Inquiry into Geosequestration Technology

BP's submission to the House of Representatives Standing Committee on Science and Innovation

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Executive Summary

Without significant action, global greenhouse gas emissions are projected to double by 2050, predominantly due to the burning of fossil fuels. Increasing atmospheric concentrations of greenhouse gases will result in climate change, to which Australia is particularly vulnerable[1].

Climate change is a long term issue (50+ years) and the goal must be to take urgent but informed measures that will stabilise atmospheric greenhouse gas concentrations by delivery of sustainable long-term emission reductions at lowest cost.

There is no single solution which can by itself deliver these global greenhouse gas emissions reductions, but there is a portfolio of technologies that have been demonstrated at scale and which collectively offer the opportunity to make the necessary reductions over the next fifty years.

Because the world will be largely dependent on fossil fuels for the next fifty years, fossil fuel-based technological solutions for carbon mitigation will be one of the major contributors to stabilisation. The potential offered by geosequestration technology (or carbon capture and storage, CCS) to reduce greenhouse gas emissions is substantial, and Australia has a unique opportunity to adopt a leading international position.

Power generation accounts for 40% of global anthropogenic (or human-induced) greenhouse gas emissions. CCS technology can be used to "decarbonise" fossil fuels used in power generation by converting them into hydrogen (H2) and carbon dioxide (CO2). The CO2 can be permanently stored in subsurface structures such as depleted oil and gas reservoirs or saline formations, thus ensuring that it does not enter the atmosphere. The hydrogen can be used to generate baseload electricity.

BP has announced plans for two industrial scale commercial Hydrogen Power projects[2] (known as DF1 and DF2) which present an immediate and effective way of putting this technology into operation.

BP's DF1 project in the UK, for example, will capture and sequester 90% of the carbon in the natural gas delivered to the plant as fuel. A conventional plant would vent all the CO2 to the atmosphere.

DF2 is planned for southern California and would use petroleum coke – a by-product of the refining process and a synthetic form of coal - as its fuel. Indeed, if applied to only 5 per cent of the new electricity generating capacity which the world is projected to require by 2050, CCS offers the potential to reduce global emissions by around one billion tonnes of carbon a year.

Any credible policy to reduce greenhouse gas emissions must embrace CCS as part of the portfolio, as recognised by the IPCC special report on CCS[3]; and this ought to be acknowledged in any fiscal or regulatory regime designed to assist low carbon or carbon free energy to compete with fossil fuels.

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[1] "The Business Case for Early Action", Australian Business Roundtable on Climate Change, April 2006, www.businessroundtable.com.au
[2] www.bp.com/alternativeenergy
[3] " Carbon Dioxide Capture and Storage", Intergovernmental Panel on Climate Change, 2005

Introduction

Climate change presents a significant economic, environmental and societal risk over the long term, and requires that urgent but informed measures are taken that will stabilise greenhouse gas concentrations at lowest cost.

Fossil fuels currently supply about 80% of all primary energy and will remain fundamental to global energy supply for at least the next 20 – 30 years. Innovation to reduce the greenhouse gas emissions from the use of fossil fuels will be a major contributor to achieving stabilization.

Energy companies like BP therefore have a key role to play in contributing to policy and education, enabling market mechanisms, and developing and deploying technological and innovative commercial solutions at large scale, based on both fossil fuel and material new energy sources.

BP and climate change

BP supports the emerging consensus that it would be prudent to limit the increase in the world's temperature to about 2° Celsius above pre-industrial levels. One way to achieve this would be to ensure that global emissions in 2050 are no higher than today's emissions. This is a major challenge, because if no action is taken, emissions are expected to double in line with energy use, from 7 billion tonnes of carbon per year, to 14 billion tonnes per year.

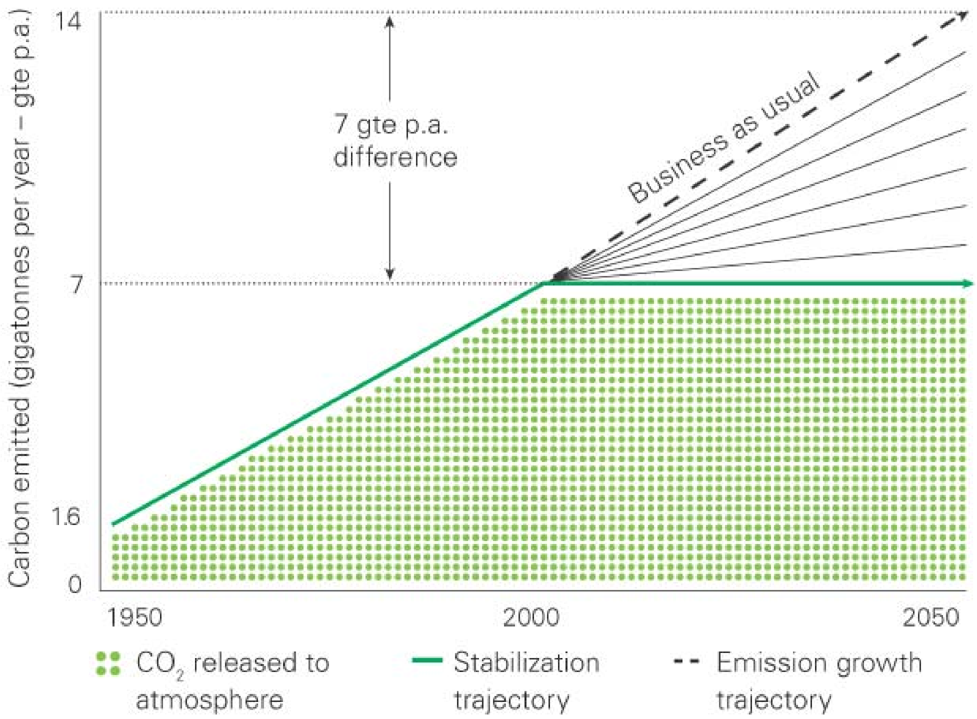
Research at Princeton University[4], supported by BP, has produced a model that describes different options to reduce global emissions, based on existing and emerging technologies. Broadly speaking, the options include:

- Capturing and storing carbon, whether biologically (biosequestration or forest sinks), or geologically (geosequestration or Carbon Capture and Storage, CCS)
- Switching from carbon-intensive fossil fuels to lower carbon alternatives e.g. from coal to gas
- Reducing energy demand through improved energy efficiency
- Increasing the use of renewables, e.g. wind, solar, hydro
- Increasing the use of nuclear power

To stabilise global emissions, by 2050 annual global emissions of carbon would need to be 7 billion tonnes below the current projected level. The Princeton research breaks this task down into smaller pieces or "stabilisation wedges", where each wedge could reduce emissions by 1 billion tonnes of carbon by 2050 (see Figure 1). Examples include:

- Doubling the fuel economy of 2 billion cars
- Replacing coal with natural gas at 1400 one gigawatt power stations
- Achieving a 50-fold increase in wind power or a 700-fold increase in the use of solar panels
- Producing 34 million barrels of bio-fuels a day
- Deploying Carbon Capture and Storage on 5% of new power growth between now and 2050.

[4] "Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies" S. Pacala and R. Socolow, Science, August 13, 2004)



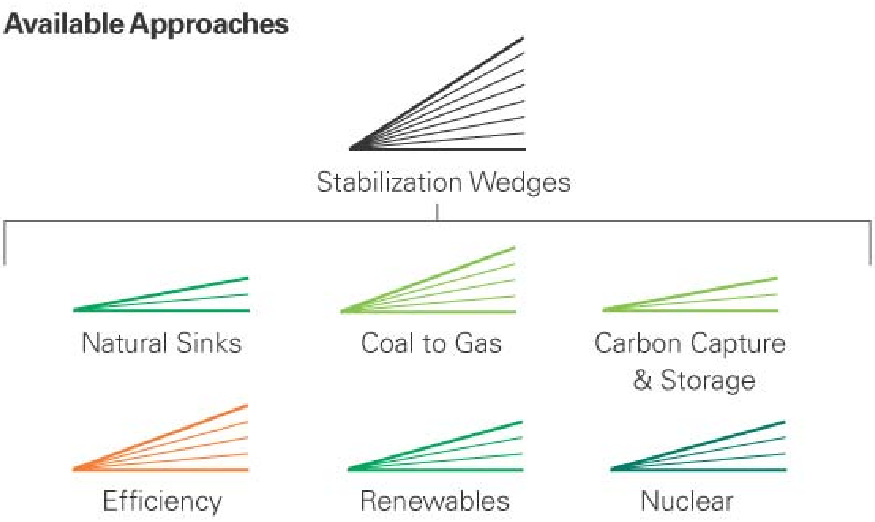


Figure 1: *The 'wedges' approach to stabilising global greenhouse gas emissions (from "Stabilization Wedges: Solving the Climate Problem for the next 50 Years with Current Technologies" S. Pacala and R. Socolow, Science, August 13, 2004)*

It can be seen that the task of stabilising greenhouse gas concentrations is not easy, and will require a broad-based and concerted effort to address both energy demand and supply. However, there are options already available which, when deployed at scale, can begin to slow the growth in emissions.

This submission will respond to the Terms of Reference laid out by the House of Representatives Inquiry and detail the potential role that Carbon Capture and Storage (CCS) can play in meeting the challenge of climate change, particularly in countries like Australia which are rich in fossil fuel resources.

BP and carbon capture and storage

Within the oil and gas industry, CO2 injection and storage has been in use for several decades. It has mainly been used with Enhanced Oil Recovery (EOR) where CO2 is pumped into depleting oil reservoirs to increase the proportion of oil reserves that can be recovered. This practice is particularly prevalent in West Texas. Storing CO2 for the express purpose of reducing greenhouse gas emissions is a more recent approach, although currently over 3 million tonnes are stored each year in projects around the world.

One of the earliest industrial scale storage projects was BP's CCS project at the In Salah gas field in the Algerian desert, launched in 2004.

In Salah is a joint venture between Sonatrach, the Algeria national energy company, BP and Statoil. Approximately 10% of the gas in the reservoirs is CO2. This CO2 is separated prior to sale of the hydrocarbon gas. Rather than venting the CO2 to atmosphere, which is the established practice on other projects of this type, the project is capturing, compressing and injecting it in wells 1,800 metres deep into a lower level of one of the gas reservoirs where the reservoir is filled with water. Around one million tonnes of CO2 are injected into the reservoir every year for long term storage. This reduces greenhouse gas emissions by the equivalent of taking 200,000 cars off the road.

In 2005, BP announced plans for the development of the first industrial-scale project to generate clean electricity from fossil fuels. Located in Scotland, the project, known as the Peterhead Hydrogen Power project, or DF1, would take natural gas from the North Sea and split it into hydrogen and CO2. The hydrogen would be burned in specially developed turbines to produce some 460 MW of baseload power, and the CO2 piped back offshore and re-injected into a mature oil field for EOR and permanent storage. This project is expected to be in commercial operation in 2010 and would reduce CO2 emissions by around 90% in comparison with conventional generation. It is estimated that some 1.8 million tonnes of CO2 will be permanently stored each year (see Figure 2).

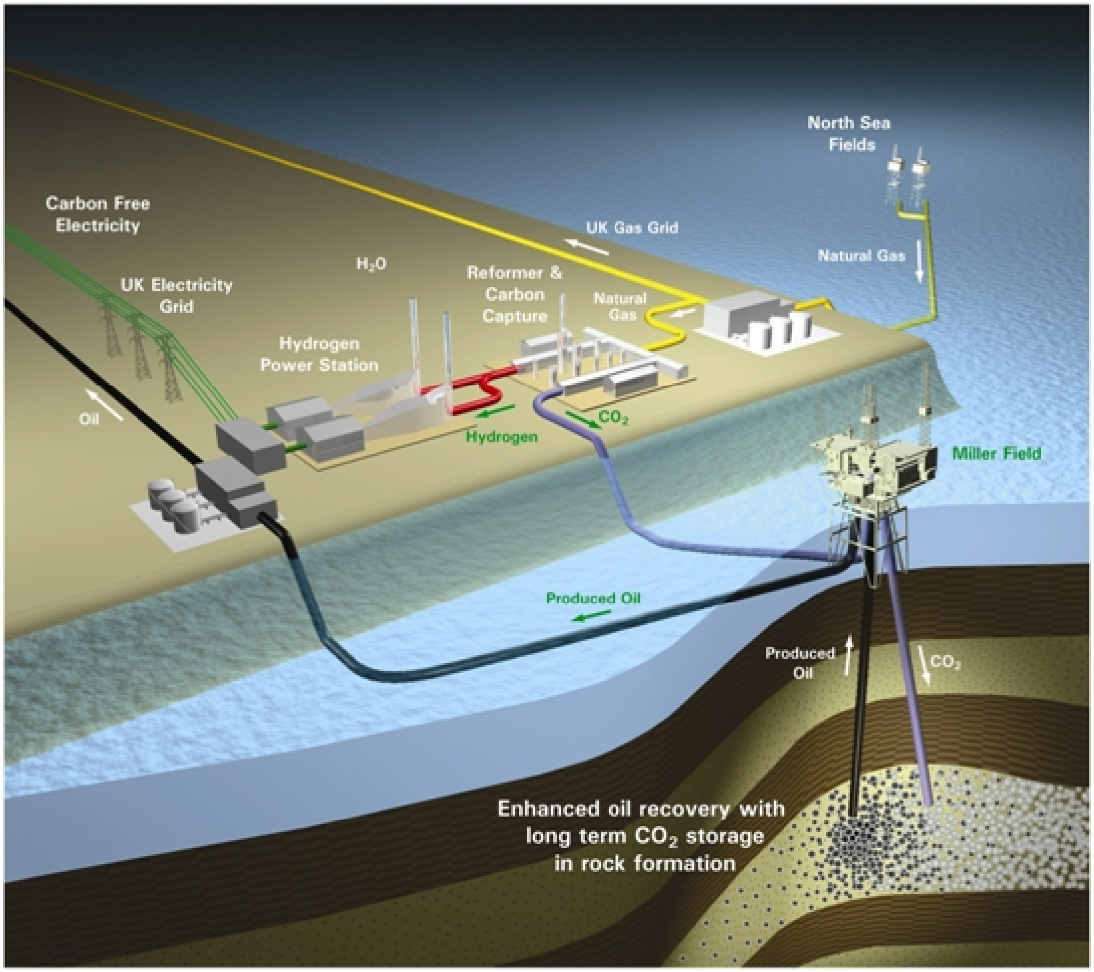


Figure 2: *Schematic of BP's DF1 project, the world's first hydrogen-fuelled power generation plant. The plant will generate electricity from hydrogen, and store nearly 1.8 million tonnes of CO2 in a mature oil and gas field in the North Sea, UK.*

In 2006, BP announced plans for development of a second power project, based at the Carson refinery in California, known as DF2. This project will produce hydrogen and CO2 from petroleum coke, a refinery by-product, to deliver 500MW of low carbon power. Almost 4 million tonnes of CO2 will be permanently stored each year.

Moving forward, we are investigating the possibility of utilising hydrogen derived from coal, ensuring the long term value of this important fossil fuel can be maintained in an increasingly carbon-constrained world. Australia has the potential to play a very significant role in the development of this clean coal power generation, and could act as a technology and intellectual property hub for deployment throughout the Asia Pacific region.

Addressing the terms of reference

1. The science underpinning geosequestration technology

The science underpinning CCS has been determined over many decades, driven primarily by the oil and gas industry and international research communities. The technology is now developing rapidly, and has three key elements: capture, transportation and storage. The most recent comprehensive assessment of the technology is the IPCC Special Report on Carbon Dioxide Capture and Storage which was published in 2005. The international Carbon Capture Project (CCP), in which BP has played a leading role, is another major contributor[5].

Capture technologies are already available, but often have only been tested at smaller scale than that required for industrial scale power generation. Capture technology options include pre-combustion decarbonisation (removing the carbon from the fuel before it is burned in the form of CO2), post combustion decarbonisation (also referred to as flue gas scrubbing) and oxy firing technologies (burning the fossil fuel in an oxygen-rich environment).

Pre-combustion technologies have been used extensively for the manufacture of hydrogen for ammonia and fertiliser applications and for upgrading of heavy crude oil in refineries. Both DF1 and DF2 are based upon the pre-combustion route i.e. first converting the fossil fuel into hydrogen and CO2, and then separating the CO2 prior to burning the remaining hydrogen. Some of the technologies available e.g. autothermal reforming of natural gas, have already been deployed at a scale close to that required for BP's DF1 project.

There is also a body of experience building with post combustion scrubbing. Although deployment of large scale amine units to capture CO2 has not yet occurred, similar units for the scrubbing of oxides of sulphur have been deployed at a relevant scale demonstrating that there is no technological barrier to building equipment of the right size.

Both the In Salah and Sleipner applications of CCS use an amine scrubbing process to capture the CO2. However, the learnings from these and the many other examples of gas treatment around the world cannot be directly applied to the capture of CO2 from a combustion process as the separation in natural gas treatment takes place at a much higher pressure making it considerably more straightforward.

Oxyfiring is currently a less mature technology that will require further testing and proving before deployment at scale.

In different industrial settings, each technology can be deployed at power plants as new-build and, in some cases, retrofit, and they have application to all fuel types from gas to coal. However all these are capital intensive, and their further development and cost reduction will continue at a limited pace in the absence of policy initiatives supporting demonstration and commercial deployment.

With regard to transportation, the oil and gas industry has over thirty years experience in transporting large volumes of CO2 in pipelines and ships. The costs

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[5] http://www.co2captureproject.com/index.htm

and issues of CO_2 transportation are well known and little further Research and Development (R&D) is required for commercial deployment.

In the United States, an extensive pipeline network has evolved to take CO_2 from natural accumulations in Colorado to the oilfields of West Texas. This network currently transports in excess of 20 million tonnes CO_2/year. The longest line exceeds 500 miles and was installed with the aid of public policy incentives aimed at improving security of oil supply in the United States. Corrosion in the pipeline network is routinely managed by drying the CO_2 so that standard carbon steel can be used.

Finally, there is the storage aspect. The oil and gas industry has over one hundred years of experience identifying and managing fluids in the deep sub-surface. The geological storage of CO_2 is very similar to the management of other liquids and gases routinely handled by the industry throughout the world. Indeed, for over thirty years, CO_2 has been injected into reservoirs for the purpose of Enhanced Oil Recovery (EOR). BP currently injects over 10 billion standard cubic feet of gas (currently primarily hydrocarbon) into oil reservoirs to aid recovery. If this was all CO_2 it would be equivalent to over 200 million tonnes/year providing ample evidence that this technology has the potential to be deployed at a material scale.

Technologically, what sets CO_2 storage apart from normal EOR operations is the requirement for assurance of long-term storage integrity. Much of the technology currently under development is concentrated upon providing confidence around this whole aspect. The structural and mechanical integrity of the reservoir and wells are areas of specific study, as are the appropriate conditions necessary to allow a reservoir to become an active storage site.

The existing experience with engineered systems (timescale of decades) and the study of natural analogues that have held CO_2 for periods of millions of years has given considerable confidence that it is both feasible and viable to design and operate geological storage systems that will contain CO_2 for periods of thousands of years at a minimum.

Ultimately, when the geological reservoir is at the end of its active storage phase, it will be closed. Once again, the industry has considerable experience of oil and gas field closure, and much of this will be used to ensure long term safe, secure storage of CO_2 in the rock. The associated issue of long term liability and the monitoring and reporting of the sealed reservoir will need to be resolved.

2. The potential environmental and economic benefits and risks of such technology

Because the world will be dependent on fossil fuels for the next fifty years, fossil fuel-based technological solutions for carbon mitigation will be one of the major contributors to stabilisation.

The potential offered by geosequestration technology (or carbon capture and storage, CCS) to reduce greenhouse gas emissions is substantial. It is estimated that up to one third of the required reductions in global CO_2 emissions could be made by CCS technology. CCS is uniquely placed to help build a bridge to a low or no carbon energy future over the next 50 to 100 years.

Australia is the 3rd largest producer of coal, and the largest exporter of coal in the world. Coal is currently the country's primary export earner. However, a future where it is likely that greenhouse gas emissions will be constrained would have a significant impact on the value of these vast fossil fuel reserves.

Within Australia, black and brown coal provide over 40% of the country's primary energy needs, and are responsible for over 30% of the country's greenhouse gas emissions. Unless a solution can be found to reduce these emissions, there can be no doubt that growth in this sector would be limited.

Given the level of expertise in CCS technology in Australia, there is significant potential to develop a CCS industry, undertaking not only domestic projects to reduce emissions but exporting this technology and know-how to international markets.

As previously mentioned, the component parts of the technology of CCS are well understood and established, with over 35 million tonnes of CO_2 per year currently being injected into subsurface structures around the world (32 million tonnes/year for Enhanced Oil Recovery and 3 million tonnes/year for climate change reasons).

The risk of leakage is one of the main areas of concern relating to CO_2 storage. This could occur either as a result of a failure of the sealing properties of the geological storage layer, or as a consequence of failure of a well that has been used to access (or passes through) the storage layer. Considerable research has been performed to assess the risks associated with leakage. The IPCC Special Report assesses the risks associated with leakage to be low and states that there is a 99% probability that any given storage site will remain integral for at least 1000 years.

The process of long-term CO_2 storage covers several phases. As soon as injection of CO_2 stops, re-adjustment of the remaining water around the CO_2 stream causes "snap-off", resulting in the trapping of 20 – 40% of the CO_2 as isolated bubbles that can no longer move. Then over a period of decades to centuries, an increasing amount of CO_2 will dissolve into the water. Once it has done this, the CO_2 saturated water is slightly heavier than unsaturated water so it will tend to sink rather than try and rise towards the surface. Finally over even longer time periods, CO_2 dissolved in water will react slowly with minerals present and become immobilised as a solid.

The requirement for assurance of long-term storage integrity is important for wider public acceptance of the technology. Much of the technology currently under development and demonstration activity on current projects like Sleipner, In Salah and future projects like that in the Otway Basin is concentrated upon providing confidence around this aspect. The structural and mechanical integrity of the reservoir and wells are areas of specific study, as are the appropriate conditions necessary to allow a reservoir to become an active storage site.

In a wider context the risk of CO2 leakage as a result of CCS needs to be compared with the risks and impacts of climate change. On this basis we consider that CCS will be perceived as an important technology in the transition to a low carbon future.

A more likely threat to the uptake of CCS technology is the fact that there is little commercial incentive to deploy it at scale in Australia. Australia has access to some of the cheapest energy in the world, and in this environment, cleaner technologies cannot compete without significant policy support.

3. The skill base in Australia to advance the science of geosequestration

Australia is well-placed to respond to the likely constraint on greenhouse gas emissions from fossil fuels. Through groups such as the Cooperative Research Centre for Greenhouse Gas Technologies (CO2CRC), Australia has built and continues to build a wealth of knowledge and expertise in the area of CCS technology.

The research programme of the CO2CRC involves targeted research activities in the science and technology of both the capture of CO2 from gas streams and the characterisation of underground storage mechanisms. The involvement of a wide spectrum of stakeholders, from different industry sectors and research communities has also been beneficial. BP is a participant in CO2CRC.

The efficient and cost effective capture of CO2 from gas streams from combustion, gas processing and chemical operations is an important precursor to ensuring that subsequent geosequestration is possible. The work being conducted in this area by the CO2CRC covers a broad range and takes into account different sources of CO2 generation and a number of alternative technology options for CO2 removal. This is complemented by monitoring of other international work.

The CO2CRC has built a strong and positive international reputation for its contribution to the understanding of the factors that characterise the storage mechanisms in both mature oil and gas fields and saline formations. The research activities cover a number of activities with a strong emphasis on carrying out regional geological studies and assessment of the suitability of individual sites for storage, the characterisation of the geological features necessary for effective storage, technical modelling mechanisms to allow predictions to be made around the capacity and behaviour of underground storage sites and the nature and effectiveness of monitoring and verification techniques necessary to ensure permanent retention of stored gas.

As part of this programme there has been extensive analysis of the opportunities for storage of CO2 in a number of sedimentary basins within Australia and in Asia. The work by GEODISC reviewed the national potential and established an effective methodology and approach for national assessments. This work showed that there is extensive storage potential in Australia. It recognised the need for source - sink matching and focused assessment of individual storage sites. For example, the well-characterised Gippsland Basin in the Bass Strait, site of the Bass Strait oil and gas production offers the potential to store over two billion tonnes of CO2. This area is favourably located relative to existing and future CO2 sources in the Latrobe Valley of Victoria.

All the data, particularly the site assessments, are available to those considering the application of sequestration - the CO2CRC is also able to offer advice and consultancy services to interested parties.

The CO2CRC is conducting a pilot programme onshore in the Otway Basin. The project involves the injection of a CO2 rich stream into a depleted gas reservoir under controlled conditions and the monitoring of the technical storage parameters. The project is large enough to demonstrate technical characteristics and provide meaningful results. It also offers the opportunity to generate extensive operational data under supervisory conditions, which is important to the independent review of the technology and successful demonstration of sequestration. The project will also offer the potential to provide a future training and research facility, subject to funding.

Many of the skills necessary for sequestration are to be found in the oil and gas industry. A number of industry players in Australia, including BP, are members of the CO2CRC and its associated activities, and are therefore contributing their global expertise and experience to the discussions. This, combined with the research programmes and pilot project outlined above, will help to develop the science, technology and expertise required for a CCS programme in Australia. Understanding technical risks will contribute to understanding overall investment risks in the adoption of the technology.

A key requirement for the commercial application of sequestration is that a sound policy and regulatory framework is in place. This is not currently the case in Australia. The development of policy and regulation should be based on sound science and understanding, and acknowledgement that CCS can play a significant role in reducing greenhouse gas emissions, not just in Australia but around the world.

4. Regulatory and approval issues governing geosequestration technology and trials

Opportunities for CCS developments are now becoming a reality in Australia, and it is important that legislation be considered now so that deployment of this critical technology is not hampered by lack of a suitable legislative policy framework.

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The draft legislative framework for CCS currently under development by the Australian Government Department of Industry, Tourism and Resources is an excellent starting point from which to facilitate the uptake of CCS, building on a proven approach to oil and gas regulation, the Offshore Petroleum Act 2006. We endorse the Government's approach that the legislation should be introduced as soon as is reasonably practicable (expected February 2007).

In order to encourage significant investment in CCS, it is important to create a level playing field for low carbon technologies that recognises and responds to the interests and rights of both petroleum and CCS title holders, and acts in Australia's national interest. This is very important as it reflects the fact that CCS technology has a significant role to play in delivering energy in a carbon-constrained world, and deployment of this technology should be encouraged at scale.

Throughout development of a legislative framework, it is important to consider appropriate risk management. For example, the objective of CO2 storage is to capture large volumes before they enter the atmosphere, rather than prevent very small quantities from re-entering the environment. CCS must become a 'commodity business' to be an effective tool in abating atmospheric CO2.

Care will need to be taken in determining the regulatory framework around CO2 storage integrity and related issues such as site selection, monitoring and abandonment provisions. An appropriate monitoring and verification should be designed to mitigate risk, rather than introduce unnecessary costs and liabilities for operators which will impede uptake of CCS technology.

There are other issues where government has a role to play. For example, proposed amendments in the London Convention will need to be agreed and the status of offshore storage in saline formations clarified. Australia's leadership on this requirement is recognised and appreciated.

5. How to best position Australian industry to capture possible market applications

With its world-class knowledge base, well-defined storage capacity and vast reserves of fossil fuels, Australia is exceptionally well-placed to become a world leader in CCS technology, both to secure the value of its own resources, and to export technology and know-how internationally.

Clearly, there are important issues of cost and what is required in terms of market and policy measures to allow the technology to be commercialised. It is not unreasonable to expect existing CCS technology to be in operation within five years, provided that stable market conditions and the necessary policy mechanisms are in place.

It is expected that technology costs of CCS will reduce over time, and will require diminishing support. If so, the competitiveness of CCS will progressively increase. Currently, some 70 per cent of the cost of CCS occurs in the cost of CO2 capture.

Infrastructure costs for moving CO2 are a significant component. But some of this cost may be offset if the re-use of existing infrastructure is feasible and encouraged. Equally, were Australia to become a global leader in the export of technology and expertise, this would further help to offset the initial costs of developing CCS technology.

Policy makers throughout the world need to embrace CCS within their mix of measures by creating a level playing field of support and incentives for low and zero carbon energy. If the ultimate objective is to reduce greenhouse gas emissions, there is no doubt that a policy framework which supports the widespread deployment of CCS is both necessary and desirable.

The costs of power generation with CCS are similar to renewables. It is important therefore to develop a climate change policy that seeks to reward low carbon (or carbon free) energy on an objective, impartial basis rather than through the "picking of technology winners". The work at Princeton demonstrates how a variety of carbon reduction strategies and technologies will be required in order to reduce significantly greenhouse gas emissions.

BP believes that a market-driven carbon price is the most efficient way of internalising the cost of climate change, at least for large emitters. But while emissions trading should remain at the core of future global climate policy - and should therefore include CCS – the current price of carbon in these schemes is insufficient to incentivise the deployment of new technology.

This is because such a scheme would focus upon encouraging the efficient use of energy amongst existing large emitters, and the marginal addition of new commercially competitive technology, such as fuel switching from coal to gas. It is not designed to deal with the much higher costs associated with developing new technology. Additional policy is, therefore, needed to focus upon accelerating the introduction and cost reduction of new technology, including renewables and CCS.

Possible policy options include:

- targeted financial support for low carbon energy and CCS (for example, extension of the Low Emissions Technology Demonstration Fund)
- accelerated depreciation for CCS projects
- clear guidance that early movers into CCS will not be disadvantaged by a future greenhouse gas regime
- clear guidance around long-term liability for CCS, based on a risk management approach
- extension of the Mandatory Renewable Energy Target to include low emission energy generated from decarbonised fossil fuels
- feed-in tariffs for low carbon energy, as introduced in Germany to drive solar and wind markets.

Australia must continue to engage internationally by playing a leading role in the Intergovernmental Panel on Climate Change, Asia Pacific Partnership for Clean Development and Climate, the Carbon Sequestration Leadership Forum and International Energy Agency. Though these discussion, a streamlined approach to technical and regulatory issues can be developed that will further encourage deployment of CCS at scale.