Carbon capture & storage
Amec Foster Wheeler
Carbon Capture & Storage

Founded 1848
165 Years History
Operating in over 50 countries

40,000 exceptionally talented people worldwide

1. UK
2. NE England
3. Scotland
4. North Sea
5. China (Beijing)
6. Netherlands
7. UAE
8. US (Wyoming)
9. Canada
10. Spain
We support the Advanced Power Generations technology Forum, UKCCSRC (UK CCS research centre), the UK Government’s CCS Cost Reduction Task Force, Process Industries’ CCS Initiative, ZEP (Zero Emissions Platform) and the GCCSI (Global CCS Institute).

Founding members of the Carbon Capture and Storage Association

For almost a decade we chaired the Energy Industries Council’s CCS forum.

partners with E4Tech and modelling company PSE we participated in the specification of requirements for a single dynamic model system for the Energy Technology Institute.

Pipeline, compression and pumping expertise

Leading industry expertise

30+ studies and FEED examples

40+ years providing the elements of CCS

1st feasibility study on large CCS clusters

1st CCS infrastructure study for Scotland
What is CCS?

Carbon Capture and Storage (CCS) is recognised as being one of the key technologies required to reduce carbon dioxide emissions and reduce the increasing threat of climate change. The capturing of carbon dioxide from another gas, processing it, transporting and injecting into the ground is not a new process.

Amec Foster Wheeler has been providing project management, consultancy, engineering and construction services for every element of CCS for over 40 years.

We have used our CO2 expertise for enhanced oil recovery (EOR) schemes in North America, and in the treatment of natural gas. Now we are applying our experience to help our customers reduce carbon dioxide emissions from power stations and other industrial facilities.

We are able to transfer and integrate our collective capabilities from our onshore and offshore oil and gas operations, our environmental, health and safety consultancy services, involvement with new technologies and pipeline expertise directly into the expanding world of Carbon Capture and Storage.

Our suite of services to support the development and realisation of a complete CCS solution from studies and consenting, environmental, health and safety services through to transportation, pipeline engineering, routing and compression services.
We have already worked on a diverse range of CCS projects. We understand the drivers and challenges and have proven experience of working with our clients to enhance the economics, efficiency and performance of CCS schemes and to develop optimized solutions for new or existing facilities.

During the early stage of project development our specialist consulting groups work side-by-side with our clients to deliver quality CCS solutions that add value throughout the project lifecycle, including:

► Technology evaluation and selection
► Optimization and integration studies
► Concept and feasibility studies
► FEED
► Project management consultancy
► Engineering, procurement, construction and commissioning

We’re objective

Our breadth of experience covers each of the key elements within a complete CCS chain and the range of available and emerging technologies within each of these areas. We are not tied to any of the technology suppliers and so our clients can be sure that our approach is objective and balanced.
Separation & capture

We can develop CO\textsubscript{2} capture solutions, using whichever technology is most appropriate, across the range of power, oil and gas, refining, chemicals, steel, cement and other sectors.

Compression & treatment

The combination of the expertise of our process and machinery specialists and our close working relationships with key compressor, pump and dehydration equipment suppliers delivers in-depth knowledge and expertise in CO\textsubscript{2} compression and treatment systems.

Transportation & storage

CO\textsubscript{2} sources can be a significant distance away from the location of potential CO\textsubscript{2} sinks. Our pipeline and upstream experts work together to develop CO\textsubscript{2} transportation solutions through a suitably designed pipeline network, develop CO\textsubscript{2} transmission and wellhead facilities, and work with our clients’ down-hole teams to generate CO\textsubscript{2} profiles for target reservoirs.

As CCS projects move out of the conceptual and study phase, we deliver high quality FEEDs and provide full support to our clients in delivering a robust basis upon which to progress their project.

We deliver

Unlike pure consultancy companies, we can also implement your project. This brings you continuity and also means that, because we are a well-known global EPC (engineering, procure, construct) contractor, the solutions that our technical experts develop are practical, constructible and based on detailed local knowledge, with our cost estimates based on real costs and real experience.

With our global network of engineering centres, and a long and successful EPC track record, we work with our clients to ‘build their vision’, providing project management, detailed engineering, procurement, construction and commissioning expertise to deliver a high quality facility that meets our clients’ expectations.

Our recent CCS clients include oil, gas and energy multinationals, national oil companies, private and private/public consortia, and other organisations, such as the World Bank and the International Energy Agency.
Why CCS?

There is mounting worldwide concern about the prospect of climate change due to anthropogenic CO2 emissions.

Global demand for energy continues to rise and fossil fuels look likely to dominate the energy mix for years to come. The energy sector accounts for around 60% of global CO2 emissions. Coal-fueled power generation accounts for around 40% of the world’s energy generation but has the largest carbon footprint of all the power generation sources.

CCS could significantly reduce CO2 emissions from coal- and gas-fired power plants and industrial sites, as well as providing the potential for carbon-negative power generation if combined with biomass- or waste-fired plants.

CCS represents a ‘bridge’ to a sustainable energy system.
What is CCS?

Carbon capture and storage (CCS) is the process of removing or reducing the CO2 content of streams normally released to the atmosphere, and transporting the captured CO2 to a location for permanent storage.

CO2 can be captured from a wide range of large sources, such as process streams, heater and boiler exhausts, and vents from a range of industries, such as power generation, cement production, refining, chemicals, steel production and natural gas treating.

There are three main groups of technologies employed. Their applicability varies according to the CO2 source:

- Pre-combustion capture
- Post-combustion capture
- Oxy-combustion capture

Once captured, the CO2 is compressed, dried and transported to a suitable storage location such as saline aquifers, depleted oil fields (where enhanced oil recovery could be employed) and depleted gas fields.
Life of asset services
Amec Foster Wheeler

We deliver projects, from concept to commissioning and beyond.

For any development, we start adding value from day one, helping our customers to evaluate the opportunity, screen options, select the right option, and then realise the revenue as quickly as possible.

Amec Foster Wheeler has a proven track record in the design and construction of power, petrochemical and gas treatment plants at all scales. This is directly applied to carbon capture where we can integrate, retrofit or design from scratch the entire emitter and capture plant.

Consultancy services

► Environmental
► Marine and coastal
► Geotechnical
► Permitting and regulatory
► Community and social affairs
► Water and wastewater
► Transportation
► Project conception
► Technology risk review
► Feasibility study

Project delivery

► Feasibility studies, concept and pre-FEED
► Advance planning
► Cost and schedule planning and control
► Technology integration
► FEED design
► Engineering and procurement
► Fabrication and construction
► Project management
► Start-up and commissioning
We deliver value at the front end, then can bring our global EPC skills and experience to bear, developing the right execution strategy, and then delivering on time, safely, cost effectively, and right first time. Right through the life of your asset we can provide the right support, from turnarounds and brownfield projects through to long term asset support, performance improvements, through to late life planning and decommissioning.

Our asset management capability aims to extend asset field life through enhanced production, recovery and reduced operating costs. This is achieved by offering a variety of flexible commercial and business models:

► Operations & maintenance
► Operational readiness
► Asset Integrity
► Duty Holder
► Production optimisation
► Modifications

We add value at every stage.
Our breadth of experience covers each of the key elements within a complete CCS chain and the range of available and emerging technologies within each of these areas. We are not tied to any of the technology suppliers and so our clients can be sure that our approach is objective and balanced.

Pre-combustion capture
A carbonaceous feedstock is fed to an oxygen- or air-blown gasifier or reformer where it is converted to syngas. The syngas is then passed through a shift reactor which increases the hydrogen and CO2 content of the syngas. The high temperature syngas is then cooled, before being washed with a solvent to absorb the CO2, leaving a hydrogen-rich gas stream and a CO2-rich solvent stream. The solvent regeneration process then releases a CO2 stream which can be dried and compressed for export.

This process offers significant integration potential as it can be configured to generate a high-purity hydrogen stream and the syngas cooling train can be used to raise a significant quantity of HP, MP and LP steam.

Compared with post-combustion technology, the fuel conversion steps required for this process are more complex, making it more challenging to apply to retrofits. But on the plus side, this process offers the potential of multi-product facilities, combining both power generation with hydrogen and/or syngas production for adjacent chemical and refinery use.

Post-combustion capture
Post-combustion processes separate CO2 from the exhaust gases produced by the combustion of fuel, such as coal, natural gas, oil and biomass, in air. The concentration of CO2 in the exhaust gas is low, typically 3-15% by volume, and the pressure is typically close to ambient. The exhaust gas is cooled by direct water contact before entering a blower designed to overcome the absorption system pressure drop.

The exhaust gas enters an absorption column in which it is washed with a liquid solvent, such as an aqueous amine solution. The CO2-rich solvent is then heated against lean solvent and regenerated in a stripping column. The solvent then returns to the absorption column while the released CO2 is dried and compressed for export.

This is ideally suited for new installations as well as retrofits. To date, it has only been used on a relatively small scale. The next steps are to improve its energy efficiency and to deploy the technology on a much larger scale.

Oxy-combustion capture
The feedstock is combusted with oxygen from an air separation unit. The temperature in the boiler is moderated by recycling a portion of the flue gas back to the combustion chamber. The flue gas passes through particle removal by electrostatic precipitator, sulfur removal by limestone scrubbing and water removal by cooling and condensation.

The CO2 can then be purified and compressed for export. Steam from the boiler is used to generate power via a steam turbine.

This process is applicable to both new build and retrofit scenarios for steam and/or power generation and process heating. Existing boilers and fired heaters can be converted to oxyfuel operation with the addition of an air separation unit, suitable boiler modifications and the addition of relatively small flue gas clean-up equipment (compared with pre- and post-combustion).
A wealth of experience

1. IEAGHG (International Energy Agency Greenhouse Gas) feasibility study on the distributed collection and transmission of carbon dioxide

   The report on the feasibility of distribution collection, the first on large CCS clusters, included a spreadsheet based tool for the economic evaluation of Carbon Dioxide transmission pipelines and networks, the first of its kind. Following on from this work we completed a project for the IEA, “Upgrade of CO2 Pipeline Cost Calculation Programs”. This project integrated our previous carbon dioxide evaluation report and tool into a tool designed to evaluate carbon dioxide and energy transmission scenarios.

2. A Carbon Capture and Storage network for Yorkshire and Humber, Yorkshire Forward, UK

   In 2008 we completed an extensive study for a carbon dioxide network in the east of the UK for a consortium of industry partners led by Yorkshire Forward. This network study considered an integrated approach for an area with a high level of emissions almost 80 million tonnes per year. The study considered the networking of the regions sources to one outfall terminal and into the Southern North Sea depleted gas fields and saline aquifers. This scheme represents over 10% of the UK’s total Carbon Dioxide emissions and was the first such scheme to be considered globally.

3. Pre-FEED Study for Humber CCS infrastructure for CO2Sense, UK

   Pre-FEED study for the regional network based on a number of scenarios based on developments in the region. The stakeholders in the project include Powerfuel Power, ConocoPhillips, Drax Power, Tata and National Grid. The intent of the pre-FEED was to provide more specific technical solutions, route appraisals and economic analysis to enable the regions first project to become the seed for future network development. The full technical and economic analysis was extensively reviewed and validated by the stakeholders and was published in 2010.
The first infrastructure study for Scotland was executed for the Scottish Centre for Carbon Capture and Storage. The study examines the possible options for transporting carbon dioxide to a number of offshore targets. The study included the five major emitters and the requirements for transport for including; onshore and offshore pipelines, shipping and reviewed the use of selected infrastructure to oil fields in the North Sea.

The potential for Scotland to act as a Carbon Dioxide Hub, given the storage potential in the UK’s northern and central North Sea oil and gas fields, is significant. Working with Element Energy, SCCS and Dundas Consultants for Scottish Enterprise, a study was conducted of the potential and ways to realise it. We provided an examination of the potential captured volumes from all of Scotland’s onshore emitters matching capture technology to each emitter, evaluating impacts, applicability and cost. Infrastructure was also considered, new and re-used, access, routes and costs for each emitter. The resulting data was then screened and options for infrastructure provided. The infrastructure section also including an examination of the potential for ship based transport solutions.

Teesside is one of the largest industrial complexes in the UK and a significant source of emissions. This report considered the options for capture technology for the industrial and power sector emitters in the region. This included capture technology assessments and selection, screening criteria and apply technology based cost metrics to provide capture costs for 30 emitters. The emitters include gas fired power generation from 50 to 1900MW, 850MW IGCC, Cogen and CHP facilities, oil refineries, heavy chemical production, plastics, ammonia and proposed biomass power stations from 49MW to 295MW.

The study also provided detailed infrastructure network options and analysis for 15 development scenarios. With an IGGC power station proposed for the region an outline network for syngas distribution and the impact assessments for replacing or supplementing natural gas fuel provision with the hydrogen rich syngas was considered.

Impact of CCS on industry and gas power generation, UK Government’s Committee on Climate Change

As part of a consortium of consultancies we provided assessments on the technological and performance impact on industrial and gas fired power generation. The study allowed the committee to assess the financial impact and economics of CCS and the impact on future energy provision. Amec Foster Wheeler provided technical assessments on the capture technology types and provided atypical solutions for a broad range of emitters. The technical issues included retro-fitting, new build, the impacts of carbon capture ready and overall performance impacts on gas fired generation.
1. **Project Maple, carbon capture retrofit options for a coal fired power station**

The study considered an operating coal fired power plant and the emission control and CCS options available to it. This included the consideration of SOx and NOx removal options and CCS. For carbon capture the available and future technologies for capture were considered, assessed and recommendations made. The project also considered the integration of the capture plant and power station, including utility tie-ins, operability and efficiency and layout. The study conducted a full market technology assessment and concept screening leading to selected options and assessments of CAPEX and OPEX enabling economic as well as a technical comparison of the options.

2. **Study and FEED for hydrogen to power project, BP, UK**

A ground-breaking industrial-scale project for BP planned to generate electricity using hydrogen manufactured from natural gas to create ‘decarbonized fuels’. It was planned to create 475 MW of carbon-free electricity, enough to power almost half a million homes in the UK. The project could also permanently store 1.8 million tonnes of CO2, the equivalent of removing more than 400,000 cars from the roads.

3. **CO2 Capture Project (CCP), UK**

Feasibility study awarded by BP, on behalf of CCP, of the application of CO2 post-combustion capture to a range of refinery, in-situ extraction of bitumen and natural gas power generation CO2 capture scenarios, including both retrofit and greenfield solutions. CCP is an award-winning partnership of several major energy companies, working to advance the technologies that will underpin the deployment of industrial-scale CO2 capture and storage.

4. **Decarbonized fuel power and desalination plant, UK**

Feasibility study to develop key technical and cost data for a decarbonized fuel power and desalinated water plant. The study considered both pre-combustion and post-combustion CO2 capture power plant configurations, targeted to export 1,000 MW of electricity, a carbon capture level of >90%, and to export up to 80 million gallons per day of desalinated water. Study included potential site locations, local infrastructure issues, seawater intakes and outfalls, feedstock supply and power, water export and CO2 export.

5. **Advanced pre-combustion decarbonization, UK**

Assessment of a novel CO2 capture technology applied within a petroleum coke-fed IGCC with carbon capture to power flow scheme. The cost of capturing and storing CO2 has a significant impact on the economics of electricity generation and therefore the aim was to achieve an overall reduction in the incremental capital and operating costs of carbon capture.

6. **Eston Grange, Progressive Energy Limited, UK**

Eston Grange, 850MW IGCC proposed for Teesside, UK. During initial stages we provided a concept pipeline design and routing for the carbon dioxide and associated natural gas supply pipelines. The work included a fundamental review of available and applicable regulations and designing to an agreed best practice with the client. This study included the concept design to establish the limits of operation and a safe operating band, feasibility study, and a pipeline routing study with associated hazard identification exercises and discussions with UK regulators.
This project required an assessment of transport options available to a CCS project on a gas fired power plant. The study considered route options for new pipelines, re-use of existing national infrastructure and redundant fuel gas supply pipelines. Capital cost assessments were provided for each option. In addition we supplied outline assessments on compression options required for each pipeline scenario.

The Longannet CCS Project was an entrant in the UK Government competition to deliver a demonstration scale CCS post combustion unit. Led by Scottish Power, the group included Shell providing storage and National Grid providing transportation onshore from Longannet to the Shell terminal at St Fergus. Amec Foster Wheeler provided the FEED engineering and field work associated with a new compressor station at Blackhill near St Fergus and approximately 300 kilometres of pipeline, the majority re-used from existing natural gas infrastructure.

The project is widely acknowledged globally as one of the most comprehensive FEED studies executed for CCS.

This project examined the compression, dehydration and conditioning requirements for demonstration scale post combustion on gas fired power plant. The study included the selection of compression equipment, evaluation and selection of dehydration equipment and the optimisation of the compression/drying system. Conditioning of the gas relates particularly to low water and oxygen specifications to meet the storage sites entry specification.
Currently providing engineering services with our partner Rhead Group as the PMC (project management consultant) for the compression and a 50 kilometre pipeline EPC (engineering, procure, construct) project at the MASDAR Taweelah project. The project captures and transports 0.8 million tonnes/year of carbon dioxide from the Emirates Steel Mussafah complex in Kahlifa Port and Industrial Zone, United Arab Emirates.

We provided project management and basic and detailed engineering for the addition of carbon dioxide flood and recycle compression systems to both production facilities. New facilities at both sites include carbon dioxide compression, injection, and dehydration systems. The new Monell facilities are designed for an initial capacity of 7.5 MMscfd of CO2, expandable to 75 MMscfd. The new Salt Creek facilities are designed to handle 70 MMscfd of carbon dioxide, expandable to 130 MMscfd.
Amec Foster Wheeler was a member of a joint industry project, led by the EI, to produce guideline documents; one for design, one for hazard analysis. Our contribution grew to providing chapters of the design document, including pipeline design, and serving on the editorial team for both documents. Amec Foster Wheeler continues to support the EI’s CCS activities as a member of the EI CCS technical committee. The guidelines are freely available from the EI website.

As partners with E4Tech and modelling company PSE we participated in the specification of requirements for a single dynamic model system for the Energy Technology Institute. The project involved CCS scheme definition, modelling requirements and needs, discussion with providers and stakeholders and the provision of a suitable specification for use as in the bidding process for the project.
Amec Foster Wheeler designs, delivers and maintains strategic and complex assets for its customers across the global energy and related sectors.

With over 40,000 employees in more than 55 countries, the company operates across the whole of the oil and gas industry - from production through processing, refining and the production of chemicals and petrochemicals - and in the mining, clean energy, power generation, pharma, environment and infrastructure markets.

Amec Foster Wheeler shares are publicly traded on the London Stock Exchange and its American Depositary Shares are traded on the New York Stock Exchange. Both trade under the ticker AMFW.

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