4

Australian CCS demonstration projects

Introduction

4.1 Although there are no large-scale projects encompassing capture, transport and storage of CO_2 generated by a coal-fired plant, there are a number of carbon capture and storage (CCS) demonstration projects underway or planned in Europe, Africa, the United States and Australia. These projects, some of which are discussed elsewhere in this report, will be crucial to the continued development and assessment of the technology.[1]

4.2 Figure 4.1 lists projects that are proposed to commence in various parts of Australia involving coal and natural gas.

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1 Stanwell Corporation, *Submission No. 32*, p. 3; CSIRO*, Submission No. 10,* p. 8*;* Chevron Australia, *Submission No. 12,* p. *7;* Anglo Coal, *Submission No. 24,* p. 21*;* Australian Government, *Submission No. 41,* pp. 32-33.

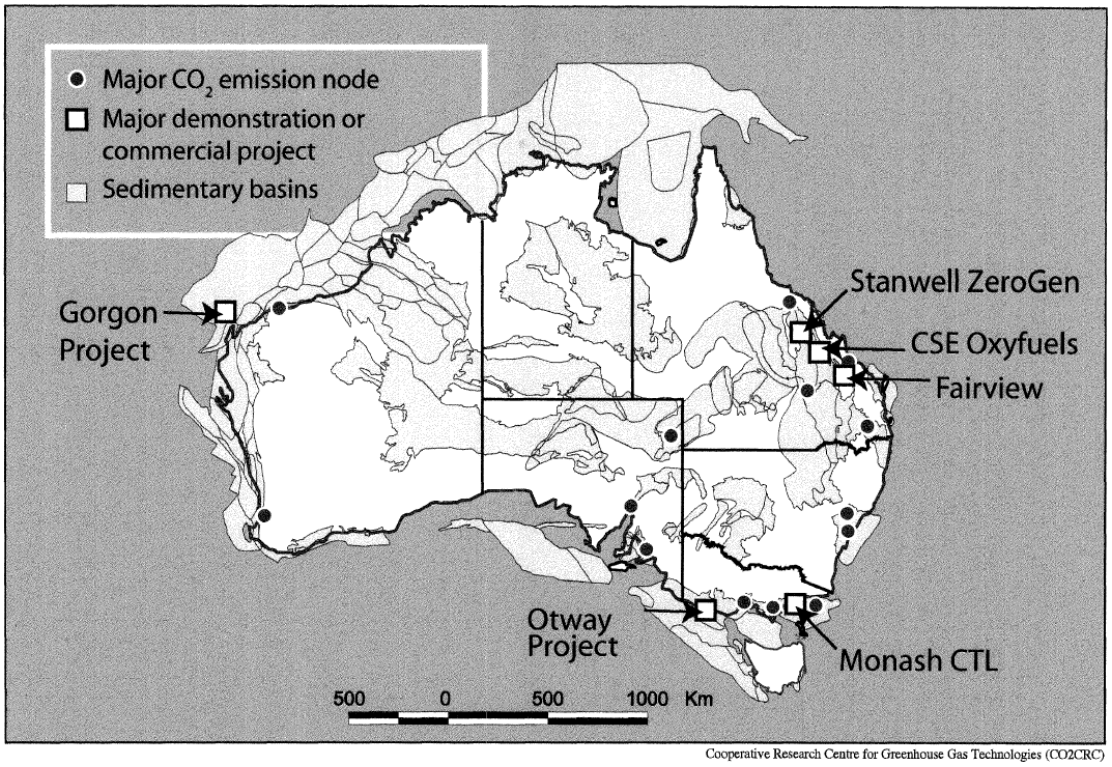

Figure 4.1 CO2CRC, Map of Australian CCS sites, Exhibit No. 3.

Latrobe Valley CO_2 Storage Assessment (LVCSA) Project

4.3 In 2005, with the assistance of a Commonwealth Government grant to Monash Energy and using the expertise of CO2CRC, the LVCSA Project evaluated the potential capacity for long-term and secure storage of compressed CO_2 in the Gippsland Basin.

4.4 The study found that the Gippsland Basin had an estimated storage capacity of 2 billion tonnes of CO_2, with some assessments as high as 6 billion tonnes. Acting as a large-scale injection facility, Gippsland Basin has the potential to store 50 million tonnes of CO_2 a year.[2] To put this in context, Australia's total emissions of CO_2 amount to 559.1

2 B. Hooper, L. Murray, and C. Gibson-Poole, (eds.), 2005. *The Latrobe Valley CO2 Storage Assessment*. Cooperative Research Centre for Greenhouse Gas Technologies, Canberra, CO2CRC Publication No. RPT05-0220, November 2005, p. 8-9.

million tonnes a year.[3] Victorian emissions total 99.5 million tonnes a year.[4]

4.5 The CO2CRC's assessment of the project concluded that:

> The LVCSA provides strong indications that the Gippsland Basin has sufficient capacity to safely and securely store large volumes of CO_2 and may provide a viable means of substantially reducing greenhouse gas emissions from coal-fired plants and other projects using brown coal in the Latrobe Valley.[5]

Otway Basin

4.6 CO2CRC is mounting a project in the Otway Basin to extract naturally occurring CO_2 and methane from the Buttress natural gas well,[6] located in Nirranda South, Victoria.[7]

4.7 The gases will be compressed to a supercritical fluid and piped 2-3 kilometres to the depleted Naylor Gas Field, where it will be injected and stored at least two kilometres below the earth's surface.[8] It is expected that up to 100 000 tonnes of CO_2 will be injected between 2007 and 2009 with monitoring to continue to mid 2010.[9]

4.8 The project will include an extensive programme monitoring the CO_2's behaviour, and new monitoring and verification technology will be developed and deployed with the aim of demonstrating that

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3 Department of Environment and Water Resources, Australia Greenhouse Office, *National Greenhouse Gas Inventory 2005: Accounting for the 108% target*, p. 1.

4 Department of Sustainability and Environment, Victorian Greenhouse Strategy, *Victorian Greenhouse Gas Inventory 2004*, p. 1.

5 B. Hooper, L. Murray, and C. Gibson-Poole, (eds.), 2005, *The Latrobe Valley CO2 Storage Assessment*. Cooperative Research Centre for Greenhouse Gas Technologies, Canberra, CO2CRC Publication No. RPT05-0220, November 2005, p. 15.

6 The separation and capture of CO_2 from a gas well differs from a coal-fired power station, as the flue gases from coal fired power stations have a much higher CO_2 content compared to gas wells, which are approximately only 20% CO_2, CO2CRC, *Geosequestration Research Report Update, Issue 1*, June 2006, <http://www.co2crc.com.au/pilot/OBPPDL/ResearchProjectUpdate_01.pdf>, accessed 7 June 2007.

7 CO2CRC, *Submission No. 36*, p. 19.

8 CO2CRC, *Your Questions Answered*, <http://www.co2crc.com.au/pilot/OBPPDL/Q_A.pdf>, p. 5, accessed 8 June 2007.

9 CO2CRC, *Submission No. 36*, p. 19.

the injection and storage of CO_2 is safe and that any leakage of CO_2 can be detected.[10]

4.9 The project's sponsors report that extensive community consultation has taken place and will continue throughout the life of the project. The drilling of the injection well began in April 2007. [11]

Monash Energy Project – coal to liquids

4.10 The Monash Energy Project has been proposed by Anglo Coal as a 'world-scale coal-to-liquids plant' at a cost of $5 billion to convert brown coal to ultra-clean, synthetic diesel.[12]

4.11 Coal to liquid plants, along with natural gas processing plants, have the current advantage of being able to capture CO_2 from their respective processing at around $10 per tonne of CO_2 avoided. This compares very favourably with estimated capture costs of CO_2 from coal-fired power stations of around $20-100 per tonne of CO_2 avoided.[13]

4.12 The project as outlined would utilise pre-combustion separation and capture methods and would transport approximately 13 million tonnes of CO_2 from the Latrobe Valley to the potential storage facility beneath the depleting oil fields of the offshore Gippsland Basin.[14]

4.13 The plant is currently undergoing a pre-feasibility investigation with trials, evaluation and planning for adoption of the technology. Pending successful completion of these trials, the project will begin production in 2016.[15]

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10 CO2CRC, *Geosequestration Research Report Update, Issue 2*, April 2007, <http://www.co2crc.com.au/pilot/OBPPDL/OBPP_NL/ResearchProjectUpdate_Issue02.pdf>, accessed 7 June 2007.

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

12 Anglo Coal, *Submission No. 24*, p. 3.

13 Anglo Coal, *Submission No. 24,* p. 9.

14 Anglo Coal, *Submission No. 24*, p. 12.

15 Anglo Coal, *Submission No. 24*, p. 12.

Gorgon Project (LNG processing and CCS)

4.14 Managed by Chevron Australia (on behalf of the Gorgon Joint Venturers), the Gorgon Project proposes to tap subsea natural gas reservoirs located 130 kilometres off the northwest coast of Australia. These reservoirs contain an estimated 1.1 trillion cubic metres of natural gases, approximately 25 per cent of Australia's known gas reserves.[16]

4.15 The CO_2 extracted from the liquid natural gas plant proposed for Barrow Island is to be disposed of in the Dupuy Formation, a saline aquifer located 2.5 kilometres beneath Barrow Island.[17]

4.16 Without sequestration, lifecycle greenhouse gas emissions from the Gorgon development are estimated to be 5.5 million tonnes *per annum*. With sequestration, emissions would be between 2.7 and 3.5 million tonnes per annum, a reduction of around 40 per cent.[18] Having considered alterative mitigation strategies, such as organic offsets, the operators of Gorgon found the proposed geosequestration project to be the most cost effective.[19]

4.17 The Gorgon Joint Venture has invested $1 billion on the project to date, and anticipate a total development investment of $11 billion.[20] They have received $60 million from the Australian Government's LETDF to help develop the geosequestration proposal.[21]

4.18 Detailed tests are being conducted to evaluate uncertainties in the injection operations and to identify any early signs of deviation from expected reservoir performance.[22]

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16 Chevron Australia, *Submission No, 12,* p. 6.

17 Chevron Australia, *Submission No, 12,* p. 7.

18 Chevron Australia Pty Ltd, *Final environmental impact assessment and response to submission on the environmental review and management programme for the proposed Gorgon development,* May 2006, p. 358; Department of Industry and Resources (Western Australia), *Submission No. 26*, p. 2; Chevron, *Submission No. 12*, p. 7.

19 Chevron, *Submission No. 12*, p. 12.

20 Chevron Australia Pty Ltd, *Final environmental impact assessment and response to submission on the environmental review and management programme for the proposed Gorgon development,* May 2006, p. 10 & p. 67.

21 Senator Ian Campbell, Minister for Environment and Heritage, *$60 million for world's largest carbon capture and storage project*, Media Release, 23 November 2006, accessed 30 May 2007, <ausindustry.gov.au>.

22 Chevron, *Submission No. 12*, p. 9.

ZeroGen

4.19 The ZeroGen Project, managed by Stanwell Corporation (owned by the Queensland Government) proposes to build a 100 MW IGCC plant with capture technology adjacent to the existing Stanwell Power Station, 29 kilometres west of Rockhampton.

4.20 The project will convert pulverised coal into a synthesis gas (consisting of hydrogen and carbon dioxide), removing CO_2 and other gases to produce a hydrogen-rich fuel used to generate electricity.[23] It will combine coal gasification and CCS and the captured CO_2 will be piped approximately 220 kilometres to the Dennison Trough and stored in deep saline aquifers.[24]

4.21 A feasibility study is underway to assess the possible integration of a coal gasification plant with CCS facilities and to confirm the feasibility and capacity of the site for the safe storage of CO_2.[25]

4.22 The decision to proceed with the project is dependent on a number of factors, including the results of a test drilling program, the completion of the environmental impact statement and community consultation, successful cultural heritage and native title negotiations, obtaining the necessary funding, and Board and Shareholding Minister approval.

4.23 Subject to the above and the granting of final approval, the project expects that the demonstration program will commence in 2011 and run for 10 years. It is estimated that ZeroGen will result in a net saving of up to 420 000 tonnes of CO_2 a year once the plant is fully operational.[26]

4.24 The Queensland Government has earmarked $300 million from the Queensland Future Growth Fund to develop clean-coal technology, and has announced that it will provide funding support for the project from this fund, though the precise amount has not been disclosed. An application for LETDF funding was lodged in March 2006.[27]

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23 Zerogen Gasification Fact Sheet, <http://www.zerogen.com.au/files/factsheetReviewOctober2006Gasification.pdf>, accessed 8 June 2007.

24 Queensland Government, *Submission No. 46,* p. 3.

25 Stanwell Corporation, *Transcript 11 September 2006*, p. 2.

26 Queensland Government, *Submission No. 46,* p. 3; Mr G. Humphries, Stanwell Corporation, *Transcript of Evidence,* 11 September 2006, p. 3.

27 Queensland Government, *Submission No. 46,* p. 3; Mr G. Humphries, Stanwell Corporation, *Transcript of Evidence,* 11 September 2006, p. 18-19.

Fairview Zero Carbon Project (ZCP)

4.25 The Fairview Zero Carbon Project (a subsidiary of Santos) will be located at Injune (near Roma), Queensland. The project will involve the extraction of methane from coal seams. The methane will be used to power a new 100 MW power station.[28]

4.26 At least 100 000 tonnes of CO_2 will be captured and injected back into the coal seam each year during the demonstration period. The project is due to commence in April 2007 and has received $75 million from the LETDF. The project will run until 2015 and is expected to cost around $445 million.[29]

HRL Limited – IDGCC technology

4.27 The HRL Limited project will build a new 400 MW demonstration power station at the Loy Yang Bench in the LaTrobe Valley that will incorporate integrated drying and gasification combined cycle (IDGCC) technology.[30]

4.28 Developed over the last 15 years, the IDGCC technology is specifically designed for brown coal and is currently at the stage of commercialisation.[31]

4.29 This new technology generates electricity at significantly higher efficiency rates by drying brown coal. As a result, CO_2 emissions from brown coal power generation are expected to be reduced by 30 per cent compared to the most efficient brown coal generation currently being produced in the LaTrobe Valley, and by approximately 50 per cent compared to older power stations.[32]

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28 Hon I. Macfarlane MP, Minister for Industry and Resources, *$125 million to lower emissions in Queensland,* Media Release, 30 October 2006, <minister.industry.gov.au>, accessed 1 June 2007; Queensland Government, *Submission No. 46,* p. 4.

29 Hon I. Macfarlane MP, Minister for Industry and Resources, *$125 million to lower emissions in Queensland,* Media Release, 30 October 2006, <minister.industry.gov.au>, accessed 1 June 2007; Queensland Government, *Submission No. 46,* p. 4.

30 Ausindustry, *Low emissions technology demonstration fund grant offers,* March 2007, <ausindustry.gov.au/library/LEDTF_gratoffers_march0720070327095527.pdf>, accessed 5 June 2007.

31 Media Release, HRL Limited, *Australia's HRL and China's Harbin Power sign Global Clean Coal Power Generation Agreement*, 21 February 2006.

32 Media Release, HRL Limited, *Australia's HRL and China's Harbin Power sign Global Clean Coal Power Generation Agreement*, 21 February 2006.

4.30 Further conversion of the coal into clean-burning gases (e.g. methane) enables relatively pure CO_2 to be captured, enabling the application of CCS.

4.31 The project is expected to cost $750 million. In November 2006, the Victorian Government committed $50 million to the project and in March 2007, the Australian Government announced that the project would receive a $100 million grant through LETDF.[33] Private equity and debt finance will contribute $600 million.

4.32 Work on the IDGCC power plant is expected to begin in mid-2007, with completion set for the end of 2009.[34]

Hazelwood 2030

4.33 The Hazelwood 2030 project aims to develop a retrofit low emission technology project at the brown coal-fired Hazelwood Power Station in the LaTrobe Valley.

4.34 The Hazelwood plant is owned by International Power (Technologies Pty Ltd) which is a 100 per cent owned subsidiary of International Power (Australia) Holdings Pty Ltd.[35]

4.35 International Power will demonstrate internationally available technology (adapted to local conditions) to dry the brown coal used to feed one of eight 200 MW generating units at Hazelwood Power Station.[36]

4.36 The high moisture content (around 60 per cent) of brown coal means that the energy conversion efficiency is lower than black coal. The coal drying demonstration project will reduce the moisture content in the brown coal to approximately 12 per cent, and consequently less energy will be needed to convert the coal into electricity. It is expected

33 Ausindustry, *Low emissions technology demonstration fund grant offers,* March 2007, <ausindustry.gov.au/library/LEDTF_gratoffers_march0720070327095527.pdf>, accessed 5 June 2007.

34 Ausindustry, *Low emissions technology demonstration fund grant offers,* March 2007, <ausindustry.gov.au/library/LEDTF_gratoffers_march0720070327095527.pdf>, accessed 5 June 2007.

35 Ausindustry, *Low emissions technology demonstration fund grant offers,* March 2007, <ausindustry.gov.au/library/LEDTF_gratoffers_march0720070327095527.pdf>, accessed 5 June 2007.

36 Media Release, International Power Australia, *Clean Coal Project Awarded Funding,* 25 October 2006.

that this process will reduce greenhouse gas emissions by 30 per cent. This phase of the demonstration project is predicted to be completed by the end of 2009.[37]

4.37 The Hazelwood 2030 project will also include CCS facilities. By early 2008, it is expected that this phase of the project will demonstrate the capture and sequestration of up to 50 tonnes of CO_2 per day (18 250 tonnes per year). If successful, the technology being used at Hazelwood may be able to be retrofitted to other brown coal plants in the LaTrobe Valley.[38]

4.38 The Australian Government is contributing $50 million from the LETDF and the Victorian Government an additional $30 million.[39] Hazlewood is contributing $289 million, with the total cost of the project estimated at $369 million.

4.39 The demonstration project is expected to be fully operational by early 2008.[40]

CS Energy – Oxy-fuel retrofit

4.40 The CS Energy project will retrofit the 30 MW generator at the Callide A pulverised coal power station in Biloela in Queensland to allow oxyfuel combustion.[41]

4.41 Stage one of the project involves the conversion of a generator to apply oxyfuel combustion and the capture of CO_2. Stage two of the project will see the 'transport, injection and storage of liquefied CO_2 in deep geological formations in a site yet to be selected'. Construction and conversion of the plant is due to start in 2007 and power generation will commence in 2009.[42]

37 Media Release, International Power Australia, *Clean Coal Technology: Transforming the LaTrobe Valley, Fact Sheet*, 25 October 2006.

38 Media Release, International Power Australia, *Clean Coal Technology: Transforming the LaTrobe Valley, Fact Sheet*, 25 October 2006.

39 Ausindustry, *Low emissions technology demonstration fund grant offers,* March 2007, accessed 5 June 2007, <ausindustry.gov.au/library/LEDTF_gratoffers_march0720070327095527.pdf>

40 Ausindustry, *Low emissions technology demonstration fund grant offers,* March 2007, accessed 5 June 2007, <ausindustry.gov.au/library/LEDTF_gratoffers_march0720070327095527.pdf>

41 Queensland Government, *Submission No. 46*, p. 3.

42 CS Energy website, <www.csenergy.com.au/research_and_development/oxy_fuel.asp>, accessed 6 June 2007.

4.42 By 2010, it is expected that up to 150 000 tonnes of CO_2 will be transported and stored.[43]

4.43 The project will cost $188 million to which the LETDF has contributed $50 million.[44] The CS Energy retrofit project has been recognised as a project of significance by the AP6.[45]

4.44 Once it is fully operational, the demonstration project will continue for another five years. If successful, oxyfuel technology may be retrofitted to other stations in the Callide Group. These stations have an overall capacity to generate 1 720 MW of electricity.[46]

Conclusion

4.45 Australia has recognised the need to reduce greenhouse gas emissions from stationary sources. Major participants, supported by the Government through the LETDF and other initiatives have already committed to projects aimed at reducing CO_2 emissions.

4.46 The projects discussed in this chapter will add value and enhance our knowledge base. They do, however, have some limitations, with no demonstration of a large-scale CCS solution.

4.47 The Gorgon project, for example, proposes to sequester large amounts of CO_2, but does not involve the use of coal for electricity generation. It should, however, add enormously to our knowledge of higher volume sequestration in saline aquifers (subject to appropriate monitoring and verification. The Australian Government needs to ensure that this is the case).

4.48 The HRL project will incorporate drying technology into the gasification combined cycle technology, seeking to apply pre-combustion technology to brown coal. Hazelwood 2030 is retrofitting a brown-coal fired power station, but only on one 200 MW generator.

43 Queensland Government, *Submission No. 46*, p. 3.

44 Ausindustry, *Low emissions technology demonstration fund grant offers,* March 2007, <ausindustry.gov.au/library/LEDTF_gratoffers_march0720070327095527.pdf>, accessed 5 June 2007.

45 Australian Government, Asia-Pacific Partnership on Clean Development and Climate: Partnership for Action 2006, <http://www.dfat.gov.au/environment/climate/ap6/appcdc-booklet-06.pdf>, accessed 7 June 2007.

46 CS Energy website, <www.csenergy.com.au/research_and_development/oxy_fuel.asp>, accessed 6 June 2007.

CS Energy will retrofit a pulverised coal power station with oxyfuel technology, but this too will be small scale. ZeroGen's application of IGCC technology is to a small capacity power generator.[47]

4.49 The major challenge is to mount a project at the 500 MW scale which demonstrates all stages in the process—from coal conversion, carbon capture, treatment and transport through to sequestration and long-term monitoring. This raises environmental risks, logistic coordination and technical challenges that are not tested or resolved by small-scale demonstrations.

4.50 The British House of Commons report, *Meeting the UK Energy and Climate Needs: The Role of Carbon Capture and Storage*, observed that:

> Most of the technology is already proven and available but there is a lack of experience in integrating the component technologies in single projects at the scale required. Multiple full scale demonstration projects using different types of capture technology and storage conditions are urgently needed.[48]

4.51 As the MIT study notes, 'the demonstration of an integrated coal conversion, CO_2 capture, and sequestration capability is an enormous system engineering and integration challenge'.[49] The operating tempo of each individual power station raises particular challenges. As the pressurised, transport-ready CO_2 is produced, it needs to be transported via a pipeline network to an injection point at the rate of production, whilst accommodating any variation in the operating cycle of the production plant. In addition, the injection system must have the capacity to inject the arriving gas at the variable rates at which it is received.[50]

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47 The Committee notes that BP and Rio Tinto have announced that they will begin feasibility studies and work on plans for the potential development of a coal-fired power generation project in WA, which would be a fully integrated CCS plant. A final decision to proceed will be taken in 2011. For further information see, BP/Rio Tinto press release, *BP and Rio Tinto plan clean coal project for Western Australia*, 21 May 2007.

48 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. 3.

49 Massachusetts Institute of Technology (MIT), *The Future of coal: Options for a carbon constrained world,* Cambridge MA, March 2007, p. 101.

50 MIT, *The Future of coal: Options for a carbon constrained world,* Cambridge MA, March 2007, p. 101.

4.52 The MIT study states that such a demonstration is important because it will:

> (1) give policy makers and the public confidence that this carbon mitigation control option is practical for broad application, (2) shorten the deployment time and reduce the cost for carbon capture and sequestration should a carbon emission control policy be adopted, and (3) maintain opportunities for the use of coal in a carbon constrained world in an environmentally acceptable manner.[51]

4.53 There is considerable support for the adoption of IGCC technology for CCS. The advantage of IGCC, with its precombustion capture, over the conversion of pulverised coal fired plants is largely due to the energy penalties that are inevitable with post-combustion techniques.

4.54 Nonetheless, it needs to be noted that a successful CCS operation on IGCC or any other type of large coal-fired power generating plant has yet to be demonstrated. More importantly, an IGCC solution does not address the reality of Australia's, and the world's, dependence on pulverised coal-fired power stations.

4.55 In the Australian context, the majority of coal-fired plants are old but will be relied upon for power generation for many years. Over half of Australia's coal fired power plants each have more than 500 MW capacity and notionally each emits 2.9 million tonnes of CO_2 per year.[52]

4.56 Moreover, the anticipated growth in the demand for electricity in Australia over the next 30 years will consume most of the output of new generating capacity. That means that most existing plants, although ageing and operating at various levels of efficiency, will remain in operation for the foreseeable future. Unless modifications are made, they will continue to release emissions at the current rate. There is no evidence to suggest that ageing and inefficient plants will be replaced by new technology cleaner plants, such as IGCC.

4.57 The Committee also heard evidence that, at this stage at least, the potential commercial risks of installing carbon capture technology in

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51 MIT, *The Future of coal: Options for a carbon constrained world,* Cambridge MA, March 2007, p. 95.

52 For a breakdown of principal power stations in Australia, see Appendix D; Australian Government, *Submission No. 41*, p. 15.

large existing Australian plants do not justify the very major investments required (see Chapter 6).

4.58 Given the reality of Australian power generation, the priority needs to be the facilitation of commercial-scale projects at existing coal-fired power stations. It is important that these projects demonstrate CO_2 capture via:

- oxyfuel combustion;
- post-combustion technology at supercritical pulverised coal plants; and
- ultra-supercritical coal plants from subcritical coal plants.

4.59 Therefore, the Committee is recommending that the Australian Government fund one or more large-scale projects to demonstrate the three phases of CCS—capture, transportation and sequestration and monitoring.

4.60 The assessment of which projects should receive funding should be based on a competitive tender process that encourages submissions for projects which utilise different fuel sources and generating methods, including: sub-critical, supercritical, oxyfuel or IGCC.

4.61 The Committee is of the opinion that the advantages of this approach will be to:

- act as an incentive for current, operational, coal-fired power stations to develop carbon capture technologies;
- enable demonstration of desired technologies while minimizing government interference in commercial practice; and
- provide data in relation to the cost components to assist the government and the industry in its cost estimations.

4.62 The tender process should also include financing models. In view of the substantial amounts of capital required, financing arrangements would need to be varied and flexible, and structured so that each project could, after completion, operate grant-free as a profitable enterprise.

4.63 Initially, direct financial assistance may need to be provided at the capital intensive construction stage. Later, incentives may need to be offered in the form of payment per tonne of CO_2 sequestered.

4.64 It is the Committee's view that Australia must be technically equipped if and when formal carbon constraints become a reality. To

this end, investment in research and development is needed now to implement CCS at a new or existing large coal-fired power station.

4.65 Australia's contribution to the worldwide understanding of the viability of CCS would contribute to addressing our greenhouse gas mitigation obligations and would materially enhance Australia's already significant contribution to responding to climate change.

Recommendation 2

The Committee recommends that the Australian Government fund one or more large-scale projects which will demonstrate the operation and integration of the CCS—capture, transportation and sequestration and monitoring. The Government's assessment of which project(s) will receive funding will be based on a competitive tender process.