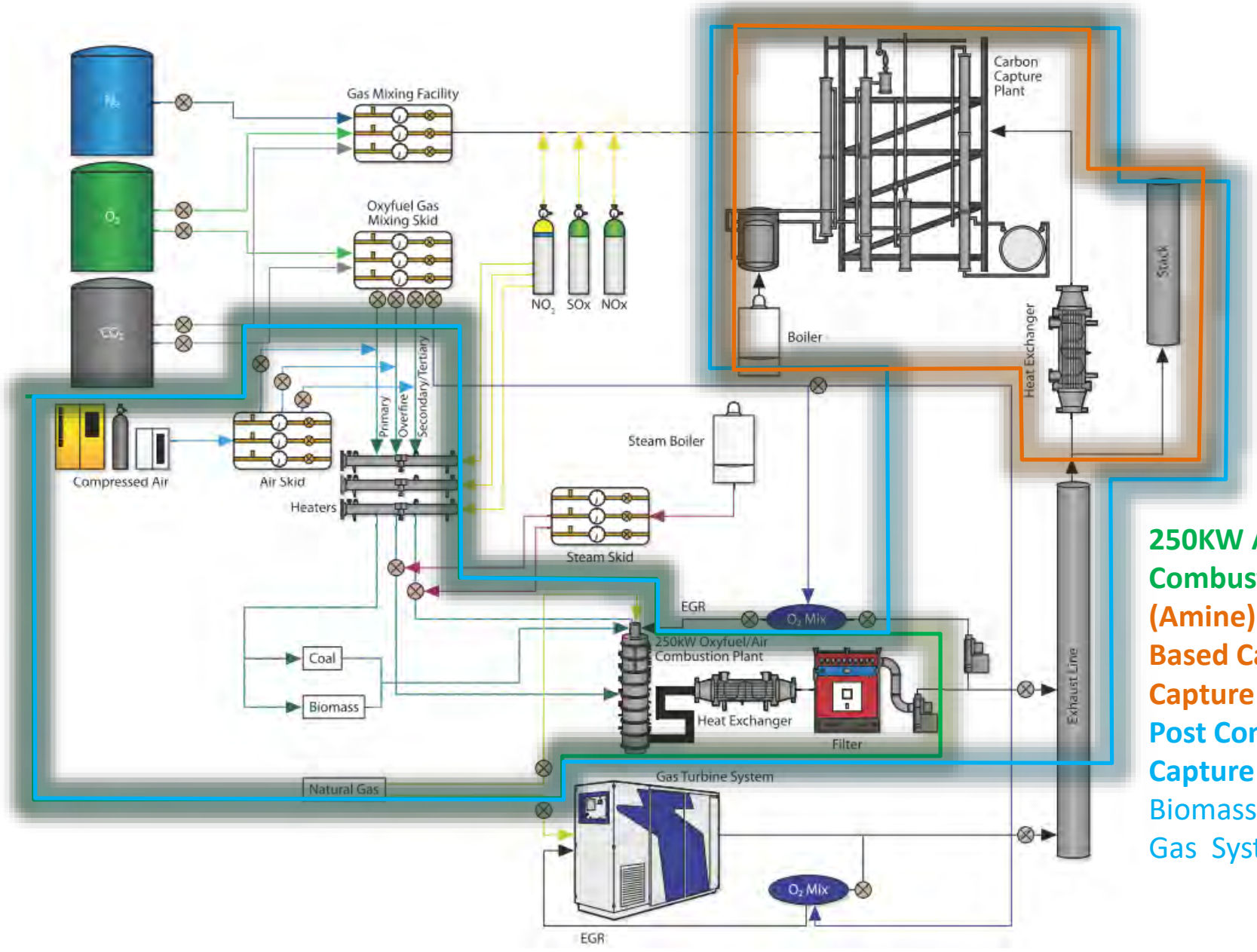
PACT Core Facility: Layout



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

UKCCSRC PACT FACILITIES

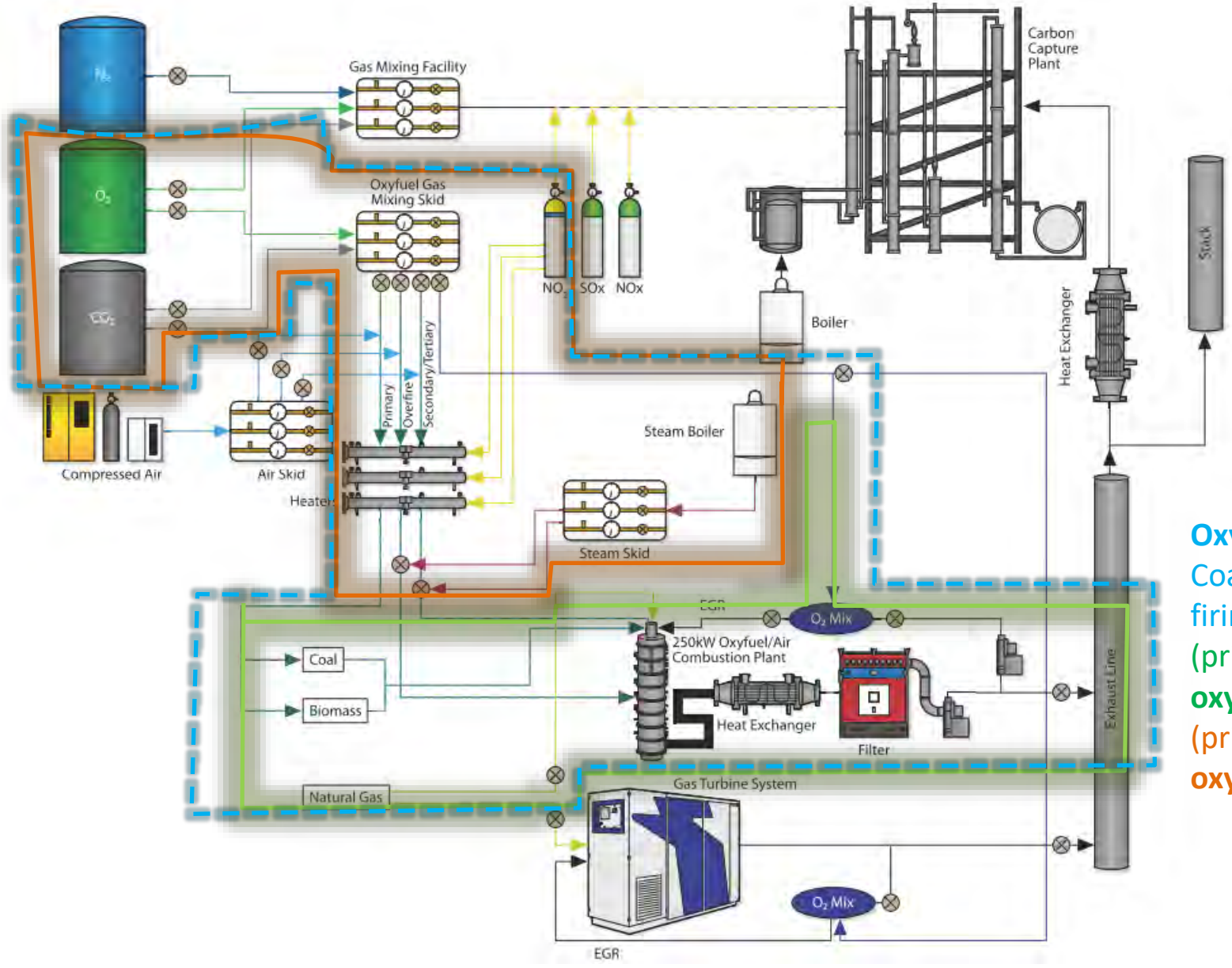
PACT Core Facility: Layout



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

UKCCSRC PACT FACILITIES

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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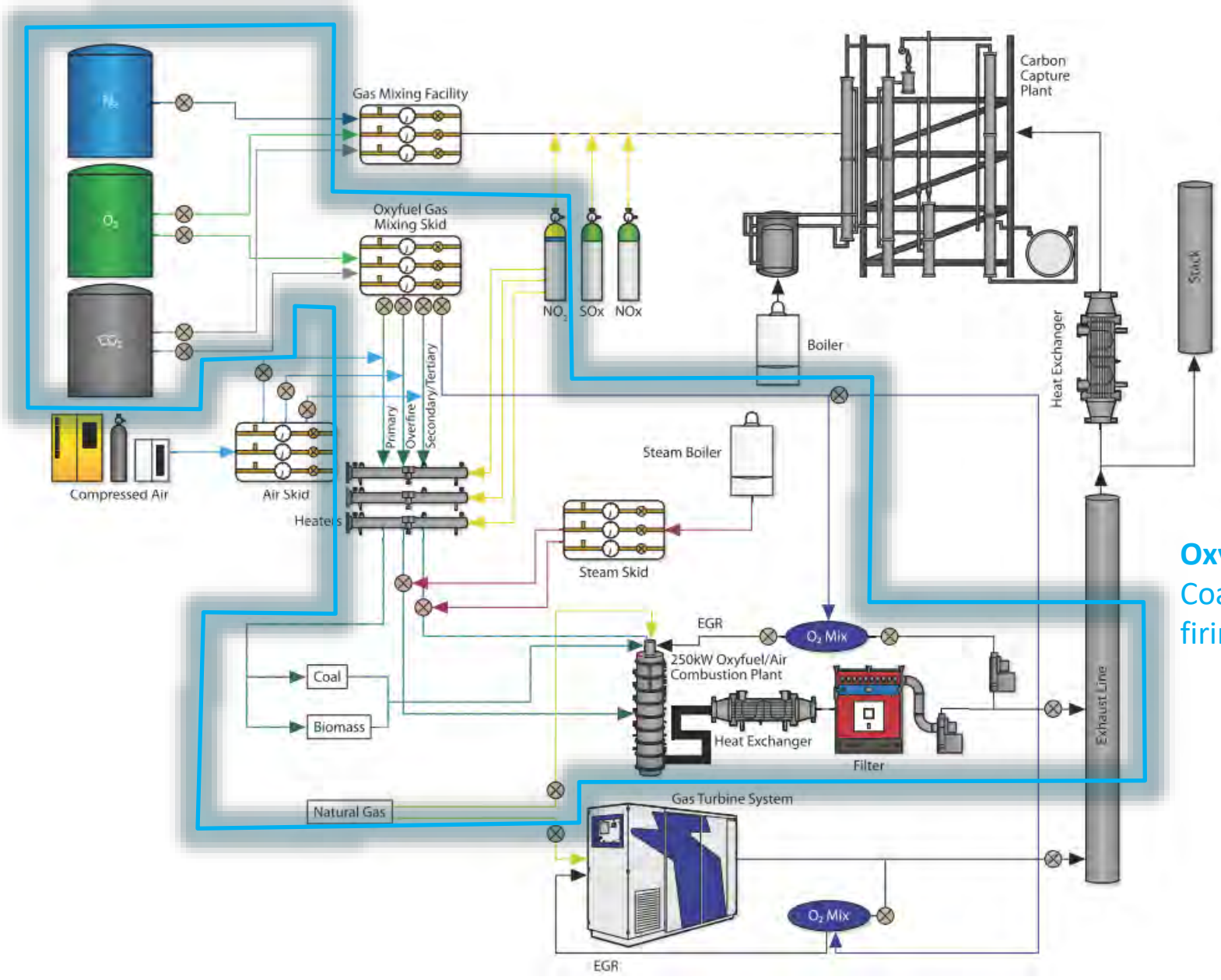
250kW Oxyfuel Combustion Plant



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

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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

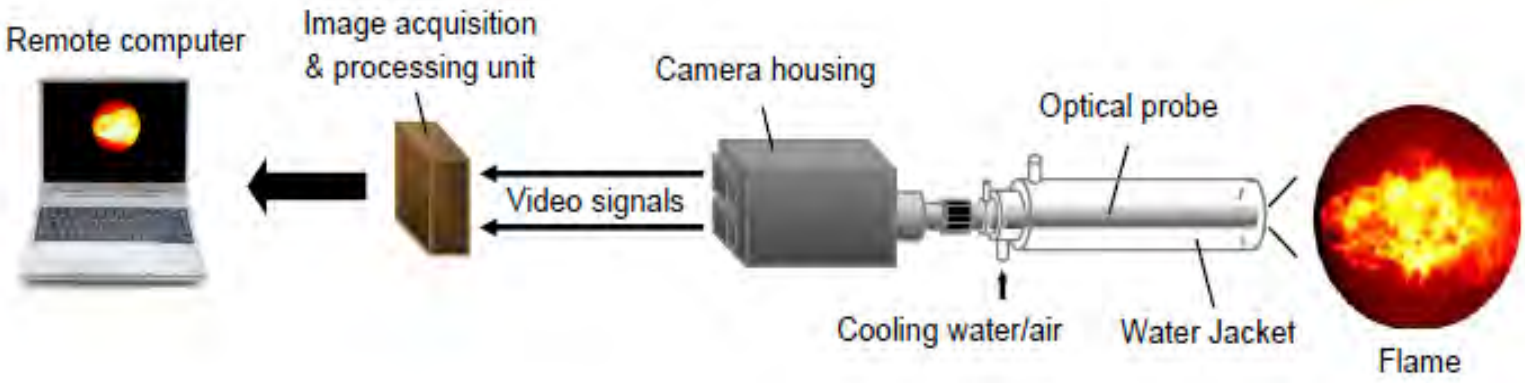
Gas Mixing Facilities

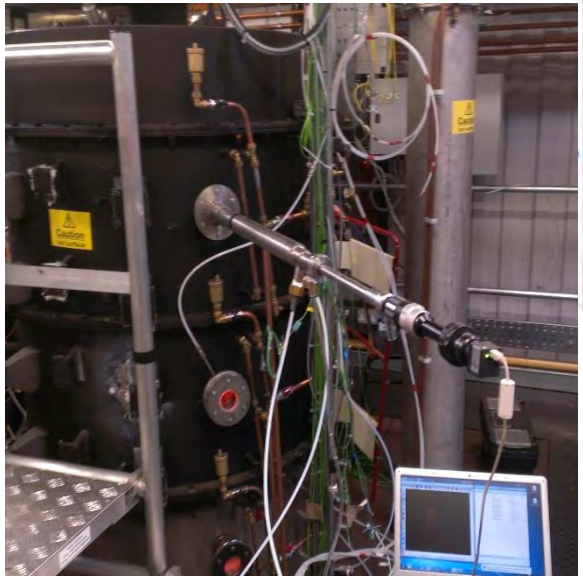
250kW Air/Oxy Rig

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

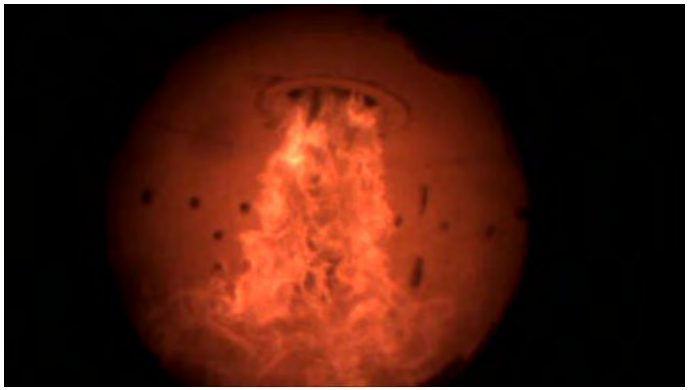
Recommendation to Combustion optimisation

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

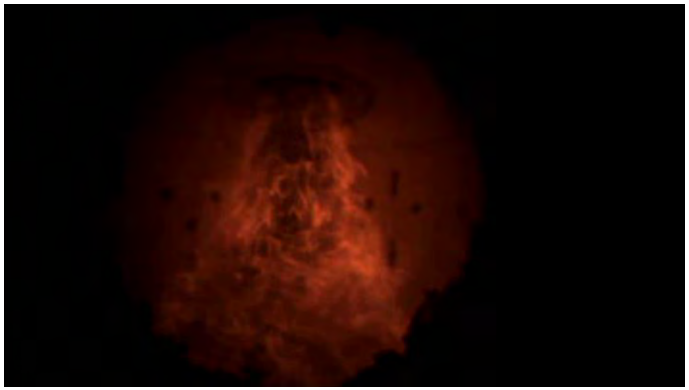
Results

Experimental calculation of the oscillation frequency - COAL

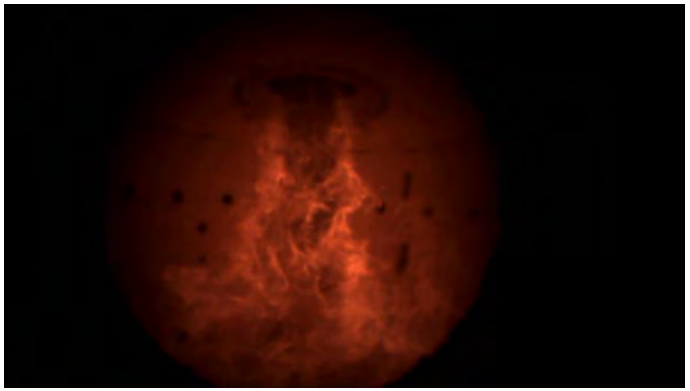
Original videos



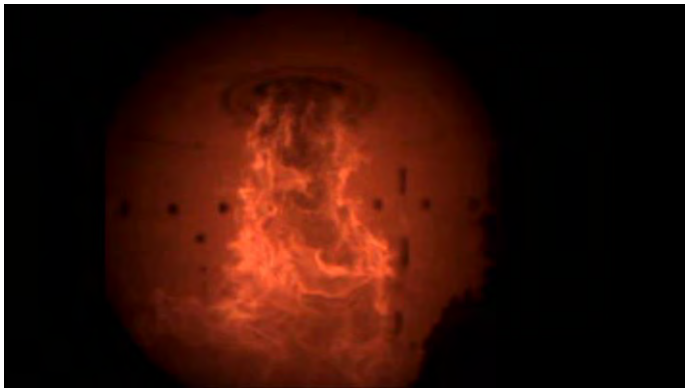
Air



Oxy24



Oxy27

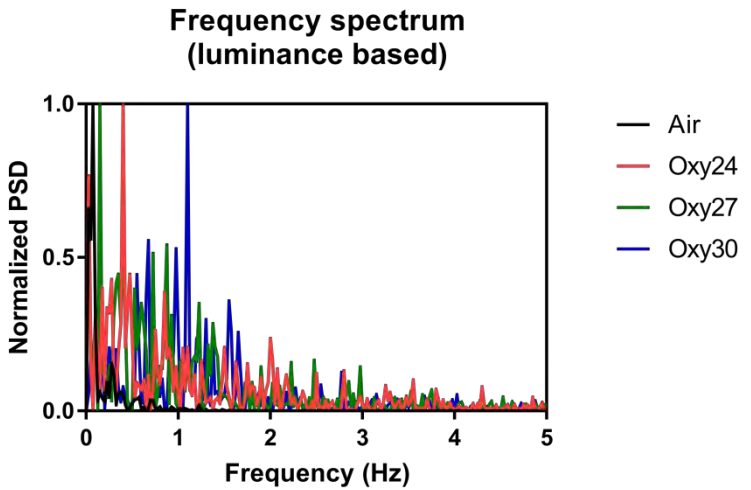


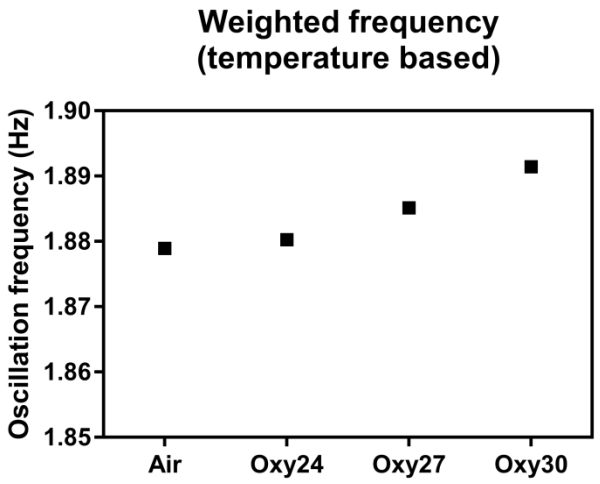
Oxy30

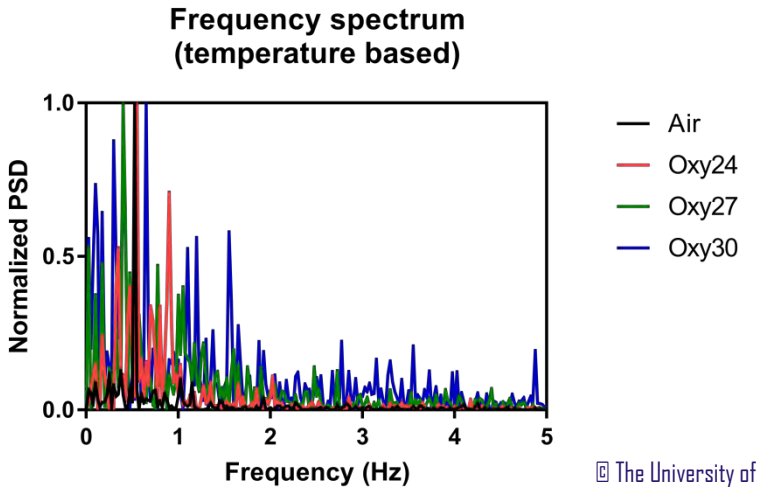
Results

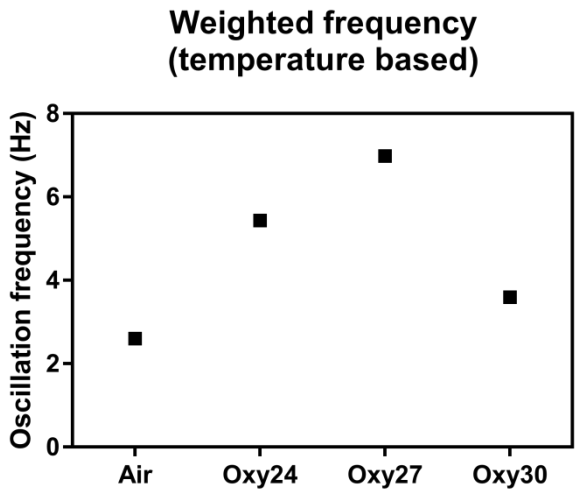
Experimental calculation of the oscillation frequency

COAL





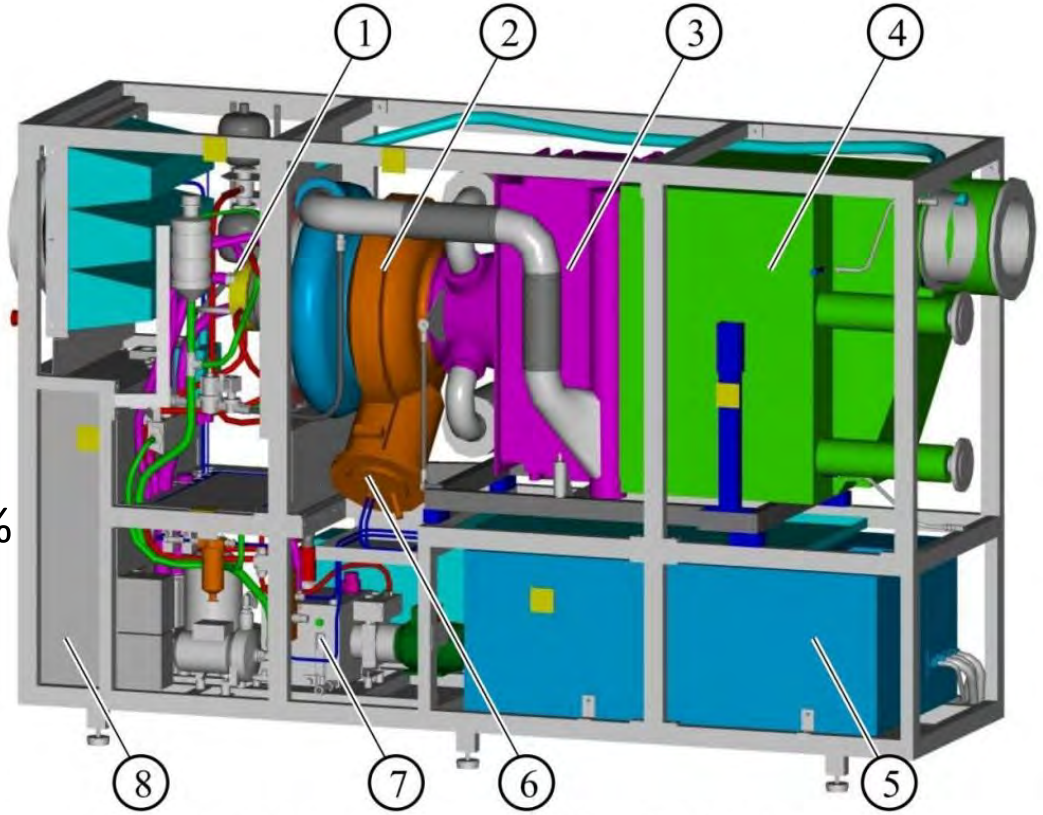




Gas Turbine System

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)

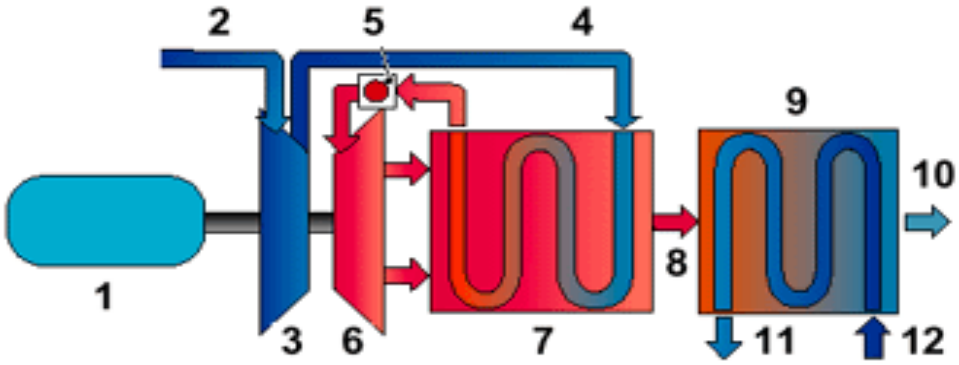


1. Electrical Generator
2. Gas Turbine Engine
3. Recuperator
4. Heat Exchanger
5. Power Electronics
6. Combustion Chamber
7. Auxiliary Systems
8. Control System

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

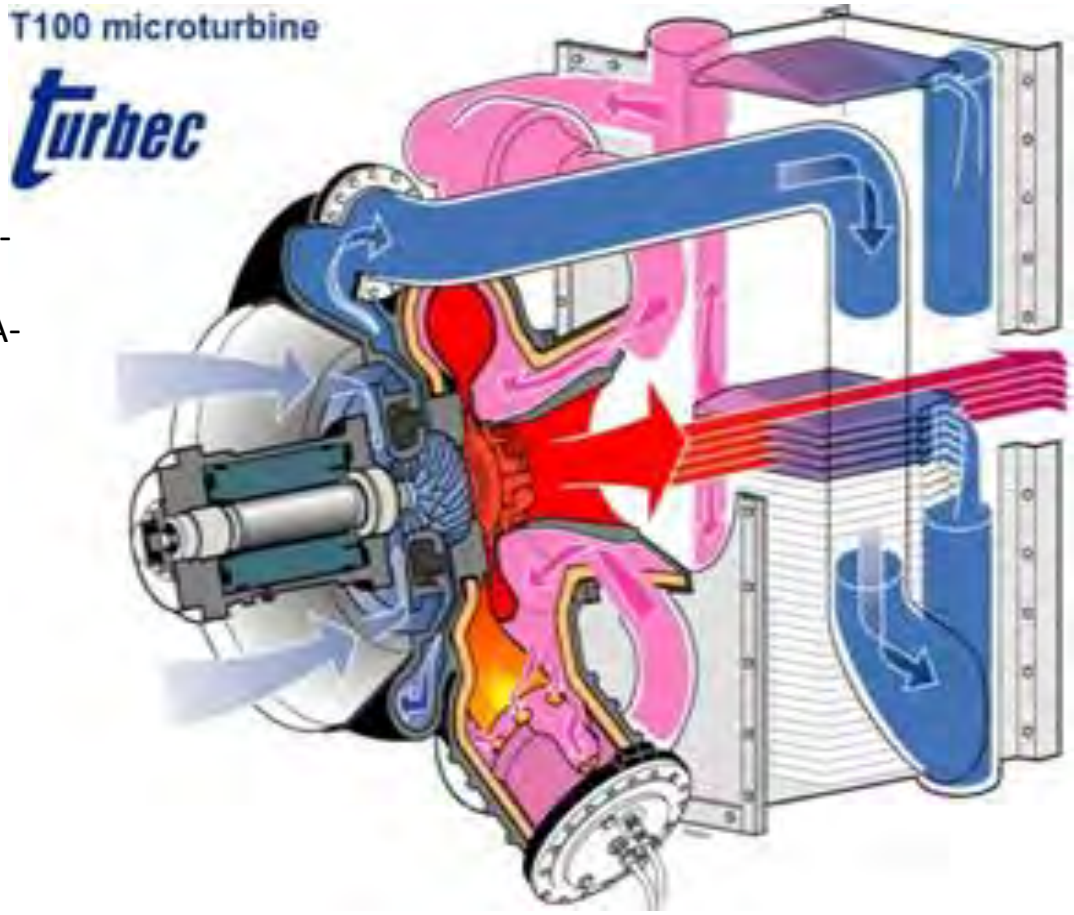


1. Generator
2. Air inlet
3. Compressor
4. Air to recuperator
5. Combustion chamber
6. Turbine
7. Recuperator
8. Exhaust gases
9. Heat exchanger
10. Exhaust gas outlet
11. Hot water outlet
12. Water inlet

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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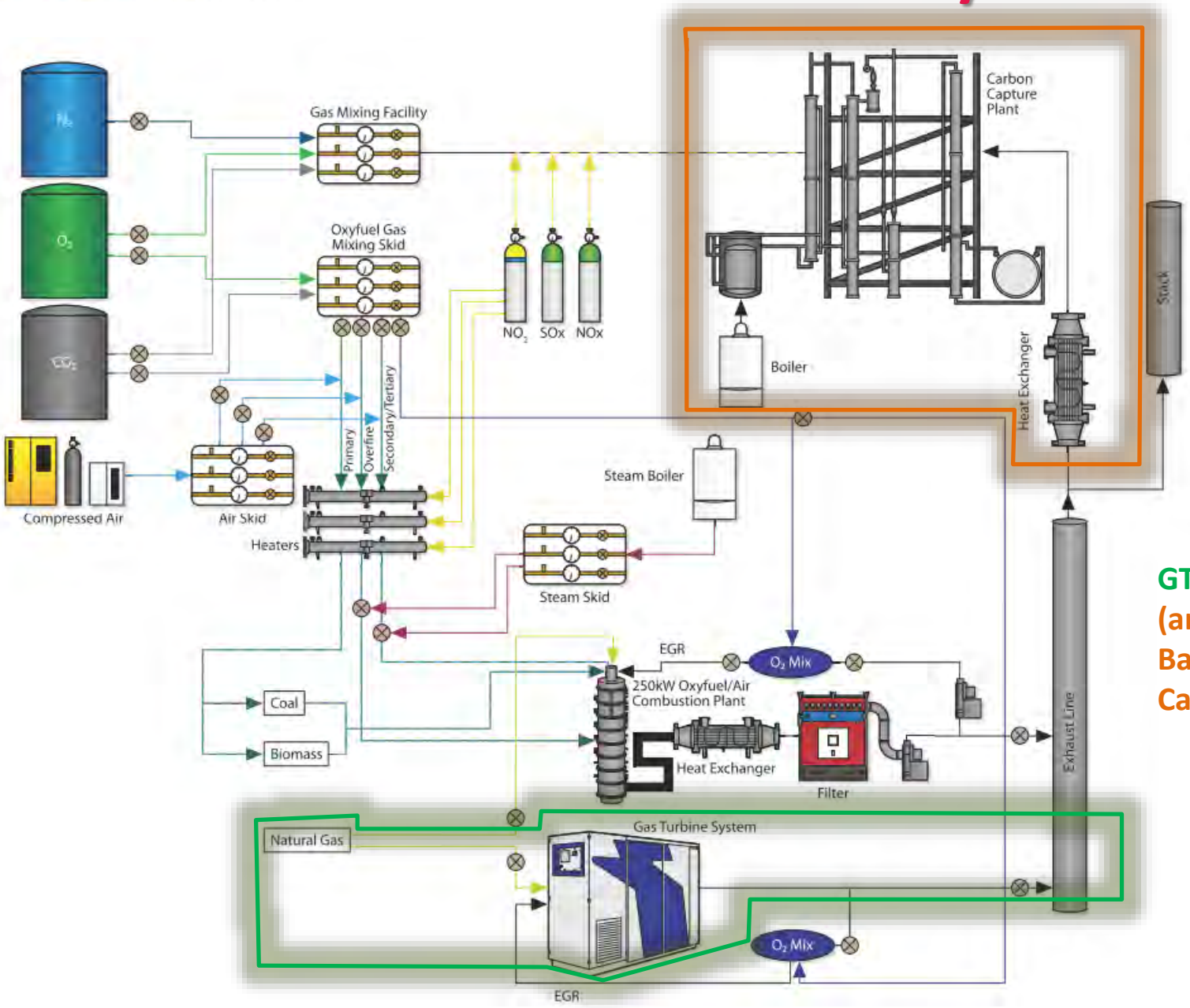
Gas Turbine System



GT + (amine) Solvent Based Carbon Capture Plant =

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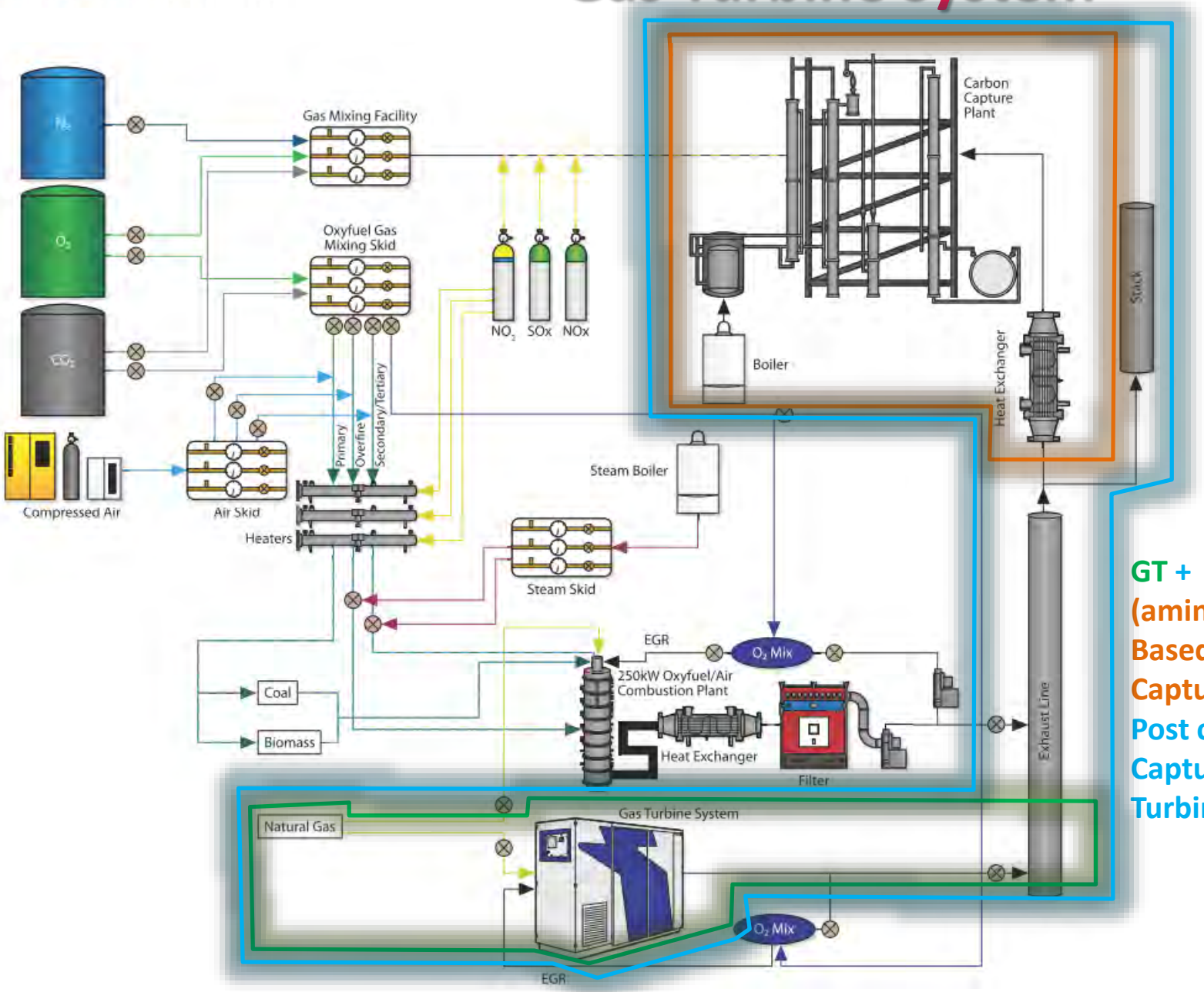
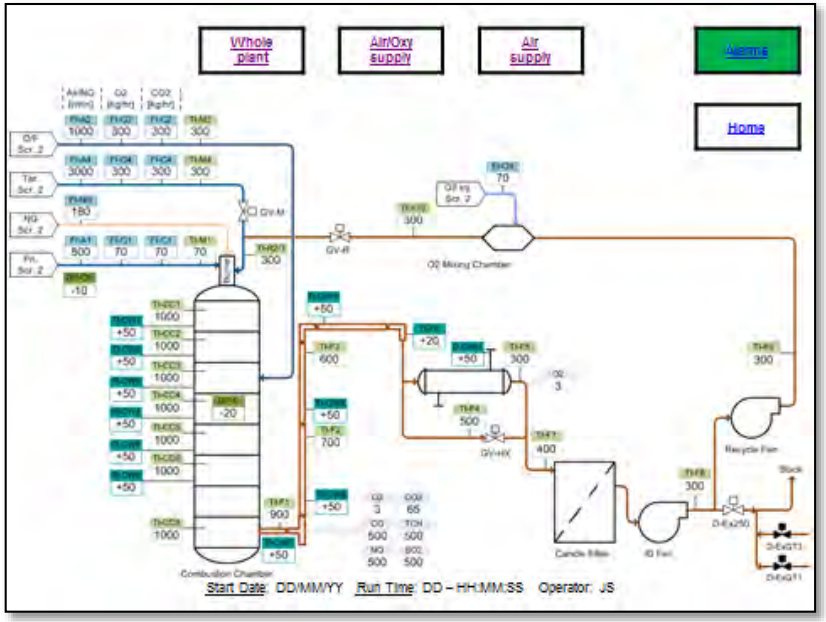
Gas Turbine System



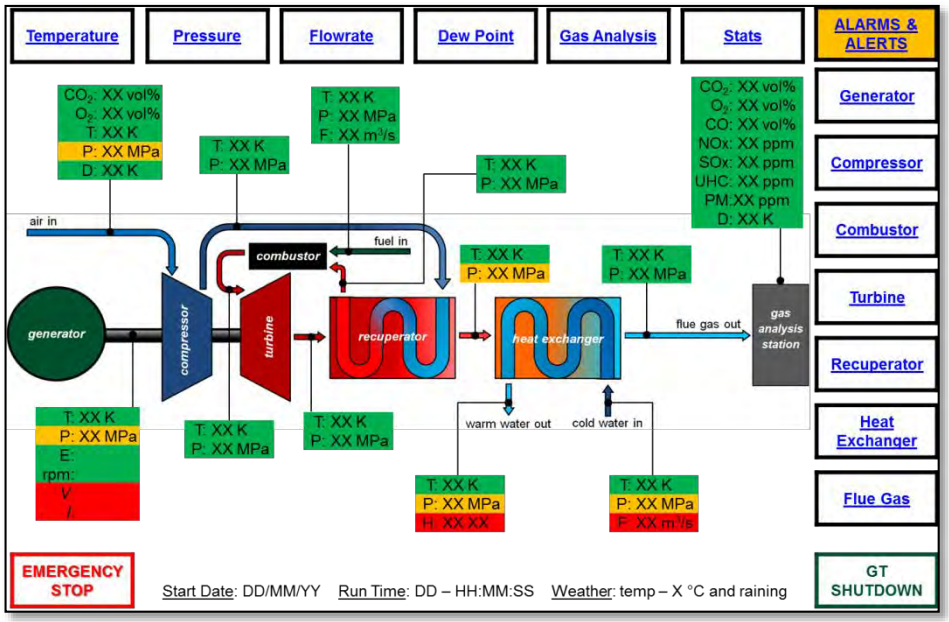
GT + (amine) Solvent Based Carbon Capture Plant = Post combustion Capture from Gas Turbine System

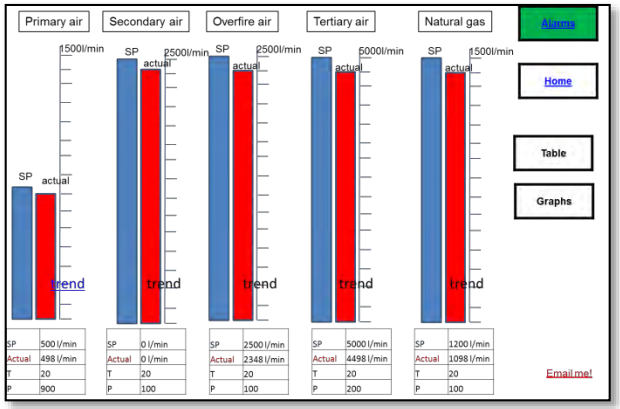
UKCCSRC PACT FACILITIES

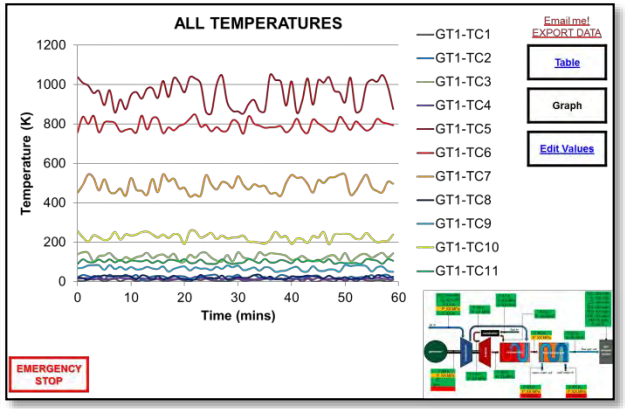
250 kW plant

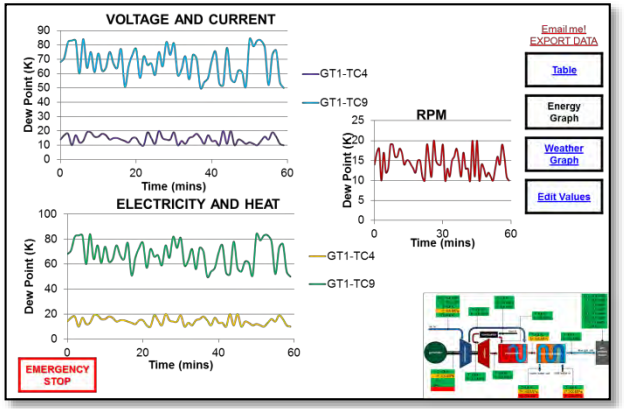


Gas Turbine





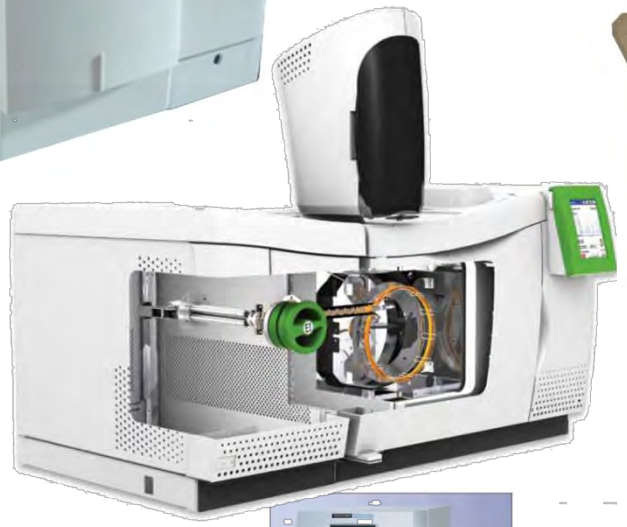




Analytical Facilities: Labs

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

UKCCSRC PACT FACILITIES

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

Dr Kris Milkowski
PACT Business Development Manager
UKCCSRC PACT Core Facilities
Unit 2 Crown Works Industrial Estate
Rotherham Road
Beighton
Sheffield S20 1AH, UK

e-mail: k.milkowski@sheffield.ac.uk
Mob: +44 (0) 7802720369

PARTNERS

Cranfield University · The University of Edinburgh · Imperial College London · University of Leeds · The University of Nottingham · The University of Sheffield

FUNDING FROM

Department of Energy & Climate Change · EPSRC Engineering and Physical Sciences Research Council · UKCCS Research Centre

CO2CRC Capture Demonstration

Abdul Qader, PhD, FAIE, FIEAust
Capture Manager

CO2CRC
BUILDING A LOW EMISSIONS FUTURE

ITCN Panel in CMTC
19 July 2017

Who is CO2CRC?

- CO2CRC is a world leading carbon capture & storage (CCS) research organisation that works closely with global industry to reduce large scale greenhouse gas emissions through:
  - Investigating carbon capture, transport and storage technologies
  - Examining the costs and drivers across the CCUS chain
  - Conducting research, development and demonstration across the CCUS value chain
  - Providing efficient collaboration amongst 150 researchers in capture and storage
  - Building experience in CCUS technology by addressing knowledge gaps

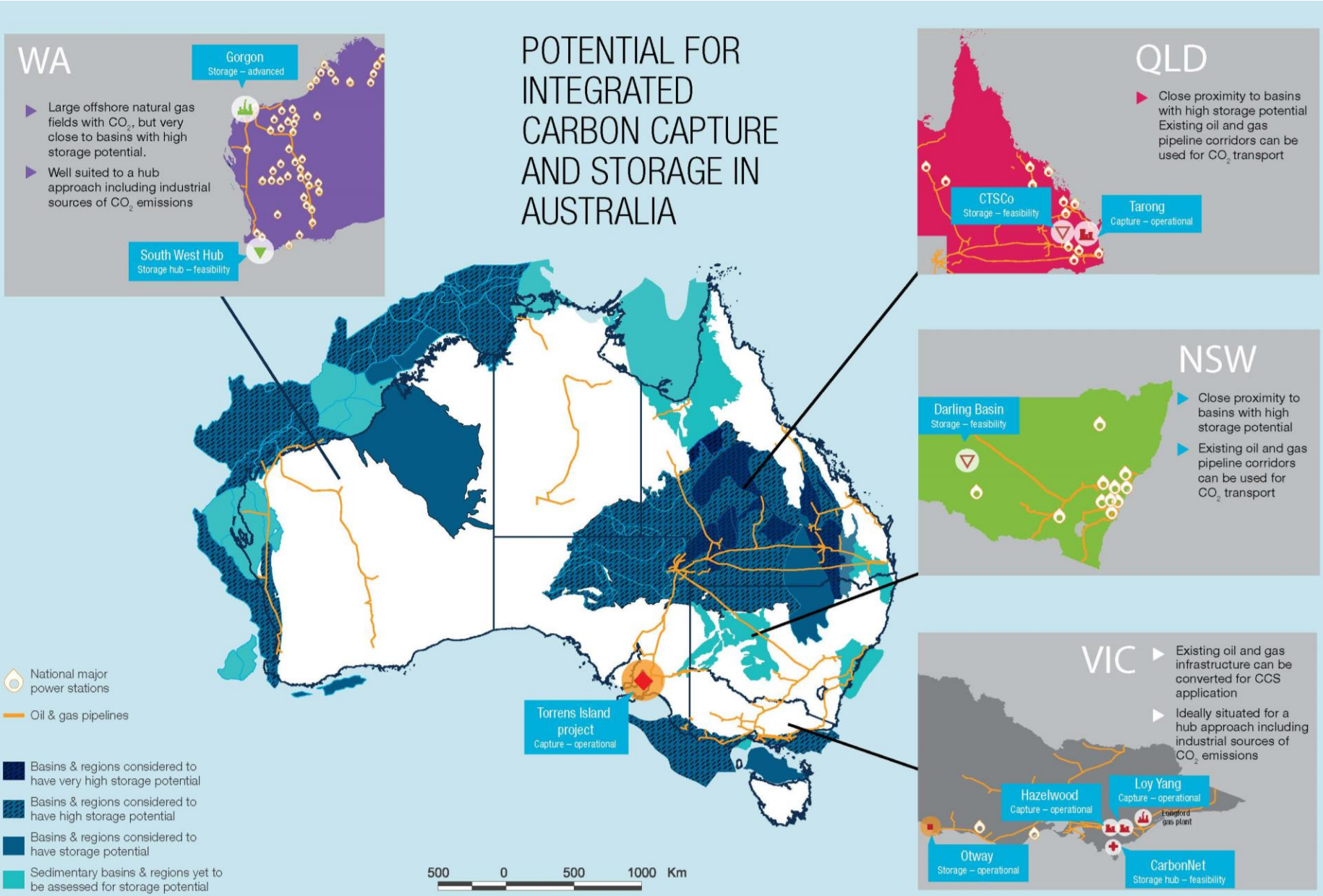
32 research and industry partners globally

WHO IS CO2CRC

CO2CRC SUPPORTS INDUSTRY TO REDUCE GREENHOUSE GAS EMISSIONS THROUGH CARBON CAPTURE & STORAGE RESEARCH

- We are the first company in Australia to have undertaken carbon capture and storage end to end
- Our research demonstrates carbon capture and storage in-field using novel technologies. We test their efficiency, accuracy and cost-effectiveness bringing confidence to industry and regulators
- We have safely injected, monitored and contained 80,000 tonnes of carbon dioxide for more than a decade
- We design, project manage and fund carbon capture and storage programs utilising the best international and local talent

Australia's Integrated CCS activities



Field Capture Projects

- First application of 3 different capture technologies in parallel and their comparison for large scale implementation
- Attained capability of scaling up of capture plants from concept till large scale (TRL level 1 till 9) with economic feasibility

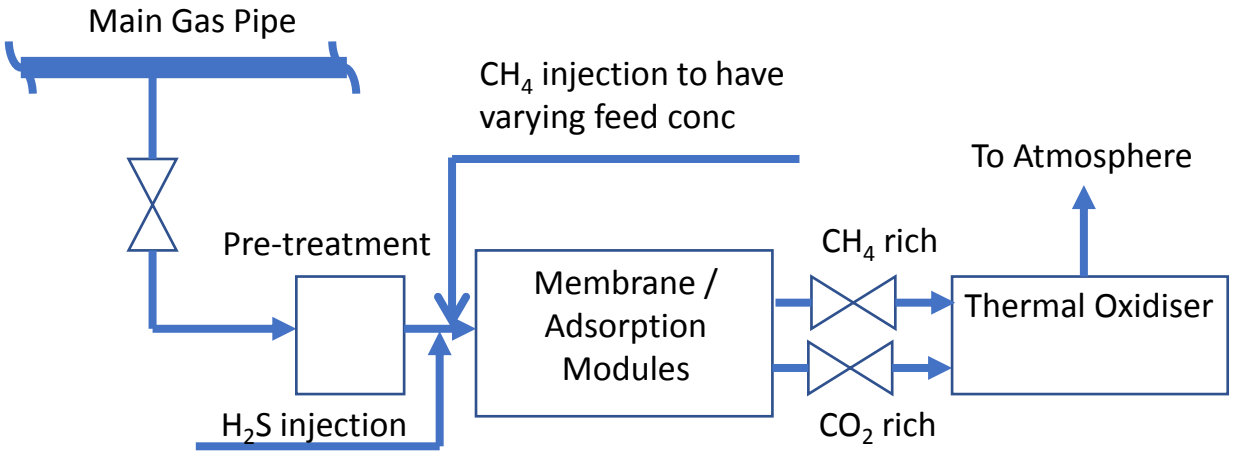
3 pre-combustion technologies at HRL, VIC :
2007-2011, ETIS/BCIA funded

3 post-combustion technologies at Hazelwood, VIC : 2007-2011 ETIS/BCIA funded

BCIA funded UNO MK 3 post-combustion at Hazelwood, VIC : 2011-2014

Membrane plant at Delta's Vales Point, NSW :
ANLEC R&D funded

Otway Capture Project



Project Aims

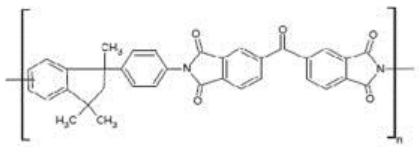
- To develop cost effective, compact technologies to capture CO_2 mainly from high CO_2 content wells.
- To test new capture materials (membranes and adsorbents) and develop new capture processes over a range of adjusted CO_2 concentrations

Main Features

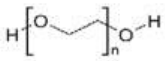
- Feed Pressure: 80 to 30 bar
- Feed CO_2 Concentration: 5% to 80% achieved by CH_4 addition (existing is ~80% CH_4 and 19% CO_2)
- H_2S addition for impurities effect tests
- Rig on a common skid delivered on site for installation and commissioning (flow diagram shown left) 2016
- Adsorbent – 4 kg, Current use: Silica (S1), Second stage: Z1; Membranes – 3 different modules
- Opportunities for vendors to conduct long term testing of capture technologies for CO2/CH4 separation at a fully instrumented site

Otway Capture Installation and Commissioning

Hollow Fiber Modules prepared for Otway



Matrimid® 5218



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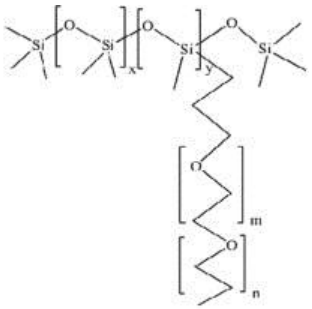
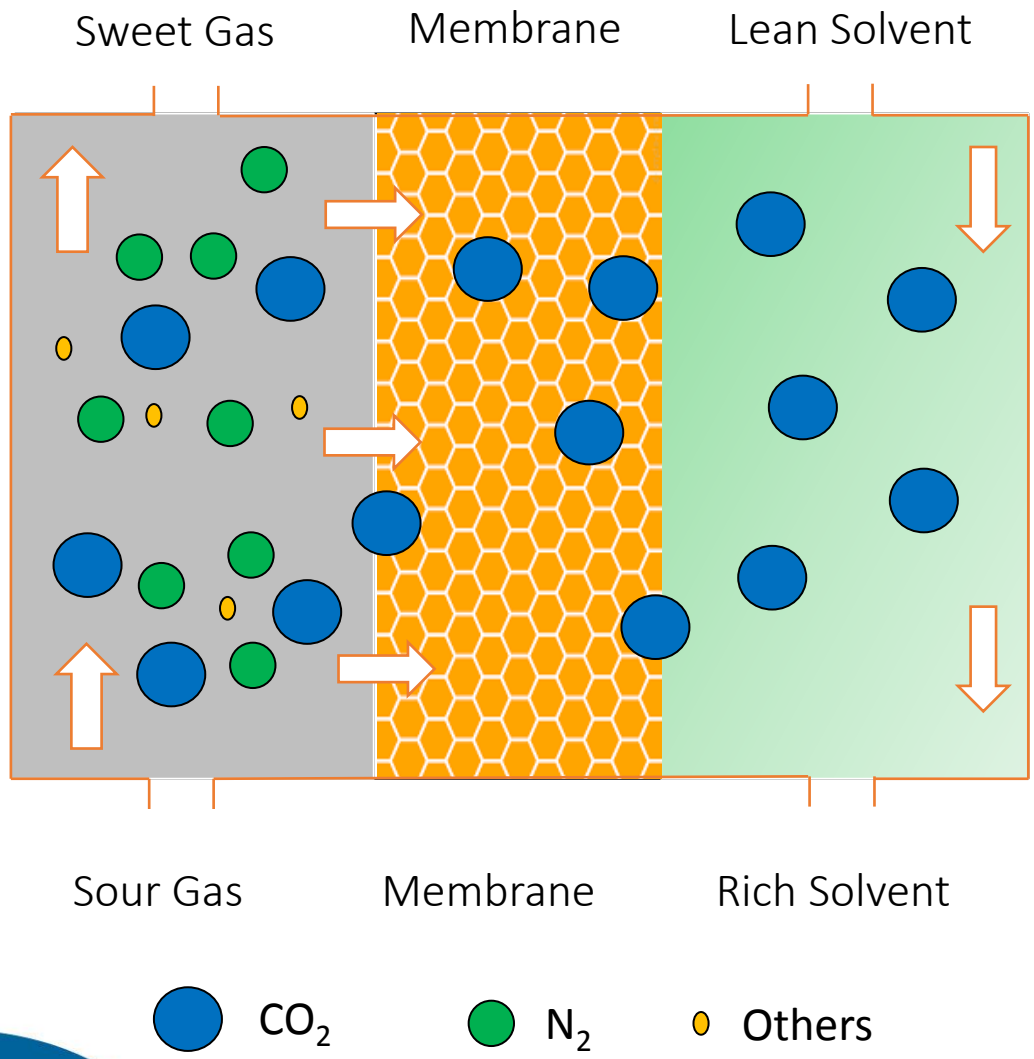


Silwet L-7607

Addition of PEO-PDMS additive (Silwet-7607) could improve plasticization resistance and long term stable performance – so composite also be used

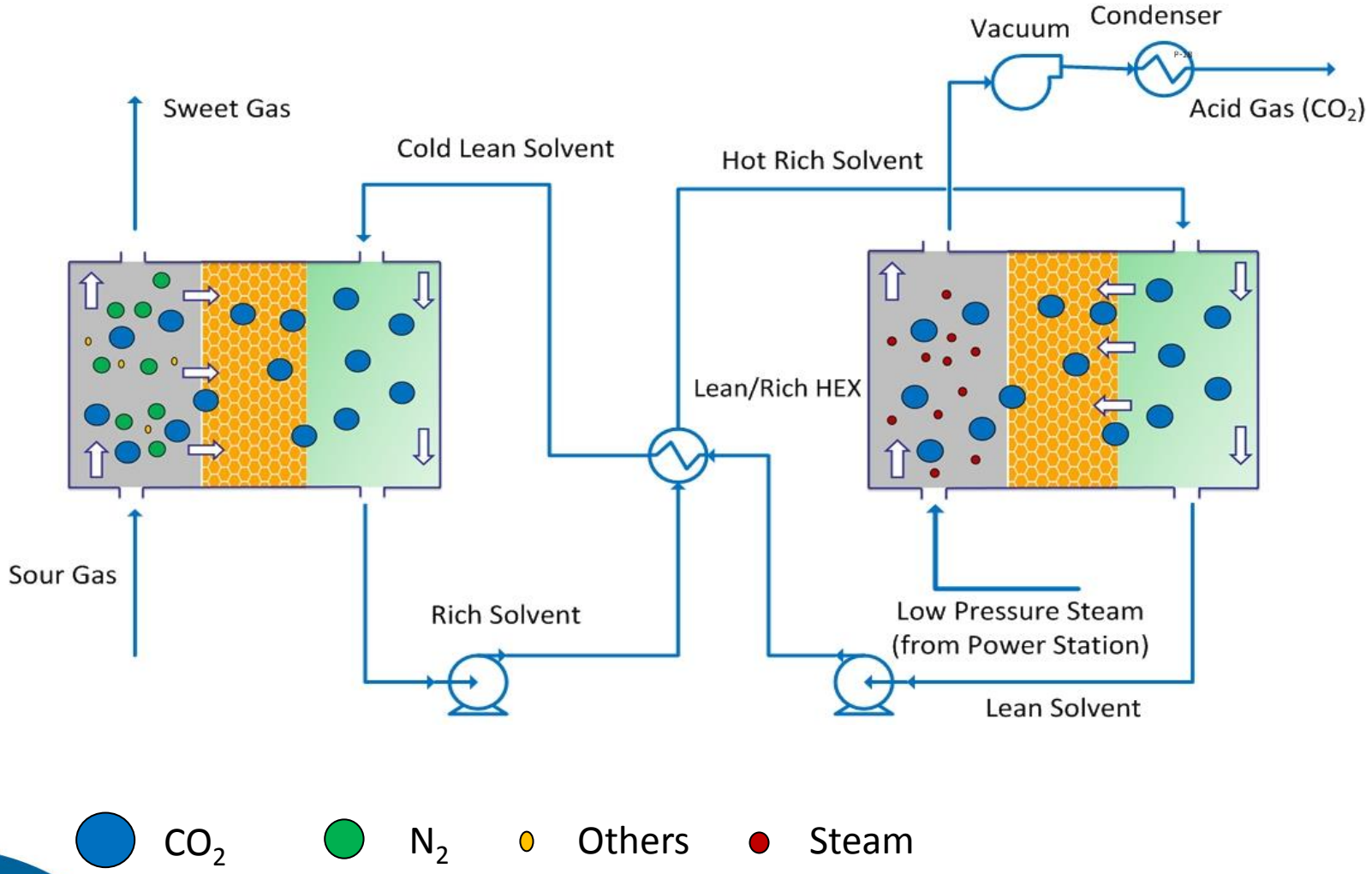
modules: -half inch module housing, 40 fibers, 40 cm fiber length inside the modules
moudle: - ¼ inch module housing, 5 fibers, 30 cm fiber length

Membrane Gas-Liquid Contactors



- Avoidance of hydrodynamic issues.
- Equipment size reduced by 60 – 75%.
- Corrosion is significantly reduced.
- Around 40% reduction in operating costs.
- Around 35 – 40% savings in capital costs.
- Footprint requirements reduced by 40%.

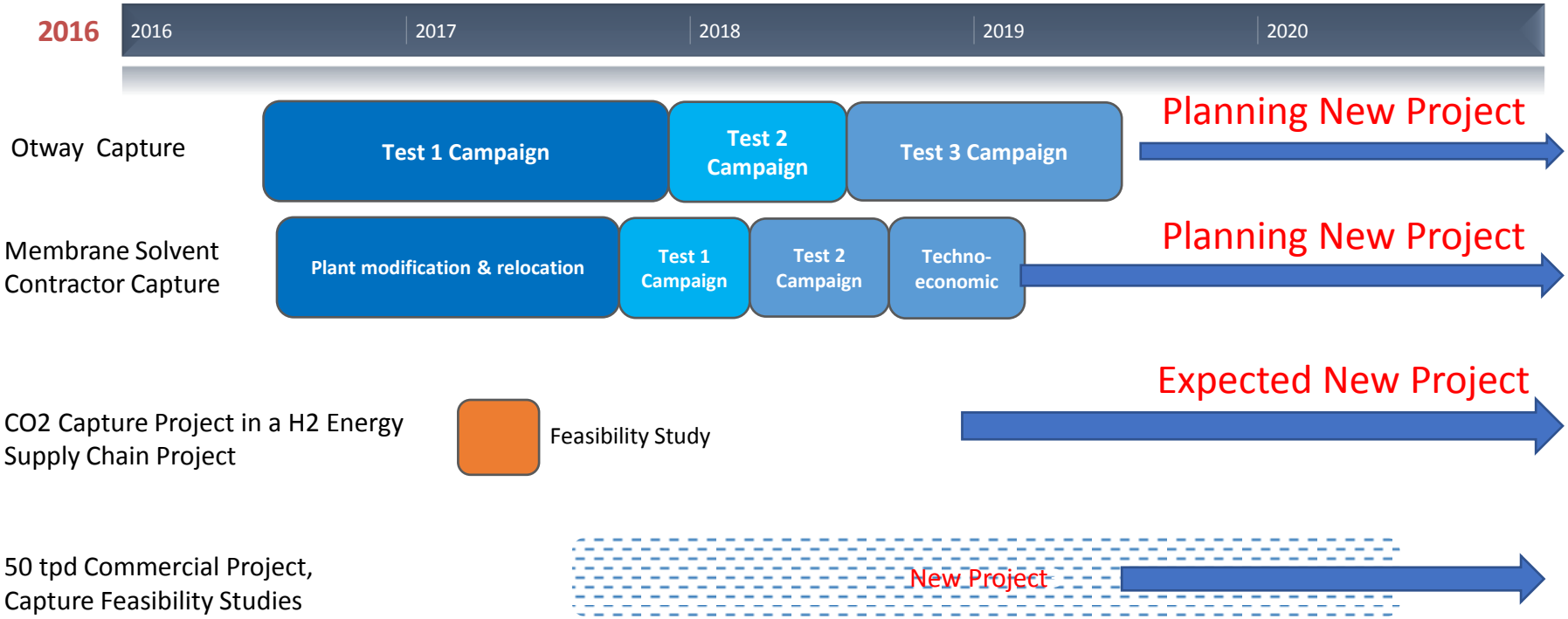
Overall Concept Design for Membrane Contactors



International Collaboration and New Capture Ventures

- We are a member of ITCN – a special web page is available under NCCC web link (www.nationalcarboncapturecenter.com)
- A feasibility study on greenhouse gas reduction with a steel manufacturer in Australia is currently being discussed.
- A commercial venture for 50 tpd food grade CO_2
- A CCUS Hub Study for a Latrobe Valley power station is underway with global participants

Current and Future Capture Program Overview



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Government, Industry and Research Partners

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BUILDING A LOW EMISSIONS FUTURE

Carbon Management Research at University of Kentucky Center for Applied Energy Research (UKy-CAER)

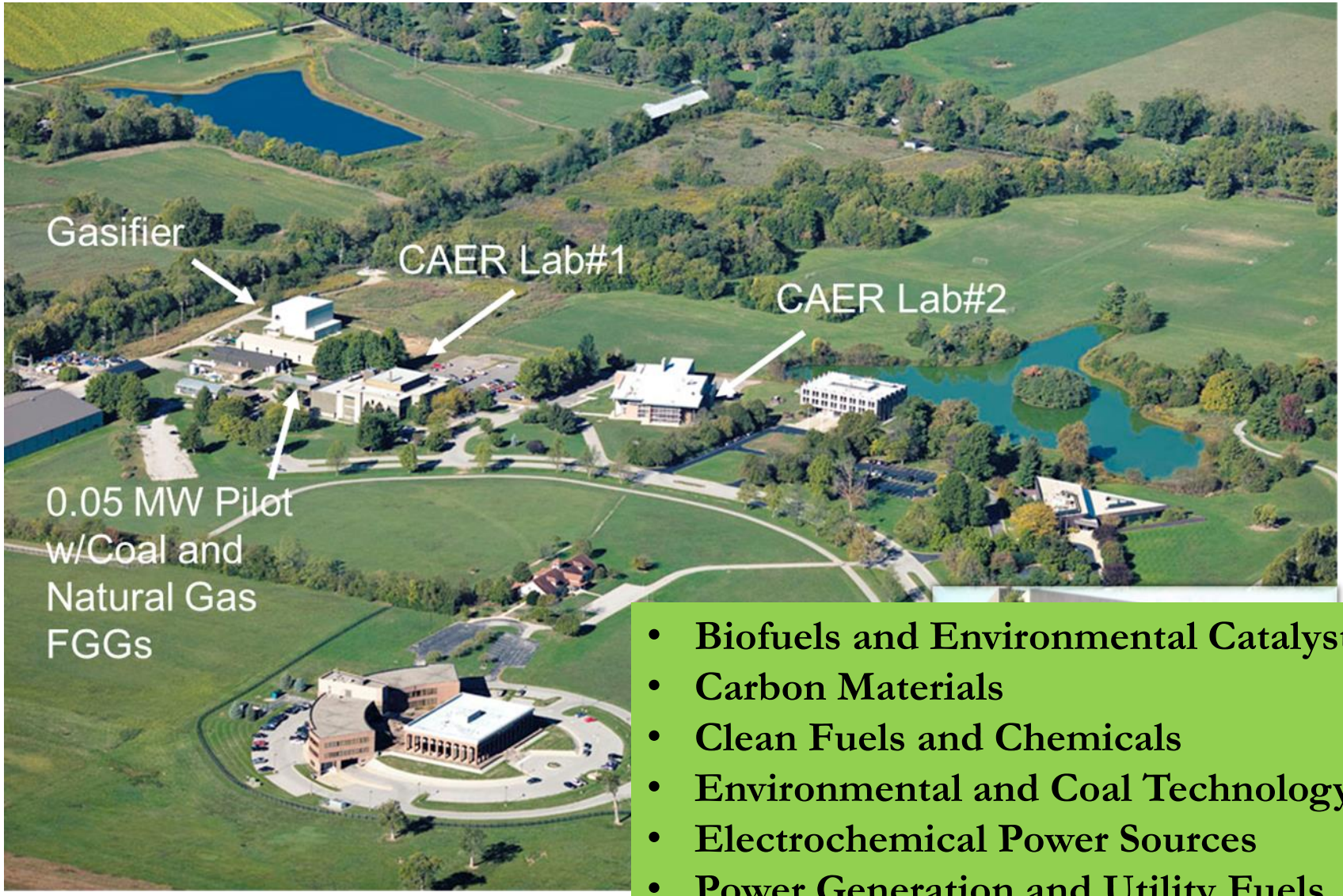
Jesse Thompson

University of Kentucky, Center for Applied Energy Research

Lexington, KY 40511

http://www.caer.uky.edu/powergen/home.shtml

University of Kentucky
Center for Applied Energy Research



- Biofuels and Environmental Catalysts
- Carbon Materials
- Clean Fuels and Chemicals
- Environmental and Coal Technology
- Electrochemical Power Sources
- Power Generation and Utility Fuels

Areas of Research

Corrosion
- Non-metallic coating
- Inhibitors
- Localized effects

Conversion
- Gasification
- CO_2 Utilization
- NG Upgrading

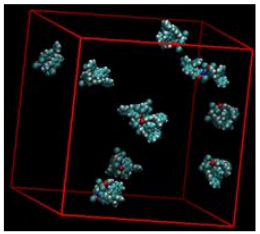
Pilot Plants
- Heat Integration
- Hybrid Processes
- Solvent & process testing

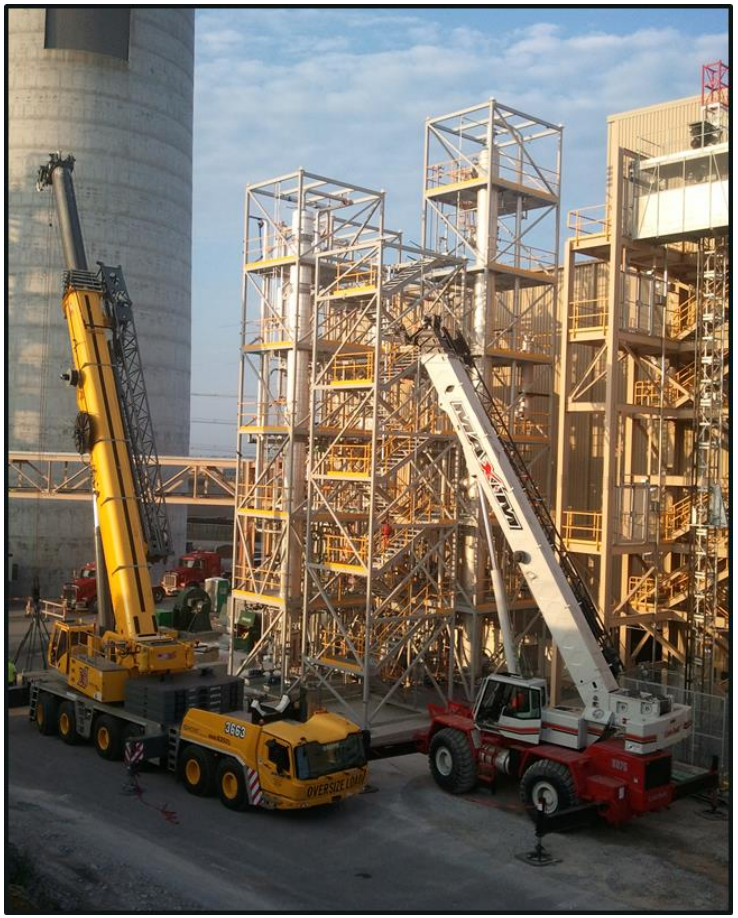
Membrane Separations
- Zeolite membranes
- Solvent enrichment

Solvents
- Chem/Physical Properties
- Emission
- Degradation

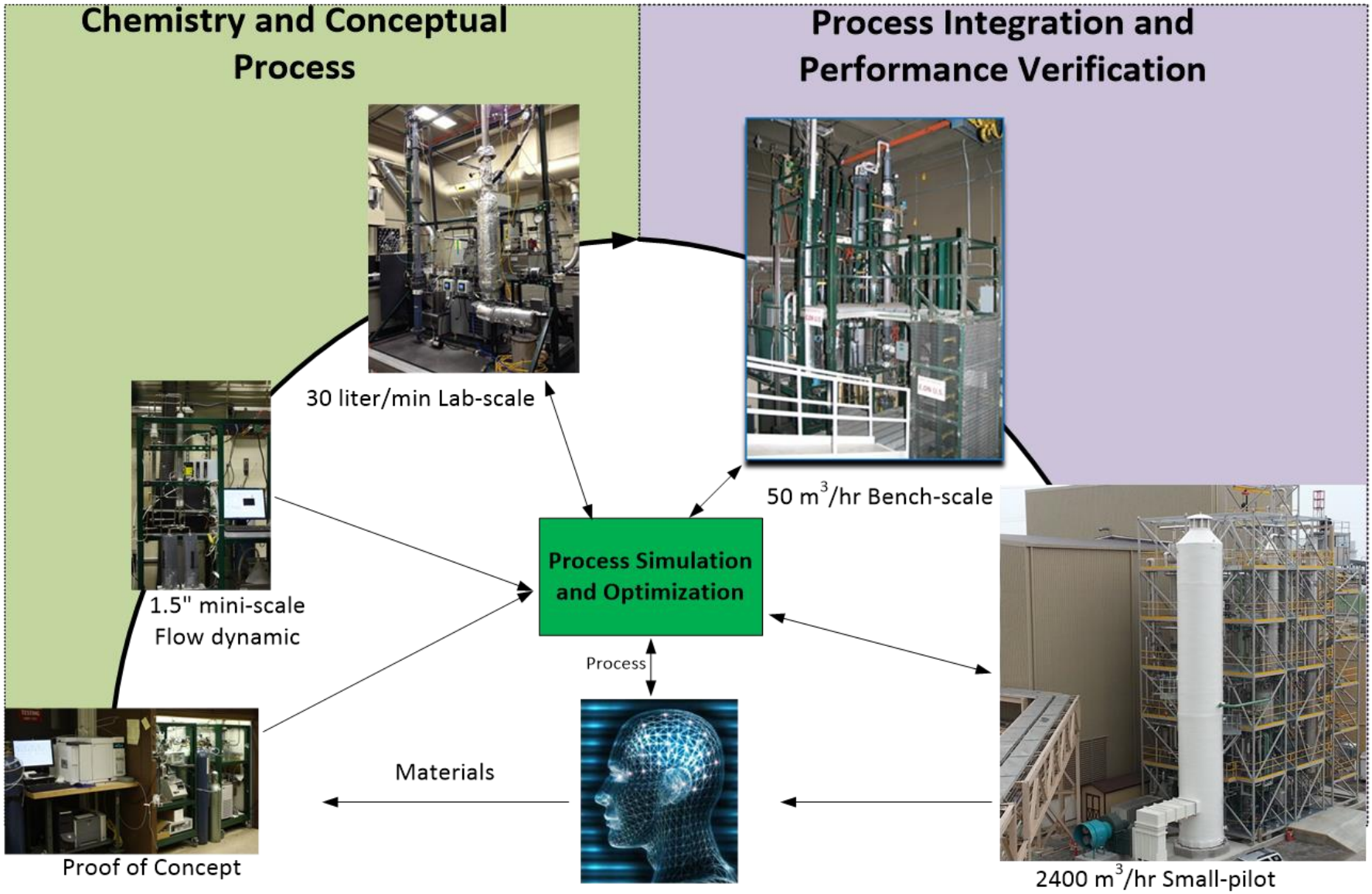
Chemical Looping
- Spouting Fluidized bed
- Combustion/ gasification
- Solid particle handling

Electrochemistry
- Water treatment
- Solvent enrichment





TRL-2 to TRL-6 Research



Small Pilot (1400 scfm) CO_2 Capture

- Unique UKy-CAER CO_2 Capture Process
  - **Heat integrated cooling tower** and liquid desiccant air drying system for decreased energy consumption
  - **Two-stage stripping** for increased solvent working capacity
- Continuous gas stream composition monitoring (**CEMS**)
- Continuous **steam usage** measurement
- Continuous **energy consumption** measurement
- Comprehensive liquid sampling ports for **solvent quality analyses**
- Comprehensive **gas sampling** ports for emissions and degradation analyses
- Liquid/gas **column profile** sample ports for absorber profile validation
- **Corrosion coupon** testing locations for material evaluation
- On-site **analytical laboratory** for routine liquid sample analysis

Phase 2 Modifications: Install CO_2 pre-concentration membrane and emission reduction systems

0.1MWth Post-Combustion CO_2 Capture

Coal-fired FGG and NG boiler

Flue Gas CO_2 Pre-Concentrating Membrane

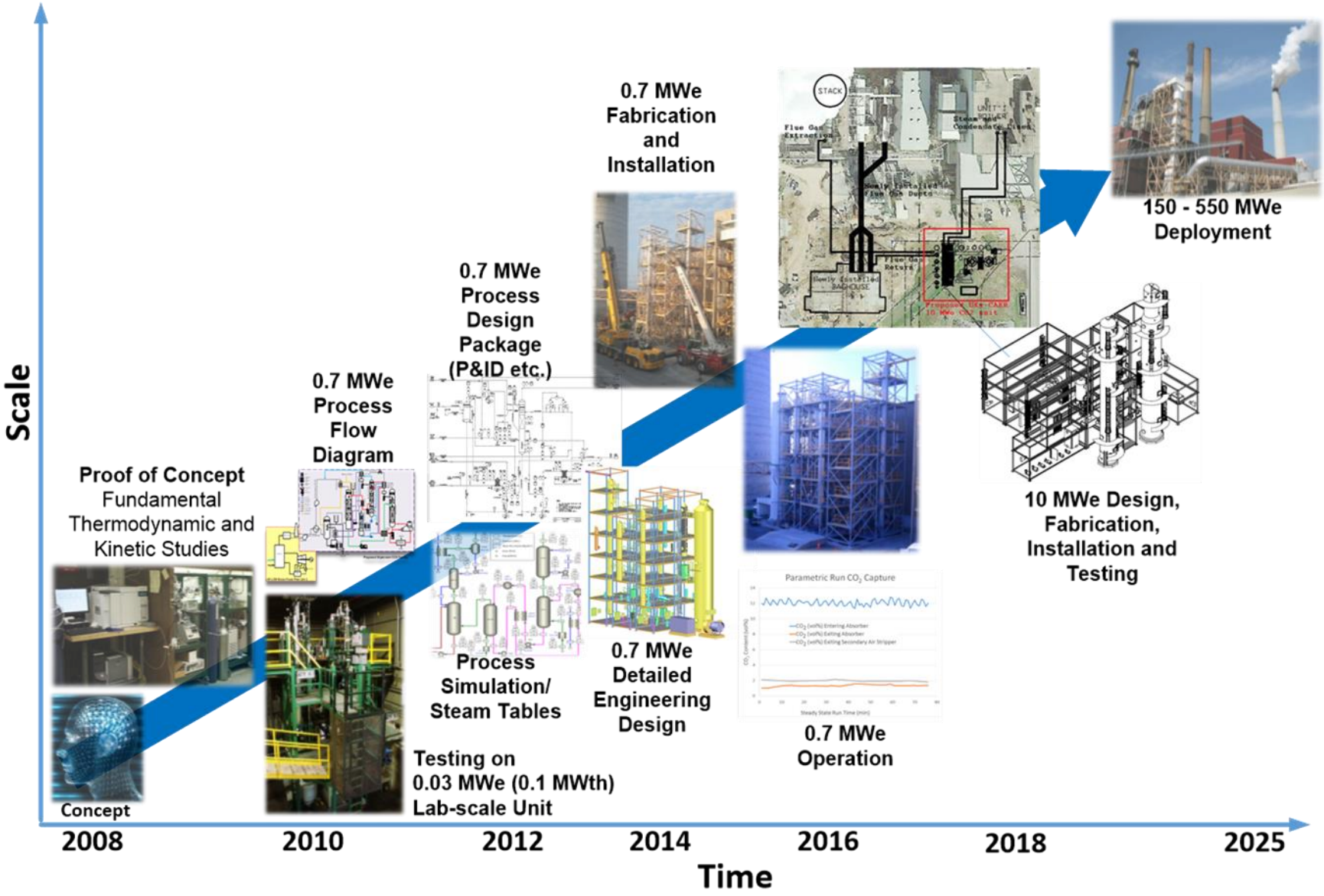
13.7 cfm Unit

Gas Sampling Equipment

Emissions and degradation testing to address EH&S concerns

- Integrated CO_2 capture process
- Solvent performance evaluation under real conditions with coal-derived flue gas
- Degradation studies for solvent degradation and make-up rates
- Flexibility for integration of other technologies (e.g., membranes) and process/method development (e.g., gas sampling)

Technology Progression



Gasification and Acid Gas Cleanup

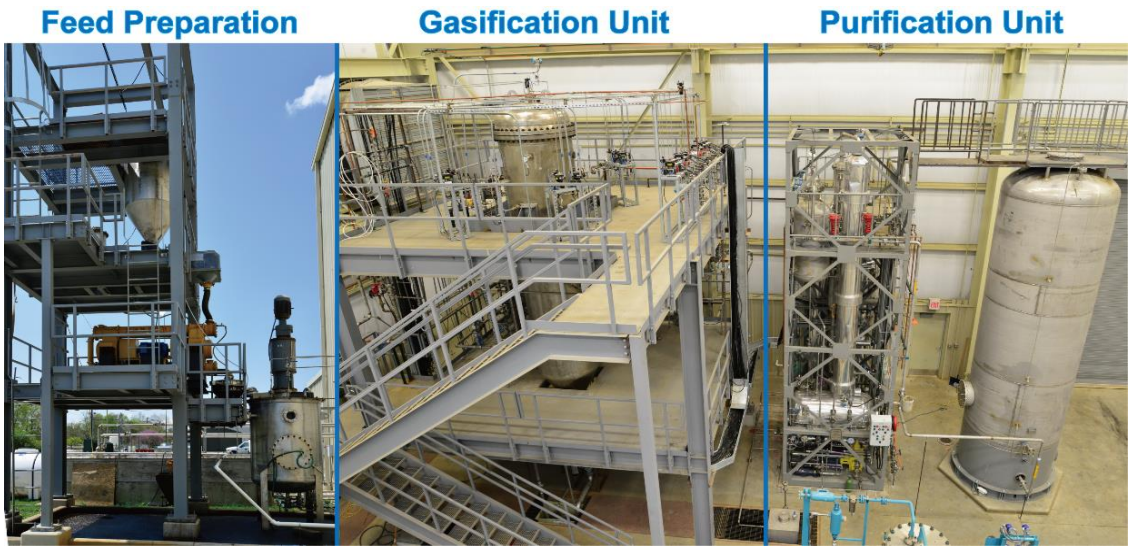
Gasifier

Coal and Coal/Biomass Integrated Feed Preparation

Entrained flow, oxygen blown, molten slag, OMB gasifier

1 ton dry coal/day

160 lb/hour syngas production

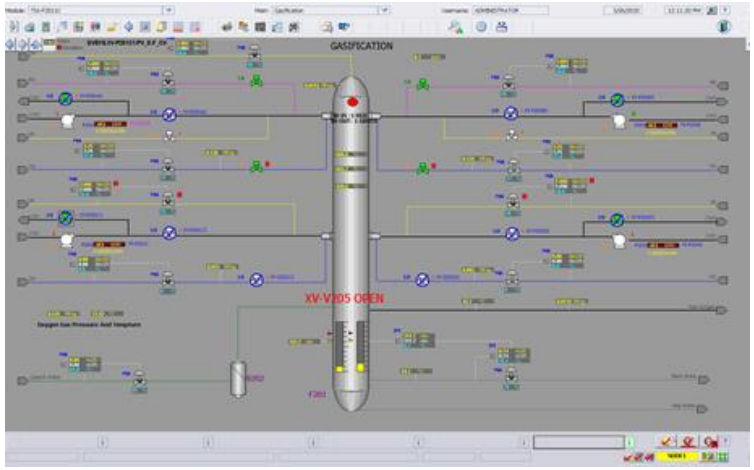


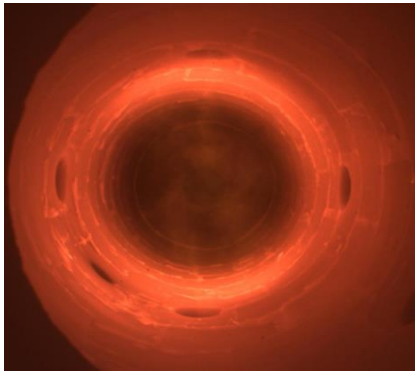
Acid Gas

Aqueous Amine system with absorber and stripper

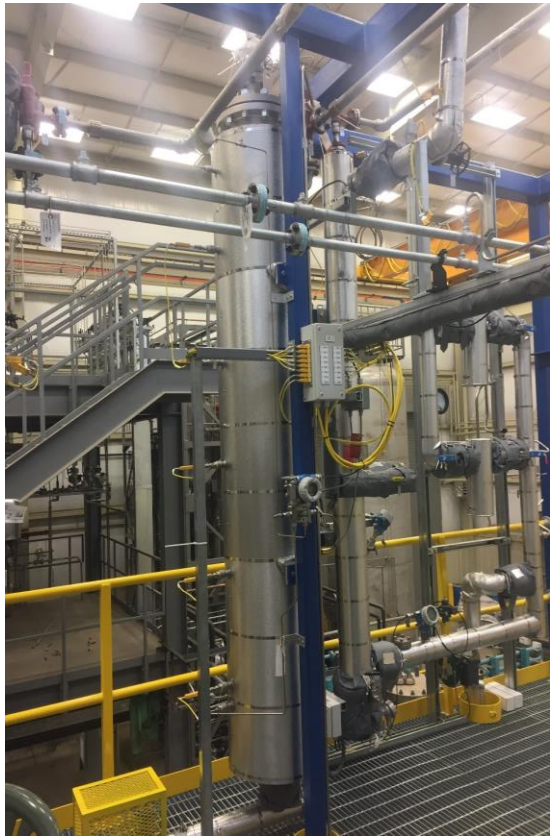
Pressurized system (400 psi)

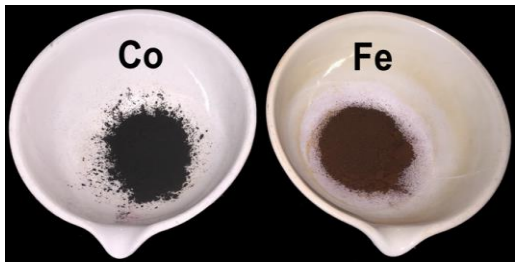
Sulfur treatment on both rejected and clean gas (<1ppmv sulfur)





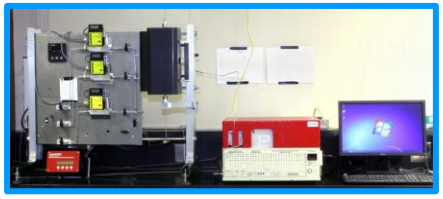
WGS and F-T Module

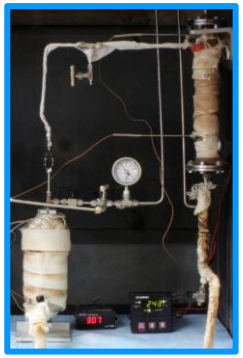




- Chart Energy microchannel reactor with production capacity of 1bbl./day
- FT Reactor is aluminum heat exchanger inside a steel kettle
- Capable of utilizing either Fe or Co based catalysts
- Wide ranging fuel production

Facilities and Apparatus: Lab-Bench Scale





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Equipment and Instrumentation for Screening, Evaluation and Physical/Chemical Property Measurements

Equipment/Instrumentation	Type	Capacity	Function
Vapor-Liquid Equilibrium (VLE) with GC (high pressure)	Parr reactor	400 mL/charge	Determine chemical/physical properties such as equilibrium CO_2 pressure, capacity and heat of absorption
High pressure TGA	fixed bed	up to 10 gram/load	Evaluate sorbent stability, CO_2 absorption rate, carbon capacity, Vapor-Solid Equilibrium
Netzsch TG/QMS/DSC System	fixed bed	up to 30 gram/load	Evaluate sorbent stability, CO_2 absorption rate, carbon capacity, Vapor-Solid Equilibrium, heat of absorption.
Electrochemical Corrosion Cell	stirred reactor	200 mL/charge	Corrosion
Traditional Corrosion Cell	equilibrium cell	2 liter/run	Corrosion
Bench-Scale Mini-Scrubber	solvent-based, simulated flue gas	1.1 kg/hr gas feed rate	Evaluate foaming tendency, batch-mode CO_2 absorption for mass transfer measurement
Bench-Scale Mini-Stripper	random packing	20 mL/min liquid feed rate	Determine batch-mode CO_2 desorption rate
Wetted Wall Column (WWC)	-	2 L/run	Determine mass transfer/kinetic data
Vapor-liquid equilibrium (VLE) apparatus (Low pressure)	-	10 mL/charge	Determine Chemical/physical properties such as equilibrium CO_2 pressure, capacity and heat of absorption
Breakthrough Solvent Evaluation Apparatus	-	10 mL/charge	Determine kinetic data/equilibrium CO_2 pressure, capacity
Stop Flow Reactor	-	20 mL/charge	Reaction rate
Pilot-scale Extruder system with material preparation	thermo-compression	20 kg/day product	Catalyst/solid sorbent production
Freeze Granulator and Freeze Dryer	slurry	2 kg/day	Catalyst/solid sorbent production
EPA Method 5 Standard Gas Sampling Equipment	Apex Instruments (2009)		Monitoring emissions of particulate matter (PM) and solvent degradation compounds for secondary environmental monitoring including EPA stack emission methods

Learning from Scale-up Studies

Amine Degradation

Lab scale experiments under harsh conditions; high temperatures, high CO_2 loading, high contaminant levels (metals)

Large amount of degradation and many degradation products identified

Bench scale experiments; less harsh and closer to actual process conditions

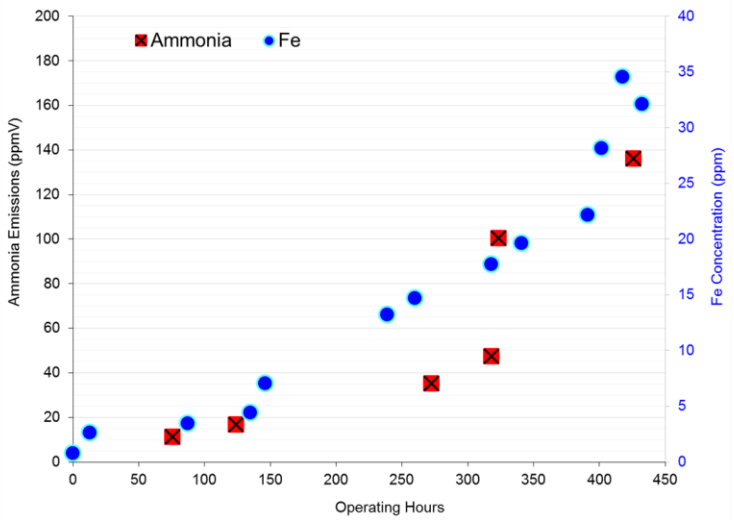
Less degradation and fewer degradation products

Pilot scale experiments; close to actual process conditions

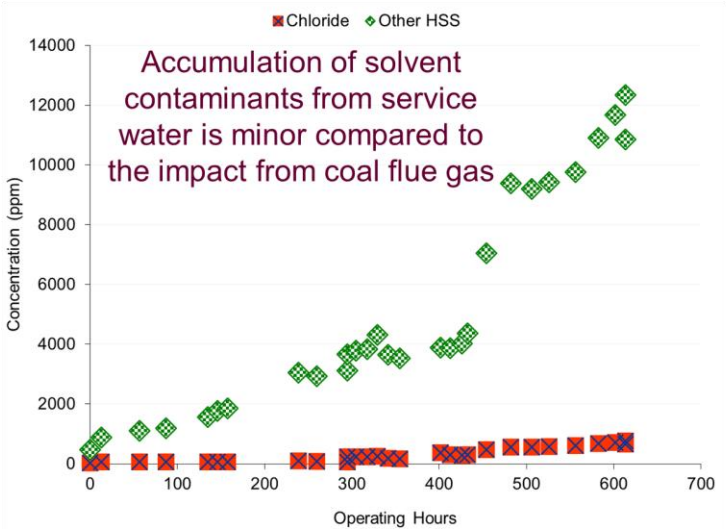
Fewest degradation products identified with lowest overall degradation

Ammonia Emissions vs Fe

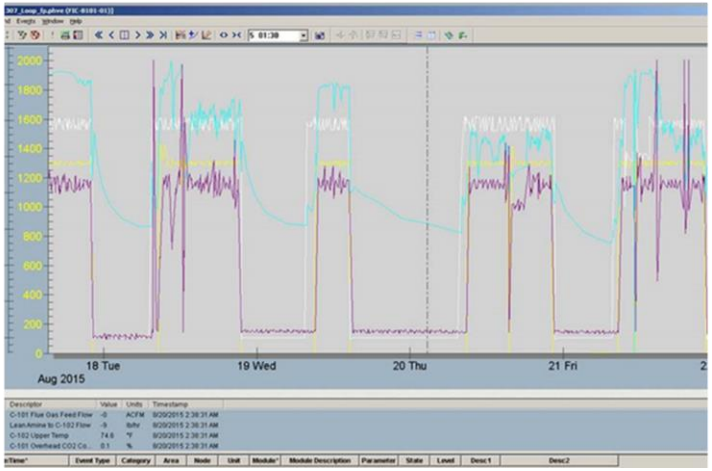
Positive correlation between NH_3 emission and higher Fe in the solvent.



Service Water Usage



Column Distribution / Channel Flow



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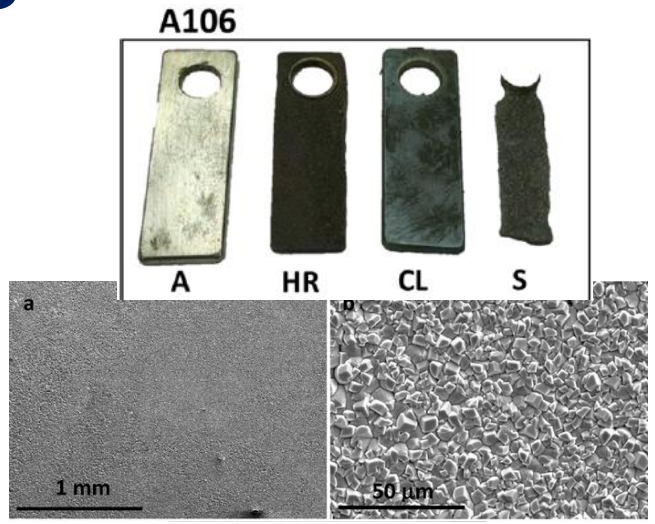
UKy-CAER Highlights

Corrosion

"Use of Carbon Steel for Construction of Post-combustion CO_2 Capture Facilities: A Pilot-Scale Corrosion Study". *I&EC*, 2017, 56, 4792-4803.

"Understanding the Corrosion of CO_2 -loaded 2-amino-2-methyl-1-propanol solutions assisted by thermodynamic modeling". *IJGGC* 2016, 54, 211-218.



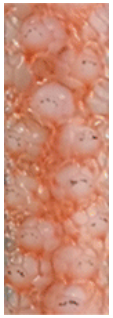
Solvent Development

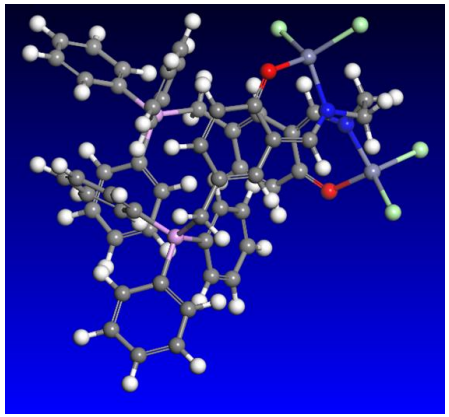
"Enhanced carbon capture through incorporation of surfactant additives". *I&EC*, 2016, 55, 7456-7461.

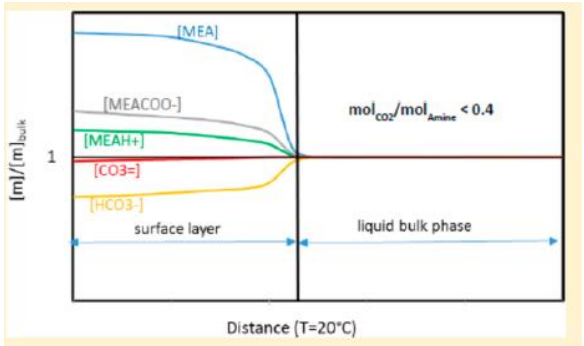
"Enhancements in mass transfer for carbon capture solvents part I: Homogeneous catalyst". *IJGGC* ,2017, 63, 249-259.

"Enhancements in mass transfer for carbon capture solvents part II: Micron-sized solid particles". *IJGGC* ,2017, 61, 138-145.

"Application of Surface Tension Model for Prediction of Interfacial Speciation of CO_2 -Loaded Aqueous Solutions of Monoethanolamine". *I&EC*, 2017, 56, 5747-5755.







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UKy-CAER Highlights

Solvent Degradation

"Pilot testing of a heat integrated 0.7 MWe CO_2 capture system with two-stage air-stripping: Amine degradation and metal accumulation". *IJGGC*, 2017, 64, 23-33.

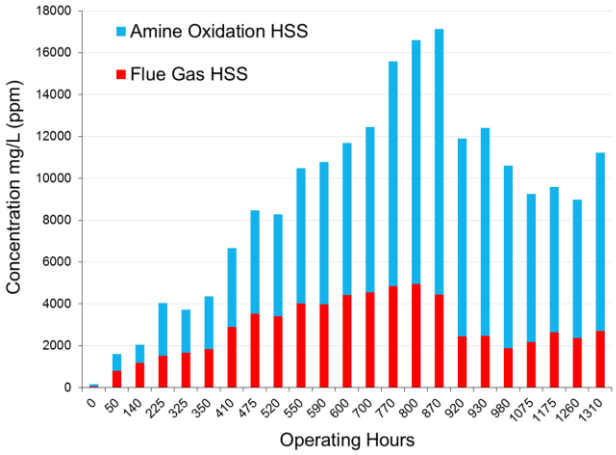
"Pilot testing of a heat integrated 0.7 MWe CO_2 capture system with two-stage air-stripping: Emissions". 2017, *IJGGC*, In review.

"Thermal degradation rate of AMP to cyclic DMOZD: Experiments and kinetic modeling". *I&EC*, 2016, 55, 9586-9593.

"Thermal degradation rate of 2-amino-2-methyl-1-propanol to cyclic 4,4-Dimethyl-1,3-oxazolidin-2-one; Mechanistic aspects and kinetics investigation". *I&EC*, 2017, In review.

"Selective removal of nitrosamines from a model amine carbon capture waterwash using modified solid sorbents". *ES&T*, 2017, In revision.

"Determining the Henry's volatility coefficient of nitrosamines in CO_2 capture solvents". *IJGGC*, 2017, Submitted.



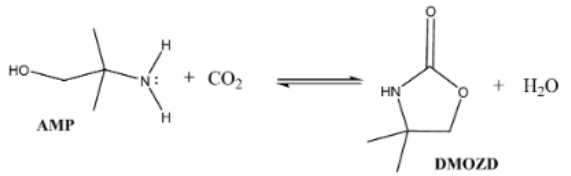
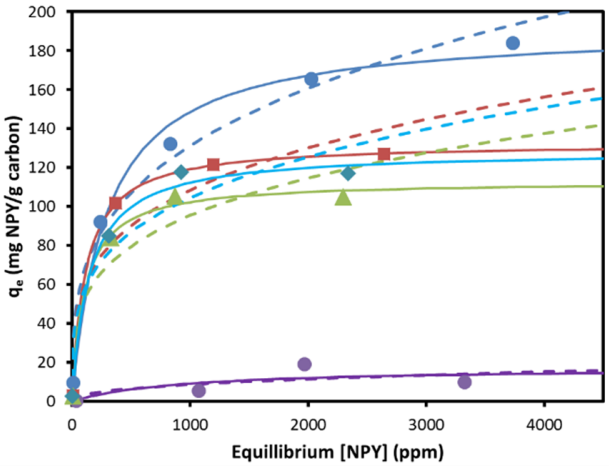


Figure 1. AMP thermal degradation, followed by cyclization and dehydration to form 4,4-dimethyl-1,3-oxazolidin-2-one (DMOZD).



Acknowledgements

Lynn Brickett and José Figueroa, DOE NETL

CMRG Members: LG&E and KU, EPRI, Duke