5

The environmental benefits and risks of CCS and public perception

Introduction

5.1 The environmental impact of carbon capture and storage (CCS) is a critical issue in determining whether this technology should be part of the suite of options used to combat increasing greenhouse gas emissions, both nationally and internationally. As the purpose of CCS technology is to reduce the negative impact of anthropogenic greenhouse gas emissions on the environment, the environmental benefits of CCS need to outweigh the potential environmental risks.

5.2 The greatest environmental risk associated with CCS relates to the long term storage of the captured CO_2. Leakage of CO_2, either gradual or in a catastrophic leakage, could negate the initial environmental benefits of capturing and storing CO_2 emissions and may also have harmful effects on human health. On the other hand, CCS has the long term potential to make a substantial positive impact on the amount of CO_2 emitted into the atmosphere by the stationary energy sector. Therefore the potential risks need to be weighed against the potential benefits, and also the possible consequences of inactivity.

Environmental benefits

5.3 The major environmental benefit of CCS to both Australia and the world is its potential to reduce atmospheric levels of CO_2 while fossil fuels continue to be used to fuel the world's energy consumption.[1]

5.4 This potential, however, depends upon the amount of CO_2 captured and the amount (if any) of leakage from transport and long term storage of CO_2. The potential benefits needs also to be measured against the level of risk to the environment through CCS, compared to the risks if CCS is not used.

5.5 A recent ABARE study, which models the impact of the global deployment of CCS and non-CCS technology, indicates that CCS has the potential to substantially contribute to global greenhouse gas emission abatement.[2]

5.6 Commenting on the ABARE study, the Australian Government submission notes that:

> While CCS technology has the potential to contribute to emission reductions in Australia, it is the broader deployment of CCS, particularly in large economies such as the United States, China and India, (which account for 41% of global greenhouse emissions) that could potentially deliver significant global environmental benefits through a substantive reduction in greenhouse gas emissions above what could be achieved without CCS technologies.[3]

5.7 The ABARE study models the emission level reductions likely to occur through the application of energy efficiency and low emission technologies, including and excluding the use of CCS.

5.8 In Australia, the benefit of emissions reduction from the uptake of CCS is better. If the use of CCS is excluded, just the application of energy efficiency and low technologies would see a global 18 per cent reduction in greenhouse gas emissions by 2050 against a business as usual scenario. With CCS, there would be a 25.8 per cent reduction in emission levels against a business as usual scenario. This suggests an

1 Australian Government, *Submission No. 41*, p. 13.

2 A. Matysek, M. Ford, G. Jakeman, A. Gurney, and B.S. Fisher, *Technology: Its role in economic development and climate change,* ABARE Research Report 06.6, Canberra, July 2006. Cited in ABARE, *Submission No. 28*, p. 1.

3 Australian Government, *Submission No. 41*, p. 14.

additional 7.8 per cent emission reduction benefit globally when CCS is used.[4]

5.9 In addition, ABARE notes that, while greenhouse gas emissions from electricity production will continue to rise until approximately 2020, if CCS technologies are applied to all new coal and gas fired electricity generation in combination with efficiency improvement and fuel switching, the result will be an absolute global reduction in electricity emissions.[5]

5.10 ABARE also notes that, while the uptake of CCS and more energy efficient and cleaner technologies is expected to markedly reduce greenhouse gas emissions by 2050, the impact on cumulative emissions is less significant. This is largely due to the time lag between these technologies becoming available and their widespread uptake.[6]

5.11 Despite this time lag, evidence to the House of Commons Science and Technology Committee's (UK) report on meeting UK energy stated that CCS technology should be thought about beyond 2020. The report concluded that 'CCS could play a vital role in helping the UK get back on track to meet its 2050 target to reduce CO_2 emissions by 60 per cent compared with 1990 levels.'[7]

5.12 MIT has also undertaken modelling on the take-up and effect of CCS. MIT modelling shows minimal uptake of CCS before 2030 and significant growth (albeit not universal) in the uptake of CCS from 2030 to 2050.[8] By 2050, MIT modelling predicts that, with universal simultaneous participation and high CO_2 prices, CCS technology is

4 A. Matysek, M. Ford, G. Jakeman, A. Gurney, and B. S. Fisher, *Technology: Its role in economic development and climate change,* ABARE Research Report 06.6, Canberra, July 2006, pp. 100-101.

5 A. Matysek, M. Ford, G. Jakeman, A. Gurney, and B. S. Fisher, *Technology: Its role in economic development and climate change,* ABARE Research Report 06.6, Canberra, July 2006, pp. 60-61

6 A. Matysek, M. Ford, G. Jakeman, A. Gurney, and B. S. Fisher, *Technology: Its role in economic development and climate change,* ABARE Research Report 06.6, Canberra, July 2006, p. 63.

7 House of Commons, Science and Technology Committee (United Kingdom), *Meeting UK energy and climate needs: The Role of carbon capture and storage.* First Report of Session 2005-06, p. 63 & p. 66.

8 Massachusetts Institute of Technology (MIT), *The Future of coal: Options for a carbon constrained world,* Cambridge MA, March 2007, p. 11.

likely to reduce global greenhouse gases by as much as 3-4 Gt per year compared to mitigation measures which do not include CCS.[9]

5.13 However, the IPCC states that current indications are that 'the majority of CCS deployment will occur in the second half of this century'.[10] The IPCC also states that, when this deployment does occur, 'the consensus of the literature shows that CCS could be an important component of the broad portfolio of energy technologies and emission reduction approaches.'[11]

5.14 From the IPCC report, the UK House of Commons report and MIT modelling, it appears likely that if even CCS technology is applied its impact on CO_2 emissions will only moderate by 2020. The significant impact of any CCS application is more likely to be in the later half of the 21st century.

5.15 According to the CO2CRC, the following is now required to achieve environmental benefits from lower CO_2 concentrations:

- a very intensive period of research, development and demonstration between now and 2015 to bring down the costs of geosequestration;
- from 2015 onwards all new power stations would be equipped with low emission technology including geosequestration. Over the subsequent 40 years all existing power stations would be phased out to be replaced with low emission power generation;
- additionally it is proposed that from 2035 onwards, low emission transportation, based on geosequestration-enabled hydrogen or electricity generation, would be progressively introduced over the subsequent 20 years; and
- by 2055, all electricity generation and transportation would be "geosequestration enabled".[12]

5.16 If such steps are taken in combination with other mitigation strategies, then atmospheric CO_2 concentrations could be stabilised.

5.17 While globally the predictions for the long term environmental benefits of CCS are positive, some evidence to the Committee

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9 Massachusetts Institute of Technology (MIT), *The Future of coal: Options for a carbon constrained world,* Cambridge MA, March 2007, p. 15.

10 IPCC, *Carbon capture and storage: Summary for policy makers and technical summary,* 2005, pp. 41-42.

11 IPCC, *Carbon capture and storage: Summary for policy makers and technical summary,* 2005, pp. 41-42.

12 CO2CRC, *Submission No. 36,* pp. 12-13.

questioned the capacity for CCS to significantly impact on Australia's CO_2 emissions from stationary power sources. Greenpeace Australia Pacific (Greenpeace), for example, noted research undertaken by The Australia Institute in 2004 which found that:

> In Australia, the use of geosequestration would lead to, at best, a 9 per cent emission reduction in 2030, and a cumulative emissions reduction from 2005 to 2030 of only 2.4 percent.[13]

5.18 Greenpeace went on to claim that comparable and/or better reductions can be achieved through equivalent investment in gas-fired power generation and a doubling of Australia's Mandatory Renewal Energy Target (MRET).[14]

5.19 Similarly, Friends of the Earth Australia argued in their submission that not only is CCS technology expensive, essentially unproven and possibly highly dangerous, it only has the potential to provide an 8 per cent reduction in emissions from electricity production.[15]

5.20 If Australia and the world remain dependent on fossil fuels to produce electricity, as is predicted for the foreseeable future, CCS provides the greatest potential to reduce the greenhouse gases emitted by our stationary energy sector.[16]

Environmental risks

5.21 Carbon dioxide is part of the atmosphere we breathe and is essential to all life forms. It is odourless and non-toxic. However, as it is denser than air, if it accumulates in low-lying areas in high concentrations then it can prove harmful to humans and animals.[17]

5.22 The most substantial risk associated with CCS is the leakage of CO_2 from storage sites. While there is some experience with geological storage of CO_2 and natural gas for periods of approximately 10-20 years, long term storage over many hundreds or thousands of years

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13 Greenpeace Australia Pacific, *Submission No. 15,* p. 12.

14 Greenpeace Australia Pacific, *Submission No. 15,* p. 12-13.

15 Friends of the Earth Australia, *Submission No. 13,* p. 4.

16 A. Matysek, M. Ford, G. Jakeman, A. Gurney, and B. S. Fisher, *Technology: Its role in economic development and climate change,* ABARE Research Report 06.6, Canberra, July 2006, pp. 100-101.

17 Australian Government, *Submission No. 41,* p. 28.

has not been proven.[18] However, as argued by CSIRO, the ongoing study of naturally occurring underground accumulations of CO_2 has increased knowledge and confidence in the viability of CO_2 storage.[19]

5.23 The IPCC Special Report on CCS suggests that the environmental risks associated with CO_2 capture and storage are low. As the IPCC stated:

> …well-selected geological formations are likely to retain over 99% of their storage over a period of 1,000 years. Overall, the risks of CO_2 storage are comparable to the risks in similar existing industrial operations such as underground natural-gas storage and [EOR].[20]

5.24 Furthermore, according to many submissions, the safety, health and environmental risks associated with CCS are similar to, or less than, those already experienced in the oil and gas industry.[21]

5.25 Nevertheless, concerns have been expressed regarding the long term storage of CO_2. Two types of CO_2 leakage that may occur are:

- abrupt leakage through injection well failure or leakage up an abandoned well; and
- gradual leakage, through undetected faults, fractures or wells. [22]

Abrupt leakage

5.26 Abrupt or catastrophic leaks of CO_2 could have serious consequences to the environment, potentially causing the death of humans and animals.[23] Leakages have been known to occur naturally, such as at Lake Nyos in Cameroon in 1986.[24]

18 TRUenergy, *Submission No. 17,* p. 1; Country Women's Association of NSW, *Submission No. 6,* p. 2; Friends of the Earth Australia, *Submission No. 13,* p. 7.

19 CSIRO, *Submission No. 10,* p. 2.

20 United Nations Environmental Programme (UNEP), *Can carbon dioxide storage help cut greenhouse emissions? A Simplified guide to the IPCC's 'Special report on carbon dioxide capture and storage',* April 2006, p. 15.

21 Anglo Coal, *Submission No. 24,* p. 21; Rio Tinto, *Submission No. 31,* p. 4; National Generators Forum, *Submission No. 35,* p. 4.

22 Australian Government, *Submission No. 41,* p. 15.

23 Friends of the Earth Australia, *Submission No. 13,* p. 6; Australian Government, *Submission No. 41,* p. 15.

24 Below Lake Nyos lies a pocket of magma that leaks CO_2 into the waters. In August 1986, a large amount of CO_2 was emitted from the lake, suffocating approximately 1 700 people and 3 500 livestock living within 25 kilometres of the site. Dr D. Maddison, *Submission No. 11*, p. 2.

5.27 There is the potential for CO_2 that is sequestered as part of the CCS processes to leak from storage points. Such leakage could occur if the well seal at the point of storage failed thereby resulting in the release of sequestered CO_2.

5.28 Evidence to the Committee from Greenpeace and the Australian Government also suggested that pressure built up by injected CO_2 could trigger small seismic events.[25]

5.29 In his submission Dr Maddison also raised potential risks associated with CCS, stating that:

> carbon dioxide sequestration is poorly conceived, cannot guarantee sequestration of gas forever as is necessary and has potential for great harm due to accidental or deliberate release.[26]

5.30 It has been suggested that CO_2 storage sites may become potential terrorist targets or that failure of the seal could result in catastrophic release. Greenpeace points out that concentration of CO_2 greater than 7-10 per cent by volume in the air puts the lives and health of people in the vicinity in immediate danger.[27]

5.31 However, evidence suggests that if storage sites are carefully selected, the chances of a catastrophic leak would be minimal. Current demonstration projects, such as the Otway Demonstration Project, extend understanding of the scientific processes and risk minimisation associated with the selection, sequestration and monitoring of CO_2 in an Australian context.

Gradual leakage

5.32 Gradual leakage could occur as a result of incorrect site selection and inadequate preparation.[28] This leakage would compromise the initial objective of removing the CO_2 from the atmosphere.

5.33 Other dangers associated with gradual leakage have also been highlighted. According to the International Association of Hydrogeologists, CCS is a potential environmental risk to overlying fresh groundwater resources and therefore CCS should only be

25 Greenpeace Australia Pacific, *Submission No. 15*, p. 16; Australian Government, *Submission No. 41*, p. 15.

26 Dr D. Maddison, *Submission No. 11*, p. 2.

27 Greenpeace Australia Pacific, *Submission No. 15*, p. 16

28 Greenpeace Australia Pacific, *Submission No. 15*, p. 16.

considered in geological formations which are not potential groundwater resources i.e. aquifers which are not connected with active groundwater flow systems.[29]

5.34 In terms of assessing the probability of leakage and escape of CO_2, Greenpeace points out that little is known about the behaviour of large quantities of CO_2. Greenpeace suggests that, because of the complex geology of each individual storage site, evaluation can only be conducted on a case by case basis.

5.35 Greenpeace states that storing CO_2 underground can dissolve the minerals that help stop the gas from escaping. The results from tests that injected CO_2 into saline aquifers in Texas showed that sequestration made aquifer water more acidic. This acidity attacked the surrounding rock formations, causing them to dissolve and thereby potentially allowing the gas to leak into the water table.[30]

5.36 In his evidence, Dr Maddison expresses similar concerns regarding potential leakage. He contends that there may be problems associated with the use of depleted gas fields, including rocks cracking as gas is removed causing structural changes which may result in the rock structure no longer being able to hold their contents for long periods of time. Furthermore, problems also exist in association with the re-pressurising of rocks when injecting CO_2 and the integrity of the well plug. Dr Maddison states that 'there is no proof that once a field is filled with carbon dioxide, the plug can or will remain intact over the rest of time.'[31]

Risk mitigation strategies

5.37 Rigorous risk mitigation strategies should be developed and implemented in order to reduce the risk of CO_2 leakage. For example, in evidence to the Committee it was noted that the risks of leakage during pipeline transportation can be reduced if care is taken that the water content of the CO_2 stream is kept low. This will avoid corrosion of the carbon manganese steel used in most pipe construction.[32]

29 International Association of Hydrogeologists, *Submission No. 8,* p. 1.

30 Greenpeace Australia Pacific, *Submission No. 15,* pp. 17-18.

31 Dr D. Maddison, *Submission No. 11*, p. 1.

32 Australian Government, *Submission No. 41,* p. 11.

5.38 Greenpeace raised concerns about the relative lack of experience with CCS risk mitigation strategies and the need for long term monitoring techniques.[33]

5.39 The CSIRO states that proper regulation is necessary to 'ensure that operators are competent, sites are appropriately chosen, and that wells are properly cemented.'[34]

5.40 CSIRO contends that catastrophic leakage is unlikely if sites are well selected, operators are competent and wells are properly sealed.[35] Rigorous site selection, diligent monitoring and management of the injection site are all critical factors and it is important that these activities are appropriately regulated.[36] Likewise, Chevron stated that 'the most effective way to mitigate the risk of containment failure is through rigorous site selection and management of injection operations'.[37]

The Gorgon Project and environmental issues

5.41 The Gorgon Project has highlighted some of the environmental challenges which arise from carbon sequestration projects. As discussed in Chapter 4, the Project plans to sequester around 2 million tonnes of CO_2 in a saline aquifer beneath Barrow Island, off the Northwest coast of Australia. Project operators, Chevron Australia, described it as, to the best of their knowledge, 'the first time a major geosequestration project has undergone such an exhaustive environmental impact assessment.'[38]

5.42 The environmental assessment, conducted by the Environmental Protection Authority (EPA), raised a range of environmental issues centred on dangers to Barrow Island's status as a Class A nature reserve. These included risk to a local population of flatback turtles, dredging, the introduction of non-indigenous species, and potential risks to rare subterranean and short-range invertebrate fauna.[39]

5.43 A submission from the Western Australian Government Department of the Environment elaborated on the risk CCS poses to these

33 Greenpeace Australia Pacific, *Submission No. 15,* p. 18.
34 CSIRO, *Submission No. 10,* p. 7.
35 CSIRO, *Submission No. 10,* p. 7
36 Chevron Australia, *Submission No. 12,* pp. 8-9.
37 Chevron Australia, *Submission No. 12,* p. 15.
38 Chevron Australia, *Submission No. 12,* p. 8.
39 Department of Environment (Western Australia), *Submission No. 3,* pp. 1-2.

subterranean fauna. The fauna are widely distributed in Western Australia, often in the sedimentary formations that are attractive for geosequestration.[40]

5.44 The Gorgon Project is based partly on positive comparisons with the successful Sleipner Project. Critics have noted, however, that the substantial differences between the sequestration sites raise further environmental questions in relation to Gorgon:

> At Gorgon, the annual volume of CO_2 to be stored is 5 times that of the Sleipner project. At Sleipner, a subsea aquifer is being used as the storage location but at Gorgon the proposed storage aquifer is under dry land. The storage location at Gorgon, some 2300 metres below the surface is 1500 metres deeper than at Sleipner. How will the CO_2 react to the temperature and pressures at this depth? Where will it migrate to? What effect will it have on subsurface geology? What effect will buoyancy have on the sequestered CO_2? Does the storage area have adequate seal integrity? Will previously drilled wellbores into the proposed storage area allow seepage back to the surface? What is the metallurgical integrity of those wells? CO_2 is highly corrosive, so what effect will there be on the well architecture? What effects could it have on fauna or flora if it does seep out? What happens to the sequestered CO_2 if there is a large earthquake in the immediate vicinity?[41]

5.45 In June 2006, the EPA recommended that the project not proceed based on potential environmental risks. The EPA stated that the joint venture had not been able to demonstrate that impacts from dredging, the introduction of non-indigenous species and the potential loss of fauna could be reduced to acceptable levels.

5.46 After further negotiations with the project partners, the Western Australian Government, on 12 December 2006, gave the approval for the Project to proceed.[42] The joint venturers agreed to allocate a further $60 million to address environmental concerns. Further EPA concerns were also addressed by a commitment from the Western

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40 Department of Environment (Western Australia), *Submission No. 3,* p. 1.

41 M. Hastings, 'Australia: Gorgon Gas Project – Ugly by name', *Australian Energy Bulletin,* <energybulletin.net/5219.html>, accessed 14 May 2007.

42 M. McGowan MLA, Minister for Education and Training (Western Australia), Media Statement, *Tough conditions imposed on Gorgon gas project,* 12 December 2006, <mediastatements.wa.gov.au>, accessed 30 May 2007.

Australian Government to expand land and marine parks and reserves in the Pilbara and lower west Kimberley.

Committee conclusion

5.47 The Committee considers there are positive environmental benefits to be gained from the deployment of CCS, providing there is also the appropriate regulation and scrutiny of environmental risks.

5.48 A regulatory risk mitigation framework needs to address:

- Criteria for CCS site selection and an assessment of the environmental impact at selected sites;
- Assessment of the risk of abrupt or gradual leakage, and appropriate response strategies; and
- Requirements for long-term site monitoring and reporting.

Recommendation 3

The Committee recommends that the Australian Government implement a rigorous regulatory environmental risk mitigation framework for CCS which covers:

- **Criteria for CCS site selection and an assessment of the environmental impact at selected sites;**
- **Assessment of the risk of abrupt or gradual leakage, and appropriate response strategies; and**
- **Requirements for long-term site monitoring and reporting.**

Public perception and education

5.49 The Australian Government's submission notes research from Canada, the UK and Australia which indicates that the public is not well informed on CCS technology and its potential for climate change mitigation. The major public concern relates to potential leakage and consequent impact on ecosystems and the environment.[43]

43 Australian Government, *Submission No. 41*, p. 32.

5.50 The Australian Government has suggested that, based on:

> public concerns about CCS, liability of leakage and the linkage between CCS and other regulations on climate change, guidelines to secure public involvement through consultation processes when developing legislation and assessing CCS projects should promote a transparent process in all stages of the carbon capture and storage life cycle.[44]

5.51 Similarly, Chevron commented that:

> Community understanding of geosequestration as an appropriate greenhouse emissions reduction tool can be addressed by ongoing research and demonstration activities but widespread acceptance will only be achieved through securing successful, large scale projects and demonstrating the long-term integrity of this approach.[45]

5.52 To this aim, and as noted in the Australian Government submission, an important element of the Otway Basin Pilot Project is to inform and educate the community about CCS.[46] Public meetings held near the proposed storage site have been conducted, with further meetings scheduled in 2007. Newsletters are also to be circulated to everyone in the nearby Nirranda community. Stakeholder groups have also been formed and will meet on a regular basis to identify and deal with any issues that arise.[47]

5.53 Nevertheless, Friends of the Earth Australia suggests that public consultation for the Otway Basin Pilot Project has been inadequate[48] — a claim countered by CO2CRC who have alternatively claimed that extensive consultations preceded the announcement and these will continue to occur throughout the life of the project.[49]

5.54 Whatever decisions are made regarding the uptake of CCS, the community needs to be fully convinced about the long-term safety of

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44 Australian Government, *Submission No. 41,* p. 32.

45 Chevron Australia, *Submission No. 12,* p. 5.

46 Australian Government, *Submission No. 41,* p. 32.

47 CO_2CRC, *Geosequestration Research Project Update,* Issue 2, April 2007, p. 1, <co2crc.com.au/pilot/OBPPDL/OBPP_NL/ResearchProjectUpdate_Issue02.pdf>, accessed 30 May 2007.

48 Friends of the Earth Australia, *Submission No. 13,* pp. 8- 9.

49 CO_2CRC, *Geosequestration Research Project Update,* Issue 2, April 2007, p. 1, <co2crc.com.au/pilot/OBPPDL/OBPP_NL/ResearchProjectUpdate_Issue02.pdf>, accessed 30 May 2007.

storing large volumes of CO_2 deep underground, particularly in areas located next to or nearby population centres.

Conclusion

5.55 The key goal of CCS is to achieve an environmental benefit by removing a large quantity of CO_2 from the earth's atmosphere and, in doing so, help redress some of the problems associated with climate change.

5.56 There are some potential environmental risks associated with CCS technology, most particularly in terms of potential leakage of CO_2 from storage sites. However, experience in monitoring the activity of naturally occurring deposits of CO_2, in transporting hydrocarbons via pipeline for many years and in the injection and storage of CO_2 over the past 10 years, means that the risk of adverse and harmful outcomes from CCS is minimal.

5.57 Furthermore, as the Australian Government submission points out, CO_2 is less reactive than other materials that are handled in a like manner and pipeline standards and operating conditions are well advanced the world over.[50]

5.58 Likewise, the Stern Review expressed the view that climate change, if unchecked, would have very serious impacts on the environment:

> The scientific evidence is now overwhelming: climate change is a serious global threat, and it demands an urgent global response … If no action is taken to reduce emissions, the concentration of greenhouse gases in the atmosphere could reach double its pre-industrial level as early 2035, virtually committing us to a global average temperature rise of over 2˚C. In the longer term, there would be more than a 50% chance that the temperature rise would exceed 5˚C. This would be very dangerous indeed; it is equivalent to the change in average temperatures from the last ice age to today.[51]

5.59 It is interesting to note comments by Rupert Murdoch who stated that:

50 Australian Government, *Submission No. 41*, p. 11.

51 United Kingdom Treasury, *Stern review on the economics of climate change,* 30 October 2006, p. vi.

> I am no scientist but … I do know how to assess a risk. Climate change poses clear catastrophic threats. We may not agree on the extent, but we certainly can't afford the risk of inaction.[52]

5.60 While recognising the risk of inaction, it is also important that one risk of environmental harm is not replaced with another. Therefore, CCS will need to be subjected to the same rigorous legislative and regulatory scrutiny as any other mining or petroleum venture. Such scrutiny will assist in reassuring the general public that sequestering CO_2 deep below the earth's surface will be safe and secure in the short, medium and long-term.

5.61 The Committee recognises that the desire to employ CCS in combating climate change must not overshadow the need to ensure that environmental risks are avoided. Specifically, it is important that CCS sites are carefully operated, maintained and monitored with this in mind. The Committee expects that the demonstration projects will provide an ideal opportunity to subject CCS to rigorous environmental, health and safety regulations before any future long-term commercial operations are put in place.

52 News Corporation, *Remarks by Rupert Murdoch, Chairman and Chief Executive Officer, News Corporation,* 9 May 2007, <newscorp.com/energy/full_speech.html>, accessed 30 May 2007.