

J. Gibbins **Director, UKCCSRC** www.ukccsrc.ac.uk

M. Pourkashanian **Director, UKCCSRC-PACT**

www.pact.ac.uk

PARTNERS

Cranfield UNIVERSITY

EPSRC

Research Council

Engineering and Physical Sciences

THE UNIVERSITY of EDINBURGH

Imperial College London







CONTACT: **UKCCSRC PACT Office** The Gateway Broad Street Sheffield, S2 5TG Email: kris.milkowski@leeds.ac.uk



200 Department of Energy & **Climate Change**



The Energy Innovation Process



http://www.energyresearchpartnership.org.uk/Innovation+Landscape



About PACT



- <u>P</u>ilot-scale <u>A</u>dvanced <u>C</u>apture <u>T</u>echnology facilities
 - Funded jointly by the EPSRC and DECC
 - Partners: Cranfield, Edinburgh, Imperial, Leeds, Nottingham, Sheffield
 - Part of the UK Carbon Capture & Storage Research Centre (UKCCSRC)
- Scope: Specialist national facilities for research in advanced fossil-fuel energy, bioenergy and carbon capture technologies
 - Comprehensive range of pilot-scale facilities
 - Specialist research and analytical facilities
 - Supported by leading academic expertise
- Aim: Catalyse and support industrial and academic research to accelerate the development and commercialisation of novel technologies
- Objectives
 - Bridge gap between bench-scale R&D and industrial pilot trials
 - Provide shared access to industry and academia



PACT Locations

- 3 Facility Sites
- PACT Office

PACT Edinburgh Facilities

Advance Capture Technology Transportable Remotely-Operated Mini-lab (ACTTROM)

Administrative & Business Centre of PACT Facilities Research Visitors Office – Simulation Software Facilities – Consultancy – CPD & training – Business engagement –

PACT Core Facilities

- Iton/day Amine Carbon Capture Plant & Synthetic Flu Gas Mixing Facility
 - 250kW Air Fired Coal/Biomass Plant
 - 250kW Oxyfuel Coal/Biomass Plant
 - 300kW Gas Turbines (CHP Generators)
 - Analytical and laboratory facilities....

PACT Cranfield Facilities

SokWth Pilot scale Chemical Looping facility
 750kWth Gas turbine burner rig with downstream probes for deposition
 150kWth PF air/oxy combustion rig
 300kWth Circulating Fluidised Bed Combustor/Gasifier
 CO2 Transport Flow Rig

Edinburgh PACT Facilities

- Advanced Capture Testing in a Transportable Remotely-Operated Mini-lab (ACTTROM)
- Integrated, mobile carbon capture media testing laboratory
- Designed for long-term on-site testing of CO₂ capture media on real flue/process gases with a possibility of multiple parallel tests
- Facility is transported to the test site and connected directly to onsite flue/process gases
- Remotely monitored and operated by University of Edinburgh
- About to go on site at Peterhead



- ACTTROM
 - Aids technology development and scale-up for technology developers
 - Provides site-specific operational data to operators, for example, in advance of the deployment of a specific capture system



Cranfield PACT Facilities

- PACT is part of new energy facilities at Cranfield
- 750kWth Burner Rig for Gas Turbine Hot Gas Path Research
- 350kWth Circulating Fluidised Bed Facility
- 50kWth Chemical/Calcium Looping Facility
- 150kWth Pulverised Fuel rig
- Dense-phase CO₂ Flow Loop Rig









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

















Air-coal 200 kW with preheated air

Air-coal 200 kW with preheated air

a) Temperature [K] at r = 0 mm

UKCCSRC PACT FACILITIES



250kW Air/Oxy Plant - Analytical

3D laser diagnostics and thermal imaging

- In-flame temperature profiles using suction pyrometry
- Heat flux profiles using an ellipsoidal radiometer and total heat flux probes
- Laser Induced Fluorescence (LIF)
- In-flame and exhaust species profiles
- 3D Particle Image Velocimetry (PIV), Laser Doppler Velocimetry (LDV);
- Flame characterisation, including shape, luminosity, and frequency, using 2D and 3D flame imaging with photographs and videos as well as computer tomographic reconstruction of the flame in 3D
- Particle velocity profiles within the top section of the furnace (for both non-reactive and reactive species)





Flicker study



- 200kW_{th} air coal combustion (benchmark simulation)
- 2D flame imaging by Kent University¹



¹Experimental Images and data courtesy of Kent University

Flicker study





Solvent-based CO₂ Capture Plant



Applications

- Testing & development of alternative solvents
- Benchmarking & energy requirements
- Solvent degradation & enhancement studies
- Real aged solvents assessment
- Plant and system modelling
- Assessment of plant flexibility and performance with different fuels (e.g. biomass) or other conditions
- Integrated systems modelling and control
- Validation of baseline economics





UKCCSRC-PACT Gas Turbine + Amine Plant







Key Simulation/Experimental Results

MEA Solvent, Flue Gas CO2 Level = 7%

Lean Flow (kg/h)			Rich Flow (kg/h)		Lean Ldg (mol/mol)		Rich Ldg (mol/mol)	
Experir	mental Moo	delling	Experimental	Modelling	Experimental	Modelling	Experimental	Modelling
5:	15 5	515	531	538	0.25	0.23	0.41	0.40
	CO2 Cap (kg/h)			CO2 Cap (%)		Reb Duty (MJ/kg CO2)		
	Experiment	al Mc	odelling	Experimental	Modelling	Experiment	al Modellin	g
	16.45		16.45	76.3	76.3	5.92	5.6	59

Absorber Temperature Profile





Absorber Composition Profile





SUPER<mark>GEN</mark> Bioenergy Hub



TyndallManchester





- Carry out system
 assessment
- GHG balances
- Process Analysis of Bio-CCS Options

- Fundamental Experimental studies
- Pilot-Scale studies
- Virtual reality System Simulation

- Fundamental Experimental studies
- Pilot-Scale studies
- Process Simulation





Impact

- The project will remove some of the significant technical barriers to bio-CCS development.
- It will progress current understanding of the potential of bio-CCS for the UK energy system so that realistic projections of deployment, costs and achievable GHG reductions can be incorporated in policy development.
- The project will accelerate UK development of bio-CCS technology
- The project will consolidate the UK's position as worldleaders in technology understanding for decarbonisation of existing coal based power generation infrastructure

Technical Challenges (1)

Case Study: Didcot Power Station A





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)













• INVENSYS UKCCSRC-PACT partnership was signed 01/2014

- Access to all their process simulation model including DYNSIM
- Available for use for initial period of 3 years



Technical Challenges (2)

Case Study: Didcot Power Station A









Virtual Reality Power Plant Simulation



Analytical Facilities: Labs



- Analytical labs
- Unique Continuous Emission Monitoring 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 (CO₂ and O₂)





Overview & Contacts



- 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

PARTNERS





Imperial College London







FUNDING FROM

Department of Energy & Climate Change

EPSRC Engineering and Physical Sciences Research Council



CONTACT: UKCCSRC PACT Office The Gateway Broad Street Sheffield, S2 5TG Email: kris.milkowski@leeds.ac.uk