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Carbon Emission Policies in Key Economies:

Responses to Feedback on Certain Estimates for Australia

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The Productivity Commission

The Productivity Commission is the Australian Government's independent research and advisory body on a range of economic, social and environmental issues affecting the welfare of Australians. Its role, expressed most simply, is to help governments make better policies, in the long term interest of the Australian community.

The Commission's independence is underpinned by an Act of Parliament. Its processes and outputs are open to public scrutiny and are driven by concern for the wellbeing of the community as a whole.

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About this supplement

The Australian Government commissioned the Productivity Commission to conduct a study of the extent to which key economies are taking action to reduce greenhouse gas emissions. The study culminated in the release of a research report by the Commission on 9 June 2011 (Productivity Commission 2011). The report analysed the costs of, and abatement attributable to, a range of emissions-reduction policies across eight countries, including Australia.

Following the release of the research report, representatives of the biofuels and solar PV industries raised a number of questions and criticisms regarding the analytical approach and data that the Commission used to analyse policies that support solar PV and biofuels. This supplement to the research report addresses those issues.

Acknowledgments

The Commission would like to thank those who kindly provided feedback on a draft of this supplementary report. In particular, the Commission thanks the Australian PV Association, the Treasury, the Department of Resources, Energy and Tourism, and the Office of the Renewable Energy Regulator for their feedback on the solar PV chapter, and the Australian Bureau of Agricultural and Resource Economics and Sciences, and the Biofuels Association of Australia for feedback on the biofuels chapter.

The Commission also engaged Life Cycle Strategies Pty Ltd as an expert external referee for the biofuels chapter and to review the life-cycle emissions intensity estimates contained therein.

1 Solar photovoltaic policies

The Productivity Commission's research report *Carbon Emission Policies in Key Economies* analysed the costs of, and abatement attributable to a range of emissions-reduction policies across eight countries, including Australia (PC 2011). The estimates have attracted significant attention. They also received some criticism, including from organisations representing the solar photovoltaic (PV) industry in Australia. Criticisms were directed at the Commission's methodology, and at some of the assumptions in its analysis (box 1.1).

This chapter addresses the key criticisms in relation to the solar estimates. Some of them were found to be valid, but others were not. Incorporation of suggested alternative parameters into the Commission's analysis that are plausible generated a lower range of estimates of the implicit abatement subsidy for policies that provided subsidies to solar PV in Australia in 2010 than initially estimated by the Commission. Nonetheless, the finding remains that the policies to subsidise solar PV in 2010 were costly compared to other abatement options, and led to negligible abatement.

Box 1.1 **Criticisms of the Commission's approach**

The most detailed criticism of the Commission's conclusions on the policies to support solar PV was published by the Australian PV Association (APVA 2011). It was argued that the Commission:

- over-stated the costs of solar PV systems
- used a static framework to analyse the costs of and abatement from policies that support solar PV
- calculated subsidies using the wholesale electricity price
- implicitly assumed that all PV systems were 1.5 kilowatts (or smaller)
- assumed that the life of PV systems was 20 years
- assumed that 50 per cent of electricity produced by solar PV systems would be exported into the electricity grid
- ignored the other benefits of policies to support solar PV.

The Solar Energy Industry Association (2011) repeated these points in a press release, as did the CEO of the Australian Solar Energy Society.

On 22 June, representatives of the solar PV industry held a press conference with independent MPs Tony Windsor and Rob Oakeshott and Greens Senator Christine Milne, during which the accuracy of the Commission's report was questioned.

1.1 The Commission's analytical approach

Some of the criticisms relate to the approach taken to analyse the costs of emissions-reduction policies.

A threshold point that needs to be emphasised is that the Commission estimated the total subsidy provided to owners of solar PV systems through particular *policies*. The marginal cost of solar PV technologies is of course a relevant consideration, because a subsidy must at least cover these costs to induce additional output. As noted in the report, estimates of the subsidy equivalent will provide upper-bound estimates of the resource cost of the policies. Without information on the shape of the supply curve for solar PV, it was not possible to separately identify the actual additional resource costs.

A second key point is that the Commission's analysis was based on comparing policy-induced effects with a 'counterfactual' — what might have happened in the absence of the policy. In particular, the Commission sought to identify which electricity source would have been used in the absence of a subsidy to renewables, and to estimate the revenue that owners of renewable energy sources, including solar PV, would have received in the absence of the policies. Based on this, the Commission estimated the net subsidy provided through each policy and the emissions intensity of the alternative electricity source.

A further point is that the Commission applied its methodology consistently across countries, policies and technologies. Given the range of policies analysed, it was necessary to make some common assumptions in the analysis, in order to compare policies on even terms.

1.2 Criticisms of the Commission's analysis of solar PV policies

The following sections address seven of the criticisms of the Commission's estimates that were made by the Australian PV Association APVA.

Issue 1: 'The Commission used a static analysis'

The APVA was critical of the study for using static analysis, stating that 'snapshot' analysis does not take into account the fact that the costs of PV are falling over time.

The Commission estimated resource costs (proxied by subsidy equivalents) and abatement for a single year (2010), because the terms of reference for the study directed the Commission to examine policies that were in place or 'committed'. To extend the analysis any further would have required forecasting what policies would be in place in the future, and their effects. This was not attempted because of the high degree of uncertainty around the features of future emissions-reduction policies, whether or not they relate to solar energy.

Issue 2: 'The Commission did not take into account "other benefits"'

The Commission's study has been criticised for not taking into account any benefits from subsidies to solar PV apart from emissions reductions achieved. Claimed benefits include employment, industry development and reductions in the costs of solar PV. (Of course, such impacts could be claimed not only of solar PV but of policies inducing other technologies as well.)

These issues were outside the scope of the terms of reference, which directed the Commission to estimate 'effective' or 'implicit' carbon prices 'per tonne of CO_2-e faced by the electricity generation sector'. To address the terms of reference, the Commission focused on the costs of policies and the abatement achieved.

This approach was applied consistently across all technologies, policies and countries — and to the extent that solar PV produces additional benefits, there is no reason to assume that they are larger or smaller than the benefits associated with other technologies, such as wind and gas. In addition, some consideration of the issues suggests that as well as the additional claimed benefits from subsidies to solar PV, there could also be additional costs. A more detailed analysis would need to take both into account, not only for policies that affect solar PV but also the use of other technologies.

Employment

The APVA (2011, p. 2) claimed that subsidies for solar PV 'have been instrumental in creating an industry with a $2 billion turnover and over 10 000 jobs'. However, while the solar subsidies have created jobs in the PV sector, these jobs are likely to have come at the expense of jobs in other parts of electricity generation and the economy more broadly. The net effect on the economy is likely to be negative. This is because the subsidies to solar PV encourage the replacement of relatively low-cost electricity with electricity generated from higher-cost technologies, which would reduce productivity, real wages and national income.

'Insurance' for households

It was further claimed that as a result of the subsidies for solar PV, '400 000 or more Australian families now have some insurance against rapidly increasing electricity prices'. However, the benefits of solar PV for the minority of households that have installed systems are offset by the higher electricity bills faced by other electricity consumers to pay for the subsidies. The subsidies to PV effectively transfer money from non-solar households to solar households. This could have equity implications for relatively poor owner-occupier households who, despite assistance, could not afford solar panels and would be faced with higher electricity prices, or for households that rent accommodation — to the extent that landlords would be unlikely to invest in solar for the benefit of their tenants. Thus the 'insurance' enjoyed by a small minority of households comes at the cost of potentially increasing the vulnerability of other households that face higher bills.

The costs of solar PV are falling over time

It was argued that the costs of solar PV are falling over time, and that subsidies will only continue to be necessary until 'grid parity' is achieved (the point at which the price to households of electricity from solar PV systems is equal to the retail electricity price). The APVA has claimed that this could come within five years. The Commission does not have a view on whether this estimate is reasonable, but would note that solar PV is not the only technology that is likely to experience reductions in costs over time.

The APVA stated that the cost of solar PV is expected to fall at a rate of 22 per cent for each doubling of capacity. However, as noted in the Commission's submission to the Garnaut Review (PC 2008), these cost reductions depend on a doubling of global, not Australian capacity. Australia represents a small proportion of global PV installation, and a very small proportion of solar PV manufacture. Even if Australian governments provided no subsidies to solar PV, the costs of the systems would be falling because of increased global demand for solar PV, implying that the future benefits (lower PV prices) could be gained without incurring any costs now. (However, it is acknowledged that there may be some economies of scale in the installation of solar PV systems.)

Quality of solar PV installations

One of the effects of the subsidies for solar PV has been a rapid growth in the number of solar PV systems being installed. There is some evidence to suggest that recent installations of solar PV systems have not always met regulatory standards.[1] Because of the key role subsidies have played in encouraging the uptake of solar PV systems, the costs of inspection, potential rectification of faults and increased risk of damage to property and human health would need to be included in any comprehensive analysis of the costs of subsidies to solar PV.

Electricity network effects

A more detailed analysis of the costs and benefits of subsidies to solar PV over the longer term would also need to take into account costs that might arise from increasing the use of intermittent renewables. For example, increasing the use of intermittent renewables could increase the need for backup generation sources that are able to respond rapidly to changes in generation from renewables.

1 NSW Fair Trading (2011) carried out an audit of 658 installations in north-west Sydney, and found that 19 per cent had major defects, 64 per cent had minor defects and 18 per cent had no defects.

At the current scale of solar PV, these issues are probably not leading to high costs. However, as more solar PV (and other intermittent renewables) are introduced into the grid, the costs could increase. This highlights that, while there may be some network benefits from increasing the use of PV, there could also be costs.

Issue 3: 'The Commission overstated the costs of PV'

The Commission's analytical approach seems to have been misinterpreted to imply that estimates of the levelised cost of electricity (LCOE — essentially the long-run marginal cost) were used as an input to the estimates of the subsidy equivalent. While the Commission reported estimates of the LCOE of coal, gas, wind and solar PV generation (PC 2011, box 4.1, p. 81 — the estimates were drawn from EPRI 2010), these were not used in the calculations. Rather, they were reported as an illustration of the relative costs of different electricity generation technologies.

As noted, the Commission estimated the subsidies provided to owners of solar PV systems as a proxy for the resource cost of the policy. The estimates were based on policy parameters, discount rates and some assumptions about the level of generation from renewable sources. The cost of solar PV technology was not used as an input into the estimates of the subsidies. Hence, even if the EPRI (2010) estimate of the LCOE of solar PV was higher than the current cost of systems, it had no direct bearing on the estimates of the subsidy equivalent of the policies.

Issue 4: 'The Commission used wholesale electricity prices to estimate the subsidy to solar PV'

In its estimates of the costs of feed-in tariffs (FITs), the Commission estimated the production subsidy to solar PV as equal to the FIT rate minus the wholesale electricity price. This approach gives the best estimate of the resource costs of FIT policies. To explain why this is the case, it is useful to set out how such policies operate.

In states and territories that have FIT policies, electricity retailers are effectively forced to purchase all the electricity that is generated using solar PV systems and fed into the grid, and pay a premium price for each kilowatt hour (kWh) of electricity (the FIT rate). In the absence of these policies, they would presumably purchase electricity from the cheapest alternative source, which would generally be the wholesale electricity market. Without the FIT policies, it is not clear that there would be any incentive for electricity retailers to pay the owners of solar PV systems any more than the wholesale price. Hence, the difference in costs for the electricity retailers is effectively equal to the FIT rate minus the day-time wholesale electricity price. This is the production subsidy equivalent (expressed in dollars per megawatt hour ($/MWh)) received by PV system owners. These costs are then passed on to electricity consumers in the form of higher electricity bills. Hence, the upper bound of the total resource cost to the community of FIT policies can be approximated by multiplying the production subsidy equivalent by the total output from solar PV systems that is fed into the grid.[2]

The APVA claimed that the retail price should be used to estimate the costs of solar PV systems:

> The abatement cost of a PV system connected to the distribution network can be calculated by calculating the difference between a PV system's Lifetime Cost of Electricity (LCOE) and the retail electricity price and then dividing it by the estimated abatement. (APVA 2011, p. 4)

This approach would not reflect the resource costs of policies that subsidise the use of PV (which is what the Commission attempted to estimate, using subsidy equivalents as a proxy). Instead, it would provide an estimate of the difference between what households would pay for electricity from un-subsidised solar PV and what they pay for retail electricity. This figure would give an indication of the subsidy that would make households indifferent between installing a solar PV system and purchasing their electricity from the grid. However, using this methodology would not be consistent or comparable with estimating the total subsidy equivalent of the policies that subsidise PV.

Indeed, using the retail price as the counterfactual instead of the wholesale price would imply that, in the absence of FITs, electricity retailers would choose to pay households the retail price for electricity they feed into the grid. Given that retailers then on-sell that power at the retail price, there would be no benefit to retailers in purchasing electricity from solar PV (in fact, transaction costs would lead to a net cost to retailers). Unless they were compelled to pay a higher price, there seems to be little reason to assume that electricity retailers would pay a premium for solar power. Using the retail price as the counterfactual would understate the resource costs of FIT policies, and would not be consistent with the Commission's analysis of the costs to the community of policies to subsidise solar PV.

The APVA claims that using the wholesale price 'ignores the avoided losses in transmission and distribution, as well as Use of System charges where relevant' (APVA 2011, p. 5). Distributed generation may lead to reductions in losses in distribution and transmission. However, the Commission did not have access to

2 If there were any producer surplus, the estimate of the subsidy equivalent would be an overestimate of the resource cost. Box 3.3 in the Commission's report (PC 2011, p. 53) depicts the areas of the subsidy equivalent that constitute resource costs and producer surplus.

reliable estimates of these effects for all countries, and for that reason did not include these effects in its estimates of the abatement attributable to solar PV.

Distributed generation could also lead to reductions in transmission charges. However, due to the way these charges are regulated, this would only be the case if solar PV reduced the need for investment in the transmission network (which, at current rates of solar PV take up, appears unlikely).

In addition, if these benefits were counted, it would also be necessary to take into account other costs (and benefits) that could arise from expanding the use of intermittent renewables (such as the need for additional back-up generation and uncertainty about network peak load requirements). These are issues that could increase the cost and complexity of managing electricity grids in the future.

The Commission applied the same approach consistently across all renewable energy sources. For example, the German FITs for renewables (which are paid for electricity from large-scale renewables and solar PV) were compared to the counterfactual of the wholesale electricity price. Comparing the FIT received by a commercial wind farm to the retail price of electricity would make little sense — the wind farm would not receive the retail price in the absence of policy. Using a different counterfactual electricity price when analysing policies that subsidise solar PV would be inconsistent and would bias the results to make subsidies to solar PV appear relatively less costly.

The APVA argued that the Commission's analysis of the large-scale component of the Renewable Energy Target (RET) was based on the LCOE of wind power, and as such the Commission should have used the same approach for the small-scale component (APVA 2011, p. 3). However, there are important differences between the way the large-scale component of the RET and the small-scale component operate in practice.

Large-scale renewable energy projects (such as wind farms) generally only proceed on the basis of a contract for the generator to sell Renewable Energy Certificates (RECs) to an electricity retailer. The subsidy to large-scale renewable projects through the RET is equal to the value of the long-term REC contract price. Given that these prices are commercial information, and not publicly available, the Commission estimated what the long-term REC price might be, using a calculation similar to that outlined by the APVA. (Specifically, the long-term REC price was estimated as the levelised cost of wind-generated electricity minus the wholesale electricity price.) This approach was discussed with a number of industry experts, and was regarded as a sensible proxy in the absence of data on long-term REC prices.

For solar PV, this would not be appropriate. Industry experts advised that in 2010, most RECs granted to solar PV systems were sold through the spot market. Hence the spot price of RECs was the relevant price for the analysis.

In the case of other Australian schemes, such as the New South Wales Greenhouse Gas Reduction Scheme (GGAS) and the Queensland Gas Target, there was no reason to suggest that the certificate prices in these schemes were not an appropriate proxy for the production subsidy equivalent. Thus, in these cases the certificate prices were used to estimate the subsidy equivalents.

Issue 5: 'The Commission did not attempt to separate economic subsidy from transfers'

The APVA claimed that the Commission 'estimates total fiscal subsidy without any attempt to separate economic subsidy from transfers (unlike other PC scheme assessments such as that undertaken for GGAS)' (APVA 2011, p. 3). This claim is incorrect. For example, the Commission stated:

> If assumption 2 is relaxed — that is, there would have been some production of the low emission product without the policy — the link between the subsidy equivalent and the additional resource costs of the policy becomes less direct. This is because, depending on scheme design, the subsidies may flow to existing production as well as incremental production, while the additional resource costs of the intervention come only from the incremental units. For this reason, it is important that the subsidy equivalent calculations used for cost comparisons across policies and countries only included policy-induced production. (PC 2011, p. 60)

Wherever possible, the subsidies to existing production (transfers) were excluded from the estimates of the total subsidy equivalent.

In the case of GGAS, the Commission relied on analysis by the Department of Climate Change to assess the extent of genuine abatement. The Department found that most of the subsidies for abatement under GGAS were paid for emissions reductions that would have occurred anyway, and that only 0.7 Mt CO_2 of additional emissions reduction was brought about by the scheme. The Commission excluded all but this 0.7 Mt, and also excluded the payment for all other emissions reductions, as the payments were essentially transfers (rather than subsidies).

In the case of solar PV, only subsidies to systems that would have been installed in the absence of the subsidies would be counted as transfers. For its analysis the Commission assumed that, given the relative cost differences between solar PV and retail electricity, up to 2010 no small-scale solar PV would have been installed without subsidies. To the extent this was the case, the estimate of the subsidy equivalent of the policies would not include material levels of transfers to pre-existing production.

It should be noted that, where it was assumed that a generator was installed as a result of a subsidy, the Commission did not attempt to estimate what proportion of the subsidy equivalent was a transfer, and what proportion was the resource cost of the policy. It was acknowledged that for any given policy, the subsidy equivalent estimate 'overstates the resource costs involved' (PC 2011, p. 47). However, the measure does provide a basis for comparing the cost effectiveness of the various policies that were in place in 2010. Furthermore, it is likely that even if the resource cost could be disaggregated from any transfers, the ranking of policies by cost effectiveness would not change. Policies to support solar PV would almost certainly remain the most costly of the policies identified.

Issue 6: 'The Commission ignored "front loading" of feed-in tariffs'

The New South Wales FIT was scheduled to be paid for only 7 years. The APVA argued that given that solar panels last for 30 years, this should be regarded as a capital subsidy, rather than a production subsidy. The Commission does not agree with this approach for several reasons.

- In 2010, when the effects of policies were estimated, New South Wales owners of PV systems were receiving a production subsidy through the FITs. The FIT revenue was paid as a production subsidy, not as an up-front capital subsidy.
- FITs were treated as production subsidies in all cases, regardless of possible future changes. Treating the New South Wales scheme differently would not have been consistent with the analysis of FITs in other jurisdictions and other countries, or for other technologies.
- FIT systems are subject to constant change as governments respond to political and other pressures. How long FITs were likely to be paid for, or the rates could not be reliably estimated.

Issue 7: 'The Commission used the wrong measure of costs'

The APVA suggested that the appropriate metric of the costs of abatement for solar PV would be an estimate of the 'energy consumer subsidy' per tonne of CO_2. The APVA defined it to mean:

> Subsidy as paid by electricity consumers (this is the subsidy that impacts on electricity bills). (APVA 2011, p. 2)

While the APVA claimed that the Commission did not estimate this figure, in fact, illustrative estimates of the effects of existing emissions-reduction policies on electricity prices were published. These included the costs of the RET and FITs (PC 2011, pp. 97–102). It is worth noting that the estimates of the impact of emissions-reduction policies on electricity prices could mask the high unit costs of abatement of some policies, where the total cost of those policies was low relative to the total amount spent by consumers on electricity in 2010.

Chapter 3 of the original report (PC 2011) explains why subsidy equivalent was considered the most suitable measure of the cost effectiveness of policies to subsidise emissions reductions.

1.3 Using different parameters

The Commission's estimates of the costs of the small-scale component of the RET and the state and territory solar feed-in tariffs were based on a number of assumptions. The APVA raised criticisms of three parameter values:

1. the life of PV systems
2. the 'solar multiplier' — the number of renewable energy certificates received by solar PV per MWh of electricity
3. the 'export factor' — the amount of solar power that is exported to the grid (and therefore receives FITs in states with net FIT systems).

The life of PV systems

In 2010, the small-scale component of the RET effectively provided an up-front capital subsidy to households that installed solar PV systems. Households were granted RECs for each MWh of electricity the systems were forecast to produce over the next 15 years. (An additional 'REC multiplier' further increased the subsidy.) At the prevailing REC prices, this effectively provided an up-front capital subsidy of $777 million to solar PV systems in 2010.

The capital subsidy was converted into an annual subsidy using an 'annuity' formula. This required making assumptions about the discount rate and the life of the asset. For solar PV systems, it was assumed that the life of the asset would be 20 years. This was based on the published literature and was also tested with governments (including the Australian Government).

The APVA suggested that solar PV systems would last longer than 20 years (it stated that most systems are sold with 25-year warranties, and that the International Energy Agency uses 30 years in its life cycle analyses). However, using a 30-year economic life has a relatively small effect on the estimate of the total subsidy equivalent. For 2010, using a 7 per cent real discount rate, a 20-year life would imply a total subsidy equivalent of around $73 million, while a 30-year life would imply a total subsidy equivalent of around $63 million.

The 'REC multiplier'

In 2010, owners of solar PV systems were granted five RECs for each MWh of electricity that was forecast to be generated by their systems over the next 15 years. This 'REC multiplier' only applied to the first 1.5 kilowatts (kW) of system capacity. For capacity above this level, owners were granted one REC per MWh of forecast electricity generation.

The Commission's analysis of the small-scale component of the RET used an assumption that the 19.8 million RECs that were granted to owners of solar PV systems in 2010 — and were eligible for the REC multiplier — were issued based on the five times multiplier. This implies an assumption that all systems eligible for the multiplier that were installed were 1.5 kW systems (or smaller).

The APVA pointed out that many households opted to install systems larger than 1.5 kW. This is consistent with more recent advice to the Commission from the Office of the Renewable Energy Regulator that the average number of RECs received per MWh of solar PV generation in 2010 was 3.2 (ORER, pers. comm., 17 August 2011)

Using this lower REC multiplier would imply that more electricity was generated from solar PV in 2010 than originally estimated: 493 gigawatt hours (GWh), compared to 344 GWh. Abatement attributable to solar PV would increase (0.3–0.5 Mt CO_2, compared with 0.2–0.3 Mt CO_2).

Including capital subsidies from previous years

In the Commission's original analysis, the total subsidy equivalent and thus abatement were estimated based on RECs granted in 2010. However, the small-scale component of the RET was estimated as a capital subsidy. In other cases where the Commission estimated the costs of capital subsidy schemes, the value of subsidies to existing generators installed prior to the year of analysis was included, as was the electricity generated by the subsidised generators. Thus for consistency, these should be included in the analysis of the RET.

Incorporating these in the analysis leads to an additional 112 GWh of solar PV generation being included in the calculations. Both the subsidy equivalent and abatement estimates are adjusted upwards accordingly.

The effect of using different parameter values for the RET

For the small-scale component of the RET, using revised parameter values to take into account the APVA's criticisms leads to higher estimates of abatement, lower subsidy equivalent estimates (except for the scenario with the 11 per cent discount rate) and a lower implicit abatement subsidy (table 1.1). The implicit abatement subsidy delivered by the small-scale component of the RET remains at the high end of the estimates for Australia in 2010.

Table 1.1 **Original and revised estimates, small-scale component of the Renewable Energy Target**
2010

		Abatement			
	Subsidy equivalent	*Low*	*'Central'*	*High*	*Implicit abatement subsidy*
	A$m (2010)		Mt CO_2		A$/t CO_2
	Original estimates (5x REC multiplier and 20 year system life)				
7% discount rate	73	0.2	0.3	0.3	230–425
3% discount rate	52	0.2	0.3	0.3	152–281
11% discount rate	98	0.2	0.3	0.3	283–525
	Revised estimates (3.2x REC multiplier and 30 year system life)				
7% discount rate	70	0.3	0.6	0.6	116–214
3% discount rate	44	0.3	0.6	0.6	73–136
11% discount rate	100	0.3	0.6	0.6	165–306

Source: Productivity Commission estimates.

The PV electricity 'export factor'

The estimates of the total subsidy equivalents under state and territory FITs were based on estimates of how much electricity is exported to the grid by solar PV systems. In states with net FITs (all bar NSW and the ACT), households receive payment only for excess electricity that they feed into the grid. The Commission assumed that 50 per cent of electricity was fed into the grid. The APVA has stated that for a 1.5kW system, around 17–28 per cent of electricity is exported to the grid. This would imply that owners of systems would receive less FIT revenue (because less electricity would be exported to the grid). Based on a graph in the APVA paper (2011, p. 5), for 2kW systems export rates would be around 20–40 per cent, and for 2.5kW systems 30–50 per cent.

Reducing the export rate parameter to 20 per cent would change the estimate of the total subsidy equivalent (table 1.2). The effects would be different for net and gross FITs.

- Net FITs — a lower export factor would imply less electricity being fed into the grid and lower FIT revenue for system owners.
- Gross FITs — in the original research report, the Commission assumed that in jurisdictions with gross FITs, households use some of the electricity they generate within the home, and then receive a FIT for that electricity. In fact, the accounting operates somewhat differently. In Australia, such schemes generally operate by simply paying PV system owners for all electricity generated, as if it had all been exported to the grid. Using this accounting framework leads to a lower subsidy equivalent.

Table 1.2 **State and territory FITs total subsidy equivalent using different export factors**

2010

	NSW 1[a]	*NSW 2*[a]	*ACT*	*Vic*	*Qld*	*WA*	*SA*	*Total*
Type of FIT	Gross	Gross	Gross	Net	Net	Net	Net	
Total subsidy equivalent ($m)								
Original estimates[b]	42.2	0.4	2.2	22.5	20.8	2.2	6.1	96
Revised estimates[c]	39.4	0.3	2.0	9.0	8.3	0.9	2.5	62

[a] The New South Wales Government changed the FIT rate on 27 October 2010. NSW 1 refers to installations before 27 October, and NSW 2 refers to installations after 27 October. [b] This row sets out the Commission's original estimates of the subsidy equivalent. [c] This row sets out the subsidy equivalent using a lower export factor (20 per cent compared to 50 per cent) and a different treatment of gross FITs.

Source: Productivity Commission estimates.

Incorporating a 20 per cent electricity export factor has a material effect on the estimate of the subsidy equivalent provided through net FITs. The different treatment of gross FITs has a small effect.

Adding it all up

The Commission has estimated the total subsidy equivalent, abatement and implicit abatement subsidy for policies that provided subsidies to solar PV in 2010 using the alternative assumptions outlined above (table 1.3).

The alternative assumptions have the effect of roughly halving the upper and lower bounds of the implicit abatement subsidy estimate. The small-scale component of the RET and the state and territory FITs nevertheless remain relatively high-cost policies achieving little abatement.

Table 1.3 **Estimates for small-scale solar PV subsidies**

Original PC estimates and estimates using alternative assumptions

Estimate	*Original assumptions*[a]	*Alternative assumptions*[b]
Total subsidy equivalent	$m	$m
RET (small-scale component)	52–98	44–100
State and territory FITs	96	62
Total	149–194	107–162
Abatement (Mt CO_2)	0.2–0.3	0.3–0.6
Implicit abatement subsidy ($/t CO_2)	431–1 043	177–497

a PC assumptions: solar PV systems have an economic life of 20 years; all RECs to small-scale solar PV were issued with a 5x multiplier; 50 per cent of electricity generated by solar PV is exported to the grid. **b** Alternative assumptions: solar PV systems have an economic life of 30 years; RECs to small-scale solar PV were issued with an average 3.2x multiplier; 20 per cent of electricity generated by solar PV is exported to the grid; different treatment of gross FIT schemes.

Source: Productivity Commission estimates.

2 Biofuels policies

This chapter provides analysis that supplements the Commission's work on ethanol and biodiesel policies in Australia in its Research Report. It addresses criticism of the Commission's approach to estimating implicit abatement subsidies for biofuel policies in Australia (box 2.1).

The supplementary analysis incorporates a review of the Commission's approach to estimating abatement for ethanol and corrects an error in the Commission's original estimates for Australian ethanol. The implications and revised results are presented in the following section.

Box 2.1 **Criticisms of the Commission's biofuel analysis**

After the release of the Commission's study, Heather Brodie, the Chief Executive of the Biofuels Association of Australia (BAA) asserted that the biofuels industry is 'not a subsidised industry' as the industry 'pays that tax [fuel excise] and it's granted back so that to Treasury and to the taxpayer it's neutral' (Metherell and Vincent 2011).

In an article in the *Australian Financial Review*, the Chief Executive of the BAA said that the Commission's study was 'misleading'. This article provided an alternative emissions estimate, stating that 'one litre of ethanol reduces emissions by 90.9 per cent compared with petrol … according to the US EPA's [Environmental Protection Agency] research' (Freebairn 2011).

The Member for New England, Tony Windsor, also raised concerns about the Commission's biofuels analysis (Windsor 2011). He questioned the Commission's treatment of the Ethanol Production Grants program and the Cleaner Fuels Grants Scheme as subsidies. Mr Windsor also asserted that the Commission:

- had not taken into account the 'appropriate life-cycle analysis in terms of how most grain is actually produced in this country' (Windsor 2011, p. 47)
- did not look at the potential of biofuels in terms of transportation fuels into the future.

Sources: Freebairn (2011); Metherell and Vincent (2011); Windsor (2011).

This report then explores the sensitivity of the ethanol results to a range of assumptions. It is demonstrated that, irrespective of the assumptions made about the current and potential abatement from biofuel, the conclusion that current biofuel policies are a relatively costly way of achieving greenhouse gas abatement remains valid.

The Commission then presents a revised range for the estimated implicit abatement subsidy for the Ethanol Production Grants program taking into account information received subsequent to publishing the original report. This information relates to the mix and types of feedstocks used to produce ethanol in Australia.

2.1 The Commission's analytical approach

In its analysis of biofuel policies, the Commission estimated implicit abatement subsidies, which provide an indication of the average cost of emissions reduction policies expressed as dollars of subsidy equivalent per tonne of abatement. Subsidy equivalents represent the value of assistance provided directly or indirectly to an industry under a policy and give an upper-bound estimate of the resource costs of these policies.

In presenting the results in this way, the full amount of the estimated cost of the policy is attributed to the reduction in greenhouse gas emissions. However, biofuel policies may have other objectives aside from greenhouse gas abatement — for example, fuel security and rural or industry development. In a context where policy objectives are not always explicit, the Commission did not attempt to apportion the cost of a given policy among its possible objectives. Therefore, a proportion of the cost may be attributable to objectives other than abatement.

Estimating abatement

The abatement attributed to a policy was determined by estimating the amount of greenhouse gas emissions that occurred in the 2009-10 financial year with the policy, relative to what would have occurred without the policy (counterfactual emissions). In the case of biofuels, this was simply a matter of estimating the difference between total emissions from biofuel consumed in the period examined and the total emissions that would have occurred if the equivalent amount of conventional fuel (adjusted for difference in energy content) had been consumed instead.

In estimating greenhouse gas emissions from biofuel and conventional fuels, life-cycle analysis (LCA) was used. This involves assessing all of the greenhouse gas emissions attributable to a product, beginning with the production or extraction of raw materials and ending with the product's disposal. This is the most systematic and comprehensive method for the assessment of the environmental impacts of transport technologies (Metz et al. 2007). This approach is particularly important to adequately account for the abatement achieved by policies that encourage consumption of biofuels relative to conventional fuels, as the emissions profiles of the two fuel types differ significantly.

Some feedstocks used to produce biofuels are byproducts from other production processes. Where this occurs, it may be appropriate to allocate upstream emissions across products (appendix M).

2.2 Criticism of the Commission's biofuel analysis

The Commission's biofuel analysis is highly sensitive to assumptions made regarding the greenhouse gas emissions of fuels over the life cycle. As outlined in box 2.1 there were several criticisms made of the Commission's analysis, in particular relating to its abatement estimates. While some critical statements regarding the Commission's approach are valid, others are unfounded.

Issue 1: the biofuels industry is not subsidised

The Biofuels Association of Australia (BAA) has argued that the biofuels industry is not subsidised and that excise is paid on biofuel and then 'granted back' through the Ethanol Production Grants program and Cleaner Fuels Grants Scheme.

A commonly accepted definition of a 'subsidy' is found in the World Trade Organisation's *Agreement on Subsidies and Countervailing Measures 1995* (to which Australia is a party). It states among other things that a subsidy shall be deemed to exist if 'government revenue that is otherwise due is foregone or not collected (for example, fiscal incentives such as tax credits)' (article 1). Using this definition, both the Ethanol Production Grants program and the Cleaner Fuels Grants Scheme would be classified as subsidies.

However, the definition of a subsidy is not necessarily relevant within the context of the Commission's analytical approach. The Commission estimated the 'subsidy *equivalent*' of a policy to quantify the amount of financial assistance provided directly or indirectly to an industry under a policy. Using this framework, a range of policies — that provide both explicit or implicit assistance — can be examined and quantified using a common dollar metric. The Ethanol Production Grants program and the Cleaner Fuels Grants Scheme provide an effective tax exemption on fuel excise by offering a rebate equal to the value of excise paid for ethanol and biofuel. Whether this assistance is provided explicitly or implicitly does not alter its estimated subsidy equivalent.

Thus, the threshold question is: do the Ethanol Production Grants program and Cleaner Fuels Grants Scheme provide assistance — either directly or indirectly — to ethanol and biodiesel producers? This needs to be considered in the context of what the counterfactual situation would be without these two policies.

- Both ethanol and biodiesel are included in the excise tax schedule and attract excise. The grants provided through the two programs — by effectively reducing the excise rate to zero — provide biofuels with an advantage over conventional fuels. In other words, by imposing a tax on a product (petrol or diesel) and providing a rebate on the tax to a substitute (ethanol or biodiesel) the government is implicitly providing assistance to that industry.
- For the Australian analysis, the Commission applied a default assumption that no biofuel would be consumed in the absence of the two grants programs. Thus, the counterfactual situation (no policy) is one where conventional fuels — petrol or diesel — would be consumed instead of biofuels. These fuels would attract excise and would not receive any rebate. Therefore, if these two programs did not exist, general revenue would be increased (by the value of the amount of conventional fuel consumed multiplied by the excise rate).

The Commission estimated the value of the Ethanol Production Grants program and Cleaner Fuels Grants Scheme as equivalent to the financial value of the grants provided to biodiesel and ethanol. This was estimated at $144 million (in 2010 dollars) for 2009-10 (for both programs combined).

Issue 2: the Commission has underestimated the abatement from biofuels

In choosing estimates of life-cycle emissions from fuels, the Commission used the most authoritative sources available. The estimates used for the Australian biofuels analysis were sourced from CSIRO, BTRE and ABARE (2003) (see annex). These estimates are the most recent Australian estimates available (the CSIRO used the same emissions intensity estimates when it released a report on Australian biofuel in 2007 (CSIRO 2007)).

Estimates of greenhouse gas emissions from ethanol were calculated as a weighted average taking into account the mix of feedstocks currently used in Australia to produce ethanol. The feedstock shares used were sourced from the Biofuels Association of Australia (2010). Feedstocks utilised in Australia include wheat starch waste, sorghum and molasses (table 2.1).

In the original study, an error was made in converting the emissions estimates for ethanol. Estimates of life-cycle emissions of ethanol by feedstock type from

CSIRO, BTRE and ABARE (2003) were not correctly adjusted for the difference in energy content between ethanol and petrol. In consequence, the abatement resulting from ethanol use in Australia was underestimated (table 2.1). This error does not affect estimates for other countries or the estimates for Australian biodiesel.

Table 2.1 **Average abatement factor, ethanol**
Australia

Fuel type	*Feedstock*	*Estimated production share*[a]	*Life-cycle emissions intensity (original)*	*Life-cycle emissions intensity (corrected)*
		%	g CO_2-e/L petrol equivalent	g CO_2-e/L petrol equivalent
Ethanol	Waste wheat starch	68	1 904	1 269
	Sorghum	18	2 115	1 539
	Molasses	14	1 904	1 276
	Weighted average	100	1 942	1 319
Petrol	Petroleum	100	3 023	2 702
Average abatement factor	**..**	**..**	**1 081**	**1 383**

[a] Feedstock production shares were estimated using the production capacity of active plants from the BAA (2010). **..** Not applicable.

Sources: BAA (2010); PC (2011).

Within the context of the assumptions and approach of the original study, this error means that the Commission's estimate for the implicit abatement subsidy for the Ethanol Production Grants program was overstated. Correcting the error has the effect of reducing the implicit abatement subsidy for the Ethanol Production Grants program from \$532/tonne CO_2-e (reported) to \$416/tonne CO_2-e. However, with the benefit of information that the Commission received after the release of the study, it is now considered appropriate to present a range of outcomes for the implicit abatement subsidy for the Ethanol Production Grants program. These are provided later in this paper.

The Biofuels Association of Australia's estimates

The Commission's corrected estimate indicates that ethanol in Australia reduces emissions by 51 per cent relative to petrol (given current production processes and the assumptions regarding feedstock shares from the original study). This is significantly different from the estimate cited by the BAA, both on their website and in recent media reports, that 'one litre of ethanol reduces emissions by 90.9 per cent compared with petrol' (Freebairn 2011).

The BAA estimate appears to be based on cellulosic ethanol produced in the United States using a mix of feedstocks such as hybrid poplar, switchgrass and corn stover (US EPA 2007). However, based on the BAA's own figures, no cellulosic ethanol of any type is commercially produced in Australia, hence this emission reduction does not apply.

Issue 3: the Commission has not appropriately accounted for waste products used to produce ethanol

The treatment of 'waste' or byproducts in LCA can have a significant impact on the level of emissions estimated. Two important factors are relevant in this context:

- The mix of feedstocks used in Australia (and the extent to which these feedstocks are 'waste' products).
- The treatment of 'waste' and byproduct feedstocks in life-cycle analysis.

The ethanol industry in Australia comprises only a few producers, and commercial confidentiality concerns make it difficult to obtain accurate information on production levels and feedstock use (CSIRO, BTRE and ABARE 2003). In addition, feedstock use can vary over time and is likely to be highly dependent on the availability and price of potentially competing feedstocks.

Contrary to some statements reported in the media, the Commission's estimates (both original and corrected) assume that the majority of ethanol produced in Australia is produced using wheat starch waste. Wheat starch waste ethanol is produced using waste starch from the gluten manufacturing process (Beer et al. 2001). The Commission also included ethanol produced in Australia using sorghum or molasses in its analysis. The mistaken view that the Commission's estimates do not include waste products may have arisen due to the overestimate of emissions intensity for ethanol in the original figures (as discussed).

When estimating life-cycle emissions from wheat starch waste ethanol, the CSIRO, BTRE and ABARE (2003) study (on which the Commission based its estimates) did not include any emissions from the production of the wheat. This means that assumptions regarding the type of agricultural processes used to produce the wheat were not required. Rather, only the emissions from processing the wheat starch waste into ethanol and any transport of the feedstock or final product were incorporated. Combustion of ethanol was not counted as this is assumed to be offset by the sequestration that occurs when the feedstock is grown.

However, subsequent to publishing its report, the Commission has received information suggesting that not all the feedstock derived from the wheat starch process used to produce ethanol in Australia is waste product and hence that some upstream emissions associated with production of the wheat might reasonably be included. This is discussed in section 2.3 and revised estimates are provided.

Issue 4: the Commission has not considered the future potential of biofuels

As discussed earlier, there has been some criticism of the static nature of the analysis undertaken. In particular, it has been argued that 'snapshot' analysis does not take into account the fact that the costs of technologies will fall over time and that technological improvements will mean that greater abatement can be achieved (for example, through the wider adoption of 'second generation' biofuels).

As noted in chapter 1 in relation to solar technologies, the Commission is not in a position to undertake this research across the range of technologies examined in its original study. However, in the case of biofuels some factors influencing future potential (from an abatement perspective) can be further explored. That is, sensitivity analysis can be conducted to see how the implicit abatement subsidy changes when the assumed level of abatement from biofuel varies. This enables a consideration of how improving the abatement potential of biofuel would change the cost effectiveness of current biofuel policies.

It is theoretically possible that, in the future, technology could develop such that the net greenhouse gas emissions from biofuel were zero over the life cycle. This would require there to be zero emissions from the production and transport of the biofuel, and for the net greenhouse gases sequestered when growing the feedstock to perfectly offset the emissions from the combustion of the biofuel. The Commission is not aware of any biofuel currently produced with these characteristics but presents this scenario as a hypothetical example of future abatement potential.

Applying this hypothetical scenario to Australia, zero-emissions biofuel would reduce greenhouse gas emissions by 2702 g CO_2-e per litre of petrol replaced with ethanol and 3300 g CO_2-e per litre of diesel replaced with biodiesel.[1] At the level of subsidy equivalent currently provided to the biofuel industry, the implicit abatement subsidy would be \$213/t CO_2-e for ethanol and \$140/t CO_2-e for biodiesel (in 2010 dollars). Therefore, even under circumstances where technological innovation significantly improves the abatement potential of ethanol or biodiesel to a point where these fuels have zero emissions, the current excise rebate arrangements

1 Assuming that petrol has an energy content of 34.2 MJ/L and a life-cycle emissions intensity factor of 79.0 g CO_2-e/MJ and diesel has an energy content of 38.6 MJ/L and a life-cycle emissions intensity factor of 85.5 g CO_2-e/MJ.

would still provide a subsidy well over $100 for each tonne of greenhouse gas emissions abated.

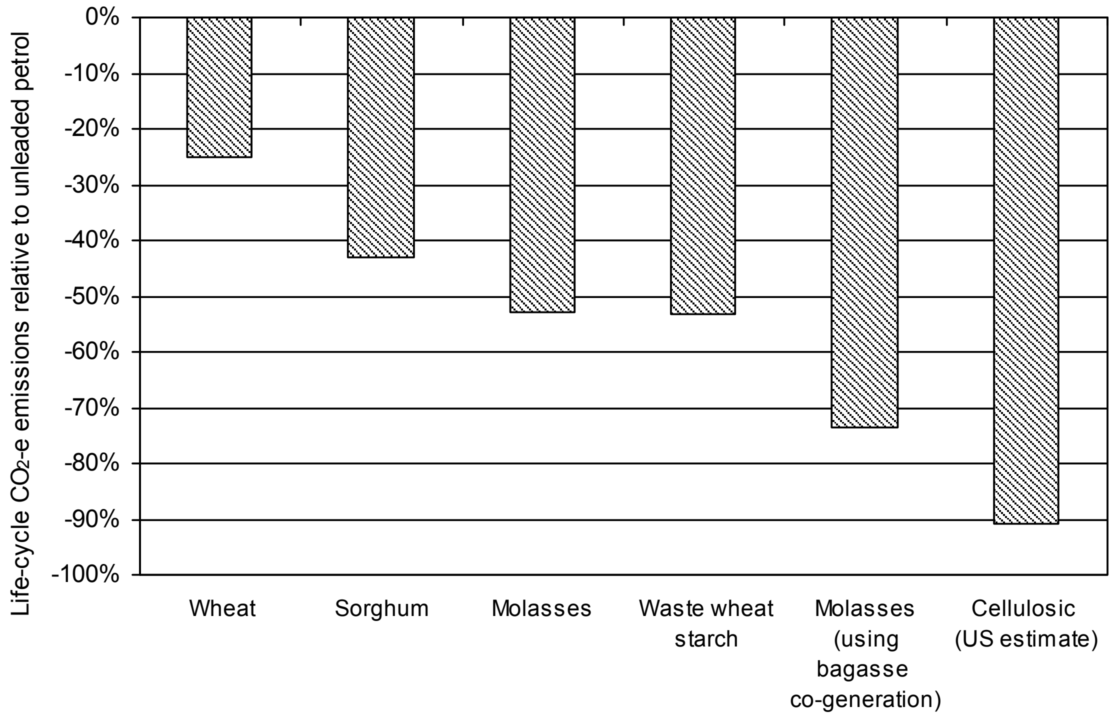
2.3 Using different parameters — ethanol

On the basis of the information received since the release of the study, the Commission considers that there are grounds to re-examine some of the original assumptions in the ethanol analysis and provide sensitivity analysis for the Australian results. The assumptions to be re-examined include:

- the mix of feedstocks used to produce ethanol — in particular, the proportion of ethanol that is produced using waste and non-waste wheat and molasses (using bagasse cogeneration)
- the treatment of waste feedstocks and the extent to which these feedstocks may have other uses.

As already noted, the Commission's estimates of abatement from ethanol are highly sensitive to assumptions about the mix and type of feedstocks used to produce ethanol. Figure 2.1 shows the range of emissions reductions (relative to petrol) that can be achieved by ethanol, depending on the type of feedstock used.

Figure 2.1 **Emissions reduction of ethanol by feedstock type**[a]



[a] Cellulosic ethanol is not currently produced in Australia on a commercial scale and is included in this figure for illustrative purposes.

Data sources: CSIRO, BTRE and ABARE (2003); US EPA (2007).

Wheat ethanol

As discussed earlier, in its study the Commission assumed that all ethanol produced using wheat feedstock was wheat starch *waste* (in accordance with BAA figures). However, as noted, the Commission has subsequently become aware of evidence suggesting that not all ethanol produced using wheat feedstock in Australia is made from waste products. The Manildra Group, located in New South Wales, is the only company in Australia that produces ethanol from wheat feedstock (this represents around 68 per cent of Australian ethanol). At the Inquiry into Mandatory Ethanol and Biofuels Targets in Victoria (2007), the Managing Director of the Manildra Group stated that Manildra uses ‘something like fifty-fifty’ waste product and raw product (Honan 2007, p. 5).

The impact of changing the proportion of waste and non-waste wheat feedstock used to produce Australian ethanol is substantial. Where it is assumed that half of the ethanol produced using wheat is produced using non-waste wheat, estimated abatement reduces to 0.2 Mt CO_2-e and the implicit abatement subsidy for the

Ethanol Production Grants program becomes \$511/t CO_2-e. Thus, the implicit abatement subsidy for the Ethanol Production Grants program could vary from \$416/t CO_2-e where only waste wheat is used, to \$664/t CO_2-e, where only non-waste wheat is used.

A greenhouse gas assessment conducted by GHD for Shoalhaven Starches (a member of the Manildra Group) in 2008 finds that the emissions intensity of ethanol produced at the Bomaderry facility would lead to a 44 per cent decrease in emissions relative to conventional petrol (GHD 2008). However, this assessment provides little detail on the proportion or treatment of waste and non-waste feedstocks used. Given the uncertainty regarding the use of feedstocks, sensitivity analysis is presented in the following section with a 'low' estimate assuming that all wheat ethanol is produced using waste wheat starch and a 'high' estimate assuming that wheat ethanol uses 50 per cent waste and 50 per cent non-waste wheat feedstock. Applying the 'low' and 'high' range using the CSIRO, BTRE and ABARE (2003) estimates indicates a range for abatement of 39-53 per cent relative to conventional petrol. Thus, the GHD estimate sits within this range.

Further, the CSIRO, BTRE and ABARE (2003) note that wheat starch 'waste' can be used for other purposes, such as cattle feed. In this context, wheat starch 'waste' would be considered a byproduct rather than a waste product and it would be appropriate to attribute some emissions to the production of wheat starch 'waste'.[2] This would mean that the estimated emissions for ethanol from wheat starch would sit somewhere between the estimate of wheat ethanol using 100 per cent wheat starch waste and the estimate for wheat ethanol using non-waste wheat, depending on the assumptions made about the proportion of agricultural emissions to be incorporated.

The Commission does not have adequate data on the use of wheat starch classified as waste to enable a firm conclusion on this point. Nor does it have the expertise in life-cycle analysis to apportion upstream emissions across end products appropriately. Consequently, the revised estimates are likely to overstate the amount of abatement achieved and underestimate the implicit abatement subsidy. Nevertheless, it is clear that while assumptions regarding the alternative uses of

2 The emissions attributable to the production of wheat starch 'waste' in this context would depend on the approach to life-cycle assessment used. Under an 'allocation approach', the emissions from the production of wheat and wheat starch 'waste' would be shared based on the economic value of each product. Alternatively, under a 'system boundary expansion' approach, if the wheat starch 'waste' would have been used as cattle feed if not for its use as an ethanol feedstock, the emissions associated with producing the substitute form of cattle feed would be attributed to the wheat starch 'waste'.

wheat starch could alter the estimated amount of abatement from the Ethanol Production Grants program, this would not change the broad conclusions.

Molasses ethanol

In its original analysis, the Commission assumed that 14 per cent of Australia's ethanol is produced using molasses as a feedstock. However, it has now come to the Commission's attention that in the production process for molasses ethanol emissions can be reduced by using bagasse for cogenerating heat and power. This involves utilising bagasse, a byproduct of sugar production, to create energy that can be used in the production process.

The Commission does not have accurate information about the proportion of molasses ethanol generation using bagasse cogeneration in Australia over the study period. As such, sensitivity analysis is provided in the following section with a 'low' estimate assuming 100 per cent of molasses ethanol also involves bagasse cogeneration and a 'high' estimate assuming no bagasse cogeneration.

A revised range

The original analysis only provided point estimates for abatement and the implicit abatement subsidy for the Ethanol Production Grants program. However, due to new information regarding feedstock use for Australian ethanol, the revised abatement estimates are provided as a range. Tables 2.2 and 2.3 provide detail on what the Commission considers to be the most likely range for the 2009-10 financial year, with revised 'low' and 'high' estimates and also the original estimate for comparison.

The revised estimates indicate that abatement from the Ethanol Production Grants program was between 0.2–0.3 Mt CO_2-e over the 2009-10 financial year and that the implicit abatement subsidy was \$394–511/t CO_2-e (2010 dollars). The original reported estimate is outside of this range and thus overstates the implicit abatement subsidy. However, once corrected, the original result sits within the revised range (\$416/t CO_2-e).

Table 2.2 **Assumptions for revised analysis**[a]

Feedstock	*Original*	*Revised 'high' scenario*	*Revised 'low' scenario*
Wheat	100% wheat starch waste (no upstream emissions incorporated)	50% wheat starch waste & 50% non-waste wheat (upstream emissions only incorporated for the 50% non-waste wheat component)	100% waste wheat starch (no upstream emissions incorporated)
Molasses	0% bagasse cogeneration	0% bagasse cogeneration	100% bagasse cogeneration
Sorghum	Non-waste sorghum	As original	As original

[a] The shares of wheat, molasses and sorghum in the total volume of ethanol produced in Australia do not change across these scenarios.

Table 2.3 **Implicit abatement subsidy, Ethanol Production Grants program**

Australia, July 2009 – June 2010

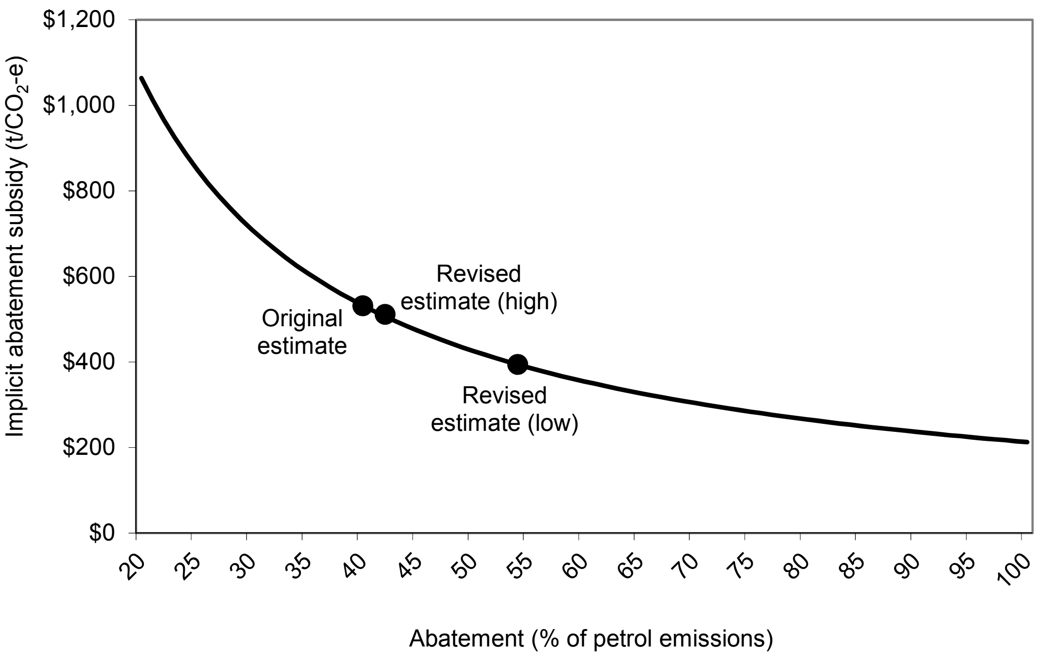
	Units	*Value (original reported)*	*Value (revised 'high' estimate)*	*Value (revised 'low' estimate)*
Subsidy equivalent	\$m (2009-10)	105	105	105
	\$m (2010)	108	108	108
Abatement	Mt CO_2-e	0.2	0.2	0.3
Implicit abatement subsidy	**\$/t CO_2-e (2009-10)**	**516**	**496**	**382**
	\$/t CO_2-e (2010)	**532**	**511**	**394**

Source: Productivity Commission estimates.

Figure 2.2 shows the 'low' and 'high' points of the revised range graphically and also depicts how the implicit abatement subsidy varies with different abatement estimates (as a percentage of petrol emissions). That is, each point of the curve shows what the implicit abatement subsidy would be for the Ethanol Production Grants program, depending on the level of estimated abatement (while holding the subsidy equivalent constant). Abatement is depicted over a range of 20 per cent (that is, the Ethanol Production Grants program is assumed to reduce emissions from conventional petrol use by 20 per cent) to 100 per cent (the 'zero emissions' scenario discussed previously).

Accordingly, the revised high and low estimates and the Commission's original estimate all appear on the curve, as they differ only in terms of estimated abatement. These are shown at the 42 per cent (low) and 54 per cent (high) abatement points. This indicates that even where the Ethanol Production Grants program reduces emissions from conventional petrol by up to 54 per cent, the average cost of abatement is \$394/t CO_2-e (2010 dollars). As noted earlier, the range is likely to be an underestimate where wheat starch waste has alternative uses (and as a result some upstream emissions from the wheat starch 'waste' ethanol should be incorporated). Thus even when generous assumptions are made about the future abatement potential of ethanol, the implicit abatement subsidy under the Ethanol Production Grants program remains well above \$200/t CO_2-e.

Figure 2.2 **Ethanol Production Grants program — original and revised estimates of the implicit abatement subsidy**



Data source: Productivity Commission estimates.

Annex

The emissions intensity of ethanol produced from different feedstocks was estimated by the Commission based on figures provided by CSIRO, BTRE and ABARE (2003). The Commission required a figure for the emissions intensity of a litre of ethanol to calculate appropriately the implicit abatement subsidy for the Ethanol Production Grants program. The 2003 study, however, calculated the emissions intensity of E10 per kilometre travelled (rather than pure ethanol per litre). Consequently, it was necessary to use the 2003 study figure to impute the emissions intensity of ethanol per litre.[3] Table 2.4 shows the emissions data from the 2003 study and the emissions intensity estimates calculated for each feedstock.

Table 2.4 **Emissions intensity data**

Feedstock	*Upstream emissions (ethanol component of E10 blend)*	*Emissions intensity*	
	g CO_2-e/km	g CO_2-e/MJ	g CO_2-e/L (petrol equivalent)
Molasses	13.71	37.3	1 276
Molasses (using bagasse co-generation)	7.72	21.0	718
Non-waste wheat	21.81	59.3	2 028
Waste wheat starch	13.64	37.1	1 269
Sorghum	16.56	45.0	1 539

Sources: CSIRO, BTRE and ABARE (2003); Productivity Commission estimates.

Box 2.2 details the components of the equation required to convert from one figure to the other. In making the conversion between the figures, two important assumptions were made.

1. As the data from the 2003 report are based on E10, the emissions intensity estimates implicitly assume that all ethanol consumed as road transport fuel in Australia is used in an E10 blend.

3 However, while this was considered the only practical approach to deriving emissions estimates, it should be noted that this may not account for some variation in emissions as a result of the way in which the ethanol is combined with other fuels, technologies and blends.

2. The emissions intensity of ethanol can be calculated using the ethanol component of upstream emissions from E10 alone.

Box 2.2 **Emissions intensity equation**

$$E_i = \frac{U_i}{\alpha} \times \frac{\beta}{\delta} \times \gamma$$

E_i = emissions intensity of ethanol (g CO2-e/L) produced using feedstock *i*

U_i = upstream emissions (g CO2-e/km) attributable to the ethanol component of an E10 blend produced using feedstock *i* (table 2.4)

$\alpha = 0.01386$ = ethanol component (kg/km) in an E10 blend for a standardised passenger car (CSIRO, BTRE and ABARE 2003)

$\beta = 0.7915$ = density of ethanol (kg/L) (CSIRO, pers. comms., 18 July 2011)

$\delta = 21$ = energy content of ethanol (MJ/L) (CSIRO, BTRE and ABARE 2003)

$\gamma = 34.2$ = energy content of unleaded petrol (MJ/L) (ABARES 2011)

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