THE AUSTRALIA INSTITUTE

Geosequestration

What is it and how much can it contribute to a sustainable energy policy for Australia?

Hugh Saddler
Energy Strategies Pty Ltd

Chris Riedy
Institute for Sustainable Futures
University of Technology, Sydney

Robert Passey

Discussion Paper Number 72

September 2004

ISSN 1322-5421

© The Australia Institute
This work is copyright. It may be reproduced in whole or in part for study or training purposes only with the written permission of The Australia Institute. Such use must not be for the purposes of sale or commercial exploitation. Subject to the *Copyright Act* 1968, reproduction, storage in a retrieval system or transmission in any form by any means of any part of the work other than for the purposes above is not permitted without written permission. Requests and inquiries should be directed to The Australia Institute.

Table of Contents

List of Tables

List of Figures

Acknowledgements

The authors wish to thank Keith Tarlo, formerly Senior Research Consultant, Institute for Sustainable Futures, University of Technology, Sydney for his stimulating ideas and hard work initiating the proposal to write this paper. They are grateful to Iain MacGill of the University of New South Wales for his many helpful comments and suggestions on drafts. They also wish to thank Hal Turton of the International Institute for Applied Systems Analysis, Laxenburg, Austria, and Richard Begley of The Allen Consulting Group for refereeing this paper. The conclusions drawn are, however, the sole responsibility of the authors.

The Australia Institute would like to thank Peter Szental and SZENCORP for providing financial support for this project.

The report also received financial support from the Australian Conservation Foundation and Greenpeace Australia/Pacific.

Abbreviations

ABARE	Australian Bureau of Agricultural and Resource Economics
ACA	Australian Coal Association
APEL	Australian Power and Energy Limited
APPEA	Australian Petroleum Production and Exploration Association
BAT	best available technology
BAU	business as usual
CCGT	combined cycle gas turbine
CCS	CO_2 capture and storage
CCSD	CRC for Coal in Sustainable Development
CEFG	Clean Energy Future Group
CO	carbon monoxide
CO_2	carbon dioxide
CO_2-e	carbon dioxide equivalent
CRC	Cooperative Research Centre
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSLF	Carbon Sequestration Leadership Forum
DEST	Department of Education, Science and Technology
ECBM	enhanced coal bed methane
EGR	enhanced gas recovery
EOR	enhanced oil recovery
ESAA	Energy (formerly Electricity) Supply Association of Australia
GEODISC	Geological Disposal of Carbon Dioxide
GGAS	NSW Greenhouse Gas Abatement Scheme
GHG	greenhouse gas(es)
H_2	hydrogen
HHV	higher heating value
IDGCC	Integrated Drying Gasification Combined Cycle
IEA	International Energy Agency
IEAGHG	IEA Greenhouse Gas R&D Programme
IGCC	integrated gasification combined cycle

IPCC	Intergovernmental Panel on Climate Change
LHV	lower heating value
LNG	liquefied natural gas
LPG	liquefied petroleum gas
MPa	megapascal
MRET	Mandatory Renewable Energy Target
MW	megawatt
MWh	megawatt-hour
NFEE	National Framework for Energy Efficiency
NO_X	oxides of nitrogen
O_2	oxygen
OCGT	open cycle gas turbine
PF	pulverised fuel
R&D	research and development
RD&D	research, development and demonstration
RE	renewable energy
SACS	Saline Aquifer CO_2 Storage
SO_X	oxides of sulfur

Summary

Geosequestration of carbon dioxide (CO_2) means injecting it into geological formations deep underground, where it will be held away from the atmosphere for hundreds, if not thousands, of years. The oil and gas industry has been investigating the potential of geosequestration to deal with the large amounts of CO_2 that occur naturally mixed with methane in many natural gas fields. One large-scale trial of this process is underway at a gas field in the Norwegian sector of the North Sea.

In the last few years, much more ambitious proposals intend using geosequestration to reduce greenhouse gas emissions (GHG) released when fossil fuels are burned, especially when coal is used to generate electricity. Around 80 per cent of Australia's electricity is supplied by coal-fired power stations, and these are currently responsible for greenhouse gas emissions of nearly 170 Mt CO_2-e per annum, about 30 per cent of Australia's total emissions. A technical system that could reduce these emissions to a small fraction of their present level, while allowing continued burning of coal, has great superficial appeal.

A partnership called COAL21 has been established by the coal mining industry, the coal-fired electricity generation industry, Commonwealth and state governments and research bodies, including CSIRO, to support and promote research on the technologies that will be needed for geosequestration. In March 2004, COAL21 launched its national action plan for reducing GHG emissions arising from coal-fired electricity generation.

Ministers of the Commonwealth Government give the impression, perhaps unintentionally, of having seized on this vision as the key to solving Australia's GHG emission problem. The same emphasis, though not explicitly stated, runs through the recent Energy White Paper and was strongly supported by the Prime Minister when launching it.

However, there is no publicly available analysis to demonstrate that this is the best energy policy option. A following statement by the responsible Federal Minister is certainly not an adequate basis for sound policy.

> The coal industry produces 80 per cent of our energy and the reality is that Australia will continue to rely on fossil fuels for the bulk of its expanding power requirements, for as long as the reserves last.

This discussion paper examines how much emissions abatement geosequestration may be able to deliver, how soon it may be able to do so, what the cost of such abatement may be and how it compares with other energy policy options to reduce emissions.

Technology status

A system to geosequester CO_2 will be very complex, and involves much more than burying the gas underground. It would first involve either converting the fossil fuel to a gas before combustion and extracting the CO_2, or capturing the CO_2 from the stream of combustion gases. It would require a mechanism to transport the CO_2 from the point of production to the geosequestration site, and then to inject the CO_2 into the geological

formation. The CO_2 capture step is in many ways the most complex and difficult. On the other hand, it is the final geosequestration step that is most uncertain over the long term. For these reasons we use the term CO_2 capture and storage, abbreviated to CCS, in the remainder of this paper, to include all elements of the whole system.

Capturing CO_2 from existing power stations would require the use of large and expensive equipment and use large amounts of energy, thereby reducing overall power station efficiency. For these reasons, retrofitting existing power stations to capture CO_2 is not considered by the industry and research communities to be a cost-effective route to CCS. A very large research effort is therefore being committed to new coal utilisation technologies that would reduce the cost and complexity of capturing CO_2. Technologies that could be applied directly to electricity generation include integrated gasification combined cycle (IGCC) and oxy-fuel combustion. The production of hydrogen or liquid fuels from coal could also be associated with CO_2 capture. IGCC is perhaps the most advanced of these, but it is still much more expensive than conventional coal-fired generation and requires further technical improvements. There are a small number of commercial-scale plants in operation around the world but the technology is not used in Australia.

Transport of CO_2 is perhaps the best understood and least complex part of the whole system, but is also relatively energy intensive and will require large investments in pipeline infrastructure. Research over recent years has improved knowledge of areas where the geology may be suitable for long-term underground storage of CO_2. At present, sites have been identified within a reasonable distance of coal-fired power stations (and associated coal mines) in Queensland, Victoria and Western Australia. However, there are no identified sites within 500km of the coal-fired power stations in the Newcastle-Sydney-Wollongong area of NSW and at Port Augusta in South Australia, which together account for about 39 percent of Australia's current net CO_2 emissions from electricity generation. This is considered to present a formidable cost barrier to the use of CCS technology with electricity generation in these areas.

Overall, the main barriers to large-scale application of CCS are the immaturity of the technology, the energy penalty and the cost of capture. A technology roadmapping exercise supported by COAL21 set 2014-15 as the earliest possible date for operation of a pilot-scale coal-fired electricity generation project with CCS. Given the size and complexity of the technology development task required, this may be optimistic. CCS power station technology systems are not yet operating on a commercial scale anywhere in the world.

Cost and cost effectiveness

In order to determine the potential performance of coal-fired electricity generation with CCS, in terms of both electricity generation and emission abatement, it is necessary to draw together data on:

- the capital and operating costs of the system (with a given cost of coal);
- the overall thermodynamic efficiency of supplying electricity, allowing for the energy penalty of CCS; and

- the ultimate level of emissions.

When this is done, taking appropriate account of the large uncertainty in the cost of CCS, it is clear that coal-fired generation with CCS will be more costly than a number of other low-emission electricity generation options including natural gas-fired combined cycle gas turbines, gas-fired cogeneration, wind and many types of biomass. All these technologies are far more mature than CCS; they are proven, already in widespread commercial use, but also, particularly in the case of wind, likely to fall considerably in cost over time as further experience with the technologies is gained. Importantly, increasing the efficiency of energy use is much more cost-effective than any of these electricity supply technologies, having negative costs after a much shorter payback time.

When account is taken of the costs of abatement (measured by $/tonne CO_2-e of abatement), energy efficiency, natural gas, wind and biomass are more economically attractive than CCS as abatement options. It is difficult to see how coal-fired power stations with the additional cost of CCS will be able to compete with the alternative means of cutting emissions, at least for some decades. This conclusion applies not only to the period between now and when CCS technology is ready for commercial use, which will be 2020 at the earliest, but also for a considerable period after CCS could begin to be widely used.

This conclusion takes no account of the risk that one or more of the technologies involved in a complete CCS system will prove to be unviable, i.e. cannot be made to operate reliably at the expected cost. History, including recent Australian history, is replete with examples of ambitious attempts to develop new technologies which either failed to realise the hopes held for them, or failed altogether. Two examples are BHP Billiton's Boodarie hot briquetted iron plant and Australian Magnesium Corporation's Stanwell Magnesium Project. The conclusion also takes no account of environmental risks, particularly the risk that CO_2 may escape from some storage sites.

How much can CCS reduce emissions?

A spreadsheet model has been developed to estimate the potential for CCS to reduce emissions from coal-fired electricity generation in Australia. CCS is assumed to have a 'best case' abatement capacity in that it is technically feasible, capable of long-term storage, environmentally safe and commercially viable. CCS demonstration power stations are assumed to be built between 2016 and 2020, with commercial viability being achieved in 2020. CCS is not applied in NSW and South Australia because of lack of sequestration sites. It is applied only to new plant, and modelling is extended out to 2030.

The most recent ABARE projections are taken as the base case for energy demand, and two other scenarios with increased end-user energy efficiency are also modelled. The ability of CCS to reduce emissions from coal-fired electricity generation was compared to the abatement potential of increased end-user energy efficiency, and replacement of new coal-fired generation with gas-fired generation and renewable energy.

It was found that use of CCS alone would reduce emissions by about 9 percent in 2030, and cumulative emissions from 2005 to 2030 by only 2.4 percent. A scenario with modestly increased energy efficiency, corresponding to the efficiency potential assumed in the Energy White Paper, could reduce emissions in 2030 by about the same amount, and cumulative emissions by twice as much. This would be achieved at zero or even negative cost.

If gas-fired generation and renewable energy were built instead of new coal-fired generation, to achieve the same cumulative abatement by 2030 as CCS would require only a doubling of the current very modest MRET target, and double that of additional gas-fired generation.

Scenarios that include more extensive energy efficiency improvements, though still well within identified technical potential, combined with use of gas-fired generation and renewables instead of new coal-fired plant, could reduce emissions in 2030 by more than five times as much as CCS alone, and cumulative emissions by ten times as much.

The key to these results is that end-use efficiency, gas-fired generation, wind power and some types of bioenergy are currently commercially available, and so do not have to wait until 2020. While it is possible CCS may be an effective abatement option after 2030, use of currently available technologies will reduce emissions much sooner and at lower cost, and make any abatement task for CCS easier.

Is CCS good energy policy?

In the absence of a decisive change in policy, growth in Australia's energy-related greenhouse emissions will mean that national emissions exceed the Kyoto commitment level by around 2009, and keep growing thereafter. The present policy of modest energy efficiency improvement plus CCS for electricity generation may slow but not reverse the growth in emissions from about 2020 onward. It is not difficult to envisage international pressures, both diplomatic and economic, that could place Australia under strong pressure to reduce emissions well before this time. Present policy does nothing to shield Australia from such a risk and is unlikely to be the best way of maximising Australia's overall energy security.

For the foreseeable future, end-use efficiency, gas-fired generation and wind will continue to have lower costs than coal-fired generation with CCS. Over the longer term, notwithstanding its cost disadvantage, CCS may become more attractive as the scale of necessary GHG emission reductions increases. It may, for example, be needed to reduce emissions to 50 percent below 1990 levels by 2050, which is the sort of emission reduction needed to achieve ultimate stabilisation of atmospheric CO_2 concentrations. Over the next two decades, however, a policy that neglects or excludes other low-emission technologies, in favour of coal with CCS, will place Australia on an unnecessary high-cost path to reducing emissions. This is not an economically optimal policy for reducing greenhouse gas emissions from the energy sector.