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Agriculture and Emissions Trading

The impossible dream?

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In July 2008, the Australian Government published its Green Paper outlining an emissions trading scheme (ETS), renamed in Australia as the Carbon Pollution Reduction Scheme (CPRS). In comparison with similar schemes, it is comprehensive, covering 75 per cent of emissions in this country. Were agricultural emissions to be included, the coverage would rise to 90 per cent. However, the Government will not decide on the sector’s inclusion until 2013; if the decision is positive, the sector will not have to comply until 2015.

The goal of an ETS is to reduce pollution. A decision is made as to how much pollution is acceptable to avoid a given amount of climate change. Permits to that level are issued to companies and represent the right to emit a certain amount of pollutants. Those wishing to increase their emissions will need to buy permits from the more efficient companies, which have reduced their emissions and therefore do not use up all their credits. The logic is that an ETS will send a price signal to polluters, encouraging them to reduce their emissions. Around 1 000 large ‘upstream’ organisations will be affected by the CPRS.

The ability to measure emissions accurately and affordably is a pre-requisite for including any source of emissions in a robust ETS. While it is relatively easy to measure energy combustion emissions, this is not the case for agriculture. The three main gases produced from agricultural enterprises are carbon dioxide, methane from the digestion systems of livestock and nitrous oxide from chemical processes and microbial activity in agricultural soils. The amount of agricultural emissions depends on a number of factors, many of them not anthropogenic (human-induced) in nature.

The Government wants to include agriculture in the CPRS because it sees the market as being the lowest-cost method of reducing emissions. Further, it considers that the exclusion of agriculture will place a larger burden on those sectors that are included. This paper argues that the Government’s rationale is incorrect; including agricultural emissions in the CPRS is problematic for several reasons.

1. Agricultural emissions cannot be measured with any reasonable accuracy or cost-effectiveness and certainly not using the parameters applied for including emissions in the National Greenhouse Gas Inventory (NGGI). An ETS, which included agricultural emissions, would lack the certainty necessary for market credibility and would fail to send the right price signals.

2. The nature of agricultural emissions themselves makes it difficult for farmers to establish practical abatement systems. Agricultural emissions are derived chiefly from animals and the soil and depend, to a large extent, on natural phenomena totally outside management control. Under these circumstances, including agricultural emissions in the CPRS is effectively a tax on production, while not necessarily resulting in lower carbon emissions.

3. In order to reduce the administrative burden of the CPRS, the Government has elected to include only those polluters emitting more than 25 kt CO_2-e per year. The agriculture sector is made up of 130 000 predominantly small businesses,

which collectively emit 16 per cent of total Australian emissions, but individually emit far less than 25 kt CO_2-e annually.

While these factors suggest that the inclusion of agriculture is inconsistent with the design principles of the CPRS, they do not suggest that the sector should be exempt from other measures aimed at reducing emissions. The paper explores a number of options for achieving emissions abatement outside an ETS, including:

1. herd management and nutrition where methane is concerned
2. soil and fertiliser management where nitrous oxide is concerned
3. carbon sequestration in both plants and soil and the ways to increase this
4. alternative policy instruments such as levy and incentive payments, accreditation standards and voluntary markets.

Currently in Australia, the political ethos regarding the inclusion of agriculture in an ETS is troubled. The Government wants to include agriculture, but not before 2015. The sector's position reflects the diversity of agriculture; some sub-sectors consider their inclusion to be self-defeating and are lobbying to be exempted from having to abate emissions at all while others are lobbying for including agriculture from the start of the CPRS. This paper suggests that both sides of the debate are inaccurate: while it might prove counter-productive to include agriculture in a formal ETS, it is imperative that the sector be encouraged to adopt best-practice methods of emissions abatement now.

1. Introduction

The much-anticipated Green Paper on the emissions trading scheme (ETS), now called the Carbon Pollution Reduction Scheme (CPRS), was released in July 2008. The Government intends the scheme to be comprehensive but there is some ambivalence towards the inclusion of agricultural emissions. A decision on this matter will not be made until 2013 and, if in the affirmative, 2015 is the earliest date that the decision will take effect.

Since early in 2008, the question of whether or not to include agricultural emissions in the CPRS has been one of the more persistent themes of the climate-change policy debate, a debate that has been clouded, unfortunately, by a general failure to understand the nature of agricultural emissions and how they might be measured. A pre-requisite for including any source of emissions within an ETS is the ability to measure those emissions accurately and affordably for, without this, the credibility of the scheme is undermined. Parties are unlikely to be willing to exchange money for permits to emit if measurement of the emissions backing those permits is subject to significant uncertainty. In fact, this is the case with agricultural emissions.

We argue that measurement uncertainties are inherent in the nature of agricultural emissions and are a difficulty that 'further research' or 'better understanding' cannot overcome. For this reason, amongst others, we argue that it is optimal not to include agricultural emissions if a robust ETS is to be the outcome.

Therefore, we suggest, policy makers would be well advised to give up the quest for the unattainable and turn their attention to developing alternative approaches to reducing agricultural emissions. Delaying the decision to include agriculture in the CPRS will only serve to shield it from the implementation of alternative abatement policies, for it will be equivalent to providing the industry with 100 per cent free and uncapped permits until at least 2013, a disincentive for early emissions abatement.

This paper begins by exploring the key aspects of the CPRS and goes on to describe the various sources of agricultural emissions. It describes how emissions are estimated for the purposes of compiling Australia's National Greenhouse Gas Inventory (NGGI) and then explains why it is not possible to measure agricultural emissions in a way that makes them suitable for inclusion in the CPRS. It ends with a discussion on possible alternative abatement policies available to the sector.

1.1 How does emissions trading work?

Emissions trading schemes are aimed at reducing greenhouse gas pollution, with the ultimate objective of halting and reversing global warming and climate change. Although several countries and states within countries have already established such schemes, Australia has lagged behind in the process and Australians, by and large, have yet to be informed as to how the schemes work and how they, as individuals, might be affected when one is introduced by the Australian Government.

An increase in anthropogenic emissions over the last century is considered to be the major cause of global warming and climate change. Anthropogenic emissions are those resulting from human activity and include the burning of fossil fuels for energy, deforestation and land-use changes. Businesses incur a cost when their local councils collect and remove their normal garbage but they have not had to pay to clean up the pollution caused by their operational business decisions. A proliferation of goods and services sold too cheaply to consumers are the consequences of a failure to cost and charge for one of the factors of production. This situation leads to market failure, which occurs because decisions left to the market fail to result in efficient and desirable outcomes. In the face of the significant market failure that has caused greenhouse gas pollution, intervention of some kind has now become necessary.

The Australian Government has chosen to adopt an ETS as the solution to reducing CO_2 emissions and hence global warming. In Australia, the scheme will be known as the Carbon Pollution Reduction Scheme (CPRS) and it will have a three-stage design.

1. The Government will choose a national cap on greenhouse gas emissions designed to assist with the implementation of its long-term target of reducing emissions by 60 per cent on 2000 levels by 2050. This will obviate the necessity of limiting each individual's greenhouse pollution, which would be a daunting task.

2. The national cap is represented by permits, each of which will grant organisations the right to emit one tonne of CO_2, thus serving to limit the amount of pollution that can be emitted into the atmosphere. Those organisations wanting to emit more than their permits allow will need to buy additional permits from more efficient organisations, thereby establishing a carbon trading facility.

3. Rather than each individual entity becoming responsible for its greenhouse gas emissions, the CPRS will limit liability to 1 000 large, 'upstream' polluters. This will reduce administrative costs and the difficulties of ensuring compliance among considerable numbers of people and organisations.

This is a cost-effective method of meeting emission goals as the market decides the price of carbon. Each year, the cap is lowered resulting in a decrease in the number of permits available, a situation that will inflate the price of carbon and increase the incentive to pollute less. Emitting greenhouse gases will come at an increasing cost.

Although individuals will not have to be aware of the quantum of their own greenhouse gas emissions, initially they may well experience higher prices for services such as electricity and transport when organisations attempt to pass on the increased costs of producing these services. However, this will also create an incentive for individuals to switch to more energy efficient providers. The trade in carbon and greenhouse gases facilitated by the CPRS will allow the Government to generate significant revenue, some of which can be used to assist individuals to reduce energy costs by relying less on coal and oil.

1.2 Agriculture in the CPRS

One of the key principles underpinning market credibility is fungibility, or the ability to substitute one commodity for another of equal value. In the context of an ETS, an emissions permit can be converted into a tradeable currency requiring a tonne of carbon from one source (say coal-fired power) to be interchangeable with a tonne of carbon from a different source (say methane emissions from livestock).

Confidence that emissions can be measured accurately and affordably is central to the efficient operation of the CPRS but the idiosyncratic nature of agricultural emissions works against achieving this necessary assurance. There are also international implications; a perceived lack of fungibility arising from the inclusion of agriculture is likely to undermine confidence in the CPRS, thereby limiting opportunities for international linking and devaluing Australian permits.

Associated with the measurement issue is the scale of agriculture. The CPRS is initially expected to cover 75 per cent of Australia’s emissions from just 1 000 enterprises whereas, by way of comparison, agriculture produces 16 per cent of Australia’s emissions from over 130 000 enterprises. The CPRS proposes a point of obligation either up or down the supply chain to reduce both the number of reporting enterprises and the cost to the scheme of including agriculture. However, moving the point of obligation from the emissions source does not overcome the emissions measurement problems or create an effective price signal to inform on-farm abatement decisions—the very purpose of an ETS.

The Government clearly expects the CPRS to be as comprehensive as possible. Excluding agriculture, it covers 75 per cent of Australia’s emissions making it one of, if not the, most comprehensive emissions trading schemes. Were agriculture to be included, CPRS coverage would increase to a staggering 90 per cent or more. Note, however, that although the schemes of some nations are narrower in the range of emissions covered, uncovered sectors may be subject to alternative mitigation measures in order to drive abatement (Department of Climate Change, 2008a).

The Government’s preference for comprehensive coverage, and therefore its need to include agriculture in the CPRS, appears based on two fallacies:

1. that the market will be more efficient than other policy instruments in identifying least-cost abatement options for agriculture

2. that other sectors will have to abate more if agriculture is excluded from the CPRS.

The first fallacy depends on the notion that the market possesses the necessary information to operate efficiently; this is incorrect because of the difficulties inherent in measuring agricultural emissions in a reasonably accurate and affordable way.

The second fallacy implies that partitioning agriculture from the CPRS absolves the sector from abatement responsibility. This is also incorrect as alternative policies are available to drive the abatement of agricultural emissions.

2. Measuring greenhouse gas emissions

2.1 Introduction

As greenhouse sceptics frequently point out, there are many natural processes that emit greenhouse gases into the atmosphere. However, the current enhanced greenhouse effect has been caused by the great increase in the emissions of some of these gases resulting from human activities, that is anthropogenic or human-induced emissions. Therefore, the foundation principle contained in the United Nations Framework Convention on Climate Change (UNFCCC) is that inventories account only for anthropogenic emissions. For some emissions sources, however, notably some of those categorised as agricultural emissions, the distinction between anthropogenic and non-anthropogenic is a relatively fine one. We discuss these cases in more detail below.

The framework for preparing an inventory of greenhouse gas emissions at both the national and individual firm levels is constructed according to the principles embodied in the UNFCCC and the methodology provided by the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (henceforward referred to as ‘the IPCC Guidelines’ or ‘the Guidelines’).

The Guidelines categorise anthropogenic emissions primarily by the nature of the physical, chemical and biological processes that produce them. There are five major source categories:

- energy
- industrial processes
- agriculture
- land use, land use change and forestry (LULUCF)
- waste.

Within these categories, six ‘Kyoto gases’, strictly groups of gases, are accounted for in national greenhouse gas inventories:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- hydro fluorocarbons
- per fluorocarbons
- sulphur hexafluoride.

These gases affect the climate by absorbing long wavelength infrared radiation emitted from the surface of the earth, termed radiative forcing, but do so to different extents. They are also removed from the atmosphere by natural processes (such as sequestration by seawater and vegetation or chemical breakdown) over different timeframes; for example, methane and nitrous oxide have atmospheric lifetimes of 12 and 114 years respectively.

2.2 Global warming potential

Global warming potential (GWP) is the factor used to convert different greenhouse gases into the common unit of carbon dioxide equivalent (CO_2-e) necessary for aggregation and comparison of different greenhouse gases. The GWP of a gas is the ratio of the total radiative forcing of a given mass; for example, one gram of the gas for a given time period, say 100 years, to the radiative forcing of the same mass of CO_2 over the same period. Shorter or longer periods change GWP values, as can be seen in Table 1. GWPs used for compiling emissions inventories under the Kyoto Protocol use 100 years; however, if the policy objective is to achieve rapid reductions in emissions, short-lived gases such as methane become more important than would appear simply by comparing relative emissions of methane and CO_2 based on 100-year GWP values.

Table 1: Global warming potentials

Gas	Chemical formula	Global warming potential for given time-horizon			
		SAR[1] 100-yr	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	1	1	1	1
Methane	CH_4	21	72	25	7.6
Nitrous oxide	N_2O	310	289	298	153

Source: extracted from IPCC Fourth Assessment Report (Forster *et al* 2007)

2.3 Energy emissions

In most countries, including Australia, energy is both the largest and fastest-growing source of emissions. Figure 1 shows that energy emissions (stationary energy, transport and fugitive emissions) account for 70 per cent of Australia's total emissions. Fugitive emissions are emissions not confined to a stack, duct or vent and include those released from equipment leaks, raw materials processing and handling, dust and other industrial processes.

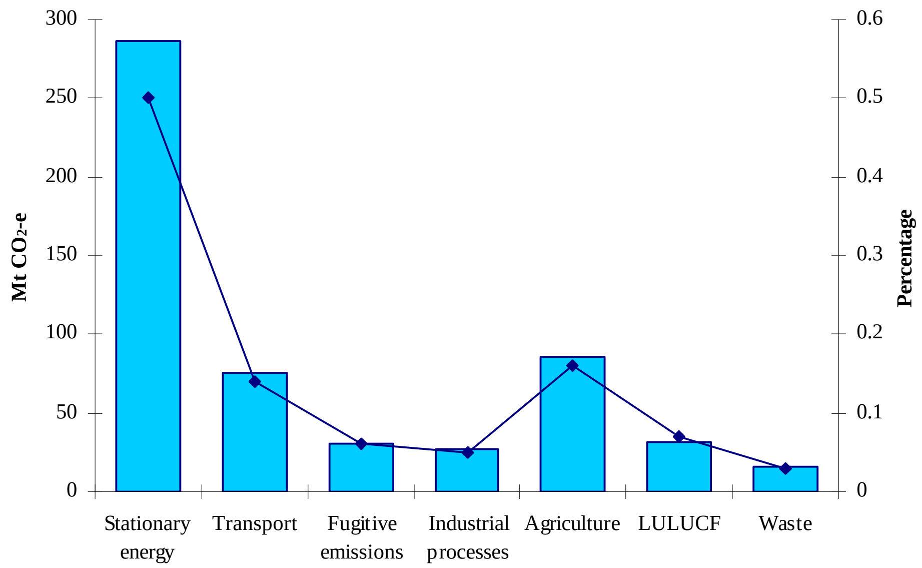
Carbon dioxide comprises the majority of energy emissions and results from the combustion of fossil fuels. Side reactions during combustion processes also cause the emission of small quantities of methane and nitrous oxide, which are therefore also

[1] Greenhouse gas accounting rules under the Kyoto Protocol use GWPs from the IPPC Second Assessment Report (SAR) produced in 1995.

part of energy emissions. Combustion energy emissions arise from all activities involving fuel combustion to produce energy, including agriculture and forestry, mining, manufacturing, transport and all other sectors of the economy where petroleum products, natural gas or coal are combusted to produce useful energy. Reports on energy emissions often separate those derived from energy use for transport from those derived from energy use for all other activities. The latter are often termed stationary combustion emissions, even though some important sources such as tractors and other agricultural machinery are not, in fact, stationary when in use.

It is important to note that the use of electrical energy is not a direct source of emissions; the emissions arise at the power station, which burns either coal or natural gas to generate electricity. A second point to note about emissions from energy combustion is that the Guidelines set CO_2 emissions from biofuels (wood, ethanol, biodiesel, biogas) at zero, based on the default assumption that the raw materials from which these fuels are produced, the crops, trees and so on, are all being grown on a sustainable basis and will regrow after harvest. Where that is not the case, however, CO_2 emissions from burning these fuels are categorised under land use change—that is, land clearing.

Figure 1: Australia's National Greenhouse Gas Inventory—total emissions



Source: *National Greenhouse Gas Inventory 2006* (Department of Climate Change, 2008b)

2.4. Agricultural emissions

Agricultural emissions are defined as those resulting from the growing of crops, the rearing of livestock and the various ways in which soil is managed to maximise crop and livestock production. Importantly, agricultural emissions do not include emissions from the fuel used in agriculture as this falls under energy emissions. In Australia, agriculture sector emissions at 16 per cent are the second highest after stationary energy combustion and, if production returns to pre-drought levels without a compensating reduction in the emissions intensity of production, it is expected that they will increase.

As shown in Table 2, methane, produced mainly through the digestive processes (enteric fermentation) of cattle and sheep, is the major source of agricultural emissions. Enteric fermentation produces 66 per cent of agricultural emissions, 10 per cent of Australia's total emissions, and the majority of methane emissions. As it has a short atmospheric life of 12 years, methane is often perceived as playing only a minor role in abatement efforts. However, the complex accounting rules that use a 100-year GWP mask the relative contribution of methane to warming.

The IPCC recommends that stabilisation of greenhouse gas concentrations takes place over the next two to three decades (IPCC 2007). Calculating the GWP of methane using a similar timeframe of 25 years, results in an increase from 21 to 72, as shown in Table 1, and the proportion of Australia's emissions attributable to methane changes from 10 per cent to 46 per cent,[2] rendering early abatement of methane emissions significantly more important.

Chemical processes and microbial activity in agricultural soils constitute the next biggest sources of agricultural emissions and together emit nitrous oxide, which accounts for 17 per cent of agricultural emissions and almost three per cent of Australia's total emissions. The balance of methane and nitrous oxide emissions comes from prescribed burning of savannas, management of manure and field burning of agricultural residues.

The fluxes of CO_2 that result from cropping and rearing livestock are much greater than are those of either methane or nitrous oxide. However, they are not considered to contribute to net anthropogenic emissions because they are recycled on an annual basis or even more frequently as crops and pastures grow, are harvested and re-grow. On the other hand, fluxes of CO_2 from long-lived tree crops, that is forestry activity, are included in the LULUCF emissions source category of national inventories because of the long life cycle of trees. The lack of recognition of the role of soil carbon in mitigating climate change is contentious, with growing evidence of the potential for farming practices to increase carbon sequestration by soils.

[2] The break-up of Australia's emissions, which appear in the national accounts and are calculated using the 100-year GWP for methane of 21, comprises 73 per cent carbon dioxide, 20 per cent methane, four per cent nitrous oxide and three per cent others (Department of Climate Change, 2008b). A quick recalculation using the 25-year GWP of 72 for methane and holding the GWP of other gases constant, changes the break-up of Australia's emissions to 49 per cent carbon dioxide, 46 per cent methane, three per cent nitrous oxide and two per cent others.

Table 2: Australia's National Greenhouse Gas Inventory—agricultural emissions

Greenhouse gas source and sink categories	CO_2-e emissions (Mt)				% total net national emissions
	CO_2	CH_4	N_2O	Total	
AGRICULTURE	N/A	69.8	20.32	90.1	15.6%
Enteric fermentation	N/A	59.3	N/A	59.3	10.3%
Manure management	N/A	2.0	1.6	3.6	0.6%
Rice cultivation	N/A	0.3	N/A	0.3	0.05%
Agricultural soils	N/A	N/A	15.2	15.2	2.6%
Prescribed burning of savannas	N/A	8.1	3.4	11.5	2.0%
Field burning of agricultural residues	N/A	0.2	0.1	0.3	0.1%

Source: *National Greenhouse Gas Inventory 2006* (Department of Climate Change 2008b)

2.5 How emissions are measured in the NGGI

All emissions are measured, or to be more precise calculated, by multiplying the level of a particular activity that produces emissions by an emission factor for that activity. However, the method of measuring energy combustion emissions is fundamentally different from the method of measuring emissions from almost all other sources.

When measuring energy combustion emissions, the activity is the quantity of fuel (coal, petroleum products or natural gas) consumed. The emission factor is calculated from the mass fraction of carbon in the fuel, on the assumption that the combustion process converts all carbon, with the exception of a very small adjustment (one per cent or less) for unburnt fuel, to CO_2. This means that one tonne of carbon (atomic weight 12) produces 44/12 = 3.67 tonnes of CO_2 (molecular weight 44), less the unburnt fuel adjustment. For most common fuels, the mass fraction of carbon is both well understood and constant, as it relates closely to the product quality specifications of the fuel. Therefore, it is simple to calculate emissions from fuel consumption data with a high level of accuracy; for example, litres of petrol, tonnes of coal and so on. For some fuels, particularly some coals, the carbon mass fraction can be somewhat variable and, in this case, taking samples for analysis from time to time can improve the accuracy of emissions measurement. In no case, however, is it considered necessary or useful to take physical measurements of the volumes of CO_2 emitted as a fuel is burned.

By contrast, the relationship between emissions and activity for almost all other emissions sources is more complex and difficult to define. For example, methane emissions from enteric fermentation processes in the stomachs of ruminant livestock (effectively cattle and sheep) depend on how much food the animal has eaten in the preceding period, the nature of that food (woody, herbaceous, grains) and the characteristics of the individual animal. Much experimental work, involving attaching cumbersome measuring equipment to animals, has established relationships between these parameters. However, these are inevitably approximate only and, even if they were precise, using these relationships to estimate emissions from a herd of free-range cattle would require constant monitoring of their diet.

In terms of the simple algorithm, emissions = emission factor x activity level, activity level is the number of cattle or sheep but there are potentially many different emission factors, depending on how much and what the animals have been eating and the operation of their digestive processes.

For these reasons, the estimates in the NGGI of methane emissions from livestock are calculated using methods and emission factors to define algorithms that are specific to Australian conditions but averaged over the total population of livestock. That is, a series of algorithms from peer-reviewed literature estimating feed intake and energy needs are used to derive Australian-specific emission factors[3] for daily methane production. Methane emissions are calculated by applying the emission factor to aggregated livestock numbers drawn from Australian Bureau of Statistics (ABS) census or survey data.[4] The estimate is then averaged with estimates from the previous two years and a three-year average reported in the national inventory (Department of Climate Change 2008c). Although this is a scientifically based methodology, there are significant uncertainties in the resulting emissions estimates, even at this high level of aggregation, as shown in Table 3. While the example above refers to methane emissions from enteric fermentation, similar measurement issues apply to all agricultural emissions.

The highly generalised nature of the NGGI emission factors prevents this methodology from being able to provide the specific and detailed information needed by farmers to drive emissions reductions in heterogeneous agricultural systems. Potentially, the result will be a lack of fungibility and equity between different farm enterprises because estimates cannot reflect the relative emissions (practices) of different farm enterprises.

The contrast between the uncertainties of these emission estimates, which are typical of all agricultural emission sources (some, such as emissions from soils, have much higher uncertainty), and the precision of energy combustion emissions calculations is clear. Note that although Table 3 shows that transport-related energy combustion emissions of methane and nitrous oxide are subject to high uncertainty, these gases account for less than five per cent of total emissions measured in CO_2-e units, so that these high uncertainties have negligible effect on the overall uncertainty of estimated emissions from these sources.

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[3] Emission factors are calculated for each state (WA is divided into three regions), seasons and cattle class (sex/age).

[4] The ABS is the principal data source for livestock and cropping. The census is taken every five 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.

Table 3: Australia's National Greenhouse Gas Inventory—uncertainty analysis

Relative uncertainty in emission estimates for the livestock sector[a]

Greenhouse gas source and sink categories	Uncertainty (per cent)	
	CH_4	N_2O
Enteric fermentation	-5.1 to +5.9	
Manure management	-9.8 to +11.1	-10.1 to +10.6

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

Relative uncertainty in emission estimates for other agriculture subsectors[a]

Greenhouse gas source and sink categories	Uncertainty (per cent)	
	CH_4	N_2O
AGRICULTURE		
Rice cultivation	**-19 to 22**	
Irrigated	-19 to 22	
Agricultural soils		**-32 to 52**
Direct soil emissions		-30 to 42
Animal production		-49 to 120
Indirect		-61 to 107
Prescribed burning of savannas	**-52 to 112**	**-55 to 115**
Field burning of agricultural residues	**-45 to 55**	**-43 to 50**
Cereals	-49 to 60	-47 to 59
Pulse	-59 to 85	-59 to 92
Tuber and root	NO	NO
Sugar cane	-45 to 60	-48 to 63
Other	-57 to 96	-57 to 99

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

Quantified uncertainty values for key stationary energy subcategories [a]

Greenhouse gas source and sink categories	Uncertainty (%)			
	CO_2	CH_4	N_2O	Total CO_2-e
ENERGY				
Fuel combustion activities				
Electricity	±5	±9	±15	±5
Petroleum refining	±4	±9	±12	±4
Manufacture of solid fuels and other energy industries	±4	±9	±12	±4
Transport				
Civil aviation	±9	±52	±52	not reported
Road transport	±4	±25	±42	not reported
Railways	±5	±39	±39	not reported
Navigation	±8	±59	±32	not reported

Source: *National Inventory Report 2006* (Department of Climate Change 2008d)

2.6 Measurement problems

This high level of uncertainty in the national inventory is indicative of the problems associated with measuring agricultural emissions, a fact that the Department of Climate Change recognises in its *National Greenhouse Accounts (NGA) Factors* publication, which states:

> … [U]nlike 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. (Department of Climate Change 2008e)

The biological nature of agricultural emissions, together with the impossibility of separating agriculture from the complex natural ecosystems it relies on for production, make this sector fundamentally different from other sectors. Three interrelating issues contribute to the measurement problems:

- the natural variability of Australia's climate and landforms
- the scientific knowledge base
- the technical capacity to measure emissions at the farm scale.

Natural variability

Australia's highly variable climate is a key driver of emissions. High-rainfall years result in higher productivity, higher carbon sequestration in vegetation and soils and hence lower emissions. Better quality pastures also provide more nutritious and digestible fodder, improving feed conversion efficiency and thereby reducing methane emissions from enteric fermentation. Conversely, dry years result in low productivity and higher emissions. Yet these naturally occurring emissions are largely outside the management control of farmers. Climate and weather also affect farm management decisions, for example on cropping, fertiliser use and stocking density, all of which have direct implications for emissions.

In addition to climate variability, natural differences in Australian landforms, such as soils and rainfall, will also affect emission responses to management practices; similar management practices will potentially produce different emissions outcomes in different regions.

As explained above, the UNFCCC's foundation principle is that emissions inventories account only for anthropogenic emissions; thus policies should reward or penalise management (controllable) behaviour and not natural (uncontrollable) events. Without precise emissions measurement techniques with the ability to identify and remove the climate signal from agricultural 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. Such an outcome would be inequitable and politically untenable and would create price volatility in the market.

Interestingly, Australia decided against including so-called additional activities, for example changes in the amount of CO_2 stored in sinks in agricultural soils, under Article 3.4 of the Kyoto Protocol because natural, variability driven emissions would create unacceptable sovereign risk (DEH 2005a). Including naturally driven emissions in an abatement policy is inconsistent with that analysis, increasing private risk rather than the sovereign risk that might have been created under the Kyoto Protocol.[5]

Scientific knowledge

Although managing for climate variability has been a major focus of agricultural research for the past decade or more, there has been no nationally coordinated research on agricultural emissions with the exception of the Cooperative Research Centre for Greenhouse Accounting.[6] Research on emissions measurement, mostly carried out in the northern hemisphere, has been largely driven by accounting needs, such as the desire to implement more data-intensive disaggregated methodologies for compiling national emissions inventories.

The proposed National Climate Change Research Strategy for Primary Industries (CCRSPI)[7] (LWA 2008) may begin to address the knowledge gap. A major collaborative effort involving all the big players in agricultural policy and research and development, it would be expected to take a holistic approach to farm-level emissions management and to cover issues including:

- improved measurement capabilities
- life-cycle analysis
- improved management practices and integrated decision tools
- low emissions technologies
- market opportunities
- information and impediments to adoption
- funding.

However, while all of these initiatives are required to help reduce agricultural emissions, it is unlikely that ‘more research’ will provide the reasonably accurate and affordable techniques for measuring farm-level agricultural emissions necessary for inclusion in the CPRS. Worse, while the Government pins its hopes on resolving

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[5] Sovereign risk refers to the risk of default on a sovereign loan or the risk of appropriation of assets held in a foreign country.

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

[7] In mid-2007, the rural research and development corporations, state and territory governments, the Australian Government Department of Agriculture, Fisheries and Forestry and the CSIRO joined to develop a National Climate Change Research Strategy for Primary Industries (CCRSPI). The strategy was due for release in July 2008.

practical obstacles to including agriculture in its scheme, it delays the development of alternative abatement policies and leaves agriculture with no incentive, in fact a disincentive, to early abatement.

Institutional capacity

Direct measurement of on-farm emissions is not a practical or cost-effective option because of:

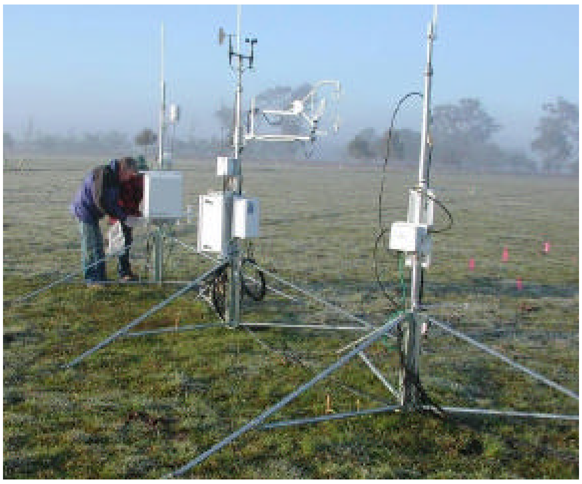
- the lack of a simple measurement technology.
- the current levels of understanding
- the diffuse nature of agricultural emissions across more than 130 000 diverse farm enterprises.

The lack of a simple measurement technology

Some measurement technologies (for examples see Figure 2) used in controlled experiments do collect emissions data; however, they would not be effective for routine on-farm decision-making because of their cost and complexity relative to their potential emissions reduction benefit.

Substituting estimation for direct measurement only introduces more uncertainties. Limited studies and the resulting lack of data, the inaccuracy of measurement instruments and the complexity of modelling biological processes all contribute to these uncertainties. The national inventory methodology of ‘emission factor x activity’ could be used to estimate on-farm emissions, but emission factors derived from site-specific or representative management plus biological data are necessary to provide reasonably accurate emissions information for farm-level decision-making. The uncertainties associated with agricultural emissions, the influence of natural variability and the research and development investment that would be required to collect the necessary data across the diversity of landforms and farm systems, suggest that the costs would be prohibitive and might not result in more abatement.

Figure 2: Measurement technologies for agricultural emissions



Micro-meteorological instruments that record atmospheric concentrations of trace gases.

Calorimeter for precise measurement of emissions and productivity in dairy cows.

Open path laser measurement of greenhouse gases.

Collar that records methane emissions from cattle.

Photos: Greenhouse in Agriculture Research Program, Victorian Department of Primary Industries and the University of Melbourne (2008)

The current levels of understanding

Although the knowledge gap with respect to measuring emissions is wide, many ‘best practices’ that deliver lower emissions have been identified and incorporated into environmental management systems.[8] The timing of fertiliser application to plant-growth stages enabling the plant to take up more nutrients, thus increasing productivity and lowering emissions, is one example of these. A ‘rule of thumb’ measure, while not accurate enough for emissions trading, is sufficient to inform on-farm abatement decisions.

[8] 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) and so on.

The policy problem relates to the relative cost of collecting data that are more accurate from site-specific measurements compared to the benefits (in terms of additional CO_2 abatement) of switching away from the 'rule of thumb' approach to measurement. Unless significant additional abatement is likely to flow from the switch to specific measurement, the additional costs involved will be unjustified.

Farmers also need decision tools to weigh up different management options such as crop rotations and make abatement decisions at the farm level. Examples are the simple-to-use greenhouse calculators[9] that calculate national inventory emissions factors for the dairy, beef, sheep, grain and cotton industries (University of Melbourne 2008). These calculators also provide best practice guides to enable the user to compare emissions outcomes under different management options. Some industry and grower groups also include emissions information as part of their farm or environmental management systems and incorporate market, economic and environmental factors thus providing a whole-of-farm management decision tool.

At the other end of the spectrum, proposed development of the Australian Government's National Carbon Accounting System (NCAS) will extend its capacity from the current LULUCF activities to include emissions from livestock, agricultural soils and savanna burning (DEH 2005b). NCAS is complex and requires a reasonable level of expertise; like any greenhouse accounting tool, it is only as good as the underlying data and its use for agricultural emissions is still a few years away.

The adage 'what gets measured gets done' is valid for abatement; but what level of accuracy is necessary and what are the relative costs and benefits? For example, the CPRS needs a high level of accuracy to ensure fungibility and maintain credibility; therefore, the ability to monitor, measure or estimate and verify emissions in an affordable and reasonably accurate way is essential. As discussed above, this is highly problematic for agriculture and policy makers should acknowledge the situation and move ahead to develop alternative abatement policies for agricultural emissions.

The diffuse nature of agricultural emissions

However, even if measurement of emissions were to present no problems, a further aspect of institutional capacity serves to render coverage of agricultural emissions by the CPRS problematic. As the Green Paper points out, annual emissions from the overwhelming majority of Australian farm enterprises fall well below 25 kt CO_2-e per year. The CPRS designers consider this the threshold below which requiring an enterprise to buy permits and then account for and acquit its emissions against those permits would impose an unreasonable administrative burden. The same logic should apply to agricultural enterprises. A comparison of the number of enterprises from non-agricultural emission sources with annual emissions greater than 25 kt CO_2-e, estimated by the Green Paper to be about 1 000, with the total number of agricultural enterprises, estimated to be more than 130 000, serves to highlight this disparity.

[9] The CRC for Greenhouse Accounting's Greenhouse and Agriculture team from Melbourne University and the Victorian Department of Primary Industries developed these calculators.

Where sources of energy combustion emissions are small, for example private motorists, the scheme proposes to ‘upstream’ liability by requiring suppliers of fuel, all of which are large businesses, to hold and acquit permits. There is nowhere, however, to ‘upstream’ liability for agricultural emissions discharged from livestock born on the farm or from agricultural soils cultivated on the farm. It has been suggested that such liability could be ‘downstreamed’ instead, for example to the abattoir, the saleyard, or the grain-receiving terminal. This approach, however, would sever any link between on-farm activities and practices and emissions liability, a fundamental drawback.

A downstream point of acquittal could not take account of, or be able to establish without huge administrative costs, the different practices and emissions patterns of individual farms. It would be obliged to impose the cost of permits in the form of a uniform levy, for example per tonne of beef carcase or per tonne of wheat. Such an approach would automatically undermine the principal *raison d'être* of emissions trading, which is to provide a financial incentive for individual emitters to take steps to reduce their own emissions as a means of reducing the cost impost of buying emissions permits. The use of averages would see efficient producers paying for inefficient ones.

This is not to say that there is no merit in imposing a levy of this kind. On the contrary, we advocate precisely such an approach later in this paper. But such a levy is quite different from, and should not be confused with, the cost of holding permits under an emissions trading scheme.

3. Alternative abatement options for agriculture

3.1 Introduction

The logic of including agriculture in the CPRS contains a further flaw, namely that a price signal will drive emissions reduction regardless of whether abatement options are available. Otherwise the carbon cost is effectively a tax on production. There are not many abatement options open to agriculture and they tend to be practice-based without accurate emission estimates. Consequently, including agriculture in the CPRS is unlikely to result in significantly higher abatement for the sector.

Emissions generally represent resources that would otherwise go into production, thus the potential ancillary benefits of agricultural abatement can be positive. For example, Victorian research on nutritional supplements has shown a reduction in methane emissions from enteric fermentation of 12 per cent per cow per day and 21 per cent per kilogram of milk solids while increasing milk yield by 15 per cent, milk protein by 16 per cent and milk fat by 19 per cent (Grainger *et al* 2008).

Despite the significant potential benefits to farmers, the uptake of techniques such as the provision of nutritional supplements appears low, even when the short-term cost of such measures is less than the likely increase in revenue. This suggests that addressing market failures, such as the information or capacity constraints impeding implementation of current abatement options, may be more important than the price signal and might yield ‘low hanging fruit’ for emissions reduction. On the other hand, leaving agriculture outside the CPRS without instituting alternative abatement policies is a disincentive for early abatement and is more likely to result in increased emissions.

3.2 Methane from enteric fermentation

As noted above, finding ways to reduce methane emissions from cattle and sheep is important for Australia’s abatement efforts. Microbes (methanogens) produce methane in the rumen as a by-product of the normal digestive processes of the animal, which then breathes or burps it out. Examples of abatement options include:

1. Genetics and herd management:	Selective breeding from animals with high feed-conversion efficiency and fecundity and culling inefficient animals reduces the emissions intensity of production.
2. Nutrition:	Improving feed digestibility and nutrients, for example by changing from extensive to intensive production systems, increases feed-conversion efficiency and results in lower methane emissions from enteric fermentation. However, the perception of these production systems as ‘low emissions’ systems is an illusion that needs to be challenged. A full life-cycle analysis is necessary to identify carbon leakage along the supply chain, including from energy use, animal wastes,

	transport of animals and supplies and fertiliser use.[10]
3. Health:	Proactive herd management to maintain healthy animals improves feed-conversion efficiency and herd productivity.
4. Feed additives and vaccination (emerging technologies):	Technologies are being developed to modify the chemistry of microbes responsible for methane production in the rumen.
5. De-stocking:	In the absence of cost-effective abatement options, de-stocking may be a rational response to the cost implications of abatement policy. Interestingly, Greenhouse Friendly, the Australian Government's voluntary carbon market, accredited an offset project in 2007 based on de-stocking and native vegetation regeneration. Because Australian agriculture has a relatively low emissions intensity (per unit of production), the likely perverse outcome of de-stocking is 'leakage' through import substitution, resulting in economic cost through lost production and environmental cost through potentially higher global emissions.

3.3 Nitrous oxide from agricultural soils

Nitrous oxide emissions result from nitrification and de-nitrification processes in soils. Synthetic fertiliser use is the main source. Plants absorb between 20 per cent and 80 per cent of applied nitrogen (Peoples *et al* 2004) with the excess causing greenhouse gas emissions or leaching and run-off, with potential detriment to water quality, and animal production of urine and faeces. Van der Meer (2008) argues that poor manure management practices increase emissions and can cause water and soil pollution; Kelly *et al* (2008) have shown that application of dicyandiamide on pastures reduced urine patch emissions by 27 per cent in mid-summer and 47 per cent in mid-spring.

Examples of abatement options include:

1. Timing of fertiliser application:	Matching fertiliser application timing and quantity to plant nutrient needs at different growth stages increases nutrient absorption by plants and results in higher productivity and lower emissions. Timing application around irrigation and rainfall events helps avoid anaerobic conditions that increase emissions.
2. Method of application:	Placing fertiliser where it is most accessible to plant roots and least subject to water logging reduces emissions. Excess fertiliser use where there is run-off can also impact on water quality.

[10] While the CPRS will cover some indirect emissions, supplies such as imported grains may not be subject to a carbon cost resulting in the relocation of emissions to the country of production.

3. Soil management:	Maintaining good soil structure and continuous plant cover, retaining stubble and managing water resources provide multiple benefits, including improving soil fertility and moisture-holding capacity, while reducing emissions.
4. Manure management:	Utilising manure to fertilise crops and pastures and improving application timing and quantity as for fertiliser (above), improves soil fertility and reduces emissions. Substituting manure for synthetic fertiliser also reduces indirect emissions.
5. Controlled release fertilisers, urease and nitrification inhibitors (emerging technologies):	These technologies work on extending the time available for nutrient uptake by plants, thus reducing emissions.
6. Reduce production:	Cutting back on fertiliser use may reduce yields but it may also be a rational option depending on the cost impact of abatement policy. Taking land out of production is a related option. As with de-stocking, this option has high potential for leakage to countries with higher emissions intensity of production.

3.4 Carbon sequestration

This paper focuses on agricultural emissions with an emphasis on methane emissions from enteric fermentation and nitrous oxide emissions from agricultural soils; but carbon sequestration by vegetation and soils is clearly an important component of net on-farm emissions (although not included in emissions inventories[11])and so is covered briefly.

Carbon sequestration options include:

[11] Vegetation that meets the definition of forests is accounted for LULUCF.

1. Agro-forestry:[12]	Agro-forestry and 'carbon farming'[13] forestry have the capacity to provide multiple benefits by way of shelterbelts, biodiversity, salinity control and water quality. They may reduce water quantity, however. The Green Paper proposes that carbon sequestration by Kyoto-compliant forests be included in the CPRS on an 'opt-in' basis. This creates the potential for distortion through competing land use (for example, switching from food to carbon farming) and 'adverse selection' where only those who will benefit 'opt-in' to the CPRS for private benefits but the public purse bears the costs of those that decide to remain outside the CPRS.
Soil management:	Minimum tillage, controlled traffic, moisture management, continuous vegetation cover and residue retention increase soil carbon. Benefits include improved soil fertility, structure, moisture-holding capacity, biodiversity and a consequent reduction in nitrous oxide emissions. Soil carbon sequestration is not included in the national accounts due to the assumed annual cycling explained above. However, these management practices have been shown to increase soil carbon and should be recognised as abatement actions. Soil carbon is traded in some voluntary markets in Australia and internationally, for example the Chicago Climate Exchange (CCX). [14]
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, resulting in soils with more fertility and ancillary production benefits. Chan *et al* (2007) found that a plant's nitrogen use efficiency increased with biochar application by up to 266 per cent, resulting in higher productivity, improved soil qualities and lower emissions.
Reduce land clearing:	Reducing the conversion of forested land to agriculture preserves carbon stores that would be released if forests were cleared. Land clearing is not included in the CPRS but will be subject to other abatement policies.

[12] 'Agro-forestry' is generally used to differentiate environmental plantings that are not intended for harvest from those planted for timber production, even on a small scale.

[13] The NSW Greenhouse Gas Reduction Scheme (GGAS) and voluntary carbon markets, including Greenhouse Friendly, accept credits from accredited biosequestration projects that meet the Kyoto Protocol's definition of forests.

[14] CCX soil carbon offsets are practice-based. Annual contracts control the process and defaults are used to estimate the quantities of carbon sequestered. Legal agreements commit the seller to maintain conservation practices during the contract period.

3.5 Alternative policy instruments

In this paper, we have discussed the characteristics that differentiate agriculture from other sectors and the reasons contradicting its inclusion in the CPRS. We have argued that abatement of agricultural emissions is both possible and necessary if Australia is to make deep cuts in its emissions. Alternative policy instruments could deliver emissions abatement similar in scale to the CPRS, but at a lower cost.

Described below are three alternative policies:

i. levy and incentive payments

ii. accreditation standards

iii. voluntary markets.

i. Levy and incentive payments

A ‘carbon levy’[15] based on an activity measure broadly correlated with emissions, for example livestock numbers, could be returned in payments to farmers for implementing and maintaining best practice techniques expected to lower emissions. This is a ‘carrot and stick’ approach. The process does not require a high level of accuracy in emissions estimates and it both rewards good and penalises poor practice. It could incorporate a ‘no-regrets’ standard with payments benchmarked[16] to carbon prices to minimise distortion in land-use choices. It could also be tiered to reflect priority abatement issues.

ii. Accreditation standards

While there are conflicting views on whether or not accreditation standards result in premium prices for accredited producers, the general feeling is that environmental concerns influence consumers’ preferences but not purchasing decisions. However, Paull (2007) found that premium prices in both domestic and export markets are driving China’s ‘green food’ boom. Regardless, consumer awareness of environmental issues is growing and 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.

The advantages of accreditation standards are:

- they can provide market-based incentives to adopt best practice
- they are supported by industry-driven research and development
- they can evolve with improved practices.

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[15] A levy would provide efficiency benefits over a tax because institutions for research and development and marketing levies are already established. A levy may also be more politically acceptable than a tax.

[16] A benchmark does not necessarily mean parity with carbon prices; it could be discounted to reflect lower transaction costs.

iii. Voluntary markets

Voluntary carbon markets are likely to continue as businesses and individuals outside the CPRS attempt to reduce their carbon footprint, providing opportunities for offsets from abatement of agricultural emissions. Criteria for voluntary markets may be less demanding than ETS criteria, and prices are usually lower to reflect the ‘riskier’ abatement scenario. In the Canadian voluntary market, for example, soil carbon sequestration is seen as temporary and offsets, although discounted to 7.5 per cent 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.

The advantage of voluntary markets is 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 under the CPRS, resulting in lower costs.

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 research and development, development of models and user-friendly tools, information and raising awareness, and capacity building for farmers and service providers. Ideally, alternative abatement policies for agriculture would be implemented along with the CPRS to maintain equity with other sectors and to reduce the risk of distortionary behaviour, although this would prove challenging.

4. Conclusion

The CPRS will form Australia's primary policy instrument for abating greenhouse gas emissions. Intended to commence in 2010, it will cover 75 percent of Australia's emissions and about 1 000 large emitters will be affected. After stationary energy, agriculture is the sector with the second highest greenhouse gas emissions but the Government intends to postpone its decision to include it under the CPRS until 2013. If the decision to do so is affirmative, the sector will not feel the impact until 2015.

There are sound arguments in favour of excluding agriculture, as discussed in this paper, but the Government's reasons for deferring its inclusion are less sound. They appear based on a belief that an ETS is superior to alternative policy instruments and that more research can overcome the proven practical difficulties hindering the inclusion of agriculture. These practical difficulties stem from the inherent variability of agricultural emissions, which differentiate agriculture in fundamental ways from other sectors. As a result, the quest for reasonably accurate and affordable measurement of agricultural emissions at the scale needed to inform on-farm management decisions has become an impossible dream.

The CPRS needs to prove robust and credible to achieve the policy goal of least-cost abatement but in order to do that emissions covered must be fungible and to be fungible they must be capable of reasonably accurate and affordable measurement. Agriculture's inclusion in the CPRS is inconsistent with these characteristics.

This does not mean, however, that the Government should absolve agriculture from the requirement to reduce emissions but that is precisely the effect of its intention to include agricultural emissions in the CPRS—just not yet. The present Government's position on greenhouse emissions in agriculture amounts to a replication of the Coalition Government's stance on greenhouse emissions as a whole.

Abatement options are currently available to agriculture, even though measurement may not be precise, but government policy has failed to provide incentives for farmers to undertake such abatement action. Similarly, alternative abatement policy options are currently available to the Government but the political will to develop them as a complement to the CPRS appears to be missing. There has been no evidence to support the assumption that the CPRS will deliver lower cost emissions abatement for agriculture compared to other market and regulatory instruments, despite the assertion that policy in Australia is now evidence-based.

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