



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
<http://ageconsearch.umn.edu>
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

ISSN 1835-9728

**Environmental Economics Research Hub
Research Reports**

**The challenges of finding efficient policy
measures to reduce Australia's agricultural
Greenhouse gas emissions**

Helen King

Research Report No. 9

November 2008

About the author

Helen King is a graduate student at the Fenner School of Environment and Society, Australian National University. This report received assistance from Environmental Economics Research Hub Project 11.

helen.king@anu.edu.au

Environmental Economics Research Hub Research Reports are published by the The Crawford School of Economics and Government, Australian National University, Canberra 0200 Australia.

These Reports present work in progress being undertaken by project teams within the Environmental Economics Research Hub (EERH). The EERH is funded by the Department of Environment and Water Heritage and the Arts under the Commonwealth Environment Research Facility.

The views and interpretations expressed in these Reports are those of the author(s) and should not be attributed to any organisation associated with the EERH.

Because these reports present the results of work in progress, they should not be reproduced in part or in whole without the authorisation of the EERH Director, Professor Jeff Bennett (jeff.bennett@anu.edu.au)

Crawford School of Economics and Government
THE AUSTRALIAN NATIONAL UNIVERSITY

<http://www.crawford.anu.edu.au>

ABSTRACT

Australia's climate change policy has a comprehensive emissions trading scheme (ETS) as its principal greenhouse gas mitigation policy instrument. While there are undoubtedly benefits of full ETS coverage, these benefits must be balanced against potential costs if emissions that cannot be affordably and reasonably accurately measured are included. The essay explores why agriculture is different to other sectors and its diffuse and diverse emissions are inherently difficult to measure and fluctuate in response environmental factors such as climate and biophysical characteristics. These characteristics, together with the scale of over 130,000 farm enterprises mean that inclusion of the agriculture sector in the ETS, at reasonable cost and to give incentive to change behaviour at the emission source, is problematic. Worse, the emphasis on including agricultural emissions in the ETS is a disincentive for early abatement action. The essay considers alternative abatement policies and concludes that a 'carrot and stick' approach utilising a range of policy instruments is the best way to deliver cost effective abatement for agriculture.

ACKNOWLEDGEMENTS

I am very grateful for detailed comments and advice from Jack Pezzey and Steve Dovers, and the encouragement of the many people with whom I discussed this research project and general issues of agriculture and greenhouse policy.

TABLE OF CONTENTS

Abstract	i
Table of contents	ii
List of figures and tables	ii
Aims	1
Introduction	1
Methods	3
Emissions trading	3
Australia's greenhouse emissions	5
Measurement problems	8
Abatement options	13
Alternative policy instruments	17
Conclusion	20
References	22
Appendix A	24

FIGURES and TABLES

Figures

1	Greenhouse gas emissions by sector, 2005	6
2	Agricultural greenhouse gas emissions by source, 2005	7
3	Australia's rainfall zones	9
4	Murray Darling Basin annual rainfall and temperature anomalies 1961-1990	9
5	Measurement technologies for agricultural emissions	11
6	Dairy Greenhouse Framework	13
7	Pathways of nitrogen conversion in soils	16

Tables

1	Key features of the ETS relating to agriculture	5
2	Uncertainties in agricultural emissions measurement	12
3	Global warming potentials	15
4	Methane production and energy loss from enteric fermentation	15

AIMS

Agriculture is the second largest contributor of greenhouse gases in Australia and consequently, abatement of agricultural emissions must be part of any policy solution that aims to make significant emissions reductions. This essay aims to identify the challenges in finding efficient policy measures for abatement of agricultural emissions by addressing the following research questions:

1. What is Australia's current and developing policy environment in relation to emissions from agriculture and emissions trading?
2. What is the current state of knowledge of agricultural emissions and abatement options?
3. What is different about agriculture from other ETS covered sectors?
4. What measurement methodologies are currently available, what are their strengths and shortcomings, and how cost-effective are they at farm and institutional scales?
5. What policy instruments are likely to be the best available for abatement of agricultural emissions?

INTRODUCTION

There is now widespread acceptance of climate change and the need for an effective global agreement if atmospheric greenhouse gases are to be stabilised at a level that will reduce the risk of dangerous climate change. The first step was taken in December 2008 at the United Nations Conference on Climate Change in Bali, with all nations agreeing to work together on a global climate agreement to replace the Kyoto Protocol at the end of the first commitment period in 2012. With ratification of the Kyoto Protocol at Bali its first official act, the new Australian Government signalled a major policy shift, with Australia taking on a leadership role internationally and committing to a long term domestic target of a 60% reduction of 2000 emissions by 2050.

Australia's climate change policy has an emissions trading scheme (ETS) "at the heart" of its mitigation efforts (Wong 2008a), although proposed design details will not be known until the release of the Government's green paper in mid July 2008¹.

¹ The Garnaut Climate Change Review Draft Report and the Carbon Pollution Reduction Scheme Green Paper were released in July 2008, subsequent to conclusion of data collection for this project.

Until then, the best indication is the Garnaut Climate Change Review's ETS discussion paper, released in March 2008 following consultation over the preceding year (Garnaut 2008). Based on the ETS Discussion Paper and Government announcements, the ETS will be a comprehensive scheme covering all sectors and the main greenhouse gases. It will initially cover 70% of Australia's emissions, with agriculture and forestry to be brought into the scheme once practical issues are resolved. Only Australia and New Zealand are proposing coverage of land-based sectors in their national ETS.

Agriculture is an important component of Australia's economic prosperity and sustainability – it contributes economically as a net exporter of food and fibre, ecologically as a land manager, and socially as the back-bone of our rural communities. It is also Australia's second highest emitter of greenhouse gases producing 16% of Australia's emissions in 2005, behind stationary energy at 50% (DEH 2007).

For Australia to achieve significant cuts in its emissions, agriculture must be part of the solution. However, diffuse agricultural emissions, the inherent variability and interrelatedness of natural systems, and the scale and diversity of agricultural enterprises make agriculture different to other sectors which have relatively few enterprises and well understood and measurable point source emissions. This in no way implies that agriculture should be 'let off the hook', however it does mean that policies to abate agricultural emissions must be well designed and carefully evaluated.

In this essay, I challenge the presumption that inclusion of agriculture in the ETS will result in least-cost abatement, and propose that a suite of integrated policy instruments is more likely to provide cost-effective abatement of agricultural emissions. To do this, the essay discusses emissions trading and Australia's greenhouse gas emissions. It then explores the measurement problems and abatement options that make agriculture different from other sectors, and considers other policy mechanisms. The analysis indicates that other policy instruments should provide similar abatement at lower cost than the ETS and that the policy debate should shift away from the ETS to reflect the policy goal of least-cost abatement.

The timeline for producing this short essay required that data collection cease at the end of May 2008. More information that is deeply implicated in the policy debate has been released since, including the Carbon Pollution Reduction Scheme Green Paper. The only significant change for agriculture from that outlined in this essay is setting a timeframe for ETS coverage of 2015 at the earliest (DCC 2008a).

METHODS

Research was undertaken principally through a literature review covering scientific, economic and policy journal papers, and analysis of government and industry policy and strategic publications. My research was informed through engagement in the policy debate including attendance at the UN Climate Change Conference in Bali in December 2007, participation in the Agriculture, Greenhouse and Emissions Trading Summit in April 2008 and informal discussions with researchers, academics and industry and government representatives at these events and through personal contact. Discussions with key policy makers also helped scope the problem and identify grey literature sources.

EMISSIONS TRADING

The justification for an ETS over other policy instruments, such as a carbon tax, is that the market will be more efficient in identifying least-cost abatement options and encouraging innovation. A 'cap and trade' ETS works by the Government determining the amount of emissions it will allow, 'the cap', and issuing permits up to that level. This 'right to emit' effectively converts greenhouse gas emissions from an unconstrained externality, into a scarce commodity for which the 'polluter pays' a 'carbon cost' set by the market through 'trades'. Fungibility, the condition that a tonne of carbon (1tC) from one source (say coal fired power) is interchangeable with 1tC from a different source (say methane emissions from livestock), is necessary for market credibility; and implicit in this is that emissions can be affordably and reasonably accurately measured.

How effective the ETS will be in reducing greenhouse gas emission is a function of its, as yet unknown, design features. Australia's climate change policy is evolving rapidly, with the Garnaut Review's Interim and Final Reports due in June and September 2008 respectively, and the Government's Green Paper on the proposed ETS due in June and White Paper in December 2008 (Wong 2008b). Discussion in this essay is based on the Garnaut Climate Change Review's ETS Discussion Paper released in March 2008 (Garnaut 2008).

The key features of the ETS for agriculture are summarised in Table 1 and included in the relevant analysis where relevant². The most pertinent feature is that

² Trade exposure is not discussed as it also applies to alternative policy instruments that impose a carbon cost on production

agriculture will not be included in the ETS until practical difficulties related to measurement of agricultural emissions are resolved. This emphasis on the eventual inclusion of agriculture in the ETS and resolution of measurement problems has a number of important ramifications. It precludes a rigorous policy analysis to determine if the ETS is the best abatement policy instrument for agriculture. The 'when not if' presumption strongly influenced agriculture's support of direct inclusion in the ETS to have input into its design (AGET 2008)³. Leaving agriculture outside the ETS also shields it from abatement policy, the equivalent of providing it with 100% free and uncapped permits, a disincentive for early abatement of agricultural emissions.

While outside the scope of this short essay, agriculture's proposed inclusion in the ETS also has international implications. Unless other nations accept abatement from agriculture, a perceived lack of fungibility could undermine confidence in the ETS and limit opportunities for linking with other ETS and international trade in Australian permits.

³ The Agriculture, Greenhouse and Emissions Trading Summit (AGET) included a senior public servant who strongly reinforced the 'when not if' position. Representatives from most peak agriculture bodies participated, and while not officially endorsed by those bodies, the AGET Communiqué has been cited as agriculture's de-facto position.

TABLE 1. Key features of the ETS relating to agriculture

Garnaut ETS feature	Issue
All six Kyoto gases.	Agriculture is the main producer of methane and nitrous oxide emissions.
Agriculture to be included as soon as practicable.	There is no affordable, reliable and accurate way to monitor, measure or estimate, and verify emissions from agriculture. If the relative costs of distortion if agriculture is not covered are higher than the measurement and verification costs if it is, agriculture could be included.
Offsets from terrestrial carbon sequestration may provide a transition to full inclusion in the ETS ⁴	Given that carbon prices are expected to rise over time, farmers may be better off 'banking' credits than risking having to buy permits at a higher price if agriculture is brought into the scheme.
Where transaction costs are lower than the cost of distortions that may arise, upstream or downstream point of obligation may be appropriate	Farm specific emissions related data will still be needed if a price signal is to reach the farm enterprise where abatement decisions are made. This will also incur transaction costs. Use of proxies may overcome the measurement problem but would not result in a price signal to drive abatement.
Transitional assistance for trade exposed emissions intensive industries (TEEI).	Agriculture is a TEEI as an exporter of commodities and from import competition. Agriculture's major competitors are developing countries not subject to a carbon cost.
Other market failures may require complementary measures	Farm scale affordable measurement methodologies, more abatement options, impediments to adoption, information, shortage of skills and capacity are all market failures that need to be addressed.

AUSTRALIA'S GREENHOUSE EMISSIONS

Australia emitted 559 million tonnes (Mt) of greenhouse gases, measured in carbon-dioxide equivalent (CO₂-e)⁵, in 2005, made up of carbon-dioxide (410 Mt, 73%), methane (113 Mt, 20%), nitrous-oxide (24 Mt, 4%) and other gases (12 Mt, 3%). As shown in Figure 1, agriculture is Australia's second highest emitting sector, accounting for 88 Mt or 16% of total emissions, behind stationary energy at 50%. Agriculture is also the major source of methane and nitrous-oxide emissions (DCC 2008b). Appendix A provides a breakdown of total emission with a detailed breakdown for agriculture.

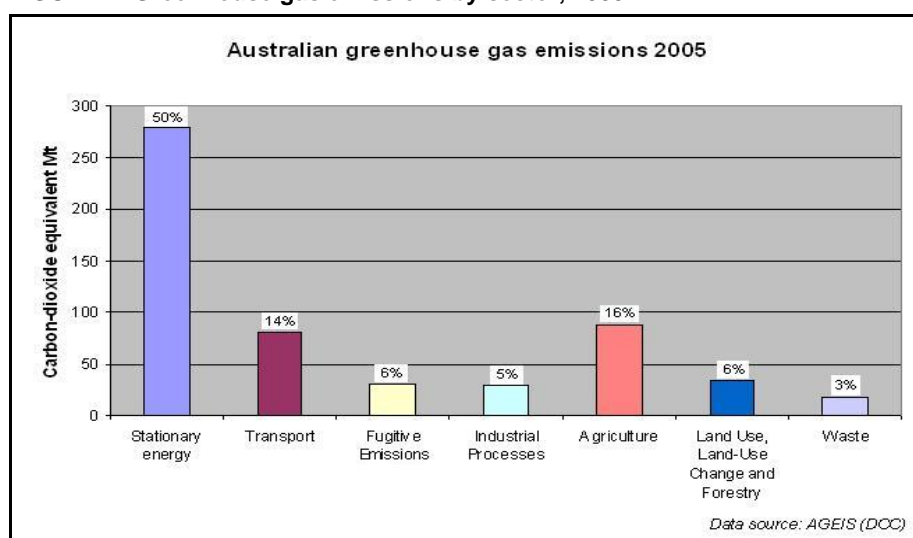
Agricultural emissions can be expected to increase if farm production returns to pre-drought levels without a reduction in the emissions intensity of production, while other sectors' emissions should stabilise then fall under the ETS. Although agriculture is shielded from mandatory abatement, the ETS may create some incentive for self

⁴ Offsets from agriculture are not available under the GPRS

⁵ As each greenhouse gas has a different global warming potential (GWP), units of carbon-dioxide equivalent (CO₂-e) are used to measure and aggregate greenhouse gases. Each gas's GWP is a factor of its capacity to trap heat and time to break down in the atmosphere, relative to Carbon-dioxide (GWP = 1). GWP's used for Kyoto accounting are taken from the IPCC Second Assessment Report (SAR), taken over a 100 year timeframe, the GWP of methane is 21 and nitrous-oxide 310 (IPCC 2006 SAR)

regulation to limit the proportionate increase in agriculture's emissions and potential for negative impact on agriculture's environmental image.

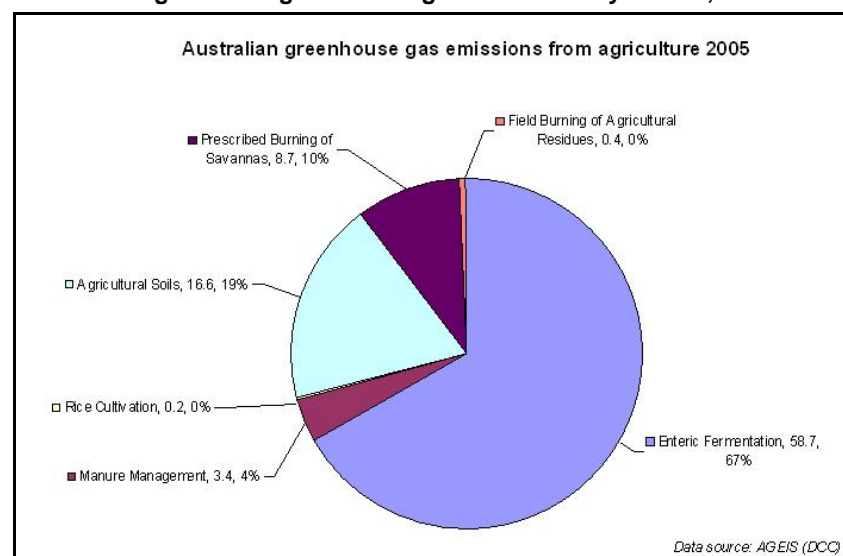
FIGURE 1. Greenhouse gas emissions by sector, 2005



Only methane and nitrous oxide are accounted for under agriculture, with carbon-dioxide emissions accounted for under stationary energy, transport and land use, land use change and forestry⁶. As shown in Figure 2 and detailed in Appendix A, the largest source of agricultural emissions is methane from enteric fermentation. Methane, a by product of ruminant digestion that is breathed or burped out, produces 67% (58.7 Mt CO₂-e) of agriculture's emissions – or 10% of Australia's total emissions. The next largest source producing 19% (16.6 Mt) of agriculture's emissions is nitrous oxide emissions from agricultural soils, released through nitrification and denitrification processes, mostly as a result of nitrogenous fertilisers. The balance of agricultural emissions are methane and nitrous oxide emissions produced by prescribed burning of savannas, manure management and field burning of agricultural residues. (DCC 2008b)

⁶ Land clearing is accounted for under Land use, land use change and forestry.

FIGURE 2. Agricultural greenhouse gas emissions by source, 2005



Emissions measures for the national inventory and for on-farm abatement decisions require different levels of precision to provide information and accuracy at relevant scales. Estimates in the national inventory draw on a variety of data sources, country specific and default emissions factors and methodologies in accordance with *Good Practice Guidance* established by the International Panel on Climate Change (IPCC 1997, 2000). It is beyond the scope of this short essay to critique the methodology, outlined here using a simplified example of enteric fermentation in cattle. Country specific emissions factors are derived using a series of algorithms from relevant peer reviewed literature sources that estimate feed intake and energy needs to derive emissions factors⁷ for daily methane production. Methane emissions are calculated by applying the emissions factor to aggregated livestock numbers drawn from Australian Bureau of Statistics (ABS) census or survey data⁸ (DCC 2008c).

While this methodology is scientifically based and available, the highly generalised nature of the emissions factors mean they do not provide the specific and detailed information needed by farmers in heterogeneous agricultural systems to drive emissions reductions.

⁷ Emissions factors are calculated for each state (WA in 3 regions), season and cattle class (sex/age)

⁸ The ABS is the principal data source for livestock and cropping. The census is taken every 5 years, the latest in 2005-06 and updated with annual survey data. Other data sources include industry bodies, experimental data and scientific literature, and experts in the field.

MEASUREMENT PROBLEMS

“unlike emissions from other sectors, emissions from agriculture are inherently difficult to measure or estimate. They occur over vast areas, they fluctuate (often wildly) over time, and are influenced markedly by management and environmental factors.” (DCC 2008d)

The above quotation summarises the measurement problems facing agriculture. It is this inherent variability of natural systems, together with the dispersed nature of 130,000 farm enterprises and their heterogeneity, that makes affordable and reasonably accurate farm-level measurement of agricultural emissions problematic.

By way of comparison, the ETS is initially expected to cover over 70% of Australia's emissions from just 1,000 enterprises, whereas agriculture produces 16% of Australia's emissions from 130,000 enterprises. Stationary energy, Australia's top emitting sector⁹, has only 28 coal-fired power stations producing point source emissions – coal can be weighed, its carbon content measured and emissions estimated with reasonable accuracy. Emerging and potential low-emission energy technologies also hold promise for a low emission future, whereas the biological nature of agricultural emissions means agriculture cannot be decoupled from the complex natural ecosystems it relies on for production, making agriculture fundamentally different to other sectors.

Three issues that contribute to measurement problems are: the natural variability of Australia's climate and landforms, the scientific knowledge base, and the technical capacity to measure emissions at the farm-scale.

Natural variability

Australia's highly variable climate is a cause of emissions that are outside the management control of farmers. Climate is a driver of emissions as high rainfall years have higher productivity, resulting in higher carbon sequestration in vegetation and soils, and hence lower emissions. Better quality pastures also provide more nutritious feed which reduces methane emissions from enteric fermentation. Conversely, low-productivity dry years result in higher emissions. Variability also affects farm management decisions on cropping, fertiliser use and stocking density – all of which have direct emissions implications. Figures 3 and 4 show Australia's rainfall zones and rainfall and temperature anomalies for the Murray Darling Basin over the past century, which would be expected to have a direct correlation with emissions.

⁹ The stationary energy sector covers all power generation, not just coal.

FIGURE 3. Australia's rainfall zones

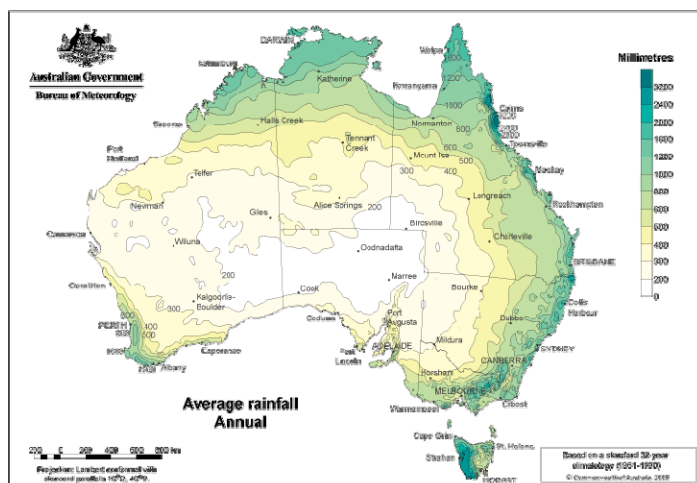
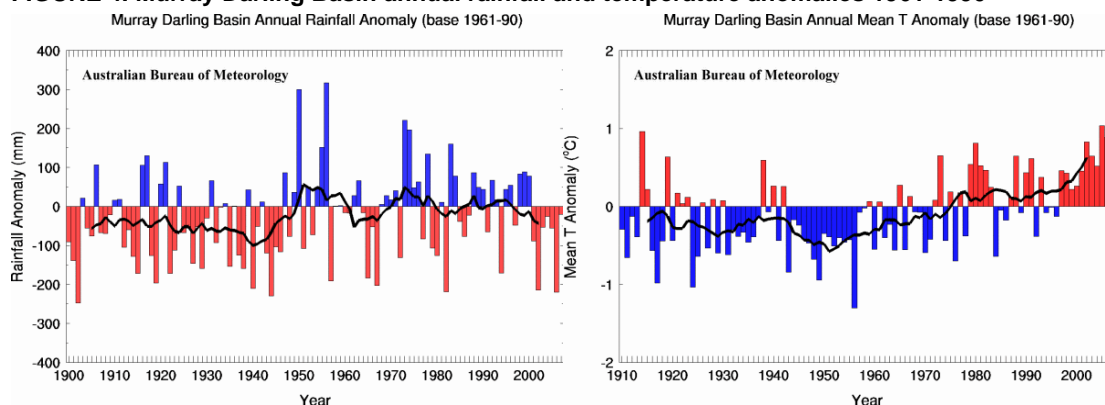


FIGURE 4. Murray Darling Basin annual rainfall and temperature anomalies 1961-1990



As well as climate variability, natural differences in Australian landforms, such as soils and rainfall, also affect emission responses to management practices. These regional variations plus climate variability mean that the same management practices will potentially produce different emissions outcomes. Regardless of the policy instruments used, incentives should reward or penalise management (controllable) behaviour and not natural (uncontrollable) events. Without precise emissions measurement techniques able to isolate the controllable component of emissions, in an ETS for example, farmers would receive windfall gains from excess permits in good seasons, and conversely would need to purchase permits for increased emissions outside their control in dry years – an outcome that is inequitable, would not be politically tenable, and which would create price volatility in the market. Australia decided against including additional activities under Article 3.4 of the Kyoto Protocol as natural variability driven emissions would create unacceptable sovereign risk (DEH 2005a), including it in an abatement policy is inconsistent and increases private risk rather than sovereign risk under the Kyoto Protocol.

Scientific knowledge

Although managing for climate variability has been a major focus of agricultural R&D for the past decade or more, with the exception of the Cooperative Research Centre for Greenhouse Accounting¹⁰, there has been no nationally coordinated research on agricultural emissions until recently. Some R&D on emissions measurement has been done, largely driven by emissions accounting needs with some industry specific research such as by the cotton industry which has a high awareness of the need to prove its environmental credentials. The measurement methodology used in the national accounts (described above) is an example of the application of the limited research that has been done, much of it in the northern hemisphere, to estimate agricultural emissions.

In recognition of the need for a strategic collaborative approach to climate change research, in mid 2007, the Rural Research and Development Corporations, state and territory governments, the Federal Department of Agriculture Fisheries and Forestry and CSIRO joined to develop a National Climate Change Research Strategy for Primary Industries (CCRSPI) (LWA 2008). While the strategy is not due for release until late July 2008, as a national collaborative strategy it would be expected to take a holistic approach to farm level emissions management and cover issues such as improved measurement capabilities, life cycle analysis, improved management practices and integrated decision tools, low emissions technologies, market opportunities, information and impediments to adoption.

Measurement capacity

The diffuse and diverse nature of agricultural emissions across over 130,000 farms together with the lack of simple measurement technology means that direct measurement of on-farm emissions is not a practical or cost effective option. Some examples of direct measurement technologies used in controlled research experiments are shown in Figure 5. While these technologies collect emissions data, their cost and complexity relative to potential benefit in emissions reduction mean they would not be cost effective for routine on-farm decision making.

¹⁰ The Cooperative Research Centre for Greenhouse Accounting was funded for seven years from 1999 to 2006 under the Commonwealth CRC Program.

FIGURE 5. Measurement technologies for agricultural emissions



Photos: Greenhouse in Agriculture Research Program, Melbourne University

Top: Micro Meteorological instruments that record atmospheric concentrations of trace gases, calorimeter for precise measurement of emissions and productivity in dairy cows.
Bottom: open path laser measurement of greenhouse gases, collar that records methane emissions from cattle, chamber to record emissions from crops and agricultural soils.

Moving from direct measurement to estimation introduces uncertainties through, for example, limited studies and data, accuracy of measurement instruments and the complexity of modelling biological processes. The uncertainties for agricultural emissions in the national accounts, shown in Table 2, are evidence of the difficulties of measuring agricultural emissions, with, for example, a low (-5% to +6%) uncertainty for methane from enteric fermentation and high (-45% to +55%) for nitrous oxide emissions from agricultural soils (DCC 2008e).

While the broad methodology of an emissions factor times an activity level could be used to estimate on-farm emissions, to provide reasonably accurate emissions information for farm-level decision making would require emissions factors derived from site specific or representative management and biological data. However, given the uncertainties associated with agricultural emissions and the investment in R&D that would be needed to collect the necessary data across the diversity of landforms and farm systems, and taking into account the influence of natural variability on emissions, it is also unlikely to be cost effective.

TABLE 2. Uncertainties in agricultural emissions measurementRelative uncertainty in emission estimates for the livestock subsector^(a)

Greenhouse gas source and sink categories	Uncertainty (%)	
	CH ₄	N ₂ O
A. Enteric fermentation	-5.1 to +5.9	
B. Manure management	-9.8 to +11.1	-10.1 to +10.6

(a) Uncertainty reported at 95% confidence limits estimated using Monte Carlo analysis.

Relative uncertainty in emission estimates for other agriculture subsectors^(a)

Greenhouse gas source and sink categories	Uncertainty (%)	
	CH ₄	N ₂ O
4. AGRICULTURE		
C. Rice cultivation	-19 to 22	
1. Irrigated	-19 to 22	
D. Agricultural soils		-32 to 52
1. Direct soil emissions		-30 to 42
2. Animal production		-49 to 120
3. Indirect		-61 to 107
E. Prescribed burning of savannas	-52 to 112	-55 to 115
F. Field Burning of agricultural residues	-45 to 55	-43 to 50
1. Cereals	-49 to 60	-47 to 59
2. Pulse	-59 to 85	-59 to 92
3. Tuber and root	NO	NO
4. Sugar cane	-45 to 60	-48 to 63
5. Other	-57 to 96	-57 to 99

(a) Uncertainty reported at 95% confidence limits estimated using Latin Hypercube.

Source: National Inventory Report 2005 (Revised) (DCC 2008)

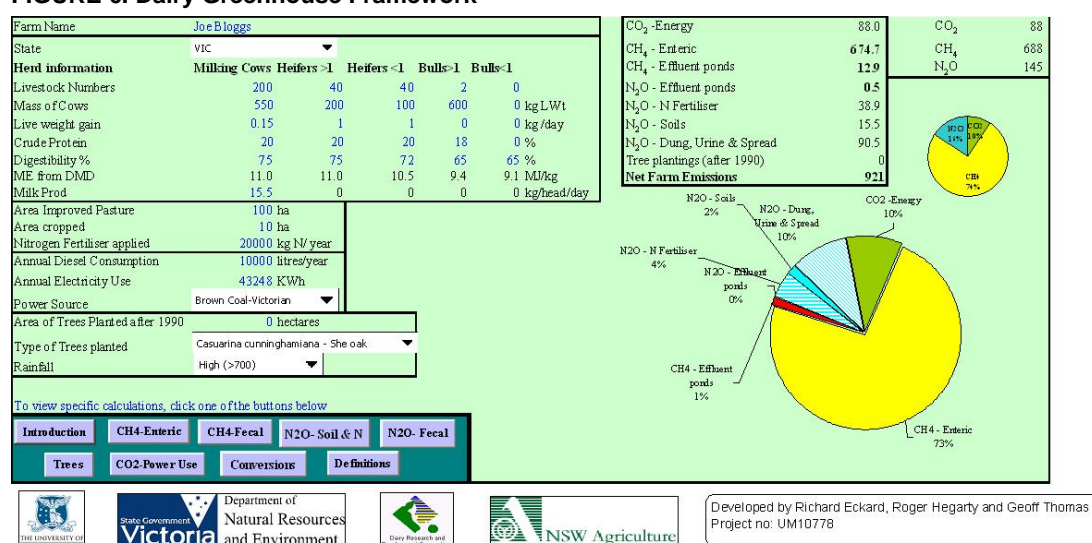
Research into agricultural emissions may not have been extensive enough to produce site specific emissions factors across the diversity of farm systems and landforms, but many 'best practices' that result in lower emissions, for example timing of fertiliser application, have been identified and incorporated into environmental management systems¹¹. While these systems may only provide a 'rule of thumb' measure of emissions or abatement, information is available and can be used for on-farm abatement decisions. Unless the costs of more precise measurement, for example of developing site specific emissions factors, are lower than the marginal abatement benefit obtained over a 'rule of thumb' approach, rule of thumb will provide lower cost abatement.

Accounting tools are also needed to provide information, such as 'what if' analysis, at the farm level. A number have been developed for the land-based sector, with varying degrees of complexity and reliability. The Australian Government's National Carbon Accounting System (NCAS) is used to estimate emissions and sequestration under Land Use Land Use Change and Forestry, and proposed future development includes emissions from livestock, agricultural soils and savanna burning (DEH 2005b), although still a few years away. NCAS is complex, it requires a reasonable level of expertise to use and, like any greenhouse accounting tool, is only as good as

¹¹ Some industry and grower groups have developed environmental management systems known variously as environmental management systems (EMS), best management practice (BMP), farm management systems (FMS) etc.

the underlying data. User-friendly greenhouse calculators¹² using emissions factors are also available over the internet for the dairy (shown in Figure 6), beef, sheep, grains and cotton industries (University of Melbourne 2008). They also provide information on best practices and enable the user to compare emissions outcomes for different management options. Some industry and grower groups also include emissions information as part of their farm or environmental management systems. These systems usually incorporate other market, economic and environmental factors providing a whole of farm management decision tool.

FIGURE 6. Dairy Greenhouse Framework



Measurement costs vary depending on the degree of accuracy required. For example, the ETS needs a high level of accuracy to ensure fungibility and maintain credibility, therefore, emissions must be able to be reasonably accurately monitored, measured or estimated, and verified – and implicitly also affordably. As shown above, this is highly problematic and although work on improving measurement should continue, it should be targeted to maximise potential benefits and alternative abatement policies adopted for agriculture.

ABATEMENT OPTIONS

A major impediment to emissions reduction is that there are few available abatement options for agriculture, and the ones there are tend to be practice based where management decisions, such as cropping rotations, are the drivers of on-farm abatement.

¹² These calculators were developed by the CRC for Greenhouse Accounting's Greenhouse and Agriculture team from Melbourne University and the Victorian Department of Primary Industries.

Agricultural abatement also has potential ancillary benefits of improved productivity as emissions generally represent resources lost to production. Victorian research on nutritional supplements to reduce methane from enteric fermentation has shown a reduction in methane emissions of 12% per cow day, and 21% per kg milk solids, while increasing milk yield by 15%, milk protein by 16% and milk fat by 19% (Grainger *et al* 2008). The apparently low adoption rates of best practices, despite their 'no-regrets' nature, suggests that addressing market failures such as information or capacity constraints impeding implementation of current abatement options may result in 'low hanging fruit' for emissions reduction. Also, the current emphasis on agriculture's future inclusion in the ETS and uncertainty over details such as permit allocation is likely to be a disincentive to adoption of available abatement options.

Depending on the abatement option, measurement could use emissions factors or 'rule of thumb' to estimate emissions or abatement, with all the inherent measurement problems discussed above, or direct measurement and experimentation when undertaken for research.

Methane from enteric fermentation

Enteric fermentation is the largest source of agricultural emissions, accounting for 67% of agricultural emissions, 10% of Australia's total emissions, and the majority of methane emissions. As methane has a short atmospheric life (12 years) its abatement can be seen as having a minor role in abatement. Conversely, methane's relative contribution to warming is masked by the complex accounting rules that uses a 100 year global warming potential (GWP). Taken over a 25 year timeframe, similar the two or three decades recommended for stabilisation of greenhouse gas concentrations (IPCC 2007), methane's GWP increases from 21 to 72 as shown in Table 3 (Forster *et al* 2007) and methane's proportion of Australia's emissions changes from 10% to 46%¹³, making reduction of methane emissions significantly more important.

¹³ A quick recalculation of Australia's emissions using the 25 year GWP of 72 for methane holding other gases' GWP constant, changes the breakup of Australia's emissions to carbon dioxide 49%, methane 46%, nitrous oxide 3% and others 2% (compared to 73%, 20%, 4% and 3% respectively in the national accounts using the 100 year GWP for methane of 21).

TABLE 3. Global warming potentials

Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	Radiative Efficiency (W m ⁻² ppb ⁻¹)	Global Warming Potential for Given Time Horizon			
				SAR ^a (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO ₂	See below ^a	1.4x10 ⁻⁶	1	1	1	1
Methane	CH ₄	12 ^c	3.7x10 ⁻⁴	21	72	25	7.6
Nitrous oxide	N ₂ O	114	3.03x10 ⁻³	310	289	298	153

Source: IPCC Fourth Assessment Report (Forster 2007)

Note: Reporting under the Kyoto Protocol for the first commitment period of 2008-12 uses GWPs from the 1996 Second Assessment Report ("SAR").

Methane is produced by microbes called methagons in the rumen as part of the normal digestive process and breathed or burped out. The resulting energy loss from a dairy cow has been estimated by Eckard (2008), as shown in Table 4, as the equivalent energy as 24 to 38 days grazing or enough to drive a six cylinder LPG car about 1,000 kilometres. Grainger (2008) has also shown that methane abatement can result in a 15% increase in milk production.

TABLE 4. Methane production and energy loss from enteric fermentation

Animal Class	Methane (kg/year)	Equivalent grazing days of energy lost per animal	Potential km driven in 6-cylinder LPG car
Mature ewe	10 to 13	41 to 53	90 to 116
Beef steer	50 to 90	32 to 57	450 to 800
Dairy cow	90 to 146	24 to 38	800 to 1350
Typical level of methane produced from enteric fermentation in the rumen of domestic livestock and relative measures of animal production or energy lost as a result.			Source: Eckard (2008)

Abatement options for reducing methane emissions from enteric fermentation include:

Genetics and herd management: selective breeding from animals with high feed conversion efficiency and fecundity and culling of inefficient animals reduces emissions intensity of production.

Improved nutrition and health: improved feed quality and nutrients increase feed conversion efficiency, but may result in indirect emissions through fertiliser use to improve feed quality. Maintaining healthy animals improves herd productivity.

Feed additives and vaccination (emerging technologies): these technologies work on the chemistry or microbes responsible for methane production in the rumen.

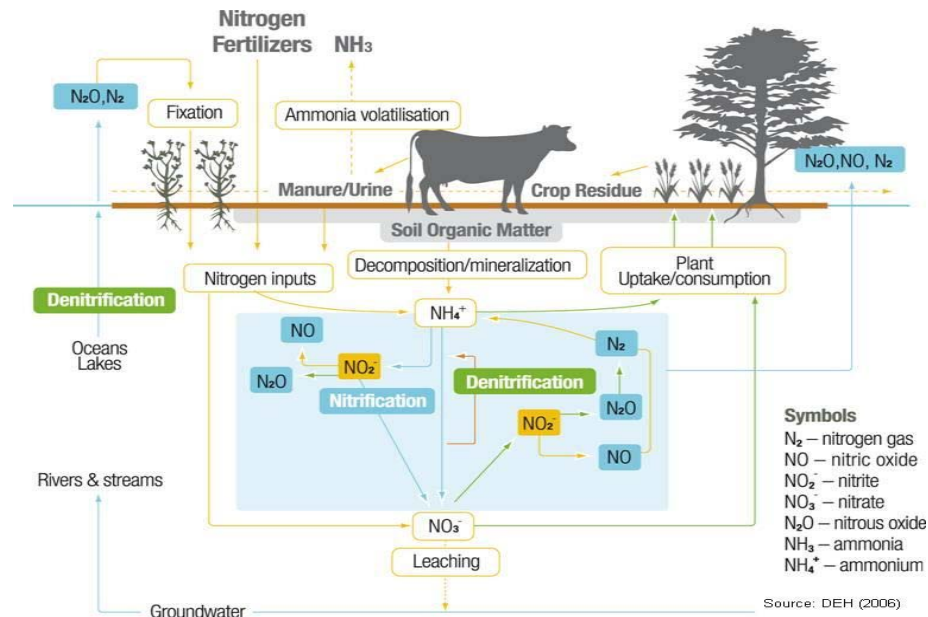
Destocking: subject to the cost implications of abatement policy, in the absence of cost-effective abatement options, destocking may be a rational response to abatement policy¹⁴.

¹⁴ Greenhouse Friendly, the Australian Government's voluntary carbon market, accredited an offset project based on destocking and native vegetation regeneration.

Nitrous oxide

Nitrous oxide emissions result from nitrification and denitrification processes in soils as shown in Figure 7. The predominant cause is nitrogen fertiliser with anything between 20% and 80% of applied nitrogen being taken up by plants (Peoples *et al* 2004), with excess nitrogen resulting in greenhouse gas emissions or leaching and run-off and potential detriment to water quality.

Figure 7. Pathways of nitrogen conversion in soils



Abatement options for nitrous oxide emissions from agricultural soils include:

- Timing of fertiliser application: includes matching fertiliser to plant nutrient needs at different growth stages and timing application around irrigation and rainfall events.
- Method of application: deposition of fertiliser where it is most accessible to plant roots and least subject to water logging.
- Soil management: maintaining good soil structure, continuous plant cover, stubble retention, water management.
- Controlled release fertilisers, urease and nitrification inhibitors (emerging technologies): these technologies work on extending the time available to plants for nutrient uptake.
- Reduce production: cutting back fertiliser use may reduce yields but may be a rational option depending on the cost impact of abatement policy, as is taking land out of production.

Carbon sequestration

While the focus of this essay is enteric fermentation and agricultural soils, carbon sequestration by vegetation and soils is clearly a component of on-farm net emissions and so is briefly covered here.

Carbon sequestration options include:

Agro forestry¹⁵: as well as potential 'carbon farming'¹⁶ forestry has potential to provide multiple benefits from shelter belts, biodiversity, salinity control and water quality (but may reduce water quantity).

Soil management: minimum tillage, controlled traffic, moisture management, continuous vegetation cover and residue retention increase soil carbon with multiple benefits of improved soil fertility, structure and biodiversity. Soil carbon sequestration is not included in the national accounts, but are traded in some voluntary markets in Australia and internationally, for example the Chicago Climate Exchange¹⁷ (CCX).

Char (emerging technology): Char is formed as a result of incomplete combustion and, unlike soil organic carbon that can be emitted if conservation practices are not maintained, char carbon-stores can persist in the soil for hundreds or more years. Char also improves soil structure and aids nutrient and moisture retention with ancillary production benefits¹⁸.

ALTERNATIVE POLICY INSTRUMENTS

In the above sections of the essay, I have discussed the characteristics that make agriculture different from other sectors, including the inherent variability in natural systems, the diffuse nature of emissions, the scale and diversity of agricultural enterprises and the inability to affordably measure on-farm emissions for decision making. I have also shown that abatement of agricultural emissions is needed if significant cuts are to be made to Australia's emissions.

¹⁵ 'Agro forestry' is generally used to differentiate environmental plantings that are not intended for harvest from those planted for timber production, even at a small scale.

¹⁶ NSW Greenhouse Gas Reduction Scheme (GGAS) and voluntary carbon markets including Greenhouse Friendly accept credits from accredited biosequestration projects that meet the Kyoto Protocol definition of forests

¹⁷ CCX soil carbon offsets are practice based, use defaults to estimate carbon sequestered, and annual contracts. Legal agreements commit the seller to maintain conservation practices during the contract period.

¹⁸ The renowned terra preta do indio (Portuguese for Indian black earth) soil of the Amazon is a result of charcoal deposited by Indians over centuries

Furthermore, getting the right policy mix for agriculture is important for Australia – economically, socially and environmentally. At the farm gate (that is, before further value adding), agriculture contributes \$b34 gross value of production (GVP) to the economy (ABS 2008), it generates 13% (\$b28) of Australia's exports and directly employs 3% (308,000) of the Australian workforce (ABARE 2007). Agriculture underpins rural and regional communities economically and socially, it manages 58% of Australia's land area (ABS 2007a) and spends \$b3.4 on natural resource management (ABS 2007b). The potential for perverse outcomes is high if abatement policies are not well formulated and integrated with broader economic, social and environmental policy goals.

While an in-depth policy analysis is beyond the scope of this short essay, three policy options, levy and incentive payments, accreditation standards and voluntary markets, that could be capable of providing equivalent abatement as the ETS, but at a lower cost, are briefly outlined below.

Levy and Incentive payments

A 'carrot and stick' approach, a 'carbon levy'¹⁹, based on an activity measure broadly correlated with emissions such as livestock numbers, could be returned in payments to farmers for implementing and maintaining best practice expected to result in lower emissions. Advantages are that it does not require emissions information and it both rewards good and penalises poor practice. It could incorporate a 'no-regrets' standard with payments benchmarked²⁰ to carbon prices to minimise distortion in land use choices, and could be tiered to reflect priority abatement issues.

Accreditation standards

There are conflicting views²¹ on whether or not accreditation standards draw premium prices. Regardless, consumer awareness of environmental issues means that environmental standards are likely to increasingly influence consumer preferences and eventually drive behaviour change. Best practice could be, and already is in some sectors, incorporated into industry or grower group best practice systems. Advantages of accreditation standards are that they can provide market based incentives to adopt best practice, they are supported by industry driven R&D and can evolve with improved practices.

¹⁹ A levy would provide efficiency benefits over a tax as institutions for R&D and marketing levies are already established. A levy may also be more politically acceptable than a tax.

²⁰ A benchmark does not necessarily mean parity with carbon prices but could be a discounted to reflecting lower transaction costs

²¹ Woolworths market research has found that 'green' products influence preferences but not purchasing decisions (AGET), however China's 'green food' boom is being driven by premium prices in domestic and export markets (Journal of Organic Systems 2007 2(1) 1-11).

Voluntary markets

Voluntary carbon markets are likely to continue as businesses and individuals outside the ETS attempt to reduce their carbon footprints, providing opportunities for offsets from abatement of agricultural emissions. Criteria for voluntary markets may be less demanding than under the ETS, and prices are usually lower to reflect the 'riskier' abatement. In the Canadian voluntary market for example, soil carbon sequestration is seen as temporary and offsets, and although discounted to 7.5% of the price of carbon, still provide a revenue gain to farmers (Brethour and Klimas 2008). While the price can adjust for permanence, additionality should be a criterion in voluntary schemes to avoid leakage. Advantages of voluntary markets are that they provide a market based incentive for farmers to reduce emissions, yet do not require the same level of accuracy in emissions estimates as the ETS, resulting in lower costs.

– oOo –

These policy options, and others, are not mutually exclusive, and a combination is likely to provide the best policy regime for abatement of agricultural emissions. Complementary policies to reduce impediments to implementation should also cover targeted R&D, development of models and user-friendly tools, information and awareness raising, and capacity building for farmers and service providers. Ideally, but challenging, alternative abatement policies would be implemented with the ETS to maintain equity with other sectors.

Selection of policies should also consider transaction costs relative to the benefits they are expected to deliver, although according to McCann (McCann *et al* 2005) this is rarely done in policy evaluation. The ETS focus has been on the cost of covering 130,000 farm enterprises, and not the range of transaction costs including measurement, establishment, compliance and policy delivery, or the relative costs of different policy options.

Measurement cost will range from very high under an ETS requiring a high level of accuracy, and very low in a practice based system where 'rule of thumb' is good enough. Establishment costs for agriculture may not be significantly different as the ETS will be in place and alternative policies may be able to use already established institutions. Farm level information will be needed (a compliance cost) under all policies – moving the ETS's point of obligation up or down the supply chain will still require information from farmers if they are to receive an effective price signal. There is little publicly available data on program delivery costs, the only example I could

find is ABARE's 2002 economic evaluation of FarmBis²² which calculated the NPV of total program costs at \$169 million or \$2,100 per adopter. The analysis included an opportunity cost for time in attending courses (an analogue for time filling out forms) and showed that an increase of less than 0.5% in farm profit would more than cover costs of the program. (Alexander and Goesch 2002).

Determining the optimum abatement policy instruments needs an understanding of both costs and benefits. The main difference in costs is likely to be measurement costs, with ETS costs higher due to the level of accuracy required. Potential benefits depend not only on the policy chosen, but also on available and emerging abatement options, so that with limited abatement options an ETS is unlikely to result in more abatement than under a practice based abatement policy. Based on this essay and using a cost-benefit approach, the ETS will not deliver least-cost abatement in agriculture.

CONCLUSION

Australia has taken a leadership stance in international negotiations and needs to demonstrate a commitment to deep cuts in emissions over the next few decades to establish its credibility – as the second largest emitting sector, agriculture must be part of the solution.

The emphasis on full coverage under the ETS and presumption that agriculture will be included when practical difficulties are resolved is stifling policy debate on whether the ETS is appropriate for agriculture. However, the inherent difficulties in measuring or estimating agricultural emissions mean that the practical difficulties are unlikely to be resolved. In the meantime, agriculture is shielded from having to undertake abatement action and policy is “fiddling while carbon burns” (Pezzey *et al* 2008).

Abatement options are available and policies that provide incentives for reducing agricultural emissions are needed, which may include a levy/incentive payment, accreditation standards and voluntary markets. Future work is needed to explore these options and associated issues.

Some possible areas for further research are:

- identifying impediments to adoption of best practice and possible incentives including a levy/payment scheme

²² FarmBis provides subsidised farm management training and is funded by the Federal and State governments. Over the 3 years from 1998-99 to 2000-01 FarmBis provided 116,000²² training activities to 93,000 participants.

assessing the potential of certification standards to drive purchaser behaviour and on-farm abatement

challenges to developing a nationally consistent environmental management system (which may provide the basis for certification)

evaluating the status of international negotiations in relation to agricultural emissions and potential roles for Australia in technology transfer

These areas are all associated and may be pursued in further research.

REFERENCES

- Agriculture, Greenhouse and Emissions Trading Summit, 2008. *Agriculture and Emissions Trading – Summit Communiqué*. Australian Farm Institute, Sydney.
- Alexander F and Goesch T, 2002. *Economic Impact of the FarmBisI Program and approaches to evaluate FarmBisII*. ABARE, Canberra.
- Australian Bureau of Agricultural and Resource Economics, 2007. *Australian Commodity Statistics 2007*. Canberra.
- Australian Bureau of Statistics, 2007a. *Australian Farming in Brief 2007*. Canberra.
- Australian Bureau of Statistics, 2007b. *Natural Resource Management on Australian Farms 2004-05 (Reissue)*. Canberra.
- Australian Bureau of Statistics, 2008. *Value of Principal Agricultural Commodities Produced 2006-07 – Preliminary*. Canberra.
- Brethour C and Klimas M (2008). *Emissions Trading in Agriculture: A Canadian Perspective*. Paper presented to the Agriculture, Greenhouse and Emissions Trading Summit, 21-22 April 2008.
- Department of Climate Change, 2008a, *Carbon Pollution Reduction Scheme*. Canberra.
- Department of Climate Change, 2008b. *Australian Greenhouse Emissions Information System*. www.climatechange.gov.au/inventory accessed 13 June 2008.
- Department of Climate Change, 2008c, *Australian Methodology for the Estimation of Greenhouse Gas Emissions and Sinks 2006: Agriculture*. Canberra.
- Department of Climate Change, 2008d, *National Greenhouse Accounts (NGA) Factors* p31. Canberra.
- Department of Climate Change, 2008e. *National Inventory Report 2005 (Revised): The Australian Government Submission to the UN Framework Convention on Climate Change 2008, Annex 7*. Canberra.
- Department of Environment and Heritage, 2005a. *Kyoto Emissions Target: Elective Additional Land Use, Land Use Change and Forestry Activities (Article 3.4) – Accounting and Risk Issues for Australia*. Canberra.
- Department of Environment and Heritage, 2005b. *National Carbon Accounting System Development Plan 2004-08*. Canberra.
- Department of Environment and Heritage, 2006. *Reducing Greenhouse Gas Emissions from Australian Agriculture: the Role of Benchmarking in Driving Best Management Practices*. Canberra.
- Department of Environment and Heritage, 2007. *National Greenhouse Gas Inventory 2005: Accounting for the 108% Target*. Canberra.
- Eckard R, Grainger C, Graham J and Griffin T, 2008. *Greenhouse emissions from livestock and fertiliser and implications for a National Emissions Trading Scheme*. Paper presented to the Agriculture, Greenhouse and Emissions Trading Summit, 21-22 April 2008.
- Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland, 2007: Changes in Atmospheric Constituents and in Radiative Forcing. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- Garnaut Climate Change Review, 2008. *Emissions Trading Scheme Discussion Paper*. Canberra.
- Grainger C, Clark T, Beauchemin KA, McGinn SM and Eckard RJ, 2008. Supplementation with whole cottonseed reduces methane emissions and can profitably increase milk

-
- production of dairy cows offered a forage and cereal grain diet. *Australian Journal of Experimental Agriculture*. 48:73-76.
- International Panel on Climate Change, 1997. *Revised 1996 Guidelines for National Greenhouse Gas Inventories*. Available from www.ipcc.ch.
- International Panel on Climate Change, 2000. *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*. Available from www.ipcc.ch.
- International Panel on Climate Change, 2007. *Climate Change 2007: Synthesis Report – Summary for Policy Makers*, p19. Available from www.ipcc.ch.
- Land and Water Australia, 2008. *National Climate Change Research Strategy for Primary Industries*. www.lwa.gov.au/ccrspl accessed 13 April 2008.
- McCann L, Colby B, Easter WK, Kasterine A and Kuperan KV, 2005. Transaction cost measurement for evaluating environmental policies. *Ecological Economics*. 52:527-542.
- Peoples MB, Boyer EW, Goulding KWT, Heffer P, Ochwoh VA, Vanlauwe B, Wood S, Yagi K, van Cleemput O., 2004. *Pathways of Nitrogen Loss and Their Impacts on Human Health and the Environment*. In Mosier, A. R., Syers, J.K and Freney, J. R. (eds). *Agriculture and the Nitrogen Cycle*. Island Press.
- Pezzey JCV, Jotzo F and Quiggin J, 2008. Fiddling while carbon burns: why climate policy needs pervasive emission pricing as well as technology promotion. *The Australian Journal of Agricultural and Resource Economics*. 52:97-110
- University of Melbourne, 2008. *A Decision Support Framework for Greenhouse Accounting on Australian Dairy, Beef or Grain Farms*. Available from www.greenhouse.unimelb.edu.au/gia.htm accessed 13 April 2008.
- Wong P (Minister for Climate Change and Water), 2008a. *Climate Change: A Responsibility Agenda*. Speech to the Australian Industry Group on 6 February 2008. Available from www.environment.gov.au/minister/wong/2008.
- Wong P (Minister for Climate Change and Water), 2008b. *Government announces detailed timetable on emissions trading*. media release, Parliament House, Canberra, 17 March 2008.

Appendix A

Breakdown of greenhouse gas emissions by sector – 2005

AUSTRALIA: Carbon Dioxide Equivalent Emissions	Total	Carbon-dioxide	Methane	Nitrous-oxide	other gh gases
Total Kyoto, 2005	Mt	Mt	Mt	Mt	Mt
Stationary energy	279.4	277.2	1.2	1.0	
Transport	80.4	78.3	0.6	1.5	
Fugitive Emissions	31.2	5.6	25.7	0.0	
Industrial Processes	29.5	17.7	0.0	0.0	11.7
Agriculture	87.9		67.2	20.7	
Land Use, Land-Use Change and Forestry	33.7	31.4	1.8	0.5	
Waste	17.0	0.0	16.4	0.6	
Total Kyoto	559.1	410.2	112.9	24.3	11.7

Breakdown of agriculture sector emissions by source – 2005

AUSTRALIA: Carbon Dioxide Equivalent Emissions	Gg (1,000 tonnes)	Gg (1,000 tonnes)	Gg (1,000 tonnes)	Gg (1,000 tonnes)	Gg (1,000 tonnes)
Agriculture, 2005	Total	CO2	CH4	N2O	other
1 Agriculture	87,888.87		67,155.19	20,733.68	
2 Enteric Fermentation	58,678.42		58,678.42		
3 Cattle	44,038.94		44,038.94		
4 Other Livestock	23.72		23.72		
5 Buffalo	8.41		8.41		
6 Sheep	14,389.38		14,389.38		
7 Goats	55.45		55.45		
8 Camels and Llamas	1.84		1.84		
9 Horses	83.20		83.20		
10 Mules and Asses	0.06		0.06		
11 Swine	77.43		77.43		
12 Manure Management	3,434.36		1,939.35	1,495.01	
13 Cattle	1,649.84		654.48	995.36	
14 Other Livestock	0.01		0.01		
15 Buffalo	0.01		0.01		
16 Sheep	3.74		3.74		
17 Goats	0.03		0.03		
18 Camels and Llamas	0.00		0.00		
19 Horses	0.14		0.14		
20 Mules and Asses	0.00		0.00		
21 Swine	1,263.84		1,238.26	25.59	
22 Poultry	516.75		42.68	474.06	
23 Rice Cultivation	216.01		216.01		
24 Irrigated	216.01		216.01		
25 Agricultural Soils	16,557.96			16,557.96	
26 Direct Soil Emissions	5,386.60			5,386.60	
27 Animal Production	4,247.31			4,247.31	
28 Indirect	6,582.41			6,582.41	
29 Other	341.64			341.64	
30 Prescribed Burning of Savannas	8,650.18		6,076.56	2,573.62	
31 Savanna Grassland	1,816.89		1,250.15	566.74	
32 Savanna Woodland	6,787.22		4,794.71	1,992.50	
33 Temperate Grassland	46.08		31.70	14.37	
34 Field Burning of Agricultural Residues	351.94		244.85	107.10	
35 Cereals	273.70		205.97	67.72	
36 Pulse	20.78		7.19	13.59	
37 Sugar Cane	49.08		25.24	23.84	
38 Other	8.38		6.44	1.95	

Source: Australian Greenhouse Emission Information System
Department of Climate Change