CARBON CAPTURE AND STORAGE
HELPING TO ACCELERATE THE IMPLEMENTATION OF CCS IN THE UK
WHY CCS?

We have modelled the UK energy system out to 2050. Without a national CCS infrastructure, the cost of reaching UK Climate Change targets will double from a minimum of around £30bn per year in 2050. This is the equivalent of an additional 2p per kWh on all UK energy use in 2050. Therefore the economic prize of CCS to the UK is potentially considerable. Our calculations show that each five years of delay in implementing CCS until 2030 will add the equivalent of £4bn per annum to the total cost of the UK energy system. The importance of CCS lies in its capability and flexibility to reduce carbon emissions from a large range of activities. It also has relatively low costs when practiced at scale. For example in the power sector, a fossil fuel sector fitted with CCS can not only provide clean electricity at an attractive baseload price, but it can also operate in a role which offers the lowest cost additional power when peaks in demand occur. Whilst there are other potential affordable ways of power generation, CCS might be the only practical option for avoiding industrial emissions. CCS allows for the capture and storage of greenhouse gases from the use of bioenergy, which result in a net reduction in the greenhouse gases in the air, or “negative emissions.” This could reduce the need to decarbonise other activities which are much more expensive to tackle.

WHAT WE ARE DOING?

» INVESTING IN INNOVATION TO REDUCE THE COST OF CAPTURE AND REDUCE THE RISKS OF STORAGE

» BUILDING KNOWLEDGE TO UNDERSTAND THE INFRASTRUCTURE REQUIREMENTS FOR CCS APPLICATION IN THE UK

» BUILDING KNOWLEDGE TO CREATE CONFIDENCE AMONGST INVESTORS, POLICY MAKERS AND INDUSTRY TOWARDS CCS OPPORTUNITIES

"THE IMPORTANCE OF CCS LIES IN ITS CAPABILITY AND FLEXIBILITY TO REDUCE CARBON EMISSIONS FROM A LARGE RANGE OF ACTIVITIES. IT ALSO HAS RELATIVELY LOW COSTS WHEN PRACTICED AT SCALE"
The £110k project was led by Element Energy with support from Pöyry Management Consulting and an industry/government steering group, set out to identify and analyse three alternative scenarios for the development of a 10GW-scale CCS sector by 2030, capturing around 50 million tonnes of CO₂ per annum from power and industrial sources.

The analysis used three ambitious, but deliverable, sector scenarios. The scenarios help to identify the challenges and steps required to overcome them in the context of real geographies and dependencies, plausible potential projects for both power and industrial CO₂ abatement, realistic decision timelines and developing project economics.

The project confirmed that developing a 10GW-scale CCS sector is feasible and affordable through a number of different pathways. By making use of stores and transport infrastructure developed under DECC’s Commercialisation Programme, later projects can achieve a competitive cost for low carbon electricity, at or below £100/MWh by 2025.

**CCS SECTOR DEVELOPMENT SCENARIOS IN THE UK**

- Scenario modelling project to illustrate how the UK can build the CCS sector by 2030
- Extended previous analysis by developing three ambitious but deliverable scenarios to achieve 10GW scale deployment
- 10GW scale deployment is achievable and affordable, capturing and storing around 50 million tonnes of CO₂ per annum from power and industry by 2030

**£110k**

The £110k project was led by Element Energy with support from Pöyry Management Consulting.
WHAT HAVE WE DONE TO DATE?

MEASUREMENT, MODELLING AND VERIFICATION OF CO₂ STORAGE (MMV)

- £5m collaborative project to develop a marine monitoring system for underwater CCS sites
- Monitoring system will use marine robotics to provide assurance CCS sites are secure
- Industrially led project supported by top UK academic groups

The project is led by Fugro GEOS in collaboration with Sonardyne, the National Oceanography Centre (NOC) and the British Geological Survey (BGS). The project will assess the economics of a range of flexible power generation systems which involve the production of hydrogen (with CCS) from coal, biomass or natural gas, its intermediate storage (e.g. in salt caverns deep underground) and production of power in flexible turbines. The work included mapping of potentially suitable hydrogen storage salt cavern sites in and around the UK and has provided us with a flexible economic modelling tool to assess the range of possible options.

£5m

The project is led by Fugro GEOS in collaboration with Sonardyne, the National Oceanography Centre (NOC) and the British Geological Survey (BGS). The ETI will invest £1m in the first phase of the project.

Although there are existing technology components which can detect CO₂ in a marine environment, there are no integrated, cost-effective and commercially available systems which can currently reliably record and report anomalies in the level of CO₂ in the sea above a large store. The need to introduce capability for the robust monitoring of underground CO₂ storage sites is in response to legislation such as the European Union’s directive on CO₂ storage. This states that any storage operator must monitor for potential leaks and examine whether any leak is damaging to the environment or human health.

Current research and evidence shows that leakage is highly unlikely. However, if CO₂ did escape, it would be difficult to predict with certainty exactly where it would reach the seabed. This is where mobile autonomous robots are very useful, patrolling over large areas at relatively low cost.

FLEXIBLE HYDROGEN POWER GENERATION SYSTEMS

- Project to increase the understanding of the economics and potential use of energy systems involving low carbon hydrogen production, storage and flexible turbine technology
- Mapping of suitable hydrogen storage salt cavern sites in the UK
- Potential to fill the gap between base load nuclear plant and low carbon power generation

This project has increased the understanding of the economics and potential use of energy systems involving low carbon hydrogen production, storage and flexible turbine technology. Our energy system modelling work suggests that systems such as these could provide a valuable contribution to the future energy mix, filling the gap between base load nuclear plant and low carbon power generation.

The £300k project was led by global engineering and construction company Amec Foster Wheeler, in collaboration with the BGS.

The £5m collaborative project to develop a marine monitoring system for underwater CCS sites

The £300k project was led by global engineering and construction company Amec Foster Wheeler.
Energy Technologies Institute

» Advancement of the safe design and operation of gas turbines using hydrogen-based fuels
» Identifying the bounds of safe design and operation
» Aim to increase the range of fuels that can be safely used in power and heat generating plant

Hydrogen is likely to be an increasingly important fuel component in the future. This £3.5m project is designed to advance the safe design and operation of gas turbines, reciprocating engines and combined heat and power systems using hydrogen-based fuels.

Through new modelling and large-scale experimental work the project is identifying the bounds of safe design and operation of high efficiency combined cycle gas turbine and combined heat and power systems operating on a range of fuels with high and variable concentrations of hydrogen.

The goals of the project are to increase the range of fuels that can be safely used in power and heat generating plant.

The project involves the Health and Safety Laboratory, an agency of the Health and Safety Executive, in collaboration with Imperial Consultants, the consulting arm of Imperial College London.

WHAT HAVE WE DONE TO DATE?
CONTINUED

SALINE AQUIFER DRILLING PROJECT WITH NATIONAL GRID

» £2m investment in the UK’s first drilling assessment of a saline formation site
» Site is 70km off the Yorkshire coast
» Involved drilling a well in the seabed to gather data

We co-invested £2m in a National Grid project which has carried out the UK’s first drilling assessment of a saline formation site for the storage of CO₂ at a site 70km off the Yorkshire coast.

The multi million pound project represents a major step forward in the creation of a CCS industry in the UK for multiple power stations and industrial sites, to store their CO₂ rather than release into the atmosphere.

National Grid led the drilling programme at the identified saline formation, a layer of porous sandstone rock over 1km below the seabed. The operation, using standard oil and gas drilling activities, involved drilling a well in the seabed to gather data to confirm that CO₂ can be safely and permanently stored at the site, while also confirming the scale and economics of the store.

The results of the drilling have confirmed the previous assessment that the store is very large and capable of storing carbon dioxide from several sources over a number of decades. The site is close to the shore and importantly, near to two major clusters of CO₂ emitters in the Humberside and Teeside region making it an ideal storage location.

The site is planned to provide storage for the White Rose CCS project at Drax, and is large enough to take CO₂ from several more projects.

SALINE AQUIFER DRILLING PROJECT WITH NATIONAL GRID

The Saline Aquifer Drilling Project, 70km off the Yorkshire coast.

£3.5m

The project involves the Health and Safety Laboratory, an agency of the Health and Safety Executive, in collaboration with Imperial Consultants, the consulting arm of Imperial College London.
 CCS SYSTEMS MODELLING TOOL-KIT

» Project to support the future design, operation and roll-out of cost effective CCS systems in the UK

A £3m project has helped support the future design, operation and roll-out of cost effective CCS systems in the UK.

The two-and-a-half year project launched in September 2011 has created a modelling tool-kit capable of simulating the operation of all aspects of the CCS chain, from capture and transport to storage.

It involved modelling technology provider Process Systems Enterprise (PSE), energy consultancy E4tech, and industrial partners EDF Energy, E.ON, Rolls-Royce and CO2 DeepStore, who expect to be involved in capturing, compressing, transporting and storing CO2 in the future. The project has resulted in a commercial product (gCCS) built on PSE’s gPROMS modelling platform.

The tool-kit will be used to support the initial conceptual design and eventual detailed design and operation of CCS systems.

WHAT HAVE WE DONE TO DATE? CONTINUED

CCS MINERALISATION

» Detailed study of availability and distribution of suitable materials to economically capture and store CO2 emissions

» Abundance of materials to meet mitigation targets

» Challenges remain to make the process economically attractive and to reduce its energy use

This £1m project, launched in May 2010 carried out a detailed study of the availability and distribution of suitable minerals across the UK along with studying the technologies that could be used to economically capture and store CO2 emissions. CCS by mineralisation has been identified by leading researchers as a promising additional method of sequestering CO2 emissions. Minerals and CO2 can react together to permanently store CO2 as a solid carbonate product, which can then be safely stored, used as an aggregate or turned into useful end products such as bricks or filler for concrete.

The project consortium involved Caterpillar, BGS and the University of Nottingham.

The objective was to investigate the potential for CCS Mineralisation to mitigate at least 2% of current UK CO2 emission and 2% of worldwide emissions over a 100-year period. The project has found that there is an abundance of suitable minerals available in the UK and worldwide to meet these mitigation targets. However, challenges remain to make the capture process economically attractive and to reduce its energy use. Significant niche opportunities exist where waste materials are used as feedstock and/or the process produces value-added products, but markets would not be at the level required to meet the mitigation targets.

£3m

The project consortium involved Caterpillar, BGS and the University of Nottingham

£1m

The project consortium involved Caterpillar, BGS and the University of Nottingham
Costain has produced a front end engineering design study for a demonstration unit, working with the University of Edinburgh and Imperial College, London.

We have invested £3.5m to date in a project with Costain to design a carbon capture pilot plant capable of capturing up to 95% of CO₂ emissions from coal fired power stations.

The project is aimed at pre-combustion carbon capture applications, involving CO₂ removal by physical separation.

Costain has produced a front end engineering design study for a demonstration unit, working with the University of Edinburgh and Imperial College, London.
WHAT HAVE WE DONE TO DATE?
CONTINUED

UK STORAGE APPRAISAL PROJECT (UKSAP)

- Produced the UK’s first CO₂ storage appraisal database
- Allows for more informed decisions on the economics of storage opportunities
- Licensed to The Crown Estate and the British Geological Survey (BGS) and publically available under the brand of CO₂ Stored

This £4m project was delivered by a consortium of project partners from across academia and industry – LR Senergy Limited, BGS, the Scottish Centre for Carbon Storage (University of Edinburgh, Heriot-Watt University), Durham University, GeoPressure Technology Ltd, Geospatial Research Ltd, Imperial College London, RPS Energy and Element Energy Ltd.

We have agreed a licence with The Crown Estate and the BGS to host and further develop an online database of mapped UK offshore carbon dioxide storage capacity produced by UKSAP.

This is now publically available under the name of CO₂ Stored. It can be accessed via www.co2stored.co.uk.

The web-enabled database – the first of its type anywhere in the world – contains geological data, storage estimates, risk assessments and economics of nearly 600 potential CO₂ storage units of depleted oil and gas reservoirs, and saline aquifers around the UK, enabling interested stakeholders to access information about the storage resource and to make more informed decisions related to the roll out of CCS in the UK.

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<tr>
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<tr>
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<td>Saline aquifer (open)</td>
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<td>Depleted hydrocarbon fields</td>
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STRATEGIC UK CCS STORAGE APPRAISAL

- The project will identify the next phase of sites under the North Sea most suitable for storing CO₂

Aberdeen-based consultancy Pale Blue Dot Energy supported by Axis Well Technology and Costain is delivering a project which will identify the next phase of sites deep under the seabed in UK waters to store CO₂ emissions from coal and gas power stations and heavy industry plants.

The 12 month project is being delivered by the ETI and funded with up to £2.5 million from the Department for Energy and Climate Change (DECC).

It will progress the appraisal of five selected storage sites towards readiness for Final Investment Decisions, de-risking these stores for potential future storage developers.

All the results from this project will be made publicly available to support roll out of CCS in the UK.

£2.5m

The project will identify the next phase of sites under the North Sea most suitable for storing CO₂ emissions.
INSIGHTS ARISING FROM THE PROGRAMME

**CCS**

By 2030 the UK should seek to produce 10GW of CCS capacity. 10GW of CCS capacity could capture 50million tonnes of CO₂ emissions per year from power and industry by 2030.

**Any low carbon transition should include CCS and Bioenergy**

Including them halves the cost of meeting UK climate change targets.

**Infrastructure is key**

By using the DECC Commercialisation projects transport and storage infrastructure you can unlock future cost reductions and increase strategic build out options.

For decarbonisation no CCS means greater reliance on nuclear and offshore wind.

**Delay in CCS implementation increases costs**

Through the need to deploy higher cost technologies to cut emissions. Failure to deploy CCS entirely would imply a doubling of the annual cost of carbon abatement from 1-2% of GDP by 2050.

**The value of CCS comes from its multiple operations**

Power generation, capturing industrial emissions, providing low carbon energy through gasification and delivering ‘negative emissions’.

10GW of CCS capacity could capture 50million tonnes of CO₂ emissions per year from power and industry by 2030.

50m tonnes

1-2% GDP
The Energy Technologies Institute is a partnership between global energy and engineering companies and the UK Government.

Its role is to act as a conduit between academia, industry and government to accelerate the development of low carbon technologies.

It brings together engineering projects that develop affordable, secure and sustainable technologies to help the UK address its long-term emissions reduction targets as well as delivering nearer term benefits.

It makes targeted investments in a portfolio of nine technology programmes across heat, power, transport and the infrastructure that links them.