University of Sheffield
Energy Institute

TERC

Finding and testing practical solutions to critical energy challenges

Funded by:

European Union
European Regional Development Fund

Department for Business, Energy & Industrial Strategy

Welcome to the Translational Energy Research Centre

One of the largest and best-equipped low-carbon energy solution R&D facilities in Europe

£38.3 million

£XX million (ERDF)

£7 million (BEIS)

£X million (TUoS)

The £38.3 million centre is part-funded by £X million from the European Regional Development Fund (ERDF) and £7 million from the UK government's Department for Business, Energy and Industrial Strategy (BEIS). This total includes funds for the Sustainable Aviation Fuels Innovation Centre.

The Translational Energy Research Centre is a unique, national pilot-scale testing facility based at the University of Sheffield

We are working to discover, demonstrate and integrate low carbon and renewable energy generation solutions from across the energy spectrum to work towards secure, affordable and sustainable energy systems for the future.

Our state-of-the-art, first-of-its-kind equipment and world-leading academic excellence combined with a whole energy system, plug-and-play approach gives you access to faster, more effective and better value research and development.

Everything you need for commercially-focused R&D

In order to expand the existing experimental research facilities for zero-carbon energy research in the UK, the Translational Energy Research Centre features a large number of pilot-scale energy test rigs on one fully-integrated site, offering significant flexibility.

The centre focuses on low carbon energy research at a technology readiness level (TRL) of three to six. By offering the chance to carry out relevant, pilot-scale tests with rapid prototyping technologies in an industrial setting, results can be scaled confidently and result in a faster transition to market.

More than thirty permanent rigs – and capacity for more

A comprehensive range of state-of-the-art equipment is available at the Translational Energy Research Centre for research into:

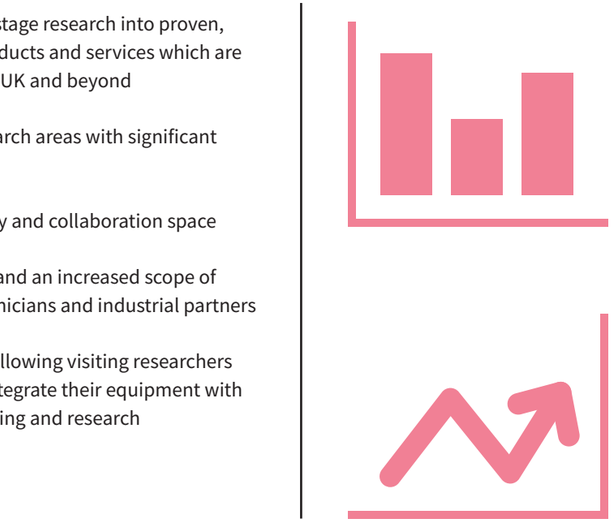
- Carbon capture, utilisation and storage
- Sustainable aviation and transport fuels
- Hydrogen
- Bioenergy
- Renewable energy
- Energy storage
- Smart grids and energy control and monitoring systems

The various rigs and facilities, together with the extensive range of online and laboratory analytical equipment, can be integrated for a ‘whole energy system’ approach, using a smart energy management module and low-carbon heat management system, with optimal synergy between the rigs and processes.

A new centre for research, innovation and development on a national and global scale

The Translational Energy Research Centre offers:

- A fast-track to turning early stage research into proven, sustainable, low-carbon products and services which are ready for deployment in the UK and beyond
- Large-scale facilities to research areas with significant growth potential
- Enhanced capacity, flexibility and collaboration space
- A large number of test days and an increased scope of testing for researchers, technicians and industrial partners
- A plug-and-play approach, allowing visiting researchers and industrial partners to integrate their equipment with our facilities to enhance testing and research



With our partners, we aim to:

- Increase the speed that new technologies can transition to market
- Remove the financial risk of large-scale industrial pilot trials
- Find solutions to some of the most complex energy demand and supply challenges
- Help the UK meet its target of net-zero emissions by 2050
- Become a global leader in energy research, with world-leading innovations alongside academic excellence

We work with:

Global companies of all sizes that need capacity to research new technology and innovations to decarbonise, or support to develop and test new low-carbon technologies.

Academic research teams wishing to access advanced testing facilities and the opportunity to collaborate.

Regional enterprises of all sizes, and in particular SMEs. We work closely with local partners to assess how to reduce the cost of energy for their business and to find solutions to operational energy loss issues.

World-leading research and innovation centres.to support research projects and provide equipment and expertise

Delivering industrial decarbonisation & net-zero emissions

Sustainable Aviation Fuels Innovation Centre

The Translational Energy Research Centre is closely aligned with the neighbouring Sustainable Aviation Fuels Innovation Centre (SAF-IC). The first centre of its kind in the UK, SAF-IC is an exciting new research facility to develop, test, validate and certify new zero carbon and sustainable aviation fuels.

Part-funded by the European Regional Development Fund, SAF-IC will develop, test, validate and assess new SAFs with ASTM D4054 standard analytical and testing equipment to take sustainable fuels through the entire approval process. SAF-IC will work in combination with the TERC facility to support state-of-the-art research and provide much-needed testing capabilities to help ready sustainable aviation fuels for commercial use.

Together, TERC and SAF-IC will be the first in the UK to capture CO_2, produce green hydrogen, convert them into sustainable aviation fuels and analyse their performance and technical sustainability in one location.

This new facility will enable the development of practical solutions to the challenge of making vital jet travel more sustainable for the industry and our planet, thanks to the decades of expertise and world-class knowledge of its key research academics.

Partners in world-changing projects

Our teams are carrying out work for major ongoing projects with research and industrial partners. Some of these projects include:

- **Industrial Decarbonisation Research and Innovation Centre (IDRIC)**

Led by Heriot-Watt University and funded by UKRI, this project is part of a drive to create the world's first net-zero emissions industrial cluster by 2040.

- **Laser Imaging of Turbine Engine Combustion Species (LITECS)**

Our researchers join a team led by the University of Strathclyde on an £8 million research programme which aims ultimately to reduce the environmental impact of aviation and power generating gas turbine engines.

- **Negative Emissions in the Waste-to-Energy Sector (NEWEST)**

Led by the Research Council of Norway and the University of Edinburgh, the project will expand the range of fuel sources that are ready to use in combination with CCUS.

Part of something bigger

The Translational Energy Research Centre in the region and beyond

The Translational Energy Research Centre and the Sustainable Aviation Fuels Innovation Centre are located in the heart of the University of Sheffield Innovation District, adjacent to South Yorkshire's Advanced Manufacturing Innovation District, alongside some of the UK's most exciting research centres. These include the world-leading Advanced Manufacturing Research Centre (AMRC) and the Nuclear Advanced Manufacturing Research Centre (NAMRC).

The facility and its neighbouring research centres will combine the work of the Translational Energy Research Centre and other Northern energy centres to improve the regional economy, enhance innovation and work towards reaching net-zero emissions in the North of England and beyond.

The University of Sheffield Energy Institute

The Translational Energy Research Centre is part of the University of Sheffield's Energy Institute. The Energy Institute brings together pioneering researchers who are passionate about changing the world and transforming lives through innovative, interdisciplinary research.

As part of the Energy Institute, the Translational Energy Research Centre has access to over 300 of the best minds in energy research. The combination of the work of the Translational Energy Research Centre and the access enabled by the Energy Institute will ensure we can align early stage research with current and future commercial goals.

Some of the largest and most exciting equipment in Europe

The Translational Energy Research Centre will host key pieces of equipment, some of which will be the first of their kind in the UK

Green hydrogen production via Electrolysis

- Green hydrogen is produced on-site via electrolysis. This is currently done using a fully-automated alkaline-based hydrogen electrolyser which can generate up to 32 Nm^3/h of pressurised hydrogen with a purity of 99.999%
- This electrolyser is designed in a fail-safe mode with remote control and monitoring features, and can operate with ambient temperatures as low as -10°C
- A polymer electrolyte membrane (PEM)-based electrolyser will be installed to increase the total production capacity to 150 Nm^3/h
- Hydrogen production is combined with a specialised compressor which increases the pressure of the generated hydrogen to 200 bar for storage
- Currently, there is storage capacity of more than 35 kg (>450 Nm^3), to be increased to up to 1500 Nm3

Polymer Electrolyte Membrane (PEM) fuel cell system

- Generates electrical power that could be used by the end user or fed into national electricity grid
- Provided with an internal bridge power system that enables instantaneous power generation from cold start
- Equipped with integrated frost protection that allows for operation at sub-freezing temperatures
- Operates at a wide range of pressure (2.7 to 10 bar) and relative humidity (5 to 100%)
- Has an integrated control and monitoring system
- Real-time monitoring of hydrogen consumption, electricity generation, fuel cell stack voltage and current, and capacity for more

Molten Carbonate Fuel Cell (MCFC): Next generation CCUS technology

- Next generation technology to capture CO_2 and produce electrical energy simultaneously
- Could lead to an increase in output power of up to 80% and could eliminate up to 70% of NO_x emissions as the operating temperature is lower than that of combustion
- Could capture up to 90% of CO_2 existing in the flue gases
- Could operate with a wide range of flue gases (that vary in their CO_2 composition) and fuel gases (natural gas, biogas, hydrogen, etc.) due to its relatively high operating temperature (~ 600°C)
- Supports extensive current and future research into low carbon energy generation, integrated energy systems and hydrogen economy
- Integrated with a hydrogen separation and purification unit, enabling the rig to produce hydrogen as a co-product of the energy generation. This is followed by the removal of impurities to achieve more than 99% purity hydrogen

Grate-fired biomass with WtE and BECCS

- A 240 kWth moving grate fired boiler which is capable of burning a range of virgin biomass and waste fuels, with waste-to-energy (WtE) compliance (Medium Combustion Plant Directive)
- The flue gas exhaust is integrated fully with the on-site Amine solvent-based carbon capture plant, enabling combined biomass combustion and CO2 capture research
- The biomass boiler can provide flue gases produced by a wide range of fuels to investigate achieving net negative emissions through BECCS
- Fuel capabilities include:
  - Virgin biomass fuels, including woodchip and pellets
  - Recycled untreated wood products (e.g. shipping pallets, cable reels)
  - Biomass waste from agriculture or forestry
  - Vegetable waste from the food processing industry
- The combustion chamber was built according to a direct pass principle for drying, gasification and combustion of the fuel, and the subsequent removal of ash from the combustion chamber

Grate-fired biomass with WtE and BECCS (continued)

- The boiler was specifically designed for research purposes and is fitted with a wide range of ports at key locations of interest within the combustion chamber and flue gas passage to allow the detailed characterisation of these zones
- Example experimental capabilities include the following analytical probes:

- Flame imaging camera probe
- Suction pyrometer
- Gas sampling probes
- Ellipsoidal radiometer
- Particle collection probe
- Deposition probes
- Corrosion probes to fit metal coupons made from materials used for the manufacturing of specialised boiler tubes

- Gas analysis can be carried out using:
  - a stack gas analyser system (O_2, CO_2, CO, NOx, THC)
  - a Gasmet FTIR
  - an ETG syngas analyser (H_2, CO_2, CO, O_2, NO_x, C_mH_n)
  - a Spectro-Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) analyser for online simultaneous multi-metal emissions detection (e.g. K, Na, Hg, Cr, Cd, Pb, V, Zn, etc)
- High combustion temperatures, as well as a long residence time of the combustion gases, guarantee a clean burning process. Furthermore, particulate removal is achieved in two distinct steps using a multi-cyclone followed by an electrostatic precipitator (ESP) to adhere to the strict emissions limits of the Medium Combustion Plant Directive (MCPD)
- Integrated Organic Rankine Cycle utilises low-grade heat from the boiler for the generation of up to 10 kWe

Solvent-based post-combustion CO_2 capture plant

- Fully instrumented, 1 tonne/day pilot-scale conventional solvent-based CO_2 capture plant with two absorber columns and solvent redistribution at each of the four packed beds
- Integrated with Gas Mixing Facility, 240kW waste to energy boiler, 300kW Gas Turbine and the Fischer-Tropsch plant to enable CCUS research on liquid fuel production from natural gas, biomass and biowastes
- Enables the development, evaluation and optimisation of a variety of solvents for energy performance, degradation studies and counter-measures
- Provisions for corrosion coupons and alternative materials test sites, and trace gas injection capability for capturing carbon from any synthesized flue gas compositions
- Integrated with rotating packed bed CO_2 capture plant for performance assessment of individual units (absorber/stripper)

Rotating Packed Bed CO_2 capture plant

- Next-generation pilot scale, process-intensified solvent-based CO_2 capture plant with a rotating packed bed absorber and stripper, designed to remove up to 1 tonne per day of CO_2 (based on MEA (monoethanolamine) from an equivalent of approximately 150kW conventional coal combustion flue gas
- Improved energy performance thanks to enhanced mass transfer
- Integrated with the Fischer Tropsch plant for CCUS research on liquid hydrocarbon production from captured CO_2
- Integrated with 240kW waste to energy boiler and two 300kW Gas Turbines, enabling post-combustion capture research from real flue gases from natural gas power plants as well as pelletised and chipped fuel combustion plants including biomass and wastes
- Integrated with dedicated gas mixing and trace gas injection facilities enabling carbon capture from any synthesised flue gas compositions, including industrial effluent gas mixtures
- Integrated with conventional CO_2 capture plant for performance assessment of individual units (absorber/stripper)
- Develop, evaluate and optimise a variety of solvents for post-combustion capture and related technologies, and investigate solvent energy performance, degradation studies and counter measures
- Provisions for corrosion coupons and alternative materials test sites

Sustainable Aviation Fuel (SAF) pilot plant

- A state-of-the-art, fully automatic, first-of-its-kind world class plug and play pilot scale research facility with full solid to liquid and gas to liquid cycle capable of producing liquid fuels from biomass and gas
- Equipped with novel Reverse Water Gas Shift (RWGS) and Fischer-Tropsch (FT) reactors, it offers the ability to synthesise sustainable alternatives to current petroleum distillates, enabling research into sustainable aviation fuels production from captured CO_2 and green H_2, or biomass syngas
- Capability to test different reactor designs and catalysts in both RWGS and FT reactors at a wide range of operational conditions
- Able to separate and recycle excess/unreacted gases to enhance conversion efficiency

- Includes a polishing step for CO_2/syngas to remove impurities to a level which does not hinder the FT catalyst
- Includes hydrocracking unit to upgrade fuel to Jet fuel range H/Cs
- Online analysis available to monitor the feed and product gas streams at various locations
- Ability to fractionate FT product into different grades (petrol, diesel, kerosene and heavy oil)
- Additional pilot plant to enable direct captured CO_2 conversion when combined with green hydrogen produced on site, accelerating innovation into next generation, low cost catalyst and reactor technologies

Multi-fuel Combined-Heat-and-Power Gas Turbine

- A micro gas turbine fueled by mixtures of natural gas (from the grid), syngas (generated onsite) and/or biogas (imported)
- Current conversion of the turbine to incorporate a hydrogen-fired combustor and hydrogen fuel handling system for natural gas and H_2 blends, which will provide burner component plug-and-play capabilities and access to testing of new engine component designs (hydrogen co-/firing, including up to dedicated H_2 combustion)
- Fuel flexibility research including multi-fuel blending and sustainable alternative fuels for lowering carbon intensity of generation
- A combined-heat-and-power (CHP) design, with an electrical output of up to 100 kW (turndown ratios of 40-100%), with thermal energy recovery of ~165 kW
- Links to onsite post-combustion CO_2 capture plants to enable gas-CCS research from turbine systems, including gas from bio-derived sources to assess the potential for net negative emissions
- Potential for integration of the gas turbine with the molten carbonate fuel cell (MCFC)
- Opportunities to incorporate CO_2 injections into the gas turbine cycle to examine (selective) exhaust gas recirculation for improving downstream carbon capture efficiencies

Hydrogen Combustion Research Furnace (HCRF)

- The HCRF supports fundamental and applied research on hydrogen combustion and co-firing with other fuels (primarily natural gas) in air, as well as having capability for oxy-fuel firing or oxygen enrichment
- Designed for advanced and rigorous flame, heat transfer and emissions characterisation; burner development and other aspects of fuel combustion and industrial decarbonisation research; corrosion, deposition and materials research
- The HCRF is designed for R&D activities, with extensive in-situ sampling ports, integrated measurement and control systems with wide-ranging, flexible capabilities, controllable and stable operating conditions supporting rigorous experimentation

Hydrogen Combustion Research Furnace (HCRF) (continued)

- Controllable 50-300kWth input and max. operating temperature of 1500°C enabling a wide range of burner designs and types to be trialled using repeatable conditions
- Sized appropriately for experimentation with a range of flame shapes up to typical industrial burner long flames (~3.5-4m)
- Enables a wide range of in-situ analyses to be conducted, including: near burner gas composition and flame heat transfer analysis, heat transfer to load and furnace analysis, emissions analysis and burner design characterisation and performance analysis, as well as many other experimental analyses
- Suitable for testing advanced measurement, instrumentation and control systems against defined and standardised conditions

Combined-Heat-and-Power Biodiesel Engine Generator

- A CHP unit capable of green power generation using a range of liquid biofuels under a range of operational conditions
- Includes Stage V emissions reduction technologies (to meet standards for non-road engines)
- The engine is fully integrated with the on-site CO_2 capture and utilisation facilities to enable the potential for net negative emissions evaluations
- 188 kW grid synchronised green electrical generation capacity, with significant thermal energy recovery

Combined-Heat-and-Power Biomass Gasifier

- A biomass gasification unit and integrated spark ignition engine (CHP) for the production of 50 kWe and 110 kWth
- Precise control of the gasification process, enabling users to achieve clean syngas production from solid biomass fuels
- Employs parallel flow, direct current updraught gasification, to provide optimal fluidisation of the stationary gasifier bed
- Syngas composition is approx. 26% carbon monoxide, 17% hydrogen and 2% methane, with extensive analytical facilities for research and development on syngas quality
- Integration of the syngas produced with: (i) the onsite Fischer-Tropsch plant for liquid biofuel production, especially jet-fuels; and (ii) the multi-fuel gas turbine for low-carbon power generation via pressurised combustion
- The flue gas output from the engine is fully integrated with the on-site CO_2 capture and utilisation facilities for assessments of BECCS for net negative emissions

High Pressure High Temperate Shock Tube facilities

- A unique high pressure (up to 100 bar) single pulse shock tube with extended drivers
- State of the art laser diagnostic facilities
- Used for chemical kinetics measurement of sustainable alternative fuels
- Investigation into the chemistry which takes place during pyrolysis and oxidation of sustainable fuels
- Kinetics of branched chain reactions to define ignition

High pressure heat exchanger (HPHE) test bed with supercritical CO_2 loops

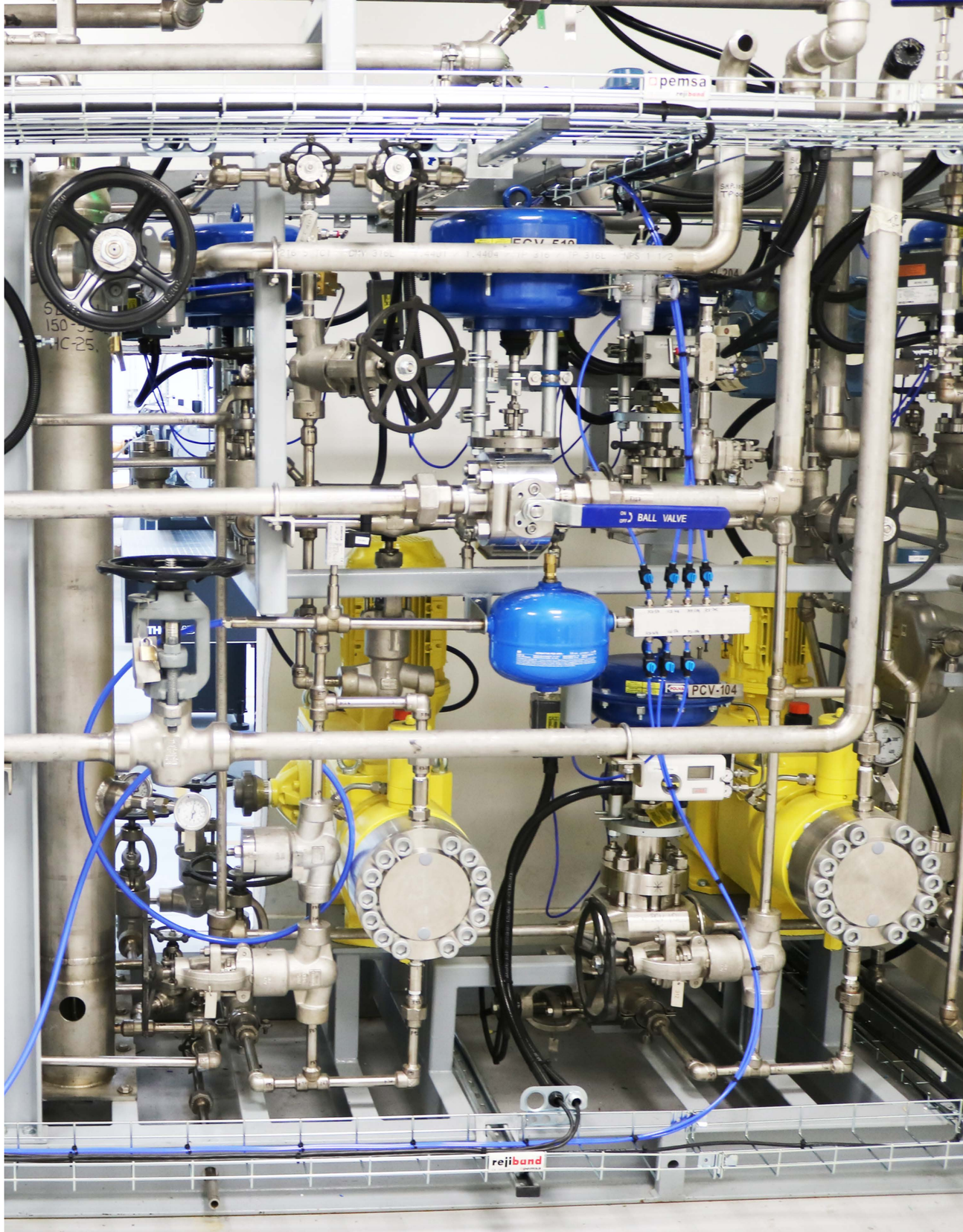
- A high-pressure, high temperature Heat Exchanger (HEX) test bed with fully instrumented fail safe operation
- Includes two supercritical CO_2 loops with operating pressures of up to 350 and 100 bars respectively
- Able to test two heat exchangers at the same time
- Supports research and development in high-efficiency power conversion cycles and their global applications in power and industrial sectors
- Provides performance data for the supercritical CO_2 cycle to model and evaluate designs, for example in fluid passages
- Suitable for a wide range of applications including supercritical CO_2 for oxy-fired gas cycles (Allam cycle) and nuclear research
- Also suitable for studying heat transfer, pressure drop, thermal stresses, impact of phase changes, impurities, fouling, corrosion and for materials research in heat exchangers using a range of fluids

Energy storage batteries

- 120kWh, 50kW lithium battery with DC and AC interfaces
- The battery can be connected to the AC grid for grid-connected research, or to a dedicated DC bus along with other assets to provide a flexible test bed to facilitate both grid-connected and ‘behind the meter’ energy optimisation

Smart energy system

- Real-time monitoring, control and coordination of the available energy resources onsite
- Flexible design of intelligent energy management system in a centralised, decentralised or distributed manner
- Hardware-in-the-loop capabilities for future energy resources, paving the way towards system ‘scale-up’



A full list of the equipment and services available at the Translational Energy Research Centre

There will be more than 30 pilot-scale permanent test rigs available at the Translational Energy Research Centre, as well as further capability

Low-carbon generation:
- Biodiesel engine generator
- CHP biomass gasifier
- Organic Rankine Cycle system
- Biomass grate boiler including bioenergy with capture and storage (BECCS) capability
- Gas turbines – with modifications for integration of molten carbonate fuel cell (MCFC)
- CHP engine for multi-sustainable fuel configuration
- Energy-from-waste boiler
- Fuel cell based micro-CHP

Oxy-fuel and high-pressure supercritical CO_2 (sCO_2) technology:
- High pressure heat exchanger test bed and
- Shock tube test facility
- 250kW of biomass air/oxy-fired combustion test facility (CTF) with capability to use coal/biomass/clean wood waste fuels

CO_2 capture and utilisation (CCU) technology:
- Amine CO_2 capture plant – modified for integration with the flue gas and co-product gas manifold systems
- CO_2 capture rotating packed bed
- Molten carbonate fuel cell (MCFC) and gas infrastructure for co-generation & next generation CO_2 capture technology
- Fischer-Tropsch and fuels plant, and product gas infrastructure for utilisation of CO_2
- Gas mixing facility – synthetic/model flue/process gas

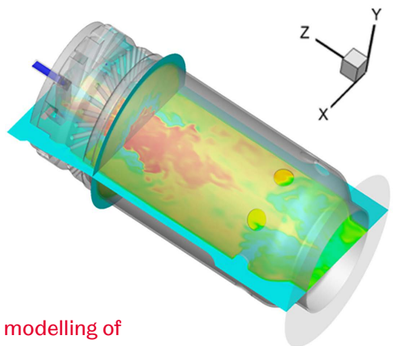
Hydrogen production:
- Hydrogen electrolyser
- Steam reforming in MCFC
- Biomass gasification
- Hydrogen combustion test rig

Clean, renewable electricity generation and storage:
- Electrical energy storage (batteries)
- Solar PV panels
- Polymer electrolyte membrane fuel cell (PEMFC)

Integration:
- Smart energy management (SEM) module
- Low-carbon heat management system

CFD modelling and simulation:
- A complementary validating system including advanced computational modelling, experimental testing and detailed imaging
- Multiple modelling stations pre-loaded with relevant software including CAD Drawing, Ansys Fluent, COMSOL Multiphysics, Aspen, Chemical Kinetic, Matlab/Simulink
- Expertise on developing multiscale modelling framework that allows for the investigation of the impact of nanoscale or microscale phenomena on the system
- Ensures a credible output and in-depth understanding and control of the impact of energy system characteristics and integration, critical reaction kinetics, emissions and combustion processes

Multi-parameter fuel cell test station:
- The multi-parameter fuel cell test station is ideal for investigating the impact of operating conditions (i.e. the temperature, pressure, gas composition and humidity) or new materials and/or designs on the performance of a single fuel cell or small fuel cell stack
- Equipped with a multi-range electronic load with a maximum load power of 100 W
- A 2-SLPM anodic mass flow controller and 5-SLPM cathodic mass flow controller
- Temperature-controlled humidifiers for the reactant gases
- Measurement of real-time cell resistance
- Equipped with an integrated potentiostat
- Operates with a flexible fuel cell fixture with uniform compression



CFD modelling of Instantaneous temperature In Gas Turbine Combustor

Analytical and measurement capabilities:
- Gas analysis and measurement facilities
- Particle, P, and aerosol measurement facilities
- Unique Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) facilities
- Hydrogen analyser, monitoring and control equipment
- Signal stack gas analyser system (O_2, CO_2, CO, NO_x, THC)
- Gasmet FTIRs for flue gas analysis (O_2, CO_2, CO, NO_x, SO_2, HCs, HCL, HF) and emissions from the CO_2 capture process (NH_3, CH_2O, amines, etc)
- ETG syngas analyser (H_2, CH_4, CO_2, CO, O_2, THC)
- Portable Servomex analyzers (O_2, CO_2)
- DMS500 submicron aerosol analyser
- Inductively Coupled Plasma-Optical Emission Spectroscopy (ICP-OES) for online multi-metal emissions detection (including K, Na, Hg, Cr, Cd, Pb, V, Zn; as well as Ag, Al, B, Br, Ca, Co, Cu, Fe, I, Li, Mg, Mn, Ni, P, S, Sb, Sc, Ti, Si, Sn)
- Analytical probes: Ellipsoidal radiometer, flame imaging camera probe, suction pyrometer, gas sampling probes, particle collection probe, corrosion and deposition probes

Additional capability:
- Composite 3D printer for energy equipment design and construction
- Both AC and DC electrical infrastructures
- Grid-tied to enable excess clean and renewable energy to be exported
- The entire facility and its various equipment and systems will be controlled by a smart energy management system, enabling research into integrated grid technologies and enabling a 'whole energy system' approach
- Plug-and-play facilities to enable visiting researchers to bring their own equipment and connect it to our infrastructure to enhance research and testing abilities
- A heat rejection network to provide permanent and visiting equipment with cooling water. Captured heat will be distributed to the building itself, as well as adjacent buildings connected via a district heating network across the Sheffield Innovation District in the future
- Additional capability added for Direct Air Capture (DAC), for which the CO_2 capture capacity of the plant will be 600kg/day and will be powered by renewable electricity generated from solar panels located onsite

Get in touch:

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