Energy Research and Teaching at Cranfield

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http://www.cranfield.ac.uk
Who are we?

- The UK’s only **100% graduate** university specialising in science, technology, engineering and management

- We have a **global reputation** for inspirational **teaching** and **research**, industrial-scale **facilities** and **first class links** with industry and commerce

We are one of the UK’s top five research intensive universities

We work with more than 750 businesses in 40 countries across six continents

Our MBA is ranked top in the UK and 15th in the World*

* Economist
Cranfield is international in many ways:

- 2,500 students from over 100 countries
- Research recognised around the globe
- Academics from all over the world
- International industry connections including Boeing, GlaxoSmithKline, Unilever, BAE Systems, Alstom, Doosan Power, Rolls Royce, Siemens, BP, Airbus

69% Europe (incl. UK)
31% rest-of-world
Themes

- Aerospace
- Automotive
- Defence & Security
- Energy
- Environment
- Healthcare
- Management
- Manufacturing
Energy Research Capabilities

- Energy policy and regulation, end-use energy systems, efficiency and life cycle analysis
- Power systems – components, integration and modelling
- CO₂ capture and transport
- Energy from biomass and waste – systems, supply chain and resource efficiency
- Environmental impacts, emissions control and waste management
- Materials, inspection, reliability, asset management and risk-based maintenance
- Conventional and advanced fuels – production and conversion technologies
- Renewable energy technologies – offshore/onshore wind, wave and tidal, solar thermal and photovoltaics
- Oil and gas production, infrastructure and flow assurance
- Electric power machines, control & grid systems
Large-scale Energy Facilities

- Algae biomass
- CO$_2$ Capture
- Combustion
- CT Structural Integrity
- Chemical Looping
- Gasification
- Gas Turbines/Burner Rigs
- Offshore Fluids
- HP Steam
- Process Systems
- Wave/Tidal
- Vertical Axis Wind Turbine
Combustion units include:

• Pulverised fuel combustor (100 - 200\( \text{KW}_{\text{th}} \), air- or oxy-fired)
• Circulating fluidised bed combustor (200-300\( \text{KW}_{\text{th}} \), air- or oxy-fired)
• Bubbling fluidised bed

Research focussed on:

• Co-firing of Biomass, Energy Crops and Waste with Coal
• Evaporator and Superheater Materials and Coatings
• Deposition and Corrosion
• Modelling corrosion performance
• Gaseous Emissions and Residues
• Component Life Assessment & Boiler Reliability
• Oxy-combustion
• \( \text{CO}_2 \) Reduction with Sorbent Injection
Bioenergy and Energy - from Waste

- Combustion/Incineration
- Anaerobic Digestion
- Pyrolysis and Gasification
- Resource Estimation
- Co-firing
- Materials and Coatings
- Deposition and Corrosion
- Gaseous Emissions and Residues
- Biogenic Content

Downdraft Gasifier
CO₂ Capture

CO₂ Capture Methods
• solid sorbents (CaO)
• oxyfuel
• amine scrubbing
• membrane separation
• process modelling

Gas Post Combustion Capture

Amine CO₂ Scrubbing
Pilot scale (50 kWth) chemical looping facility - largest UK facility

- Flexible in configuration, either as
  - Twin CFB legs or
  - Single entrained flow riser with bubbling bed (2nd reactor)

- Chemical looping mode—either for oxy-combustion, O₂ or H₂ production
CO$_2$ transport

Pipeline integrity
• Low temperature fracture
• Crack arrest methods

Supercritical CO$_2$ dynamic flow loop facility
(UKCCSRC – PACT)
• Operates above 90 bar, 40 deg (capable for up to 700 bar & -50 to 150 deg) in flow mode (fluid flow rates up to 5l/min)
• Measurement of physical properties - density, pH, temp, pressure
• Impurity injection – H$_2$O, H$_2$, H$_2$S, NO$_x$, SO$_2$ and O$_2$

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Gas Turbine Engineering Laboratories

High Pressure Air Plant

CNC facility and workshops

Hot end instrumentation facility

High Speed Test Houses

HP Regenerative Air Heater

Low Speed Aerodynamics - Renewables

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Gas Turbine Fuels and Materials

- Deposition, Erosion and Corrosion on Turbine Blading
- Blade Materials and Coatings
- Impact of Plant Cycling
- Thermal Barrier Coatings
- Impact of Gas Contaminants from biomass/waste-derived gases
- Component Life Assessment
- Combustor Materials
- High Temperature Heat Exchangers

Gas Turbine Burner Rig (750kW_{th}, >1500°C) (UKCCSRC – PACT)
Surface Science and Engineering

- Advanced Coatings
- Corrosion Life Modelling
- Process Simulation - physical/mathematical

- EB-PVD ion plater (1000°C process temp)
- EB-PVD evaporator
- Resistive heated evaporators
- Multi-target sputtering systems
- Single target sputtering systems
- Pack cementation, over pack CVD and gas phase CVD
- Controlled atmosphere plasma spraying
- Hot isostatic pressing
- Electroplating
- Metallurgical and Surface Analysis Suite

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Subsea Energy Systems

Floating Systems
- Wave Spectrum
- Hydrodynamics
  - scattering (FK+Diff)
  - radiation
  - restoring
- Hydroelasticity
- Riser Dynamics
- Fully coupled equation of motion

Multiphase Flow and Flow Assurance
- Multiphase flow – modelling & measurement
- Severe and hydrodynamic slug – control & simulation
- Sand transport
- Separation and transport options
Offshore Structural Integrity

• Fatigue analysis
• Fracture Mechanics
• Materials & Corrosion
• Integrity Monitoring
• Engineering Criticality
• Large-scale testing
• FEA

Photo: DONG Energy

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Offshore Renewable Energy

- Vertical Axis Wind Turbine Test Facility
- Algae Biomass Laboratory
- Ocean Laboratory
Solar Energy

Solar thermal
• Mirror manufacture
• Chillers
• Cycle modelling

Photovoltaics
• Film deposition
• Surface analysis
• Device characterisation & modelling

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Post-graduate Energy Teaching

Over 200 Masters students across a range of Energy courses
Over 80 PhD research students

Energy Masters Courses

- Biofuels
- Carbon capture & storage
- Energy supply for low carbon futures
- Energy systems & thermal power
- Flow assurance
- Materials for energy systems
- Offshore materials engineering
- Offshore renewable energy technology
- Pipeline engineering
- Process systems engineering
- Renewable energy engineering
- Renewable energy technology
- Risk management
- Subsea engineering

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During the laboratory tours, please keep within the boundaries marked by black/yellow striped lines on the floor.

If a fire alarm sounds, please leave the laboratory through the nearest available fire exit - follow your guides to the closest assembly point.