Author/s:
Freebairn, J

Title:
A comparison of policy instruments to reduce greenhouse gas emissions

Date:
2016-09-01

Citation:
Freebairn, J. (2016). A comparison of policy instruments to reduce greenhouse gas emissions. Economic Papers, 35 (3), pp.204-215. https://doi.org/10.1111/1759-3441.12141.

A Comparison of Policy Instruments to Reduce Greenhouse Gas Emissions

John Freebairn[1]

Department of Economics, University of Melbourne, Vic 3010

j.freebairn@unimelb.edu.au

(03) 8344 6414

Key words: greenhouse gas emissions, external costs, policy

Running title: Greenhouse Gas Emissions

[1] With the usual caveats I gratefully acknowledge the comments and suggestions of the referees and editor on an earlier version.

Received Date : 18-Aug-2015

Revised Date : 29-May-2016

Accepted Date : 30-May-2016

Article type : Special Section

A Comparison of Policy Instruments to Reduce Greenhouse Gas Emissions

Abstract

Tax, emission trading schemes, regulations, and subsidy policy instruments to reduce Australian greenhouse gas emissions are assessed. Australian recent and proposed examples are used as illustrations. Comparative pollution reduction cost, tax interaction distortion costs, redistribution effects and operating cost properties are evaluated. A tax instrument with a comprehensive base, combined with recycling the revenue windfall to households, is argued to be a suitable guideline for future policy; and some regulations to counter information and other market failures can be important complements.

1. Introduction

Australia proposes substantial reductions in greenhouse gas emissions over the next decade or two. There is bipartisan agreement to reduce the 2020 pollution level by 5 per cent below the 2000 level; and this is a much larger reduction relative to a business as usual scenario recognising a larger population and higher real income. The Coalition government negotiated a further reduction of 26-28 per cent below the 2005 level by 2030 at the December 2015 Paris summit. Labor, if elected, is promising a larger 2030 reduction of at least 40 per cent.

Although there is a degree of bipartisan support for some of the policy interventions to mitigate greenhouse gas emissions, on the key instruments the two main parties have used, and propose to use in the future, very different policy instruments. Labor introduced a carbon tax from July 2012. It was withdrawn in July 2014 by the incoming Coalition government as an election promise. Also, there are legitimate debates about alternative key design issues which differ from the Labor version, including a broader tax base, compensation for trade exposed energy intensive industries, and details of the revenue recycling part of the package. A subsidy scheme, Direct Action (which incorporates the earlier Carbon Farming Initiative), was legislated by the Coalition government in 2014, and the first of quarterly auctions was held during the first half of 2015. Other interventions with loose bi-partisan support have included: a raft of regulations, including the renewable energy target, and energy efficiency design regulations for appliances and buildings; other subsidy schemes, including for investment in renewable energy and in energy efficiency; and, public investment in the provision of information.

This paper describes the operation of different policy instruments government could use to reduce greenhouse gas emissions and it evaluates their comparative properties. Policy instruments considered are a carbon or emissions tax, an emissions trading scheme, regulations on production methods and product design, and subsidies to invest in R&D and more energy efficient products and methods of production. Examples from recent and proposed Australian policy are used to illustrate. The different policy intervention options to reduce emissions are evaluated against a number of criteria. These include: the cost effective reduction of greenhouse gas emissions to meet Australia's target reductions;[1] interactive distortions of the pollution reduction instrument with income and other taxes on labour market decisions; distributional equity taking the status quo as the benchmark; and, operating complexity and costs.

2. Greenhouse Gas Emissions and Policy Task

Table 1 shows Australian greenhouse gas emissions in 2014-15 of 560 million tonnes of CO2-e. The combustion of fossil fuels in the production of electricity, for heating and steam, and transport accounts for two-thirds of the total. Other important emitters are agriculture, and mostly by ruminant animals, and then a few industrial processes, including manufacture of cement. Fugitive emissions from mining activities, the decay of wastes, and changes in land use are other contributors.

Table 1 Australian Greenhouse Gas Emissions, 2014-15

	Million tonnes of CO2-e	Percentage of total
Electricity	186	33
Direct combustion	94	17
Transport	93	17

[1]A larger and more difficult policy question about the appropriate pollution reduction is not considered. This debate is difficult because greenhouse gas emissions are a global externality problem with long life spans. Nordhaus (2015) provides a comprehensive review of the challenges in reaching a global agreement, along with a discussion of some of the options.

Fugitives	38	7
Agriculture	81	15
Industrial processes and product use	32	6
Waste	13	2
Land use, land use change and forestry	23	3
Total	560	

Source: Department of the Environment, December 2015.

The policy task of changing decisions to reduce greenhouse gas emissions embraces not just the first round polluters noted in Table 1. The vast majority of businesses who use energy and other pollution intensive inputs in their production processes, and households who purchase and consume products which directly and indirectly involve different quantities of greenhouse gas emissions, can change decisions to reduce pollution. The flow of greenhouse gas emissions can be decomposed with an identity often attributed to Kaya (Kaya and Yokoburi, 1997)

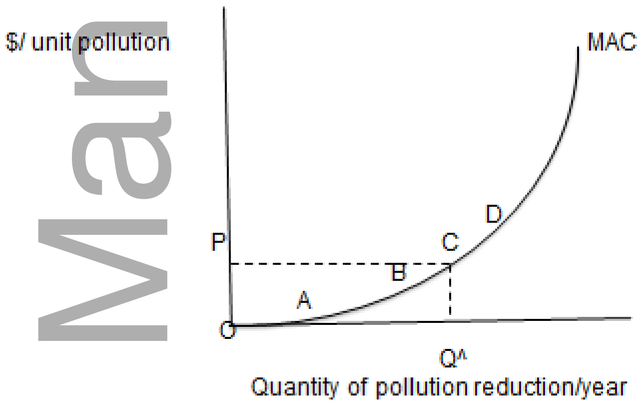
$$GHGE = (GHGE/E)\ (E/Y)\ (Y/POP)\ POP \quad (1)$$

where, GHGE is greenhouse gas emissions, E is energy, Y is national income or consumption, and POP is population. Pollution can be reduced by a combination of less pollution ways of producing energy, lower GHGE/E, and greater energy efficiency per unit of final goods and services, lower E/Y. Less pollution per unit of energy can flow from, for example, replace coal with gas or replace fossil fuels with non-renewables to generate electricity, and by carbon sequestration, such as reforestation and carbon capture and storage. Improved energy efficiency examples include more energy efficient transport and manufacturing processes, and households reducing the mix of energy intensive versus energy extensive goods and services, for example more energy efficient white appliances and the choice of public transport, bicycle or walking rather than large cars. In many cases, investment in R&D will be required for, or an integral part of, both sets of decision changes to reduce greenhouse gas emissions.

One way of evaluating the cost efficiency of the different policy intervention options is the marginal abatement cost (MAC) function, or supply function for pollution reduction. As shown in Figure 1 the MAC ranks the different decision changes by all businesses and households to reduce emissions from lowest cost per unit to highest cost. Potential decision changes include the first two right hand terms of (1). The base case or business as usual scenario at the current level of pollution, point O, assumes a zero price for greenhouse gas emissions. For a zero pollution cost, it assumes also that businesses and households have taken decisions which maximise their objectives subject to constraints. Decisions to reduce pollution are less satisfactory and involve additional costs. Available estimates of the MAC, including The Treasury (2011), Pearce (2012) and Clarke et al. (2014), find a convex MAC. Decision changes to reduce the pollution intensity of energy production and the energy efficiency of other business and household production in the E/Y term of (1) are included in the MAC, including among the lower cost options.

The importance of long lived capital items used in the production and use of energy means the MAC will be more elastic the longer the time frame and the greater confidence businesses and households have with stability of the future path of policies. New technology, changes in the structure of the economy and changes of attitudes will shift the function over time.

Figure 1 Marginal Abatement Cost (MAC) Function



For a given target reduction of pollution, say Q^ in Figure 1, a least cost policy intervention would change decisions with the lowest MAC. For example, suppose there are four possible decision changes with costs of A, B, C and D along the MAC. If two decisions to reduce pollution are driven by the policy, the least cost option would select decisions A and B, the highest cost option decisions C and D, with combinations A and D, or B and C, in between.

Distribution effects of tax, ETS, regulation and subsidy instruments to change business and household decisions to reduce greenhouse gas emissions can be evaluated with partial equilibrium product models (for example, Guest, 2009), multiproduct models through to computable general equilibrium models (for example, The Treasury, 2008, Adams et al., 2014, and Clarke, et al., 2014). With partial equilibrium models for individual products (or for product supply chains), initial effects of the policy instrument change one or both of the supply and demand curves. The more elastic supply relative to demand, the greater the share of additional production costs, taxes and subsidies passed forward to the household. Many studies of the incidence of indirect taxes conclude that most of an indirect tax is passed forward to buyers as higher prices (including ABS, 2012, Warren et al., 2005, and Valadkhani, 2005).

Comparative redistribution effects, and the efficiency effects associated with interactions of the different policy instruments to reduce pollution and existing taxes, can be assessed with functions describing the effective purchasing power of an individual linked to a revenue neutral government constraint. In the base case (before policy intervention to reduce pollution) effective purchasing power, EPP(B), is given by the ratio of disposable income and an index of the purchase cost of goods and services

$$EPP(B) = [W(1-Ty) + SS] / [P(1+Ti)] \qquad (2)$$

where, W is the market wage, SS is social security payment, P is an index of consumer prices pre-indirect tax, Ty is income tax, and Ti is indirect tax (including GST and excises). Magnitudes of each of the right hand terms will vary across income and demographic groups. Average rates of income and indirect taxes affect equity; and marginal rates affect incentives and rewards which drive efficiency effects.

The different policy instruments to reduce greenhouse gas emissions will alter effective purchasing power in (2) in different ways (to be described in detail in Section 3 below). They may directly change production costs and the price term by ΔP, and the indirect tax term by ΔTi, and more specifically ΔTi = Tc with Tc the carbon price. Also, government revenue and expenditure may change, namely income tax as ΔTy and social security payments as ΔSS. Expanding (2), a general expression for effective purchasing power under policy options to reduce greenhouse gas emissions, EPP(PO), is

$$EPP(PO) = [W(1-Ty+\Delta Ty) + SS+\Delta SS\} / \{(P+\Delta P)(1+Ti+Tc)] \qquad (3)$$

Comparison of (3) with (2) using average changes provides the framework for assessing the comparative equity effects of the different policy instruments; and comparison using marginal changes is used to assess the efficiency effects of interactions between the greenhouse gas reduction policy with existing general taxes (as discussed by Bovenberg et al., 2008). The policy options will be assessed in the context of an approximately zero change in the aggregate government budget outcome; with Tc an increase in revenue, and ΔTy and ΔSS additional expenditure.

3. Comparison of Greenhouse Gas Emissions Reduction Policy Instruments

The tax and ETS which place a price on the pollution externality, regulations to reduce pollution, and subsidies to entice pollution reductions are described in general and with illustrations from recent Australian policy. The implications of the policy instruments for economic efficiency, both in cost effectively reducing pollution and interaction effects with current taxes, for redistribution in the context of a neutral government budget constraint, and operating feasibility and costs are assessed.

3.1 A carbon or Emissions Tax

Conventional economic advice recommends special indirect taxes to internalise the external costs incurred in the production or consumption of particular products and production methods (as described in public finance texts, such as Stiglitz and Rosengard, 2015, and environment economics texts, such as Kolstad, 2010). In this spirit, the review of Australia's Future Tax System (Henry et al., 2010) recommended a carbon or emissions tax to privatise the external costs of greenhouse gas emissions. Ideally, the rate of the additional tax would be set at the marginal external cost.[2]

The carbon tax introduced in Australia in July 2012 and through to July 2014 as a major component of the Clean Energy Future package (Gillard, et al., 2011) provides an example.[3] The tax was collected from less than 400 businesses on a base representing about 60 per cent of the emissions in Table 1. At an initial rate of $23/tonne CO2-e, additional tax revenue of about $8 billion a year was generated. About a half of the revenue windfall was redistributed to low and middle income households, and the other half to a range of subsidies for the energy intensive trade exposed industries and for investments in renewable energy and improvements in energy efficiency.

A comprehensive base for a price on greenhouse gas emissions would include all the items in Table 1. Operating procedures are relatively straightforward for electricity generators, the refiners and distributors of other fossil fuels (assuming a close relationship between the fuel and pollution at the time of combustion by the very large numbers of energy input using businesses and households), large miners with fugitive emissions, and large industrial firms and waste managers. And, costs of administration and compliance are low. As few as 1000 firms initially would be involved for a base which covers about 80 per cent of Australian emissions. With current technology, measurement of greenhouse emissions by agriculture, land use and some small industrial firms seem very expensive

[2] Over time, economic models argue that the price on pollution should increase. Garnaut (2008) uses a Hotelling-type model to project the price to rise at the real interest rate as the flow of pollution runs down the maximum stock of pollution consistent with a threshold level of climate change of a temperature increase of two degrees. Nordhaus (2008) with his DICE model has price increasing with increases over time in the marginal cost of emissions as a larger global stock of pollution increases climate change and adaptation costs.
[3] Details of the design and operation are given in Besley, et al. (2014).

for both government and the firms; and other “easier measures” such as livestock numbers and meat production are poor proxy measures of pollution.

The Clean Energy Future carbon tax of 2012-14 was not applied to fuel purchased by households, primary producers and small vehicles less than 4.5 tonnes, the tax on large vehicles was delayed, and small polluters of less than 25,000 tonnes CO2-e per year were exempt. About 60 per cent of greenhouse gas emissions shown in Table 1 were subject to the tax, or a quarter less than a relatively low operating cost comprehensive base.

An interesting and important side-debate on the base for an Australian price on greenhouse gas emissions concerns the eligibility or not to purchase permits from overseas if they are lower priced than reducing domestic pollution. Several studies for Australian schemes, including The Treasury (2008) and Adams et al. (2014), have found it cost effective to purchase up to a half of the Australian pollution reduction from approved international permits.

The first round of a carbon tax on greenhouse gas emissions directly affects the pollution intensity of energy produced, term GHGE/E on the right hand side of (1). Responding to the change in the relative costs of different options to produce energy, decision changes are made if the additional cost of the decision option to lower pollution is less than the carbon tax. With elastic energy supply functions, most of the higher costs of the changed energy production decisions and the tax on remaining pollution per unit of energy are passed forward as higher energy prices to business and household users of energy inputs.[4] These second round energy price changes induce households and businesses to improve energy efficiency, that is, to reduce the second right-hand term E/Y of (1). In addition and over time, the changed relative prices work to increase the incentives and rewards for investment in R&D to develop new technology to further reduce the GHGE/E and E/Y terms.

The cost effectiveness of a tax on greenhouse gas emissions to reduce pollution can be explained with Figure 1. For a pollution price of P, all of the decision options to reduce pollution along the MAC with a cost less than P, including options A and B, would be taken because reducing pollution is a lower cost decision option than paying the tax; by contrast, for more expensive decision changes than P, including C and D, it is more cost effective to pollute and pay the tax. A price on pollution draws on the information held by businesses and households throughout the economy, and generally not available to government, to find the least cost ways of reducing pollution (to Q^ in Figure 1).

[4] For electricity, the magnitude of the tax flow through varies with the marginal production unit. In particular, the increase will be larger for coal and base production during off-peak demand than when gas is the marginal peak demand supply.

Consider next the efficiency costs associated with interaction of the tax on pollution with other taxes using (3). A price on pollution increases the cost of goods and services to households, the denominator of (3) via the higher cost of production term ΔP and the carbon tax Tc. The reduction of effective purchasing power would increase existing income tax and indirect tax distortions to labour and other decisions. However, the also generates a windfall increase in government revenue. This revenue windfall can be used to reduce income tax, namely ΔTy in the numerator so that EPP(PO) in (3) is close to EPP(B) in (2).

Most of the redistribution effect of a pollution tax reduction in effective purchasing power can be offset by recycling the revenue windfall as lower income taxation and higher social security payments while maintaining changes in relative prices and incentives to choose less pollution intensive options. Also, to assess welfare in aggregate, and not shown in (3), lower greenhouse gas emissions mean less climate change and in the future lower costs of adaptation.

Effects of the Clean Energy Future policy package of 2012-14 on redistribution and tax interaction efficiency can be assessed with the aid of (3). About a half of the $8 billion a year revenue windfall was recycled to households as increases in social security payment rates to more than offset the estimated increase in the CPI by 0.7 percentage points and by an increase in the effective income tax free threshold from $16000 to $20542. In terms of distribution effects, low and middle income households gained (about two-thirds of households according to Gillard et al., 2011), and those higher up lost. Only for a small group of taxpayers did the effective marginal tax rate fall, so the package aggravated tax distortions and efficiency costs (Freebairn, 2014).

Available data, together with confounding changes in other variables affecting decisions, make it difficult to assess the effects of the carbon price before, during and after the 2012-14 period of the Clean Energy Future. For simplicity, consider electricity, the largest source of greenhouse gas emissions and principle focus of the tax. Garnaut (2014) highlights that the carbon tax was a relatively small contributor to a large jump in retail electricity prices over recent years; investments in infrastructure were more important. Table 2 shows annual Australian electricity produced, share of renewables, electricity greenhouse gas emissions, and average emissions per unit of electricity.

Table 2 Australian Electricity Production and Electricity Generated Greenhouse Gas Emissions, 2001 to 2015

	Electricity generated (GWh)	Renewables share (%)	Electricity CO_2-e emissions (million tonnes)	Average emissions intensity (tonne/MWh)

2001-02	224 870	7.8	184	0.818
2002-03	222 120	8.5	187	0.842
2003-04	229 784	8.2	195	o.848
2004-05	228 649	8.9	197	0.860
2005-06	232 829	9.3	201	0,863
2006-07	243 153	8.7	204	0.840
2007-08	243 153	8.2	206	0.848
2008-09	247 524	7.5	212	0.855
2009-10	243 217	8.6	205	0.813
2010-11	247 524	10.5	199	0.783
2011-12	250 740	10.6	199	0.793
2012-13*	249 715	13.3	187	0.748
2013-14*	248 297	14.9	181	0.730
2014-15	223 211	na	186	0.834

*Period with carbon tax

Source: Department of Industry and Science (2015), Australian Energy Statistics, Table O, and Department of the Environment (2015), Quarterly Update of Australia's National Greenhouse Gas Inventory, June, Data Table 1A.

Looking at the crude numbers in Table 2 supports a small effect of the carbon tax in reducing electricity greenhouse gas emissions. The importance of renewables increased, pollution per unit of electricity fell, and electricity production declined in the 2012-14 period with a carbon tax compared with the preceding years, and there was a reversal in 2014-15 when the carbon tax was repealed. To an important extent these changes are part of longer term trends driven by other factors such as technology, other policy interventions, including regulations such as the renewable energy target, and subsidies for solar energy, and other drivers of higher electricity prices and lower electricity consumption.

An important limitation on the effectiveness of the Australian carbon tax experience in changing decisions has to be the political uncertainty. The Coalition actively and persistently contended it would withdraw the tax if elected, and it did so. Such uncertainty about future policy must have cast a doubt on rushing into lumpy, large scale and long-lived investment decisions to reduce greenhouse gas emissions, and so muted many potential long term decision changes.

3.2 An Emissions Trading Scheme (ETS)

An alternative policy instrument to a pollution tax which places a price on greenhouse gas emissions is an emissions trading scheme (ETS). To correct the market failure associated with treatment of the atmosphere as a common property resource where greenhouse gases can be dumped for free, an ETS creates a required property right to emit pollution. The limited quantity of pollution property rights, and a smaller quantity than current pollution, then has a scarcity value which places a price on pollution in much the same way as a tax. In Figure 1 a limited quantity of rights to pollute of Q^ has an average price of P.

A market price generated by the limited supply of permits to pollute with an ETS, and where the permits are allocated by auction, results in similar efficiency, redistribution and operating cost effects as a tax discussed in Section 3.1 above (see, for example, Hepburn, 2006, Clarke, 2011, and Goulder and Schein, 2013). In effect, government revenue from the sale of the pollution permits to polluters generates similar government revenue as the tax revenue. Even then, there are some subtle differences, even if of second order of importance, between a tax and an ETS: with a tax, government sets the price and the market determines the pollution reduction, while with an ETS, government sets the pollution quantity and the market determines the permit price; and, with uncertainty of, and shifts over time of, the MAC, the tax option provides price certainty and uncertain and variable pollution quantity reductions, while an ETS provides a certain pollution quantity with an uncertain and variable market price for the permits.

Rather than auction the permits to pollute, some versions of an ETS in effect gift the property rights to the polluters, and then these property rights are tradable. Most initial allocation of the limited property rights to pollute involves a variant of grandfathering to current polluters as a less than 100 per cent share of current pollution. This model was used in the early stages of the European ETS, and it is implied in the proposed Labor party ETS if elected to government in 2016 (Labor Party, 2016). Outcomes for an ETS which initially allocate the pollution rights to the polluters rather than by auction (and a tax) have: similar effects of increasing the relative prices of pollution intensive production methods and products to reduce pollution at least cost; governments do not gain a revenue windfall, rather the initial recipients of the newly created pollution property rights receive the windfall; and, as a consequence, governments either have to run a larger budget deficit to compensate households for higher costs of living or, if no compensation is paid to households, the households bare most of the higher costs of reducing pollution and society incurs the additional tax interaction distortion costs of a lower effective purchasing power of EPP(PO) of (3) compared with EPP(B) of (2).

3.3 Regulation: Renewable Energy Target (RET)

RET regulations are expected to be a major contributor to meeting Australia's greenhouse gas reduction target by 2020, they illustrate the effects and properties of the regulation instrument relative to the price and subsidy options, and to date the general RET model has had bi-partisan support. Dating from 2001, the RET is one of the more durable policy interventions to reduce greenhouse gas emissions. The current version for large scale electricity generation is a minimum renewable energy quantity of 33,000 GWh per year by 2020, or more than 20 per cent of the projected total electricity quantity and a doubling of current renewable energy (Climate Change Authority, 2015).

While primarily a regulation, one component of the operation of the RET is akin to an ETS. A system of required renewable energy certificates represents a government created tradable property right allocated to industry which creates a market to produce the required renewable energy target at least cost.

Cost inefficiency of regulations versus the comprehensive base tax or ETS instruments is illustrated with the RET. As discussed in Sections 3.1 and 3.2 above, a price for pollution provides incentives and rewards for individual businesses and households throughout the economy to use their private information to change decisions with a result that the marginal abatement cost is equated across the different decision changes affecting both the pollution per unit of energy and energy per unit of income in (1). By contrast, regulation requires government to use limited public available information, and often in responses to self-interested lobby groups, to choose both a few decisions to change and the magnitude of the change. In the context of Figure 1, regulations are as likely to choose the higher cost options C and D to meet a reduction of Q^ pollution over the lower cost A and B options. More specifically for the RET example, RET primarily changes decisions to reduce the GHGE/E term of (1). Yet, many low cost reduction decisions to reduce pollution are in the E/Y term of (1). Even within the first term of (1), pollution per unit of electricity, the RET rules out potential lower cost options such as investment in fossil fuel generation equipment and R&D to improve energy efficiency, change the mix of coal and gas generation, and invest in carbon capture and storage (Nelson, 2015).

If a price instrument already is in operation, a regulation either is redundant if the additional cost of meeting the regulation is less than the carbon price (i.e. $MAC < P$), or it chooses decision changes at a higher cost than the price which represents the cost of other available decision changes to reduce pollution (i.e. $MAC > P$).

Cost and price effects of the RET are likely to vary between the short run and the long run. A conventional long run comparative static equilibrium assessment would have the RET induced increase in the cost of electricity generation to meet the regulation constraint passed forward as a higher electricity price to business and household buyers. In the context of the measure of effective purchasing power in (3), there would be an increase in the ΔP term. With no windfall carbon tax government revenue to reduce income tax or increase social security payments available with the price instrument, households ultimately bear most of the cost of the regulation, ΔP, as a fall in EPP(PO) < EPP(B). Also, there is an efficiency loss with interaction of the existing income and indirect taxes and the product price increase reducing effective purchasing power; causing larger distortions to labour and other decisions.

A comparison of the equity effects of a regulation with a price intervention which achieves about the same aggregate reduction in pollution favours the price intervention. Because regulation is less cost effective, the ΔP effect in (3) will be larger for the regulation. If most of the taxation revenue windfall of a price instrument is recycled as lower income tax so that $Tc \approx \Delta Y$, households will face a smaller reduction in effective purchasing power of EPP(PO) in (3) and be better-off with a price instrument than with a regulation instrument.

In the short run however, the RET may cause a fall in the average price of electricity generation, the opposite of the long run equilibrium. With a combination of static or even declining demand for electricity and long lived sunk investments in fossil fuel generation capacity, the required RET investment in renewable energy augments the available aggregate renewable plus non-renewable electricity generation capacity. The increase in aggregate generation capacity, along with variable cost much less than average cost, likely will lead to a fall in price from an initial and pre-RET equilibrium average total cost to a lower price that covers only variable cost.[5] This short run may last for some time until fossil fuel capacity is retired. Ironically, over this short run period the lower electricity price reduces the incentive for the millions of business and household electricity users to improve energy efficiency, a so called rebound effect to increase pollution in the short run.

Quiggin (2014) provides some counter arguments in favour of the RET as a worthwhile instrument, even as a complement to a price instrument. If one accepts his position that the carbon price is set too low, then the higher economic or shadow price of further reducing emissions supports a RET as a second best and complementary policy intervention. Given the importance of large, lumpy and long-lived investments in electricity generation, policy continuity is important for such investment

[5] Retail electricity prices have risen over recent years, primarily because of increases in investment in transmission and delivery infrastructure and the regulatory structure used to set prices (Garnaut, 2014).

decisions. In this context, and Australian politics, the continuity and robustness of RET to date is superior to the observed short term life of the carbon tax and the absence of bi-partisan agreement for future policy.

3.4 Other Regulations

An important set of regulations which reduce greenhouse gas emissions are in part motivated to correct other market failures. Examples include regulations on energy efficiency of vehicles, household appliances, light bulbs and buildings. Other market failures include the lack of information, asymmetric information, short-sighted and time-inconsistent decision making, and in some cases confused or non-linked rights and responsibilities of landlords and tenants. This is not to ignore that the inherent cost inefficiencies of government regulations discussed above for the RET apply also to these regulations. Regulations have to balance these and other government failures in reducing pollution against the benefits from correction of these other market failures in private sector decisions.

Another potential welfare improving application of regulations concerns altering decisions which generate pollution external costs and where the operating costs of a price instrument are very high or even prohibitive. As noted in Section 3.1 above, sources of pollution in Table 1 not likely to be included in a price base because of measurement challenges may be reduced by regulations on land use, some agriculture and waste disposal practices, and for small industrial businesses.

Design of the details of each regulation would take into consideration the nature and the magnitude of the market failure to be corrected, and the relative efficiency, equity and simplicity of regulation versus alternative policy interventions.

3.5 Subsidy: Direct Action

A key component of the Direct Action program introduced by the Coalition government in 2015 to replace the Labor government carbon tax is a subsidy in exchange for private sector bids to reduce greenhouse gas emissions;[6] a safeguard measure is to follow from July 2016 as a restraint on greenhouse gas emissions by large polluters who do not bid for or secure a subsidy (Australian Government, 2014). An Emissions Reduction Fund with a current allocation of $2.55 billion for four years has been established to fund a reverse auction of private sector bids to reduce pollution for up to the next 10 years; and, with the prospect of additional funds. Over the second half of 2015, the

[6] The scheme incorporates, and in essence extends the scope of, the Carbon Farming Initiative which was a component of the former Labor government Clean Energy Future (Gillard, et al., 2011) package to reduce emissions from the agriculture and land uses sectors not covered by the carbon tax base.

outcomes of two rounds included a commitment to reduce emissions by 93 million tonnes of CO2-e over a period as far ahead as ten years at an average cost of about $13/tonne. Most of the subsidised pollution reduction decisions involve land management and agriculture.

In one view, the much lower price of $13 for the Direct Action subsidy compared with the $23 for the Clean Energy Future tax per tonne of CO2-e appears to support the subsidy instrument as a cost effective intervention to reduce pollution.

On the other hand, where a tax or ETS instrument can be applied, and this seems feasible for about 80 per cent of Australian greenhouse emissions shown in Table 1, there are compelling logical cost efficiency arguments against the subsidy instrument. First is concern about the net reduction of pollution. Some of the deemed eligible for subsidy pollution reduction decision changes may happen anyway. Government has a limited information base to measure the business as usual scenario, and then what decision changes require a subsidy to reduce pollution. Inevitably, government will use a set of rules to assess the business as usual scenario. Some subsidised bids will incur type 1 errors (with decisions subsidised that would have been taken anyway). Other decisions will incur type 2 errors (disallowing some low cost pollution reduction decision changes). The net result is a higher average cost per unit pollution reduction compared with the price instrument.

Second, the administrative and compliance costs of a subsidy scheme will be much larger than for the price and regulation instruments. Less than 1000 large businesses are involved with a price imposed by a tax or ETS; and then changes in relative prices flow through to the rest of the economy. By contrast, many more businesses and households seeking a subsidy to improve energy efficiency (term E/Y of (1)) would need to be involved in the administration of a subsidy scheme. Not only does the subsidy scheme involve many, many more entities, the higher compliance and administrative costs effectively will reduce the set of pollution reduction decisions tapped, many of which would be low cost options. As a particular example, a tax imposed on a small number of large refiners and importers of petroleum products is simple and the higher relative prices for petroleum intensive production methods and products flows to all business and household users. A subsidy by contrast would require bids from the million or so businesses and 24 million Australians to reduce their consumption of petroleum products.

Third, relative to the price and regulation instruments to reduce greenhouse gas emissions, a subsidy incurs larger efficiency losses under a government revenue budget constraint via the interaction effects with distortions caused by current general revenue raising taxes. A subsidy has the polluted pay the polluter. Consider changes to the measure of effective purchasing power per period of work described in (3). A subsidy has no effect on the denominator, in particular no price change, $\Delta P = 0$, with the subsidy offsetting the extra cost of the pollution reduction decision option, and no carbon tax, $Tc = 0$. But, funding the subsidy requires an increase in general revenue taxes, ΔTy in the numerator, which involves a substantial marginal cost (Cao, et al., 2015). By contrast, and as argued in Section 3.1 above, provided the carbon tax revenue windfall is recycled as lower income tax rates, there is only a small tax interaction distortion cost associated with $\Delta P > 0$, and $Tc \approx \Delta Ty$; and, for the regulation intervention discussed in Section 3.3 above, the ΔP term will be a little larger, and with $Tc = \Delta Ty = 0$.

In the balanced budget context, households bear the cost of the subsidy instrument to reduce greenhouse gas emissions via a much larger income tax rate, ΔTy, with the only partial offsetting benefit of a lower quantity of pollution.

3.4 Other Subsidies

Over the last decade Australian governments have allocated significant funds to subsidise R&D and private investment in renewable energy and to improve energy efficiency. For example, the Clean Energy Finance Corporation was provided with $10 billion and the Australian Renewable Energy Agency were important parts of the Clean Energy Future package (Gillard et al., 2011), and they remain important. Assessment of the economic efficiency case for these input subsidies depends on the context.

Suppose a context of a carbon tax or ETS instrument which largely internalises the external costs of greenhouse gas emissions. That is, the price instrument alone largely corrects the pollution market failure. One important effect of the price is to increase the incentives for, and the rewards from, private investment in equipment and in R&D to reduce pollution via developing new technology and methods to reduce the two right hand terms of (1). Unless there are additional, peculiar and specific market failures in the credit market and for R&D for energy production and for the use of energy not encountered in other R&D applications for, say, biotechnology, agriculture, manufacturing and health, there is no market failure argument for additional special subsidies for credit and R&D to reduce greenhouse gas emissions. The general market failures of public good properties and external benefits with R&D which are economy wide are partly addressed by; direct government funding of basic research; and for more applied research by patents and taxation concessions. These attempts at correcting market failures with R&D apply with similar effects to R&D to reduce pollution as to R&D to increase productivity in other parts of the economy.

In modern Australia, the credit market has no demonstrated market failures either in general or for the specific case of investments to reduce the first two right hand terms of (1).

An alternative economy context in which to evaluate the efficiency case for targeted subsidies for credit and R&D to reduce greenhouse gas emissions is one where for whatever reason the carbon tax or ETS, or combinations of the price regulation and subsidy interventions, are assessed to only in part correct the pollution market failure. Then, a type of second best argument might be made for selective subsidies for credit and R&D for decisions to reduce pollution. Even then, the problems of additionality, the large numbers of potential applications, and the tax interaction distortion costs discussed in the preceding section for Direct Action subsidies are downsides.

4. Looking Forward

Australia, along with the international community, has committed to substantial and larger reductions of greenhouse gas emissions over the future. A long term carbon tax or ETS with auctioned permits, and removing most of the current regulations and subsidies, offers a more cost effective, equitable and low operating cost policy strategy than the recent history of mixed and changeable policies.[7]

A modified version of the Clean Energy Future carbon tax in place over 2012-2014 provides a starting point. A comprehensive base would include all fossil fuels, without the exemptions for many petroleum products, and cover about 80 per cent of current emissions; with agriculture emissions the main exemption. Maintaining the status quo equity and minimising tax interaction distortion effects requires the taxation revenue windfall to be recycled as lower income tax rates, and then as reductions in marginal rates across the income profile, and compensating increases of social security rates. With the majority of countries committed to lower rates of emissions, the case for compensating energy intensive trade exposed industries is weak and less relevant than for the 2012 tax.

With a comprehensive base and medium to long term price intervention, regulations for renewable energy could be phased out. If regulations to reduce greenhouse gas emissions from electricity generation are to be maintained, even if only over the medium term, a lower cost option to the current focus on renewable energy would focus on all decision options to reduce pollution per unit of electricity.

[7] Wood et al. (2016) provide an alternative policy scenario for the future. Their proposal has a similar long run desired outcome as proposed here. They offer a more detailed and pragmatic transition path to meet political constraints as they see them.

Regulations to correct information and other market failures, particularly affecting the choices of energy efficient equipment, likely will be worthwhile complementary instruments.

Arguments for special and additional subsidies for credit and for R&D for the energy production and energy uses activities to correct economy-wide market failures for the capital market and R&D activities are not compelling if an effective price on pollution is in place.

Policy design to reduce greenhouse gas emissions by agriculture, land use and other small businesses, about 20 per cent of current pollution, is challenging. Measures of emissions at the firm level are limited, and operating costs are high. A package of regulations and subsidies, building on those now in operation, may be a second best option.

References

Adams, P., Parmenter, B. and Verikios, G. (2014), 'An Emissions Trading Scheme for Australia: National and Regional Impacts', *Economic Record,* 90(290), 316-344.

ABS (2012), Government Benefits, Taxes and Household Income, Australia 2009-10, Catalogue 6537.0, Canberra.

Australian Government (2014), Emissions Reduction Fund White Paper, Commonwealth of Australia, Canberra.

Besley, D., Downie, C., Kennedy, S. and Writer, S. (2014), 'Carbon Pricing in Australia: An Early View from Inside', in Quiggin, J., Adamson, D. and Quiggin, D. (eds.), *Carbon Pricing: Early Experiences and Future Prospects,* Edward Elgar, Cheltenham, 25-48.

Bovenberg, A., Goulder, L. and Jacobsen, M. (2008), 'Costs of Alternative Environmental Policies in the Presence of Industry Compensation Arrangements', *Journal of Public Economics*, 92(5-6), 1236-1253.

Cao, L. et al., (2015), Understanding the Economy-Wide Efficiency and Incidence of Major Australian Taxes, Treasury Working Paper 2015-01, The Treasury, Canberra.

Clarke, H. (2011), 'The Basic Economics of a Carbon Tax', *Australian Economic Review,* 44(2), 123-136.

Clarke, H., Fraser, I. and Waschik, R. (2014), 'How Much Abatement Will Australia's Emissions Reduction Fund Buy?', *Economic Papers,* 33(40), 315-326.

Climate Change Authority (2015), *Australia's Climate Change Policy Options*, Australian Government, Canberra.

Department of Climate Change (2008), *Carbon Pollution Reduction Scheme: Australia's Low Pollution Future (white Paper),* Commonwealth of Australia, Canberra.

Department of the Environment (2015), *Tracking to 2020*, Commonwealth of Australia, Canberra.

Freebairn, J. (2014), 'The Carbon Tax and Tax Reform Debate', in Quiggin, J, Adamson, D. and Quiggin, D. (eds), *Carbon Pricing: Early Experiences and Future Prospects*, Edward Elgar, Cheltenham, 67-88.

Garnaut, R. (2008), *The Garnaut Climate Change Review,* Cambridge University Press, Cambridge.

Garnaut, R. (2014). 'Resolving Energy Policy Dilemmas in an Age of Carbon Constraints', *Australian Economic Review,* 47(4), 492-508.

Gillard, J., Swan, W. and Combet, G. (2011), *Clean Energy Future***,** Australian Government, Canberra.

Goulder, L. and Schein, A. (2013), 'Carbon Taxes Versus Cap and Trade: A Critical Review', *Climate Change Economics*, 4(3), 1-23.

Guest, R. (2009), 'The Economics of Carbon Abatement: An Integrated Diagrammatic Framework', *Economic Papers*, 28(2), 93-101.

Henry, K., Harmer, J., Piggott, J., Ridout, H. and Smith, G. (2010), *Australia's Future Tax System, Report to the Treasurer,* Commonwealth of Australia, Canberra.

Hepburn, C. (2006), 'Regulation by Prices, Quantities, or Both: A Review of Instrument Choice', *Oxford Review of Economic Policy,* 22(2), 226-247.

Kaya, Y. and Yokoburi, K. (1997), *Environment, Energy and Economy: Strategies for Sustainability,* United Nations University Press, Tokyo.

Kolstad, C. (2009), *Environmental Economics,* Oxford University Press, Oxford.

Labor Party (2016), Climate Change Policy, www.alp.org/climatechangepolicy (15/5/2016)

Nelson, T. (2015), 'Australian Climate Change Policy-Where to from Here?', *Economic Papers,* 34(4), 257-272.

Nordhaus, W. (2008), *A Question of Balance,* Yale University, New Haven.

Nordhaus, W. (2015), 'Climate Clubs: Overcoming Free-riding in International Climate Policy', *American Economic Review,* 105(4), 1339-1370.

Pearce, D. (2012), 'Empirical Uncertainties in Climate Policy Implementation', *Australian Economic Review*, 45(1), 114-124.

Quiggin, J. (2014), 'How I Learned to Stop Worrying and Love the RET', in Quiggin, J., Adamson, D. and Quiggin, D. (eds), *Carbon Pricing: Early Experiences and Future Prospects*, Edward Elgar, Cheltenham, 89-100.

Stiglitz, J. and Rosengard, J. (2015), *Economics of the Public Sector,* W W Norton and Co, New York.

The Treasury (2011), *Strong Growth, Low Pollution: Modelling a Carbon Price,* Commonwealth of Australia, Canberra.

Valadkhani, A. (2005), 'Goods and Services Tax Effects on Goods and Services Included in the CPI Basket', *Economic Record,* 81, S104-S114.

Warren, N., Harding, A. and Lloyd, R. (2005), 'GST and the Changing Incidence of Australian Taxes: 1994-95 to 2001-02', *eJournal of Tax Research,* 3(1), 114-145.

Wood, T., Blowers, D. and Moran, G. (2016). Climate Phoenix: A Sustainable Australian Climate Policy, Grattan Institute, Melbourne.

Table 1 Australian Greenhouse Gas Emissions, 2014-15

	Million tonnes of CO2-e	Percentage of total
Electricity	186	33
Direct combustion	94	17
Transport	93	17
Fugitives	38	7
Agriculture	81	15
Industrial processes and product use	32	6
Waste	13	2
Land use, land use change and forestry	23	3
Total	560	

Source: Department of the Environment, December 2015.

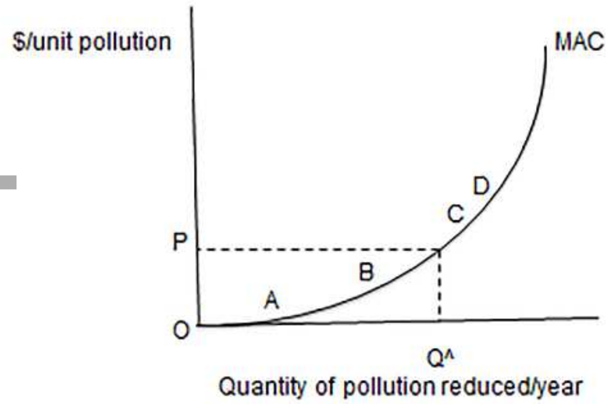
Table 2 Australian Electricity Production and Electricity Generated Greenhouse Gas Emissions, 2001 to 2015

	Electricity generated (GWh)	Renewables share (%)	Electricity CO2-e emissions (million tonnes)	Average emissions intensity (tonne/MWh)
2001-02	224 870	7.8	184	0.818
2002-03	222 120	8.5	187	0.842
2003-04	229 784	8.2	195	0.848
2004-05	228 649	8.9	197	0.860
2005-06	232 829	9.3	201	0,863
2006-07	243 153	8.7	204	0.840
2007-08	243 153	8.2	206	0.848
2008-09	247 524	7.5	212	0.855
2009-10	243 217	8.6	205	0.813
2010-11	247 524	10.5	199	0.783
2011-12	250 740	10.6	199	0.793
2012-13*	249 715	13.3	187	0.748
2013-14*	248 297	14.9	181	0.730
2014-15	223 211	na	186	0.834

*Period with carbon tax

Source: Department of Industry and Science (2015), Australian Energy Statistics, Table O, and Department of the Environment (2015), Quarterly Update of Australia's National Greenhouse Gas Inventory, June, Data Table 1A.

Figure 1 Marginal Abatement Cost (MAC) Function



ecpa_12141_f1.tif