

10 Carbon Capture and Storage in the UK

*Bushby Y.E., Gilfillan S.M.V. and Haszeldine R.S.
Scottish Centre for Carbon Storage, School of GeoSciences,
University of Edinburgh, EH9 3JW, Scotland, UK
ybushby@staffmail.ed.ac.uk, stuart.gilfillan@ed.ac.uk,
Stuart.Haszeldine@ed.ac.uk*

SUMMARY

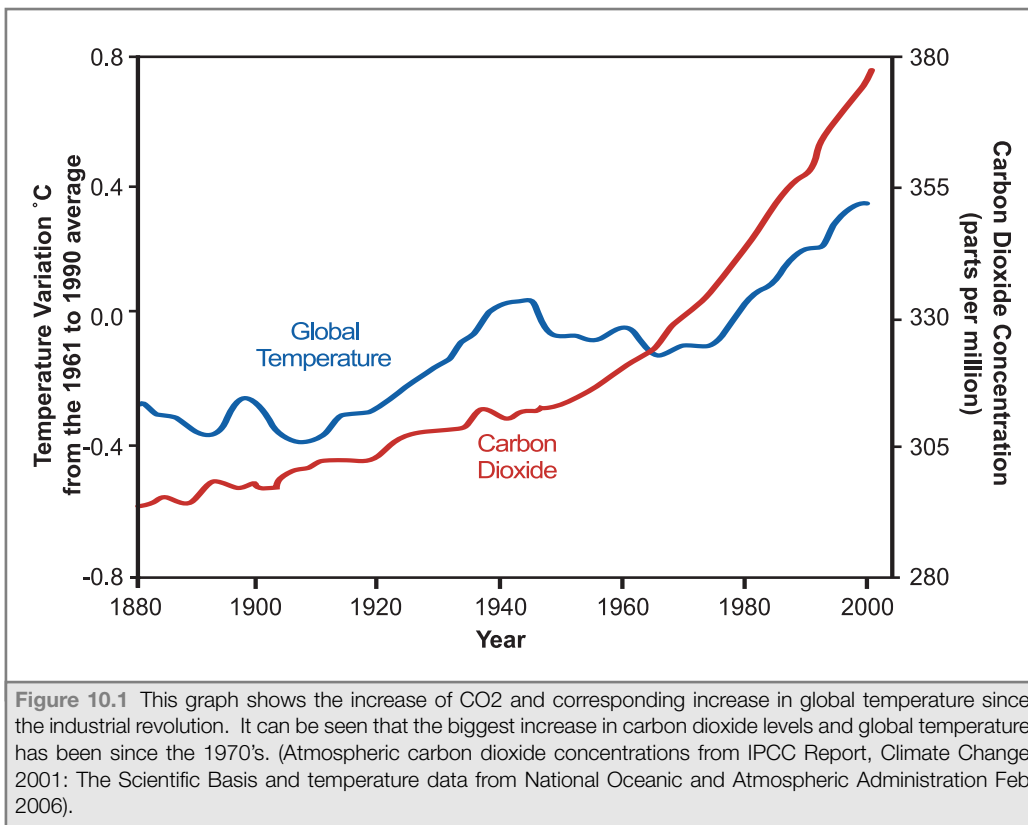
The subject of this chapter is Carbon Capture and Storage, which includes these main points:

1. About three quarters of electricity in the UK is produced using fossil fuels which in turn produces approximately one third of total UK carbon dioxide emissions. Carbon Capture and Storage can reduce UK emissions rapidly, whilst renewable energy and low-carbon generation technologies are developed and built.
2. Capture of carbon dioxide is most beneficial at large point sources such as power stations and industrial facilities. Existing power stations can be retrofitted with carbon capture equipment and new power stations can be built to be ready for capture.
3. Capture of carbon dioxide is already a common industrial process, although the amount of carbon captured will need to be much greater for use on power station emissions. Transport of carbon dioxide is already used on a similar scale onshore in the oil industry.
4. Storage of carbon dioxide is feasible by injection through boreholes into deep geological formations. Many of these formations have stored oil and gas for millions of years and their natural trapping mechanisms can be utilised. Possible storage sites are old oil and gas reservoirs, unmineable coal seams and saline aquifers.
5. With well designed, selected, and managed storage sites, scientists estimate that 99% of carbon dioxide can be retained over a period of several thousand years. This would store the carbon well beyond the era of fossil fuel use.
6. The UK is well suited to Carbon Capture and Storage technology. A quarter of existing power plants must be replaced by 2025 and this poses a perfect opportunity for Carbon Capture and Storage to be implemented. There are a large number of suitable storage sites present in the North Sea. These could economically and safely store hundreds of years worth of carbon dioxide from UK electricity generation and are located close to many potential carbon capture sites.

Bushby, Y.E., Gilfillan, S.M.V. & Haszeldine R.S. (2007). Carbon Capture and Storage in the UK. In *Energy and the Natural Heritage*, ed. by C.A. Galbraith and J.M. Baxter. TSO Scotland, Edinburgh. pp.

10.1 Introduction

Climate change is a global problem which requires global solutions. One significant cause of recent and projected climate change is an increase in greenhouse gas concentrations in the Earth's atmosphere. These increased proportions of greenhouse gases have enhanced the Earth's natural greenhouse effect. The greenhouse gas making the largest contribution is carbon dioxide (CO₂) and it is now clear that most of the increase in atmospheric carbon dioxide levels are the direct result of combustion of fossil fuels and biomass since the industrial revolution of the 1850's¹ (Figure 10.1). Global greenhouse gas emissions have increased by 70% between 1970 and 2004.



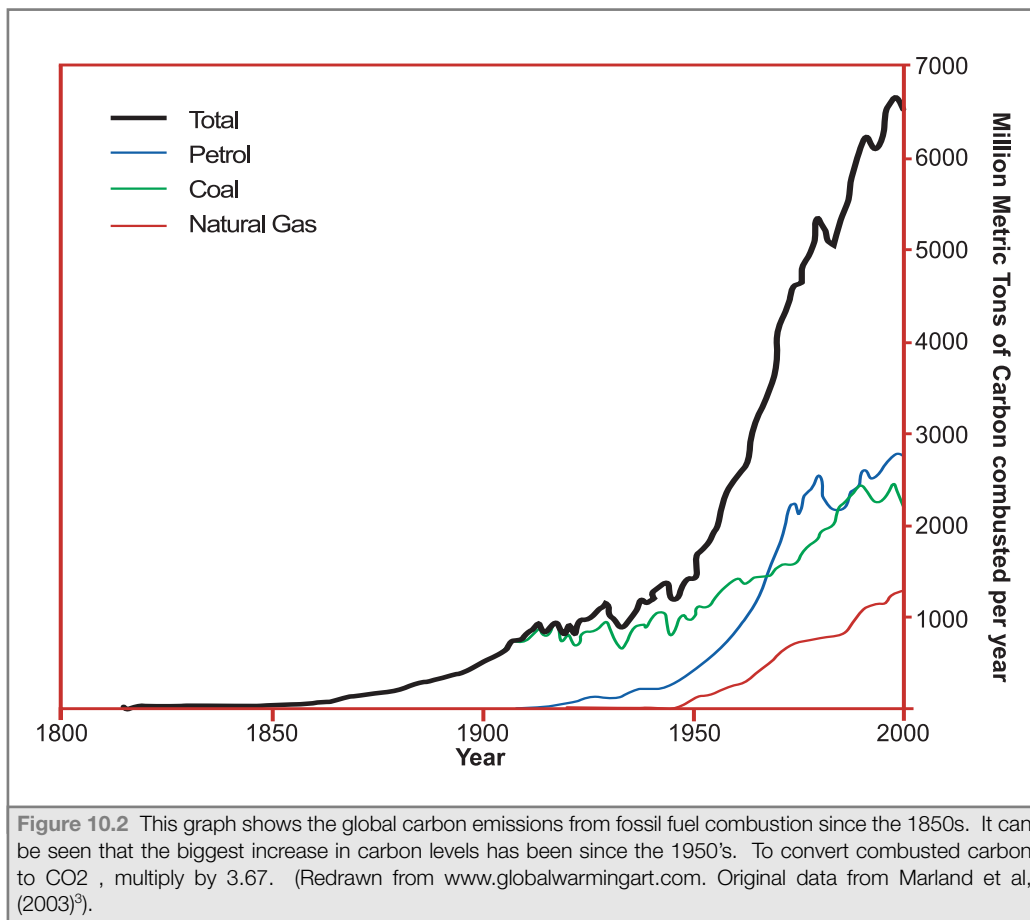
10.1.1 Threat of climate change on global ecosystems

Many ecosystems around the world are, and will be, threatened by climate change and its associated disturbances (e.g. sea level rise, ocean acidification and an increase in severe weather events such as drought, wildfire and flooding). Complex life on the surface of planet earth participates in a carbon cycle, where carbon is exchanged through natural processes between the biosphere, geosphere, hydrosphere and atmosphere. It is currently believed that net carbon uptake by terrestrial forest ecosystems is likely reach a peak within the next 50 years and then weaken or even reverse¹. This is predicted to have the effect of accelerating climate change and thereby placing more species, and human civilizations, in danger.

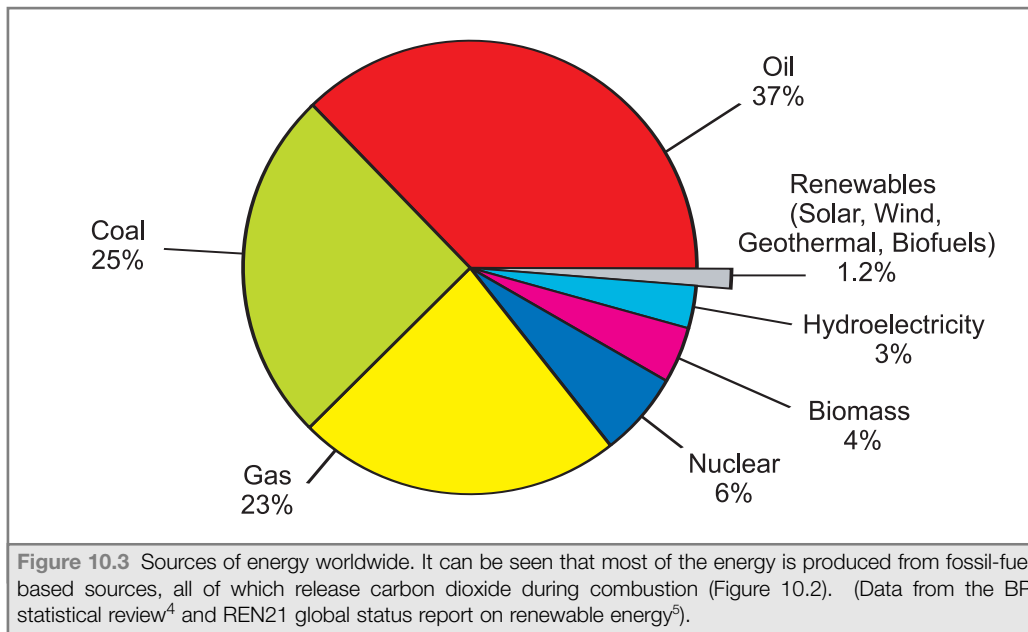
The most recent Intergovernmental Panel on Climate Change (IPCC) report in 2007 identified that approximately 20-30 per cent of plant and animal species studied are likely to be at an increased risk of extinction if global average temperatures rise by just 1.5 - 2.5°C¹. These increased temperatures would cause major changes in ecosystem structure and function, species ecological interactions and species' geographic ranges¹. It would drastically reduce biodiversity and cause severe disruption to both the natural world and to people, due to reducing water and food supplies. Additionally, increasing atmospheric carbon dioxide is already leading to the progressive acidification of oceans which is expected to cause major impacts on the metabolism of invertebrates, the ecology of the shallow seabed, and marine shell forming organisms^{1,2}.

10.1.2 Global carbon dioxide emissions and fossil fuel use

Global emissions of greenhouse gases from human activity are estimated to range between 22.8 and 25.3 billion tonnes of carbon dioxide equivalent per year³ (carbon dioxide equivalent includes the contribution to global warming made by other greenhouse gases such as methane and nitrous oxide). The vast majority of these greenhouse gases are the direct result of the burning of fossil fuels for transport, heating and electricity generation.



Modern industrialised society is dependent upon fossil fuels to meet its energy requirements and will be for the foreseeable future (Figure 10.3). At the present time an estimated 75 per cent of the world's energy is produced from fossil fuels^{4,5} accounting for the release of more than 7 billion tonnes of carbon in 2006. In order to effectively tackle climate change and ocean acidification, the world must drastically reduce its carbon dioxide emissions.

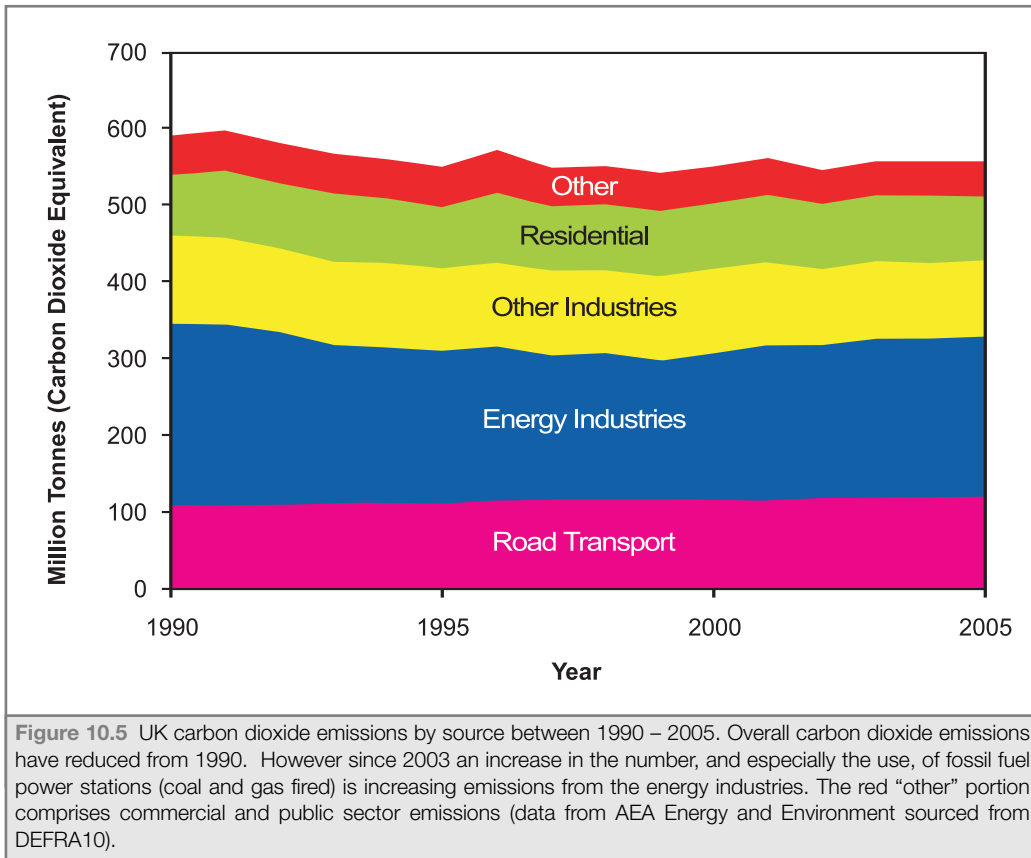
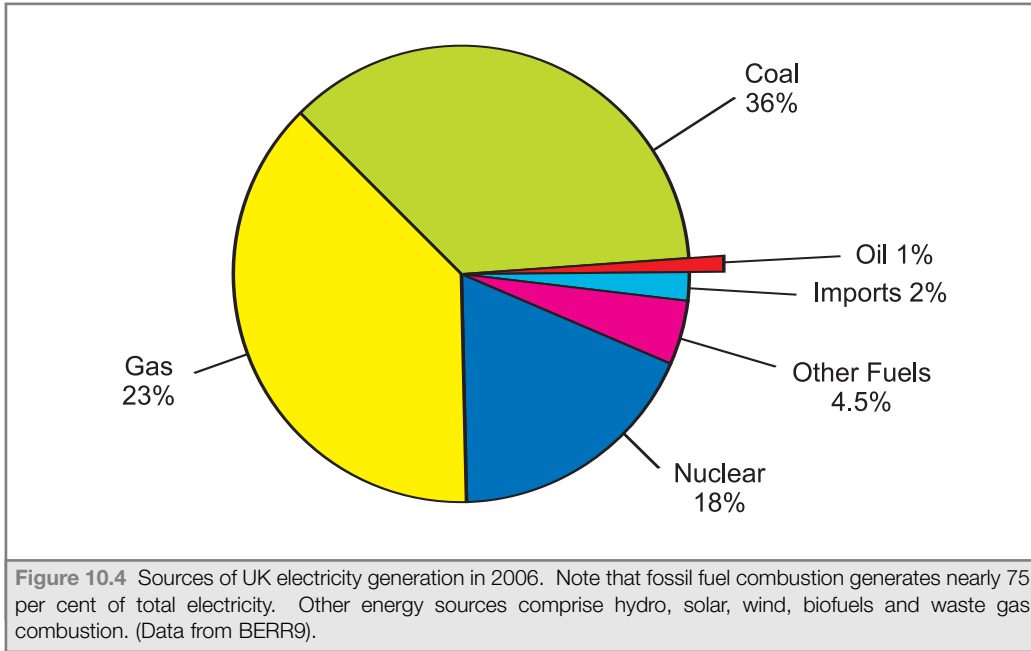


Even with strong development in the renewables sector, the International Energy Agency projections show that it is very probable that more than half of the industrial world's energy will still be generated by burning fossil fuels in 2050⁶. This is primarily because energy produced from fossil fuels is considerably cheaper, and more flexible to transport or transmit, than that produced by renewable sources. Many developing countries are unable to sustain both renewable energy development and improvements in healthcare, water and food supplies. Further pressure is created by increasing energy demands in China and India where there are no carbon dioxide reduction aims. The world also has the added pressure of an increasing population. China and India are predicted to become major emitters of carbon dioxide, and in 2007 China surpassed the USA as the largest carbon dioxide emitter⁷ – some 7 years ahead of previous predictions by the International Energy Agency⁸.

10.1.3 The UK perspective

The UK contributes about 2 per cent of global man-made greenhouse gas emissions¹, with 556 million tonnes of carbon dioxide equivalent in 2005.¹

Nearly 75 per cent of electricity in the UK is generated from fossil fuels (Figure 10.4) and has contributed the majority of the 208 million tonnes of carbon dioxide equivalent produced by the energy industries. An additional 99 million tonnes of carbon dioxide equivalent was produced by other industries (Figure 10.5).



Whilst the UK is slowly reducing its greenhouse gas emissions, the government has realised the threat of climate change to both the UK economy^{12,15} and the global population. For this reason the UK Government has committed to drastically reduce UK carbon dioxide emissions by 2050, by 60 per cent of 1990 emission levels. The UK Parliament Climate Bill of 2007-08, will commit the UK to the world's first legally binding reduction of carbon dioxide, with specified intermediate targets. In order for these targets to be met the UK must engage in multiple options to decarbonise energy, especially electricity. There are numerous policy and technology options, amongst these different options are:

1) Reduce UK energy use by reducing demand.

This can be expressed by using less energy, and by using energy more efficiently to continue producing wealth. This is typically a cost effective method but difficult for the government to implement and to produce rapid changes.

2) Develop low carbon and renewable energy technology, e.g. hydro, wind, tidal, solar.

Renewable energy is typically highly favoured by the public. However there are significant problems in overcoming the time and high initial capital costs needed to develop reliable and cost-effective electricity.

3) Consider the re-introduction of nuclear electricity generation

This can be costed as being financially attractive, however there is no appealing solution to waste storage and it is subject to the long term availability of fuel-grade uranium resources (Sustainable Development Commission, 2006¹¹).

4) Discover and deploy methods of low carbon transport, for individual and mass transit, air and sea travel and freight.

Transport fuels are the most difficult to decarbonise. Bio-fuels are impossible to grow nationally, in the quantities needed by the UK, and imports compete with food or forest land use. Greatly improved use of public transport is possible, but requires behaviour change by many individuals. Hybrid vehicles are a near-term improvement, although zero-carbon electric, or hydrogen, vehicles will need decarbonised supplies (from Carbon Capture and Storage).

5) Capturing and storing large amounts of carbon dioxide from fossil fuel power stations.

This is the subject of active and achievable development and rapid deployment. However the Carbon Capture and Storage process means that fuel needs to be imported, more fuel is used to generate the same net electricity, and there will be waste streams of CO₂ solvents.

Capturing and storing the carbon dioxide from fossil fuel power stations has the potential to be an effective tool for climate change mitigation. The majority of electricity in the UK is supplied by fossil fuels which generate approximately 37 per cent of UK carbon

dioxide emissions. If releasing this to the atmosphere were to be avoided through the implementation of Carbon Capture and Storage technologies, the UK would reduce its carbon dioxide emissions by up to 30 per cent. The added benefit is that Carbon Capture and Storage will permit the UK continued use of fossil fuels for electricity and heat generation during the timespan that is required to develop renewables, and possibly nuclear energy, into more reliably engineered and cost-effective methods of electricity production.

10.2 INTRODUCING CARBON CAPTURE AND STORAGE

Power stations and most industrial plants emit carbon dioxide in large volumes at individual sites. These are known as point sources and it is now possible for this carbon dioxide to be captured from these point sources instead of emitting it into the atmosphere. This carbon dioxide can then be transported and stored safely underground. This process is simply called Carbon Capture and Storage (CCS for short).

Carbon Capture and Storage therefore holds a great promise to dramatically reduce global carbon dioxide emissions from the burning of fossil fuels. This chapter will now

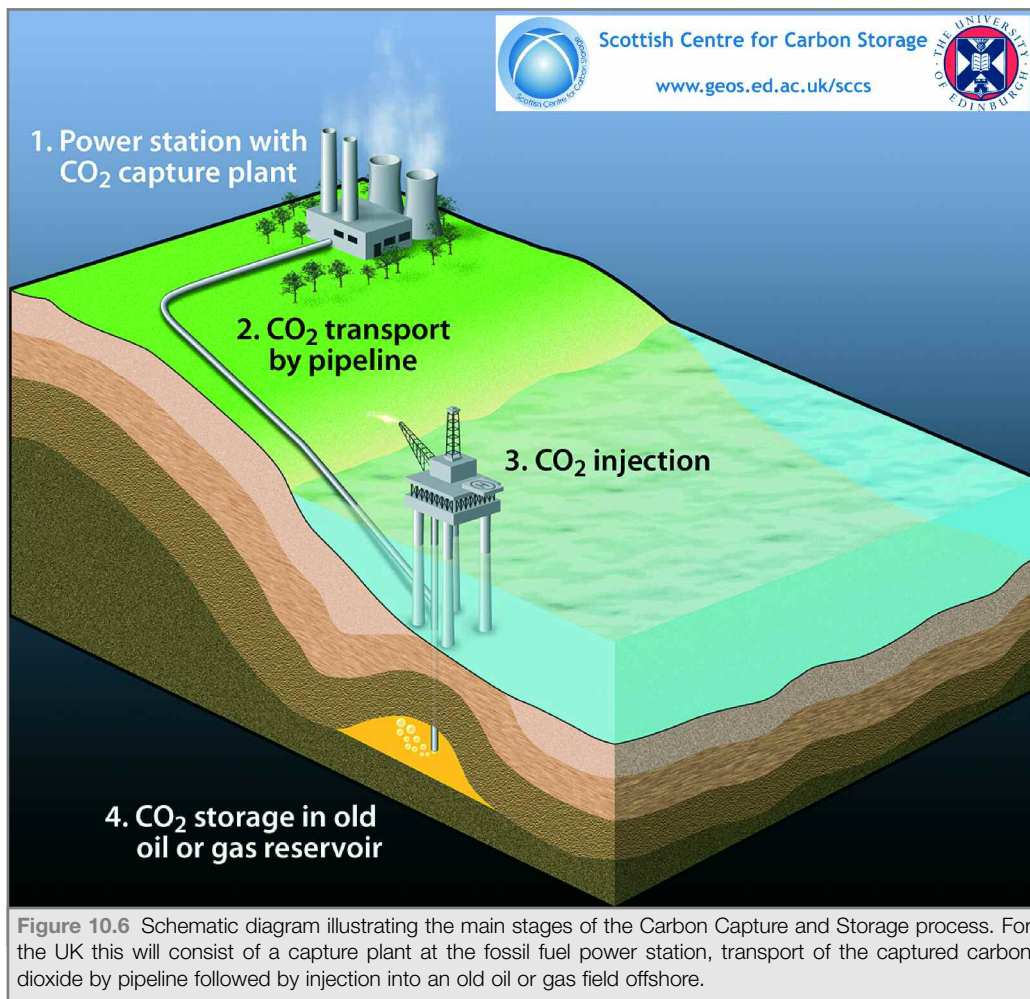


Figure 10.6 Schematic diagram illustrating the main stages of the Carbon Capture and Storage process. For the UK this will consist of a capture plant at the fossil fuel power station, transport of the captured carbon dioxide by pipeline followed by injection into an old oil or gas field offshore.

provide an overview of the processes involved in Carbon Capture and Storage, and thereafter address some of the questions commonly posed regarding the benefits, costs and risks of the technology. A short discussion about what policies are needed to implement Carbon Capture and Storage concludes the chapter.

10.2.1 How does Carbon Capture and Storage work?

Carbon Capture and Storage technology has three individual steps:

- (i) **Capture or removal of carbon dioxide from fossil fuel combustion or biofuel combustion at industrial processes, most importantly electrical power stations.**
- (ii) **Transportation of the carbon dioxide from the point of capture to a storage site.**
- (iii) **Injection of the carbon dioxide underground into deep geological formations for long term storage (more than 10,000 years).**

The following section will explain each of these three steps individually.

10.2.1.1 Capture of Carbon Dioxide

Capture of carbon dioxide is a common industrial process. Nevertheless, to apply this existing technology to power plants would require an increase of size scale by a factor of 3 to 10. Capture has been used for several decades to provide carbon dioxide for industries, such as those making carbonated (fizzy) soft drinks, de-cafeinating coffee, or dry cleaning of clothes. The oil industry has also used carbon dioxide separation to purify natural methane gas, and in refineries where hydrogen gas is made from natural hydrocarbons. At present there are three different ways that can be used to capture carbon dioxide from a point source¹³ and these are:

- a. Post-combustion capture
- b. Pre-combustion capture
- c. Oxyfuel combustion

a. **Post-combustion capture**

Post-combustion capture describes the capture of carbon dioxide, which forms 3-15 per cent of the flue gas **after** it is produced from burning a fossil fuel. Capture of the carbon dioxide usually occurs by passing the flue gas through an amine solvent, allowing the carbon dioxide to dissolve. Once dissolved the amine solvent can be pumped to a different part of the power station where it is heated to release the pure carbon dioxide. A distinct advantage of this technology is that it could be fitted to existing power plants, such as those that burn coal, the fossil fuel that produces the most carbon dioxide per unit of electricity generated. This practice is called retrofitting and several sites around the UK are being considered for this.

b. **Pre-combustion capture**

Pre-combustion capture involves the capture of carbon dioxide **before** the fuel is burnt. To do this the fossil fuel is gasified or 'partially' burnt in a combustion chamber at a higher pressure than normal and with a controlled amount of oxygen.

This produces hydrogen and a relatively pure stream of carbon dioxide (15-60 per cent) that can be easily separated and captured. The hydrogen can then be burnt to produce heat for electricity generation without producing any further carbon dioxide (water vapour is the main by-product). This capture technology is well understood and is already used in industrial applications such as the production of carbon dioxide during production of hydrogen from splitting hydrocarbon in oil refineries. This technology has not yet been applied to a process as large as power generation.

c. Oxyfuel combustion

Oxyfuel combustion involves burning hydrocarbon fuel in a chamber which is rich in oxygen (more than 95 per cent), rather than air (which contains 16 per cent oxygen). This produces water and more than 80 per cent carbon dioxide as by-products. Cooling of this mixture of gases allows the water to be condensed. This leaves an almost pure stream of carbon dioxide which is then ready for transport to a storage site. At the time of writing (2007) this is the least developed of the three capture technologies.

10.2.1.2 Costs of capture

The capture step of Carbon Capture and Storage is the most expensive, and is the step that has been least well developed technologically. The biggest problem is that all of the capture processes require energy to separate the carbon dioxide from the other gases. This is known as the energy penalty and is the main expense of the process, typically comprising 75 per cent of the costs¹³. As a result of the energy required for the process, carbon dioxide capture makes a power station less efficient, meaning more fossil fuels need to be burnt for the same amount of electricity produced. However, the technology is currently being researched extensively and at the time of writing it is believed that a power station using Carbon Capture and Storage, by any of the three capture methods listed above, will emit 85-95 per cent less carbon dioxide than one which has no carbon dioxide capture. Additional problems are the production of wastes: ash from coal (as at present), and new streams of degraded solvents – especially from post-combustion capture.

10.2.1.3 Transportation of Carbon Dioxide

Once the carbon dioxide has been captured, it is pressurised to greater than 70 atmospheres, when it forms a liquid. The liquid is denser than gas, and consequently allows the carbon dioxide to be transported, as it can easily be pumped.

Special carbon dioxide pipelines can be used to transport the carbon dioxide in a similar way to natural gas which is transported to homes around the world. Transport of carbon dioxide is carried out extensively in the United States to provide carbon dioxide for Enhanced Oil Recovery (see below). Small amounts of carbon dioxide can also be transported in tanker ships similar to those that transport oil. Ship transport of carbon dioxide has been used for many years to provide carbon dioxide for brewing and soft drink industries. However as the tankers can only transport a limited amount of carbon dioxide at a time, pipeline transport is more efficient for distances up to 500 kilometres.

Liquefied carbon dioxide has already been utilized around the world for Enhanced Oil Recovery projects (EOR). This technology involves injecting carbon dioxide into old oil

reservoirs in order to increase oil production. When the carbon dioxide is injected into oil reservoirs, it makes the oil less sticky, freeing it from the small pore spaces where it is trapped. The addition of carbon dioxide also increases the pressure acting on the oil in the reservoir and the carbon dioxide effectively pushes oil out from the pore spaces in the rock where it is trapped.

The costs and the energy required for carbon dioxide transport must be considered. The conversion of the carbon dioxide gas to a liquid requires energy, in addition to the energy required for pumping. Increased revenue from using captured carbon dioxide for enhanced oil recovery can be used to offset some costs. To minimise any environmental and economic costs, storage sites would ideally be located as close as possible to the power plant.

10.2.1.4 Storage of Carbon Dioxide

Once the carbon dioxide has been captured and transported to the storage site it can then be injected. In the early stages of Carbon Capture and Storage research two distinct settings for storage were considered. They were:

- a. Ocean Storage
- b. Deep geological formation

a. Ocean Storage - Can carbon dioxide be stored in oceans?

Storage of carbon dioxide at the bottom of deep oceans was investigated as a possible method in the early stages of Carbon Capture and Storage research. The process would involve injecting a stream of carbon dioxide into the ocean from a fixed pipeline or below a moving ship.

The environmental impacts of this technique were found to be generally negative and the UK Government does not support this type of storage. Additionally, this method is currently outlawed by international marine treaties and injection of large amounts of carbon dioxide into the marine environment may acidify large amounts of sea water. Marine life is highly sensitive to such changes and therefore injecting carbon dioxide is certain to adversely affect marine life.

A final negative reason is that ocean storage is not a permanent method of carbon dioxide storage. There is a high risk that carbon dioxide will over time return to atmosphere, as there is not a distinct physical barrier to prevent the carbon dioxide from doing so. For these reasons this method of storage has been deemed unsuitable and no further research into it is being undertaken.

b. Deep geological formations – can we store carbon dioxide underground?

Many deep geological formations have acted as natural storage facilities for oil and gas for millions of years. It is therefore easy to appreciate why those natural trapping structures could be utilised to store carbon dioxide underground for many thousands of years. There are several different types of underground sites which could be used to store carbon dioxide:

– *Exhausted oil and gas fields*

Oil and gas fields consist of a layer of porous rock with a non-porous cap rock above.

The oil and gas is held in the small pore spaces within the porous rock structure in a similar fashion to how the spaces in a sponge hold water. Oil and gas are trapped in these reservoirs by the cap rock, which has a dense non-porous structure with few spaces, preventing gas or oil movement through it. This acts as a lid on the reservoir, sealing the oil and gas underneath.

Once the fossil fuels have been removed, carbon dioxide can be injected through a well into the layer of porous, sponge-like rock. The sediment grains and clay particles which form the cap rock are too densely packed for the carbon dioxide to move through it, meaning that the carbon dioxide is permanently trapped in the field.

Exhausted oil and gas fields are ideal for carbon dioxide storage. A great deal is known about these sites and the knowledge gained from Enhanced Oil Recovery (see above) means that carbon dioxide injection has already been conducted on a range of sites and associated injection technology has been developed. However, a programme of monitoring must be undertaken after carbon dioxide injection, to ensure that pre-existing boreholes, which have punctured the natural cap rock seal, do not act as leakage pathways for carbon dioxide. It is thought that oil and gas fields could hold about 30 years of emissions from UK power plants.

– *Unmineable coal seams*

Unmineable coal seams offer another method of carbon dioxide storage. Whilst underground, coal has a layer of natural gas (usually methane - CH₄) chemically attached to it. Once carbon dioxide is injected, it will push the methane off the coal and adsorb onto the coal in place of the methane. An additional benefit is that during carbon dioxide injection, the methane could be recovered and used to produce energy. This could be used to cover some of the cost of the carbon dioxide storage.

However, there are two problems with this technique. Firstly burning of the methane will produce more carbon dioxide and secondly, in order for the carbon dioxide to be permanently stored the coal can never be mined. The coal is 'sterilized' as a fuel resource even if mining the coal becomes economically worthwhile to mine it in the future. There are no coals in the UK (in 2007) where this technique has been applied.

– *Saline aquifers*

Saline aquifers are deep underground stores of salt water. They are an attractive option as they are commonly found offshore, could hold a very large amount of carbon dioxide and are of no real use to humans due to the un-drinkable water. The UK North Sea contains several large saline aquifers and their use would keep transport costs to a minimum. The current estimates indicate that several centuries' worth of total UK carbon dioxide emissions could be held in these aquifers.

The main problem with this type of storage is that a relatively small amount of information is available when compared to old oil and gas reservoirs. Further research needs to be completed to determine if the potential storage capacity is as large as preliminary research suggests.

10.3 How would the carbon dioxide be stored in the rock?

Carbon dioxide can be trapped in four distinct ways which are explained in the following section.

10.3.1 Structural Storage

Carbon dioxide is more buoyant than water meaning that when injected into a reservoir it will rise up through the pore spaces in the reservoir rock until it reaches the impermeable cap rock. Good cap rocks such as shales and mudstones are impenetrable to the carbon dioxide and will prevent it from leaking back to the atmosphere. As already mentioned, many natural gas fields around the world have stored both carbon and natural gas for millions of years in this way.

10.3.2 Residual Storage

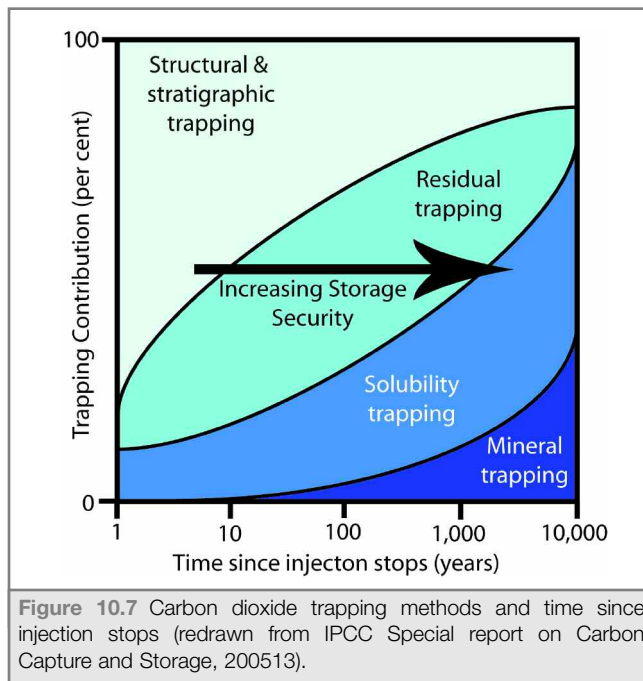
The porous rocks in oil and gas reservoirs behave like a tight, rigid sponge. A sponge traps air residually and, for this reason, to soak a sponge in water it must be squeezed several times to replace the trapped air with water. In a similar fashion when liquid carbon dioxide is injected into a rock formation, much of it is trapped as isolated microscopic bubbles within the pore spaces of the rock and this is known as residual trapping.

10.3.3 Dissolution Storage

In the same way that sugar dissolves in hot tea, carbon dioxide quickly dissolves in water. This water containing carbon is denser than the freshwater surrounding it. Therefore the water containing the dissolved carbon dioxide will sink to the bottom of the reservoir, so trapping the carbon dioxide.

10.3.4 Mineral Storage

When carbon dioxide is dissolved in water it forms a weak acid (carbonic acid) which can dissolve and react with the minerals in the reservoir rock. If the conditions in the reservoir are favourable new minerals can be formed. They would coat the interior of pores within the reservoir rock and lock away the carbon dioxide within the rock. However, under most conditions this process is extremely slow and this is therefore the least useful storage mechanism.



10.4 Monitoring and Verification of Carbon dioxide

Verifiably measuring the quantities of stored carbon dioxide is essential, especially if this technology is to be used to meet national or international commitments on reducing emissions or is to be used as a basis for emissions trading. Operators of carbon dioxide storage sites will also need to monitor site performance to verify that there is no leakage from the storage reservoir.

Carbon dioxide can be measured at any stage of the Carbon Capture and Storage chain, and techniques for this are already available. During the carbon dioxide capture process, flows of gas would be measured as a normal part of the operation. During transport, carbon dioxide pipelines in the USA constantly monitor large quantities of pumped carbon dioxide. At the injection site, metering on oil rigs is established to measure oil and gas production for tax purposes, similar methods could be used to measure the amount of carbon dioxide injected into geological storage sites.

Oil and gas companies now have the technology to trace gas flows in underground reservoirs using a number of methods which are directly applicable to monitoring stored carbon dioxide. Whilst all of these methods are currently in use in the hydrocarbon industry, monitoring carbon dioxide storage will need to be carried out accurately and cheaply over a much longer time period than current monitoring technologies will allow and hence further research in this area is required¹⁴.

10.5 Commonly Asked questions

The following section briefly answers some of the most commonly asked questions asked in relation to Carbon Capture and Storage technologies.

10.5.1 Will the carbon dioxide escape?

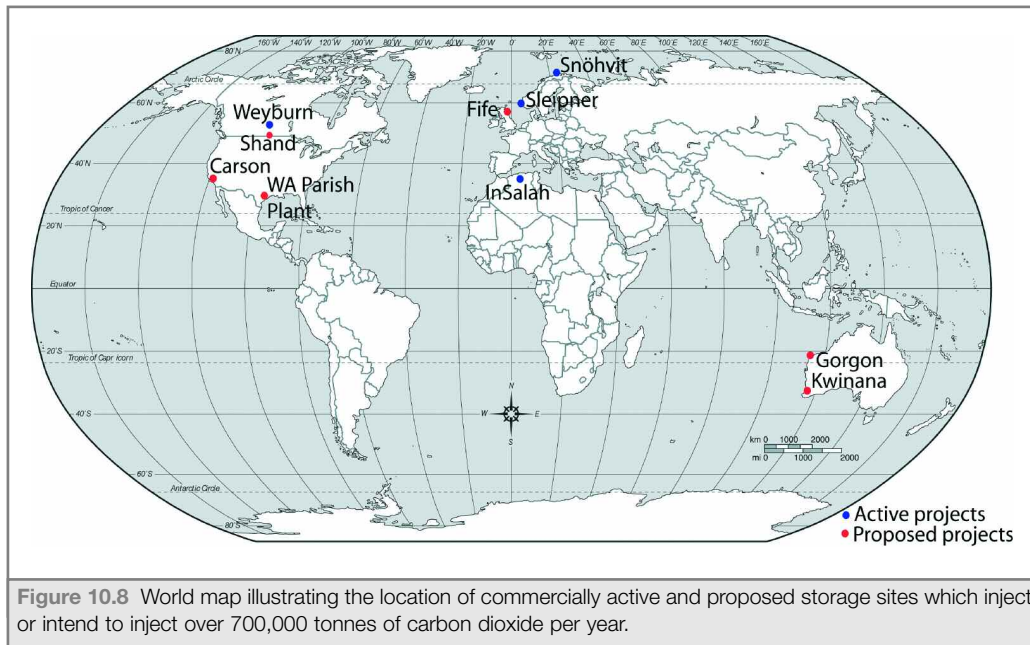
As outlined in the previous section of this chapter there are several ways in which carbon dioxide is held within the rock structure. The initial means is structural storage, where the carbon dioxide is trapped beneath a non-permeable (no flow) cap rock. This is the same mechanism by which most of the oil and gas fields around the world trap oil and gas. Many of these fields have stored oil and gas for hundreds of thousands to many millions of years and provided that the man-made carbon dioxide is placed in a similar geological site which has been adequately characterised and well chosen, long term storage can be achieved.

As well as oil and gas, around the world there are many sites that have naturally contained carbon dioxide from natural sources for millions of years. Hence, with thorough planning, research and testing of storage sites, carbon dioxide can be reliably trapped underground for thousands and possibly millions of years. One of the conclusions of the latest IPCC (the UN Inter-governmental Panel on Climate Change) report states that more than 99 per cent of the carbon dioxide could be retained over 1000 years with well designed, selected and managed sites¹³. This would store the carbon dioxide well beyond the era of extravagant fossil fuel use by humans.

10.5.2 Has Carbon Capture and Storage been used before?

As of 2007, only a handful of industrial scale projects are in operation world wide. Sleipner in the North Sea has been operating since 1996 and is the world's oldest carbon dioxide storage project injecting over 1 million tonnes of carbon dioxide per year into a saline

aquifer. In Salah in Algeria has been operating since 2004 and injects about 1 million tonnes of carbon dioxide per year into the saline aquifer beneath a gas field. Weyburn in Saskatchewan is a commercial Enhanced Oil Recovery operation where carbon dioxide has been stored and monitored. Smaller injection sites are in the Lacq region in France, a range of Enhanced Oil Recovery and Carbon Capture and Storage test sites in the U.S. and Canada. Large commercial injection sites are planned to be operational during 2007 at Snøhvit in Norway, and 2008 in Western Australia (Figure 10.8).



The UK is a good location for Carbon Capture and Storage. The UK has a large number of exhausted oil and gas fields and a large number of saline aquifers offshore (Figure 10.9). Coal and gas fired power plant are within tens to hundreds of kilometres of a wide range of geological storage sites (Figure 10.9). There is extensive expertise within the country in pipeline engineering and offshore oil and gas production. This expertise could be readily applied to Carbon Capture and Storage.

10.5.3 Will Carbon Capture and Storage be expensive?

The costs of Carbon Capture and Storage technologies depend on a number of factors including the type of power station, the type of capture technology used, transport distances, whether Enhanced Oil Recovery could be used to offset initial costs and future oil prices. The main cost factor is that carbon dioxide capture plants require more energy to operate. This reduces net plant efficiency and more fuels are required to create the same amount of energy. Electricity price will therefore increase. This is widely estimated to increase by 1.0 p/kWhr, from 3.0 to 4.0p/kWhr wholesale price. If this is passed on to UK domestic consumers without additional profit, this is only about £30-£50 extra per average household per year.

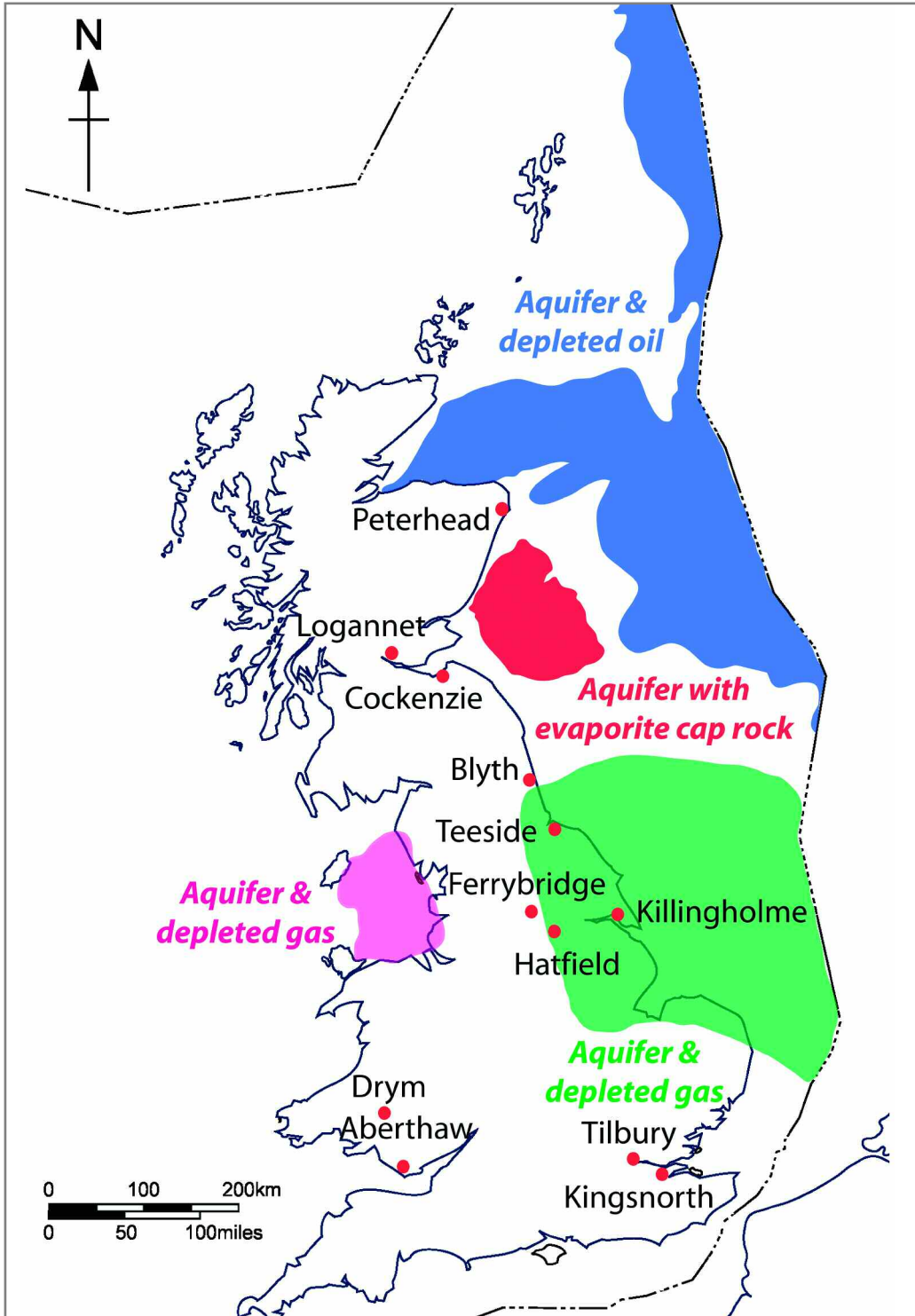


Figure 10.9 Map of Great Britain illustrating potential offshore sites for carbon dioxide storage and proposed sites where carbon dioxide capture is being planned to take place.

Oil production in the UK North Sea is nearing the end of its life and Enhanced Oil Recovery could postpone abandonment of the old oil fields. However Enhanced Oil Recovery has never yet been used for oil fields under the sea. Several evaluations have been made of Forties and of Miller in the UK North Sea, Gullfaks, Draugen and Heidrun in the Norwegian North Sea but all have been rejected on economic reasons.

The high initial costs of new plant for Carbon Capture and Storage technologies, and extra operating cost, do mean that governments will have to provide financial incentives and support to help implement the capture and storage technologies for the first plant(s). In 2007 the UK government announced a competition to build the first joined up Carbon Capture and Storage system in the UK from power plant to storage¹⁶. This is intended to be operational at a 300 MW scale by 2014. The EU plans to encourage the build of 12 Carbon Capture and Storage plants to be operational by 2015. These will lead to improved plant built before 2020. After 2020, the EU ambition is for all new fossil fuel plants to be using Carbon Capture and Storage.

As with all new developments, building commercial scale plants will help to bring costs down. Therefore companies must be encouraged by government to incorporate Carbon Capture and Storage technologies into their new build and existing power stations. Governments must make clear statements on the importance of Carbon Capture and Storage on the future economy, clear subsidies must be given to develop cheaper capture technologies. Carbon dioxide storage in Norway's Sleipner field was encouraged by the Norwegian carbon dioxide emissions tax and many U.S. Enhanced Oil Recovery projects are financially viable due to tax incentives.

The UK requires 80 Giga Watts of electricity generation at peak load. Before 2020, 25 GigaWatts of this generation capacity (including nuclear) needs to be replaced because it is out of date or polluting. This rebuild of a number of plants is the perfect opportunity for Carbon Capture and Storage to be implemented. Planning consent granted for new power plants during 2007 started to reflect this, to require that Carbon Capture and Storage equipment can be retrofitted later.

10.5.4 Shouldn't the UK be investing more money into renewables rather than Carbon Capture and Storage?

Even with above average estimates (IEA 2006 Alternative scenario 8) on the deployment of renewable energy, fossil fuels will still be the main source of electricity for the UK for at least another 40 years. No single renewable technology is currently deployable in that timescale to meet the UK electricity needs, and fossil fuels will need to fill the energy gap. Carbon Capture and Storage offers the UK the window to store carbon whilst renewables or other low carbon technologies are being developed and deployed.

10.5.5 Is the UK ready to demonstrate this technology?

The UK has the technical and business ability to start Carbon Capture and Storage immediately. The different technologies that make up Carbon Capture and Storage are now mature enough for full-scale demonstration. Delays mean that carbon dioxide in the atmosphere and ocean continues to increase and the effects of climate change and ocean acidification will increase. Many of these changes, and poorly known feedbacks, are irreversible on human timescales. The industrial world will simply run out of time. Carbon

Capture and Storage has the potential of significantly reducing UK emissions very soon. As early as 2020, Carbon Capture and Storage offers emission cuts of 5-10Mt carbon dioxide per year on each coal or gas plant with commercially functioning sites. An aggressive programme could decarbonise all the UK fossil power plant fleet by 2025, by a combination of retro-fits onto existing power plants, and as part of new-built plants. This would reduce UK carbon dioxide emissions by over 150Mt/yr. This is a small part of worldwide carbon dioxide emissions, but the key point here is that, once a technology has been proven to work – then the technical and commercial risk greatly decreases and other industries and nations can confidently replicate that system. Before the first aeroplane, flight could be a theory. The first flight proved that machines heavier than air could work. The first Carbon Capture and Storage challenge is to build a handful of power plants. The second challenge is to spread that learning globally. Five years saved from UK emissions by rapid Carbon Capture and Storage development, could mean five years saved from Chinese emissions soon after.

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The authors are financially supported by the Scottish Funding Council, The UK Energy Research Centre, and NERC

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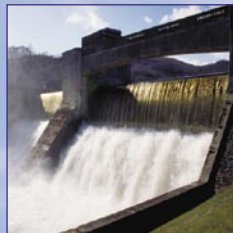
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