OVERVIEW

Key points

- More than 1000 carbon policy measures were identified in the nine countries studied, ranging from (limited) emissions trading schemes to policies that support particular types of abatement technology.
  - As policies have been particularly targeted at electricity generation and road transport emissions, the Commission analysed major measures in these sectors.
- While these disparate measures cannot be expressed as an equivalent single price on greenhouse gas *emissions*, all policies impose costs that someone must pay. The Commission has interpreted 'effective' carbon prices broadly to mean the cost of reducing greenhouse gas emissions — the 'price' of *abatement* achieved by particular policies.
- The Commission's estimates essentially provide a snapshot of the current cost and cost effectiveness of major carbon policies.
  - The subsidy equivalent, abatement achieved and implicit abatement subsidy have been calculated for policies and aggregated by sector in each country.
- As a proportion of GDP, Germany was found to have allocated more resources than other countries to abatement policies in the electricity generation sector, followed by the UK, with Australia, China and the US mid-range.
- Estimates of abatement relative to counterfactual emissions in the electricity generation sector followed a similar ordering, with Germany significantly ahead, followed by the UK, then Australia, the US and China.
- The estimated cost per unit of abatement achieved varied widely, both across programs within each country and in aggregate across countries.
  - Emissions trading schemes were found to be relatively cost effective, while policies encouraging small-scale renewable generation and biofuels have generated little abatement for substantially higher cost.
- The relative cost effectiveness of price-based approaches is illustrated for Australia by stylised modelling that suggests that the abatement from existing policies for electricity could have been achieved at a fraction of the cost.
  - However, the estimates cannot be used to determine the appropriate starting price of a broadly-based carbon pricing scheme.
- The estimated price effects of supply-side policies have generally been modest, other than for electricity in Germany and the UK.
  - Such price uplifts are of some relevance to assessing carbon leakage and competitiveness impacts, but are very preliminary and substantially more information would be required.

Overview

The Australian Government asked the Productivity Commission to undertake a research study into effective carbon prices that result from emissions-reduction policies in Australia and other key economies (box 1). It is one of a suite of studies that the Australian Government has commissioned to help it, and a Multi Party Climate Change Committee it has formed, consider various issues concerning the introduction of a carbon price in Australia.

By providing information about the extent of climate action in key economies and sectors, it was anticipated that this study would shed some light on Australia's mitigation effort relative to other selected countries. In addition, by estimating impacts of mitigation policies on particular sectors such as electricity generation, it could assist in assessing potential impacts of Australia's policy actions on the international competitiveness of domestic emission-intensive trade-exposed industries.

In addition to Australia, the countries covered by this study are: China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom and the United States. These countries are taking action to address climate change in various ways. Some have introduced emissions trading schemes (ETSs), and all have in place a range of more limited, less direct measures, such as mandatory renewable energy targets, feed-in tariffs, energy-efficiency measures and capital subsidies for constructing or installing sources of renewable energy.

All of these measures either encourage abatement or discourage emissions of greenhouse gases. They essentially alter relative prices to favour production and consumption of low-emissions products over high-emissions ones. While this might suggest that they can be expressed in terms of either explicit or implicit carbon prices, there is no carbon price equivalent that can capture the nature, amount and costs of abatement, nor the product price impacts, resulting from schemes that promote particular forms of abatement.

What all schemes do have in common is that they involve a cost (which someone must pay). These costs can be expressed in subsidy equivalent or resource cost terms, and can loosely be thought of as the 'price' of *abatement* achieved by particular policies. They have accordingly been the focus of the Commission's analysis.

Box 1 What the Commission has been asked to do

The terms of reference require the Commission to:

- examine and detail key emissions-reduction policies either in place or 'committed' in Australia and other key economies
- estimate the 'effective carbon price' per tonne of carbon dioxide equivalent (carbon) emissions faced by the electricity generation sectors in these economies, and selected industries drawn from manufacturing and transport sectors in these and other countries, where relevant and data permitting
- report on the methodology, assumptions and data sources used, so as to inform further analysis in this area.

What are the study countries doing?

The first part of the task was to compile a comprehensive list of measures adopted or proposed in each country. These country 'stocktakes' were not confined to policies in particular sectors, although in practice the bulk of them target emissions from the electricity generation and transport sectors.

Applying a broad interpretation of emissions-reduction policies (table 1), the Commission identified over 1000 measures in total, with more than 300 in the United States (federal and state), around 230 in Australia and 100 in the United Kingdom. While sheer numbers of policies say nothing in themselves about the materiality or effectiveness of the aggregate response made by governments, they indicate how complex the policy environment can be and, particularly in federal systems, the potential for overlapping policies with high administration and compliance costs.

While most policies focus to varying degrees on emissions from electricity generation and transport sectors, other sectors are commonly targeted as well. For example, most countries were found to have policies encouraging reafforestation or curbing deforestation.

Table 1 **A taxonomy of existing emissions-reduction policies**

Explicit carbon prices	***Regulatory instruments***
Emissions trading scheme — cap-and-trade	Renewable energy target
Emissions trading scheme — baseline and credit	Renewable energy certificate scheme
	Electricity supply or pricing regulation
Emissions trading scheme — voluntary	Technology standard
Carbon tax	Fuel content mandate
Subsidies and (other) taxes	Energy efficiency regulation
Capital subsidy	Mandatory assessment, audit or investment
Feed-in tariff	Synthetic greenhouse gas regulation
Tax rebate or credit	Urban or transport planning regulation
Tax exemption	Other regulation
Preferential, low-interest or guaranteed loan	***Support for research and development (R&D)***
Other subsidy or grant	R&D — general and demonstration
Fuel or resource tax	R&D — deployment and diffusion
Other tax	***Other***
Direct government expenditure	Information provision or benchmarking
Government procurement — general	Labelling scheme
Government procurement — carbon offsets	Advertising or educational scheme
Government investment — infrastructure	Broad target or intergovernmental framework
Government investment — environment	Voluntary agreement

Several countries have introduced or have committed to emissions trading schemes

Among the study countries, the United Kingdom and Germany are part of the European Union's cap-and-trade ETS — which commenced in 2005 — and New Zealand introduced its own scheme in 2008.

- The EU scheme covers power stations, combustion plants, oil refineries and iron and steel works (but not road transport fuels). It will extend to the aviation sector in 2012 and petrochemicals, ammonia and aluminium in 2013. In May 2011, the spot price for permits was around €16–17 (A$22–23).
- The NZ scheme covers electricity generation, industry, liquid fossil fuels and forestry, and is expected to expand coverage to agriculture by 2015. Currently, emissions are uncapped.

Japan and South Korea have announced that they will introduce ETSs (although in both cases implementation has been delayed). China is considering trialling a pilot ETS in some provinces as part of its 12th Five Year Plan. The Australian Government has recently announced its intention to introduce an ETS that will commence with fixed price permits moving to a floating price in three to five years.

There are also sub-national ETSs in place or proposed. The Regional Greenhouse Gas Initiative covers electricity in 10 states in the north east of the United States (but the cap is not currently binding). The Western Climate Initiative was intended to cover seven US states and four Canadian provinces. It aims to reduce emissions to 15 per cent below 2005 levels by 2020. But, it appears that only California among the US states is committed to implementing an emissions trading scheme by 2012. Another example is the New South Wales Greenhouse Gas Reduction Scheme, which is a baseline and credit scheme applying to its electricity sector.

There is a myriad of policy measures in the electricity generation sector

The most widely applied emissions-reduction policies are mandatory renewable energy targets (most with tradeable permits), feed-in tariffs, and capital subsidies (often in conjunction with feed-in tariffs).

- Mandatory renewable energy targets apply at the national level in Australia, Germany and the United Kingdom (under an EU mandate), Japan, and South Korea (committed for 2012). China has an ‘aspirational’ target only. Although the United States does not have a national level mandatory renewable energy target, over 41 states have renewable targets of one form or another, most mandatory.
- Feed-in tariffs apply at a national level in Japan, the United Kingdom, South Korea and Germany, and at a state level in Australia. China and India operate national and state/province-based schemes. Feed-in tariffs also exist in some US states, where they operate mainly as commercial arrangements between utilities and small-scale generators that the utilities use to meet their renewable energy targets. New Zealand does not currently use feed-in tariffs.
- Capital subsidies are common and provided for widely varying purposes, from assisting in the provision of large-scale generation capacity, to helping individual households and small businesses install small-scale generation.

Other policies being used to a lesser extent included fossil fuel taxes (Japan and India), differentiated electricity taxes (United Kingdom), and preferential loans for investment in renewable generation.

Fuel policies are widely used to reduce road transport emissions

Countries seek to reduce emissions in the road transport sector primarily through fuel taxes, production subsidies for biofuels, vehicle fuel efficiency standards and/or labelling, fuel mandates, and differentiated vehicle taxes and subsidies.

Study countries also employ a range of other transport policies (such as urban planning and transport infrastructure funding) that may less directly effect emissions reductions. For example, transport infrastructure policies, such as those that encourage modal shifts in activity from road to rail, are sometimes publicly justified in part by their potential for reducing emissions. Similarly, road congestion pricing, which is largely an instrument for containing traffic flow and reducing travel times, might also yield local environmental benefits as well as possible reductions in carbon emissions.

The Commission’s analytical approach

The threshold conceptual task for this study has been to develop a consistent measurement approach for comparing many different policy interventions — in essence, finding a way of comparing apples and oranges. Understanding how the various policies work was the essential first step.

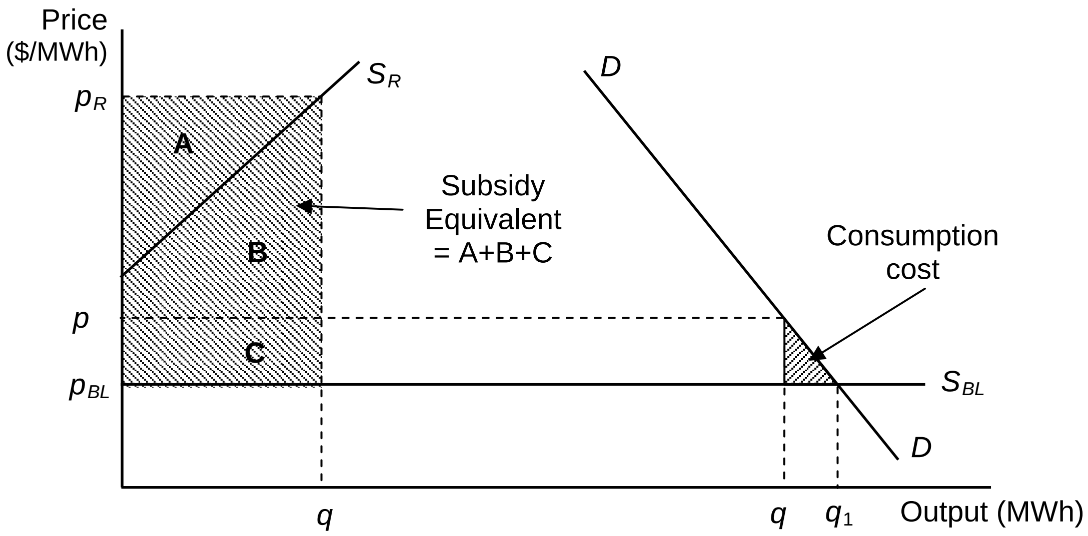
Despite the variety of specific policy instruments, all emissions-reduction policies can be classified as those that either:

- penalise consumption of high-emissions products
- encourage production of low-emissions ones (box 2 shows diagrammatically how such schemes work).

But whichever side of the market particular policies target, they will have implications for the other side. Policies that effectively tax one commodity implicitly subsidise others. And effective subsidisation of a commodity implicitly taxes others.

A carbon pricing mechanism, for example, raises the price of products generating carbon emissions (thus reducing demand for those products) while, at the same time, effectively subsidising production of low-emissions substitutes, by increasing the price that can be charged in the market. A carbon pricing mechanism will therefore give rise to a wide range of responses generating abatement, based on consumer and producer assessments of the relative costs and benefits to them. It is this market-based objective assessment of the costs and benefits of abatement options that underpins why direct pricing mechanisms generally will deliver any given amount of abatement at least cost.

Box 2 **How subsidies and renewable energy targets work**



This figure is a stylised representation of an electricity generation market, with emissions-intensive, baseload electricity being provided at a constant unit cost equal to price p_{BL}, pre-intervention. Total consumption is q_1. Introducing a mandatory renewable energy target will induce abatement on the supply and demand sides, but at a cost.

On the supply side it is assumed above that the mandatory renewable energy target will induce supply from a mix of generators using zero-emissions technologies including, for example, wind and solar. As some of these facilities will be more costly than others, the supply curve is shown as the upward sloping line S_R. If the renewables target is set at quantity q_R, the price required by marginal generators will be p_R.

- The implicit subsidy paid per megawatt hour (MWh) to renewables producers is $p_R - p_{BL}$, and the subsidy equivalent is equal to the shaded area A+B+C. Abatement would be equal to the difference in emissions intensities of the baseload generator and the renewables generators (the latter being zero in this case), multiplied by the amount of renewable electricity q_R.
- Part of the subsidy equivalent, area A, is ‘producer surplus’ to renewables generators — the size of this depends on the excess of the price received over their costs of production. The remainder (areas B+C), is the additional *resource cost* of supplying q_R (that is, additional to the cost of the baseload generation being replaced).

On the demand side there will also be some abatement and cost to consumers, if the cost to electricity retailers (which is equal to the subsidy equivalent) is passed through in prices. As depicted, the electricity price rises from p_{BL} to p inducing a reduction in consumption of (fossil fuel sourced) electricity equal to $q_1 - q$, and some additional abatement. It also means that there is a cost equal to the shaded triangle labelled *consumption cost*. This measures the *net* consumer valuation of the forgone consumption.

Many other emissions-reduction policies instead directly support use of low or zero-emissions technologies or production of 'cleaner' products. Sometimes this is done through explicit budgetary subsidies. More common mechanisms are mandated targets or regulation. In these cases, the transfers to producers of certain products or technologies are less transparent. Whether the subsidies are explicit or implicit, the effect in terms of increasing payments to induce additional production from targeted producers is the same (the subsidy equivalent is illustrated by the shaded rectangle in box 2).

Where schemes differ is in relation to who ends up paying for them — taxpayers who pay for explicit budget subsidies, or households and firms who pay the increased product costs due to regulations and mandates. Where users pay, the policies will also generate some 'demand-side' abatement and impose a consumption cost.

A carbon price cannot mimic all the effects of a subsidy scheme

While both carbon pricing mechanisms and more targeted abatement policies work by changing relative prices, they change *different* relative prices. Finding a price-based metric for comparing diverse emissions-reduction policies across countries is elusive. While all such policies can in principle be captured in terms of a subsidy that would have equivalent effects, they cannot be similarly summarised as a price or tax rate. In other words, there can be no carbon tax that could achieve the same abatement, with the same cost and consumer price effects, as measures that do not directly price or tax carbon.

That a carbon price cannot mimic a policy that just subsidises a particular form of abatement is shown in the four examples relating to renewable energy policies set out in box 3. In effect, there are several different carbon price 'equivalents', with each replicating a different aspect of a subsidy scheme. These measures yield useful insights (particularly the carbon price that will deliver the same abatement at lowest cost). But they are also sometimes represented as comparable effective carbon prices, which they are not.

Box 3 **The elusive 'implicit' carbon price**

There are a number of different carbon prices that could capture a particular aspect of the impacts of a subsidy scheme, but none can replicate all aspects.

- First, there will be a carbon price/tax (equal to the subsidy rate) that could induce the same amount of renewable energy as a renewables subsidy, but it would likely generate greater abatement overall.
- Second, there will be a carbon price/tax that would generate the same resource costs as the subsidy scheme, but this would generate a different type and level of abatement (depending on the coverage of the carbon price mechanism).
- Third, there will be a carbon price/tax that would deliver the same total amount of abatement as the renewables subsidy, but from the lowest-cost sources.
- Fourth, there will be a carbon price/tax that would deliver the same *average* increase in electricity prices as a renewables subsidy (assuming that the subsidy is paid for by electricity consumers rather than by taxpayers). But this carbon price would be too low to support the renewable production brought forth by the subsidy.

What the Commission has estimated

While there is no one carbon price 'equivalent' that would comprehensively capture what the set of policies in the study countries are actually achieving, or at what cost, all policies (carbon pricing mechanisms and explicit or implicit subsidy schemes) impose costs that ultimately someone must pay. These costs of abatement can be compared. Accordingly, the Commission has measured:

- what each country is effectively spending on abatement programs; that is, the subsidy 'equivalent' of policies. These subsidy equivalents also provide an (upper) indication of the resource costs of the policy (which are much harder to estimate directly)
- the amount of abatement being achieved
- the average implicit abatement subsidy (that is, the subsidy per unit of abatement).

The Commission has also measured the costs of any abatement from higher consumer prices resulting from the suite of policies analysed in each country.

Which policies?

The Commission analysed policies applying to road transport in addition to electricity generation. Like electricity generation, road transport is an important upstream input for most if not all industries and it has direct impacts on consumers. It also attracts a number of specific emissions-reduction policy measures.

Emissions associated with electricity generation and transport account for around half of Australia's emissions. While manufacturing industries were not specifically covered, they are substantial users of emissions-intensive products — particularly electricity but also road transport. Hence, the study effectively covers a significant proportion of abatement policies relevant to manufacturing. This is particularly so for emissions-intensive trade-exposed industries that have a high reliance on electricity, such as aluminium production. Moreover, there appear to be relatively few emissions-reduction policies specific to manufacturing industries in the countries studied.

Policy choice was also influenced by the requirement to examine 'committed' policies, interpreted as those having tangible evidence of being implemented — for example, in the process of being enacted. In practice, it proved difficult to quantify many committed policies because of a lack of detail about their eventual operation and coverage.

Policy measures were screened against several criteria, including that they penalise emissions or give an incentive to abatement, and that they do so in a reasonably direct way. A materiality test was also imposed, though as information began to accumulate some policies initially considered material turned out to be otherwise, and vice versa.

While policies that had the *effect*, if not the explicit intent, of reducing emissions were not necessarily excluded, for inclusion, policies needed to impose additional costs. This effectively excluded 'no regrets' measures; that is, policies that would have been undertaken regardless of their impact on greenhouse gas emissions to achieve domestic objectives (such as revenue raising or reducing local pollution). In such cases, the marginal costs of any associated 'by-product' abatement can be negligible. Inevitably though, some policies fell into a grey area, such as China's 'Large Substitute for Small' (LSS) generator modernisation program, which is discussed further below. For policies with multiple objectives, in most cases it was not possible to decompose abatement estimates (or for that matter costs), and sensitivity analysis has been used to capture the range of possible outcomes.

Based on these criteria, policies such as explicit carbon prices, taxes on fossil fuels and electricity production or consumption, feed-in tariffs for renewable energy production and renewable energy mandates (with or without certificates/credits), capital subsidies for investment in renewables, and biofuel content standards for transport fuels were generally included. Although the selected policies typically represent only a small proportion of the total policies that exist in each country, the Commission is reasonably confident that it has captured those that have induced the bulk of each country's abatement in these sectors.

That said, some significant classes of policy, including energy efficiency programs, research and development support, and transport infrastructure expenditures, were excluded, for largely pragmatic measurement reasons outlined in box 4.

Box 4 **Why were some key policies excluded?**

Research and development policies were excluded because it was considered that the connection between the policy and the eventual emissions reduction that might be achieved (and cost incurred for that matter) was prospective and therefore too uncertain. Given the Government's apparent interest in assessing comparable effort, the Commission has primarily focused on what policies are in place and having effect already.

Energy and fuel efficiency policies are widely employed by most study countries, and generally regarded at least in part as emissions-reduction measures. But measuring their impacts is complex and uncertain. Some claim that these policies are privately cost effective (that is, they make consumers better off) and thus lead to abatement at a negative cost (benefit). Others claim it is more likely that such policies override consumer preferences leaving them worse off. Depending on the assumptions made, the costs of such policies could therefore be negative or positive. Measuring abatement of such policies is also fraught. Net abatement will depend not only on the efficiency of appliances and vehicles but also on their use. For instance, studies suggest that when people upgrade to more energy-efficient appliances and vehicles they tend to use them more — a so called 'rebound effect'.

Equally problematic are policies such as public transport and rail freight *infrastructure expenditure*, which also can have extremely complex links to emissions reductions. Net emissions impacts will depend on the degree of modal switching, the effect on total trips and the relative emissions intensity of different transport modes.

Measuring abatement induced by the policy measures

In seeking to measure the abatement achieved under the various policies, it is necessary to know the counterfactual — that is, all else given, what would the level of emissions have been *without* the policy?

In the case of electricity generation, for example, the 'marginal generator' can vary depending on market circumstances, and this can have a substantial impact on the amount of abatement that can be attributed to an abatement policy. For example, if subsidised renewable electricity sourced from wind or solar displaces gas-fired electricity, the abatement achieved will be far less than if coal-fired electricity generation were displaced. Operators will naturally choose to displace higher-cost energy sources before cheaper ones (such as coal) irrespective of the relative emissions intensity of the sources.

Apportioning abatement to particular policies or programs proved difficult where there was overlap between them. For example, in the United States, large-scale renewables are eligible for substantial Federal Government subsidies, but most states also have mandatory renewable energy targets, meaning that the same project can benefit from both programs. Care has been taken to ensure that any induced abatement is only counted once, irrespective of how many policy measures the one project may be eligible for.

Adding it all up

As far as possible, for each policy measure, a subsidy equivalent (as a proxy measure of total costs) and an implicit abatement subsidy per tonne of carbon abated (as a proxy for average costs), are reported. However, as noted, in some cases it has not been possible to isolate the abatement effects of particular measures.

The Commission also aggregated the subsidy equivalent measures to produce an estimate of the total and average abatement subsidy for the electricity generation and biofuel sectors in each country.

These measures facilitate comparison not only of the costs associated with each country's policy mix, but also of the *cost effectiveness* of different measures within and across countries in each sector. They are useful indicators of the extent to which different governments are prepared to devote community resources to encouraging abatement — either directly through explicit financial subsidies paid by taxpayers, or indirectly through higher prices paid by consumers.

The Commission has also provided rough estimates of the increases in product prices potentially attributable to the various supply and demand-side interventions in each sector for each country. Where supply-side measures are directly paid for by consumers, the subsidy equivalents for all measures were added together before estimating the increase in product price. In the United Kingdom, Germany and New Zealand this total includes the revenue raised from the electricity sector through the respective ETS schemes operating in those countries. The impact on the prices of electricity and transport fuels is of policy interest in itself, given the link to competitiveness of end users.

Key results

The following sections present the estimates for electricity generation and road transport (biofuels and fuel taxes) from the supply-side and demand-side perspectives. For the supply-side analyses, it should be kept in mind that the subsidy equivalent figures will tend to overestimate resource costs — potentially by a factor as high as two — but on the reasonable presumption that that they do so consistently for all countries and all low-emissions technologies, the *comparative* picture is not affected. (It should be noted that the Indian Government ultimately chose not to participate in this study, so that no estimates could be made for that country.)

Most estimates are based on 2010 data, but in some cases 2009 or 2008 data were the latest available. In essence, the estimates provide a recent ‘snapshot’ of the impacts of policies in that year (that is, relative to the counterfactual of not having the policy). As this policy space is highly dynamic, a different picture could emerge in a relatively short period. For example, many policies seek to influence investments, with ramifications for abatement in years to come.

Electricity generation

Supply-side measures

The key estimates for the electricity generation sector are summarised in table 2.

Table 2 **International comparisons, electricity generation sector**

Results in A$ 2010

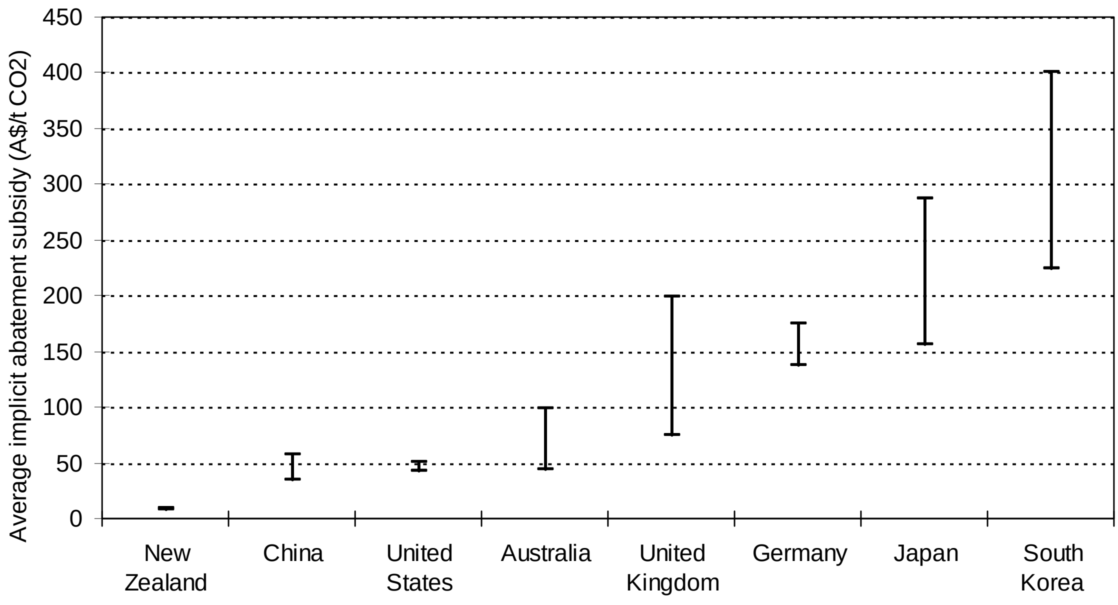
Country	*Total subsidy equivalent*	*Total subsidy equivalent as a percentage of GDP*	*Total abatement*	*Abatement as a percentage of counterfactual electricity sector emissions*	*Total electricity sector emissions*	*Average Implicit abatement subsidy*	*Electricity price uplift*
	A$m	%	Mt CO_2	%	Mt CO_2	A$/t CO_2	%
Australia	473–694	0.04–0.05	7.0–10.7	3.5–5.2	196	44–99	1–2
China	1 835–2 309	0.03–0.04	40.7–52.1	1.2–1.5	3 370	35–57	1
China including abatement from LSS	1 835–2 309	0.03–0.04	159.2–225.6	4.5–6.3	3 370	8–15	..
US	2 886–3 339	0.02–0.02	66.5–66.7	2.8–2.9	2 270	43–50	–
UK	2 042–2 433	0.08–0.10	12.3–27.4	7.5–15.4	151	75–198	17
EU ETS coal/gas switch	115–403	0.00–0.02	4.0–14.1	2.6–8.5	151	29	..
UK excluding all ETS effects	1 648–1 752	0.07–0.07	8.2–13.3	5.2–8.1	151	124–213	..
Germany	10 019–11 769	0.28–0.33	67.1–73.1	18.3–19.6	299	137–175	12–14
EU ETS coal/gas switch	15–80	0.00	0.7–3.9	0.2–1.3	299	20	..
Germany excluding all ETS effects	9 868–11 553	0.28–0.32	66.4–69.1	18.2–18.8	299	143–174	..
Japan	669–940	0.01–0.02	3.3–4.3	0.8–1.1	396	156–287	1
South Korea	313–379	0.03–0.03	0.9–1.4	0.5–0.7	191	225–401	–
New Zealand	..	..	..	..	..	8–10	1–2

While there will likely be a focus on the implicit abatement subsidy estimates, these are not carbon price equivalents of the policies in place (and, for the reasons outlined earlier, nor can they be converted into price equivalents). Furthermore, a high or low implicit abatement subsidy in isolation cannot be interpreted as good or bad — it must be considered in conjunction with both the amount of abatement achieved and the cost of achieving it.

- Australia’s electricity generation sector’s average implicit abatement subsidy was comparable to estimates for China (excluding China’s ‘Large Substitute for Small’ program) and the United States (using the lower bound estimates the numbers are A$44, A$35 and A$43/t CO_2 respectively) (figure 1)
- Australia’s abatement as a proportion of total electricity sector emissions (presumed to occur in the absence of these measures) was estimated to be higher than for China (depending on policy coverage), Japan and South Korea, broadly comparable with the United States, and lower than the United Kingdom and Germany.

Figure 1 **Implicit abatement subsidies vary widely for electricity generation**

2009, 2010



- Although the United Kingdom and Germany achieved more abatement than Australia (in absolute terms and relative to electricity sector emissions), they did so at a substantially higher cost, both absolutely and relatively. For example, using the lower bound estimates, Germany achieved around 67 Mt of abatement, with a total subsidy equivalent of approximately A$10 billion and an implicit abatement subsidy of A$137/t CO_2. The comparable figures for Australia are 7 Mt of abatement, a total subsidy equivalent of A$473 million and an implicit abatement subsidy of A$44/t CO_2.
- That high implicit abatement subsidies are not necessarily a guide to effectiveness is clearly illustrated by South Korea and Japan. These countries have the highest unit subsidies, but their abatement has been very modest — as a proportion of electricity sector emissions, the lowest of the study countries.
- The results for the United States are probably underestimated. They are based predominantly on two key federal programs (Renewable Electricity Production Tax Credits and the Treasury Grants) and state renewable energy mandates. There are many other programs in operation (particularly in individual states), and it was not possible to quantify the impact of all of them in the time available. The United States has also announced an intention to regulate major emissions sources directly under standards to be introduced under the Clean Air Act (US), but the timing and effect is uncertain.
- The co-existence of the European Union's ETS with other national measures appears to have had quite different effects on the results for the United Kingdom and Germany.
  - In the United Kingdom, the ETS appears to have led to some switching from high-emissions coal to lower-emissions gas-fired electricity. This yielded substantial abatement. If the effects of the European Union ETS are removed from the United Kingdom estimate, aggregate abatement falls by as much as a half, and the total subsidy equivalent by around 20 per cent. The net effect is to increase significantly the implicit abatement subsidy estimate for the remaining policies.
  - If the effects of the European Union ETS are excluded from Germany's results, both the aggregate abatement and the total subsidy equivalent fall slightly. The net effect on the average implicit abatement subsidy is also negligible. The reason is that Germany has had limited surplus gas-fired generation capacity, and hence relatively little fuel switching. By contrast, renewables constitute a relatively large share of Germany's electricity generation sector, and receive generous subsidies. In aggregate, the effects of the ETS are swamped by the very high subsidies to renewables. Hence, in

contrast to the United Kingdom, excluding the ETS from Germany's results has little effect on the estimates.

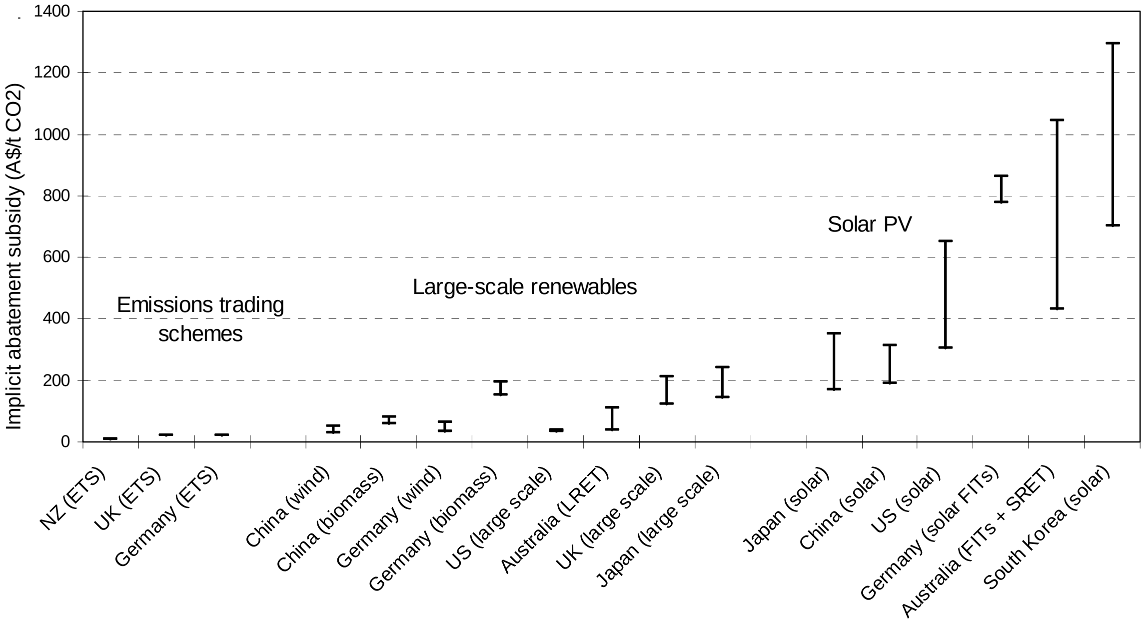
- The results for China depend very much on whether its 'Large Substitute for Small' program of modernising its electricity generation plants is included in the analysis. If it is, the implicit abatement subsidy under the low scenarios falls from A$35/t CO_2 to A$8/t CO_2. Under reasonable assumptions, the replacement of old inefficient generators with new, larger and much more efficient generators seems to be cost effective in its own right. This means that the cost impacts are negligible or negative if the 'Large Substitute for Small' is classified as an emissions-reduction policy (a 'no regrets' measure). In other words, including this policy adds considerable abatement at no cost. But this could be regarded as an incidental outcome of a policy that is seemingly justifiable on the grounds of reducing generation costs (and most probably also promoting local environmental objectives). In a more market-based economy, such cost-reducing generation replacement would be expected to occur automatically and thus would not have been considered an emissions-reduction policy.

Overall, key insights to emerge are that the European Union ETS has driven relatively low-cost abatement, where it has induced switching from coal to gas-fired electricity generation. Policies supporting renewable energy sources are more expensive, reflecting the higher costs of large-scale renewables production and particularly small-scale solar technology, which was found to be very expensive in all countries examined (figure 2).

Demand-side analysis

Measuring consumption costs requires knowledge of how demand responds to changes in price, and how much of the subsidy is actually passed through in product prices. There is little empirical information as to how these factors will vary from one country to another. In some countries, notably China, retail price regulation limits the ability of electricity suppliers to pass on costs, so the consumption effects may be negligible, at least in the shorter term. The Commission has accordingly had to make some simplifying assumptions about demand responsiveness and cost pass-through to provide indicative results in this area. Two alternative elasticities were used to estimate the range within which demand responses seem most likely to occur, based on empirical evidence of the responsiveness of demand to price changes.

Figure 2 **Implicit abatement subsidies by technology and country**
Electricity generation, 2009, 2010



The estimated impact of emissions-reduction policies on electricity prices and thus on consumption costs varies considerably across countries. For most countries, the estimated impacts are small. This is partly because the renewable energy generation induced by the policy measures is a small proportion of total electricity generation, and/or the total subsidy equivalent estimate is not large. For example, for Australia, the impacts on electricity prices in 2010 were estimated to be of the order of one to two per cent, and the consumption cost is estimated to be in the range A$2–3/t CO_2 abated. (Recent changes to the Renewable Energy Target are expected to lead to larger increases.)

The key exceptions are Germany and the United Kingdom, where it is estimated that existing emissions-reduction policies have raised electricity prices by 12 and 17 per cent, and reduced emissions by 3 and 19 per cent, respectively. This is due partly to the direct price impact of the European Union ETS on retail prices, and partly to the large subsidy equivalents associated with other measures promoting renewable energy paid for by consumers. As a result, the estimates of consumption costs are commensurately much larger than in other countries, though still less than the implicit abatement subsidies discussed above.

A general finding from these results is that if demand is responsive to price, additional and relatively low-cost abatement can be achieved from electricity price increases. (Indeed, the incentive provided for demand-side abatement is a major reason for the relative cost effectiveness of carbon pricing mechanisms.)

Road transport

Abatement costs were estimated for biofuel policies and fuel taxes — biofuels on the supply side and fuel taxes on the demand side. Fuel taxes are levied for a variety of reasons, but because they act reasonably directly on a key source of emissions (fossil fuels used by vehicles) they can be considered a form of carbon tax. Multiple objectives are also a feature of biofuel policies in many countries. Though typically portrayed as an emissions-reduction measure, biofuel policies have also been used for industry assistance reasons and regional development reasons. (In China, for a time in the early 2000s, it was an opportune way of using stale grain stocks.)

Supply-side analysis of biofuels

Biofuels contribute to emissions reductions by replacing fossil fuels. Carbon sequestered in the biofuel is released back into the atmosphere once combusted, but there can be a net gain compared with using petrol and diesel. However, *net* emissions reductions will depend on the emissions intensity of the production processes used to grow the crop, manufacture the biofuel and deliver it to consumers, as well as the choice of feedstock, as some are much more emissions-intensive than others. This is why life-cycle analysis is needed to properly compare the net emissions from biofuels relative to the fossil fuel alternative. In some cases, the estimated gains are very small and possibly negative.

Analysing the key policies for each country indicates that Australia's implicit abatement subsidy for biofuels was similar to the United Kingdom, Germany and New Zealand but substantially less than was estimated for the United States. However, costs and abatement varied widely across these countries (table 3).

- The United Kingdom, Germany and the United States — all with fuel content mandates — had high total subsidy equivalents and abatement.
  - Germany stands out as having achieved the highest abatement relative to emissions for the road transport sector (3.6 per cent), at an implicit abatement subsidy of more than A$300/t CO_2, which nevertheless was at the lower end of the results for all countries.
  - The United States stands out for substantial abatement but at very high cost — with the implicit abatement subsidy estimated to be in the range of A$604–672/t CO_2.
- New Zealand committed a very small amount of resources to biofuels and hence was achieving very little abatement.

Table 3 **International comparisons, biofuel policies**

Results in A$(2010)

	Total subsidy equivalent			*Total abatement*			*Total abatement as a percentage of counterfactual road transport emissions*			*Implicit abatement subsidy*		
Country	*Low*	*Central*	*High*	*Low*	*Central*	*High*	*Low*	*Central*	*High*	*Low*	*Central*	*High*
	A$m	A$m	A$m	Mt CO_2-e	Mt CO_2-e	Mt CO_2-e	%	%	%	A$/t CO_2-e	A$/t CO_2-e	A$/t CO_2-e
Australia	..	144	..	..	0.4	..	..	0.6	..	..	364	..
China	1 998	1 998	1 998	..	..	..	..	..	..	..	..	..
Ethanol	..	..	..	-1.4	-0.3	0.8	-0.43	-0.09	0.24	..	-6 105	..
Biodiesel	..	..	..	..	0.2	..	..	0.05	..	..	592	..
Germany	..	1 711	..	..	5.5	..	..	3.6	..	..	310	..
Japan	57	57	57	0.092	0.090	0.087	0.044	0.043	0.042	617	634	653
New Zealand	..	3	..	..	0.008	..	..	0.06	..	..	391	..
South Korea	196	196	196	0.5	0.3	0.2	0.6	0.4	0.3	415	635	831
United Kingdom	..	680	..	..	2.0	..	..	1.7	..	..	335	..
United States	12 470	17 477	..	..	26	19	..	1.7	1.2	604	666	672

Japan and South Korea had relatively high cost biofuel schemes that achieved minimal abatement.

The results for China suggest that only under the most favourable assumptions could its biofuel policies have been achieving net abatement. Under more plausible scenarios, the net abatement was negative. This amounts to China having subsidised emissions rather than abatement. This result appears to be due to the high application of fertiliser to grow feedstock for ethanol, and the high level of energy use to convert feedstock into fuel.

In summary, while the results for biofuels vary, and are particularly sensitive to assumptions about life-cycle emissions intensities, most biofuel policies are high-cost means of achieving abatement. The cost per tonne of abatement — as measured by the implicit abatement subsidy — was typically A$300–600/t CO_2 and possibly as high as A$800/t CO_2. For most countries, this cost is substantially higher than for most supply-side measures in electricity generation (though broadly comparable with solar subsidies).

Fuel mandates and taxes

The Commission has explored the impact of a key supply-side policy measure on retail fuel prices, namely the fuel mandates operated by the United States, Germany and the United Kingdom. These tend to increase fuel prices by the requirement placed on fuel distributors to blend more costly biofuels into petrol and/or diesel. However, the Commission's results suggest that, to date, the mandates appear to have had only a modest effect on prices, with at most an impact of around 1 to 2 cents per litre on retail prices of petrol and diesel.

Treating fuel taxes as carbon taxes?

If regarded as emissions-reduction measures, the various taxes on fuel such as excise taxes (but excluding broadly-based consumption taxes) have been relatively effective at achieving abatement (table 4). Put another way, in the absence of fuel taxes, emissions from road transport would be significantly higher than they are today.

As for electricity, the Commission has had to make some simplifying assumptions about demand responsiveness. In this case, these assumptions are even more speculative, given the much larger tax-induced changes in price. But even if demand were only mildly responsive to price, it is likely that fuel taxes have led to substantial abatement relative to the counterfactual of no fuel taxes, mainly because the tax rates are substantial. For example, the 'high' estimates for Germany indicate that abatement relative to the counterfactual of no fuel taxes could have been of the order of 40 per cent. Even under the 'low' scenarios (which assume a more inelastic demand response) most countries would seem to have achieved relatively large amounts of abatement. The consumption costs per tonne of abatement are significant, but lower than the costs of many other sources of abatement. Germany's result underscores that consumption costs rise more than proportionately with the rate of tax.

However, it is arguable whether existing fuel taxes should be categorised as an emissions reductions measure. In most countries such taxes have been raised over many decades for general revenue purposes or as 'road-user charges'. Any resultant abatement could be considered incidental. There are some recent instances of increases in fuel taxes having been justified in part on emissions-reduction grounds, but so far these increments are small relative to the pre-existing tax rates, and some countries have made no such distinction.

Table 4 **Abatement and consumption costs of fuel taxes**

2010

Country	*Average fuel tax*	*Consumption cost*	*Abatement*	*Abatement as a percentage of counterfactual road transport emissions*	*Average consumption cost*
	A$/L	A$m (2010)	Mt CO_2-e	%	A$/t CO_2-e
Australia	0.36	373–1 189	6–21	8–23	57–59
China	0.14	449–1 383	20–68	6–17	20–23
Germany	0.78	3 437–11 492	29–102	17–41	113–119
Japan	0.64	2 238–7 301	21–73	9–26	100–105
New Zealand	0.43	54–174	1–3	7–19	71–73
South Korea	0.50	1 046–3 432	12–41	13–34	83–87
United Kingdom	0.96	3 323–11 125	24–85	17–42	130–139
United States	0.11	1 749–5 421	92–291	6–16	19

Some implications

The Commission's results show that the study countries are each using a wide range of policies, with varying costs and effectiveness. But what can the results tell us about directions for climate policy? In particular, what do they say about comparable effort and impacts on international competitiveness?

Comparing 'effort'

There is significant interest in assessing the relative 'effort' of different countries in mitigating climate change. But effort can be interpreted in different ways.

For some it means how much abatement is being achieved and, relatedly, how much the emissions intensity of a country's production is being reduced. But how much abatement is the right amount for each country? Imposing the same proportionate cut in emissions across all countries would take no account of the costs of those reductions. Efficient global abatement will occur where the marginal costs of abatement are equalised across all countries (at the global carbon price that achieves the desired level of global abatement). This efficient outcome would not deliver the same emissions intensities across economies — countries with high abatement costs would abate relatively less (instead 'buying' cheaper abatement from other countries).

Others measure effort by the total costs countries are prepared to incur in implementing emissions-reduction measures. But as the Commission's estimates highlight, high policy costs are often unrelated to the effectiveness of policies in delivering abatement. If effort were measured in this way, a country that adopted more inefficient abatement measures could be inappropriately given greater credit than others generating more cost-effective abatement.

The Commission's estimates of abatement and abatement costs also need to be carefully interpreted in the context of a country's 'effort'.

- The estimates provide a point-in-time, and necessarily partial, picture of the costs and abatement impacts of key policies in two important emitting sectors. In each country there will be a range of other policies, market developments and individual actions not captured in the estimates that will have an effect on total emissions, positive and negative.
- They are not compared with any desirable 'yardsticks' about what each country should be doing.

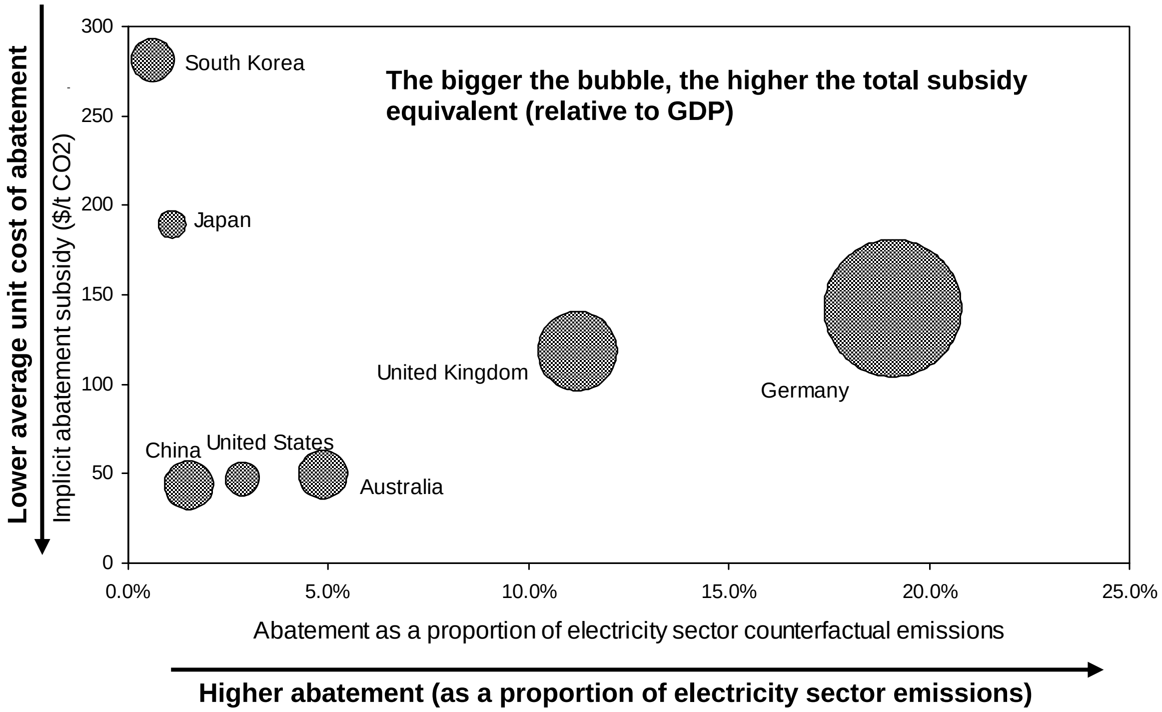
That said, presenting the aggregate estimates in combination, and scaled relative to the size of each country's economy, provides some insights as to their policy performance (figures 3 and 4).

The electricity generation sector

For example, Australia's estimated total subsidy equivalent for the electricity generation sector, expressed as a proportion of GDP (represented by the size of its 'bubble' in figure 3), was much the same as for South Korea and China. But, relative to South Korea, Australia's suite of measures appears to have been much more cost effective and to have produced more abatement. Compared with China, Australia's policies were about as cost effective, but achieved greater abatement. Proportionately, Australia achieved more abatement than the United States at about the same level of cost effectiveness, but devoted more of its GDP to achieving this outcome.

Figure 3 **'Effort' and reward — how countries compare**

Electricity generation 'central' estimates, 2009, 2010



The United Kingdom and Germany stand out as having invested substantial amounts in achieving abatement. Germany achieved substantially more abatement than the United Kingdom but at a slightly higher average cost. The extent to which that reflects inefficient policy choices or rising marginal costs of abatement is unclear.

Japan also stands out because its investment is much smaller than most other countries and equally is not achieving much abatement. And the abatement it does achieve comes at a high average cost.

Biofuels

Using the same approach for biofuels reveals that, as a proportion of GDP, Australia's commitment of resources to achieving abatement was less than for most other study countries, but policy cost effectiveness appeared comparable to Germany and the United Kingdom, in the range of A$300–400/t CO_2-e (figure 4). But Australia achieved relatively less abatement when measured as a proportion of road transport sector emissions. Germany has devoted considerable resources to biofuels, and proportionately was found to have achieved the highest amount of abatement.

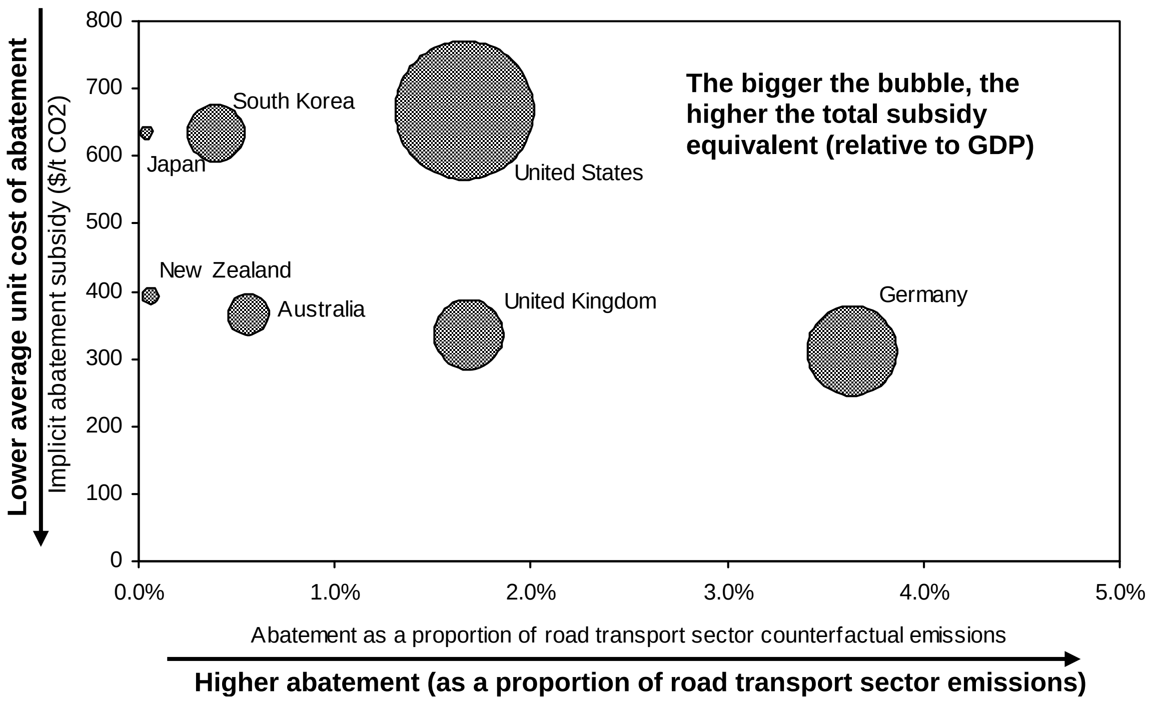
The United States stands out in this analysis, having by far the highest commitment of resources relative to GDP and poor cost effectiveness for only moderate proportionate abatement. This result appears to have been driven by the payment of assistance to domestic biofuel producers to induce local production at the expense of cheaper imports.

Cost effectiveness against a carbon price benchmark

The cost effectiveness of a country's policy measures can best be placed in perspective by making comparisons with the carbon tax (or emissions permit price) that would achieve the same amount of abatement when applied on an economy-wide basis. Economy-wide models for each country would be needed to estimate these prices. While a number of such models exist, developing and applying them consistently to all of the economies in sufficient detail to capture the impacts of particular policies would be an extensive and time-consuming task (and thus could not be attempted for this study).

Figure 4 **'Effort' and reward — how countries compare**

Road transport (biofuels) 'central' estimates, 2010



Nevertheless, to provide some indication of the cost effectiveness of actual policy measures, the Commission undertook some highly stylised modelling for Australia, using an 'off-the-shelf' version of the MMRF model.

- Based on conservative assumptions, the modelling suggested that the 12.5 Mt abatement achieved by existing policies for the electricity generation sector in 2010 (including demand-side abatement) could have been delivered instead by a carbon price (for the electricity sector only) in the order of $9/t CO_2, or at a fraction of the existing cost.
- Alternatively, it was estimated that a carbon pricing mechanism applying to the electricity generation sector, and imposing the same costs as the policies in place in 2010, could have reduced emissions by more than double the abatement achieved.

The results highlight the potential gains from exploiting lower-cost opportunities for abatement over higher-cost ones. However, they do not indicate what carbon price would be required to achieve additional abatement in combination with existing schemes; nor can they be extrapolated to estimate the carbon price that would achieve agreed emissions levels.

Implications for competitiveness

Government policies that encourage abatement or discourage emissions obviously can also, by changing input prices and production costs, affect the competitiveness of firms. But the extent will depend on *how* the government intervenes.

- Explicit budget subsidies decrease the costs of the low-emissions producers, enabling them to be competitive at prevailing market prices. While businesses using these products will not have to pay for the subsidies directly via higher prices, taxes will need to be higher (or government spending lower elsewhere), with ramifications throughout the economy.
- Implicit subsidies to low-emissions producers will generally be passed on via higher prices to consumers and user industries, reflecting higher average costs of production.
- Explicit carbon taxes or emissions trading schemes will directly increase product costs according to their emissions intensity, with these costs being passed on to consumers and user industries.

In this study, the Commission has provided rough estimates of the impact of emissions-reduction policies on the retail prices of electricity and transport fuels. Putting aside fuel taxes, the increase in retail prices of the policy measures analysed appears only to have been significant for electricity in Germany and the United Kingdom (more than 10 per cent). Elsewhere, the impacts to date appear to have been negligible, but these estimates must be treated as preliminary at best.

The ultimate impacts of higher electricity or transport prices on downstream user industries will depend on their ability to pass through costs to their customers. Accordingly, sophisticated modelling would again be required to assess the flow-on impacts on production costs and any likely changes in world prices resulting from policy interventions domestically and internationally. Moreover, assessing the ultimate impact on producers' costs in Australia and abroad would also require that account be taken of any policies serving to *counter* the cost impacts of emissions reduction policies. It would also require comparisons with key competitor economies, which may include countries other than those the Commission was asked to look at in the present exercise.

Summing up

Virtually all of the countries studied have implemented a large number and variety of emissions-reduction measures, ranging from (limited) ETSs to policies that support particular types of abatement technology. A number of these policies, particularly in the electricity generation and road transport sectors, have had material effects in terms of costs, but few appear to have had significant impacts on abatement.

The Commission’s estimates essentially provide a snapshot of the cost and performance of major emissions-reduction policies in 2010. They are necessarily partial and sensitive to a range of assumptions.

- The resources committed by different countries to emissions-reduction policies in electricity generation are estimated to vary as a proportion of GDP, with Germany being well in front of all other countries, followed by the United Kingdom, with Australia, China and the United States ‘mid-range’. The cost effectiveness of these actions in achieving abatement has also varied widely, both across programs within each country and in aggregate across countries.
- There is also wide variation in outlays and cost effectiveness of biofuel policies. The United States spent proportionately more on biofuel policies than any other country, but did not achieve commensurately more abatement. For China, the estimates suggest its policies might have increased emissions rather than reduced them.
- Price-based instruments (such as the European Union ETS) appear to be relatively cost effective — at least where they are not crowded out by other policies. Policies that have encouraged small-scale renewable generation and biofuels generally have been much less cost effective and have led to relatively little abatement.
- The overlapping of policies in many countries makes it difficult to apportion abatement to particular policies. In some cases, a multiplicity of policies appears simply to be driving up costs and rewarding producers for virtually no additional abatement.

While lending empirical support for the relative cost effectiveness of pricing approaches, the estimates and analysis in this report provide little guidance in themselves as to what the appropriate starting price of an ETS should be. And while the Commission’s price uplift estimates are relevant to issues of competitiveness and carbon leakage, they are highly preliminary. Substantially more information would be required to make a proper assessment.