4 The electricity generation sector

Key points

- The Commission estimated the total subsidy equivalent and the abatement attributable to a subset of policies that are having the greatest impact in the study countries. The estimates give an indication of the resources the countries are devoting to emissions reductions, the level of abatement that policies are achieving, and their cost effectiveness.
- When expressed as a proportion of counterfactual electricity-sector greenhouse gas emissions, the total abatement from the policies analysed is estimated to be highest for Germany, followed by the United Kingdom, Australia, the United States, China, Japan and South Korea.
- Likewise, when total subsidy equivalent estimates are expressed as a proportion of GDP, the estimate is highest for Germany, followed by the United Kingdom, Australia, China, South Korea, the United States and Japan.
- The estimated implicit abatement subsidies — which give an indication of the cost per tonne of abatement in each country — were highest for South Korea, followed by Japan, Germany, the United Kingdom, Australia, the United States, China and New Zealand.
- Implicit abatement subsidy estimates can be used to compare the relative costs of different approaches to reducing emissions:
  - The European Union Emissions Trading Scheme delivers significant abatement in the United Kingdom at a relatively low resource cost.
  - Policies that encourage large-scale renewable energy projects were found to be the next least costly, but impose higher costs where some policy instruments are used.
  - Subsidies for solar photovoltaic systems were consistently found to have been the most costly way of achieving abatement for all countries.
  - The Chinese Government’s policy of shutting down small coal-fired power plants and replacing them with more efficient plants, appears to have been cost-effective in its own right, because the savings in operating costs from using more efficient technologies outweigh the costs of new plant.
- Illustrative calculations, based on various simplifying assumptions, suggest that the analysed policies have induced little demand-side abatement in percentage terms, except in Germany and the United Kingdom.

This chapter presents the Commission's quantitative analysis of abatement and costs of a selection of policies in the electricity generation sector of the study countries. The analysis is restricted to electricity generation — the use of fuel (fossil, nuclear or renewable) to create electrical energy. Electricity transmission, distribution and retail are not included in the analysis. The first section describes the types of policies that were assessed and the approach taken. Section 4.2 sets out comparisons of the estimates for the supply side of the electricity generation sectors in the study countries. Section 4.3 sets out the supply-side results for each country. Section 4.4 contains illustrative estimates of the effects of the policies on electricity prices and demand-side abatement.

4.1 Reducing emissions from electricity generation

The terms of reference requested the Commission to 'estimate the effective carbon price per tonne of CO_2-e faced by the electricity generation sectors' in the study countries. For the reasons set out in chapter 3, the Commission's approach was to estimate the total subsidy equivalent for a range of policies in each country, and the abatement (from the supply side and demand side) attributable to these policies.

The scope of the quantitative analysis

Governments use a range of policy instruments to reduce emissions from electricity generation — well over 100 policies were identified in the policy stocktakes for the study countries (available on the Commission's website). Quantitative analysis was restricted to a subset of policies that:

- act directly on electricity generation
- penalise emissions or provide an incentive for lower-emissions generation
- have a material effect on electricity-sector emissions and/or involve significant resource costs for the study countries.

In general, the analysis covered the policies that were having the most material effects in each country in the relevant period. However, time and data constraints meant that some policies that could have met these criteria were not included in the quantitative analysis. In addition, numerous smaller policies that were not included in the analysis could, in combination, have material effects (this is potentially significant for the United States). Where the exclusion of policies may have had a material effect, this is noted in the relevant section. In general, the omission of policies from the analysis is likely to have led to underestimates of subsidy equivalents rather than of abatement.

The policies that were analysed fit into three broad categories:

- *Production subsidies* operate by paying a subsidy to lower-emissions generators for each unit of electricity they supply into the grid. Commonly-used instruments include renewable energy certificates (RECs), feed-in tariffs (FITs), and production tax credits (chapter 2).
- *Capital subsidies* are transfers that subsidise the capital costs of investment in low-emissions generators. Instruments include direct cash transfers, investment tax credits, government-provided loans, and loan guarantees.
- *Emissions trading schemes* (ETSs) change the marginal costs of electricity generation — the more emissions-intensive the technology, the greater the increase in its marginal cost. Depending on the price of emissions permits, this can make low-emissions electricity less costly than higher-emissions electricity, and increase the market share of gas and renewables.

All study countries have a similar suite of regulatory policies directed at improving the energy efficiency of products and buildings using electricity. These include:

- compulsory energy efficiency labelling and minimum performance standards for a range of household appliances and some commercial and industrial machinery
- mandatory energy efficiency standards for new residential and commercial buildings and major renovations to existing buildings
- requirements for government agencies to increase the energy efficiency of their operations
- mandatory energy audits and reporting for large energy users
- direct financial assistance to consumers and businesses to encourage the purchase of more energy efficient appliances and machinery and the improvement of energy efficiency in buildings
- requirements for electricity providers to subsidise energy efficiency improvements by their customers or the wider community.

A number of these policies are outlined in more detail in chapter 2 and appendix C. The policy stocktakes on the Commission's website provide a more complete listing of the energy efficiency policies implemented in individual study countries.

Energy efficiency policies will generally reduce the demand for electricity and lead to lower greenhouse gas emissions. However, as outlined in chapter 3, their effects — and particularly their costs — are very uncertain and hence are not estimated here (appendix C discusses these issues in some detail). However, while the breadth and diversity of policies across countries makes comparisons difficult, Australia generally has a similar mix and stringency of energy efficiency regulations for electricity usage to those in most other study countries.

In addition, as previously discussed, research and development policies were not included in the quantitative analysis, because of their uncertain effects and the fact that outlays in one year are unlikely to have much impact in the same year of analysis.

What the Commission has estimated

The policies chosen for the quantitative analysis all provide a subsidy (explicit or implicit) for electricity generation from lower-emissions sources (generally renewables or gas). The Commission estimated how much these policies reduced emissions in the most recent year for which data were available (generally 2009 or 2010), the costs of the abatement and the cost effectiveness of policy instruments and technologies.

Detailed descriptions of the methodological approaches and data are set out in appendixes D–L (available on the Commission's website). The estimates were based on publicly-available information, and information provided by the governments of the study countries and by contractors. Governments were given the opportunity to comment on drafts of the appendixes that related specifically to their countries.

Estimating subsidy equivalents

For each policy, the Commission estimated a subsidy equivalent. This measures the outlays required to 'buy' certain amounts of abatement from particular sources. A subsidy equivalent is also an upper-bound proxy for resource costs; that is, the economic costs of the policies designed to promote lower-emissions generation. The subsidy equivalent was estimated in different ways for each policy instrument (details are set out in appendixes D–K).

Where several policies provide subsidies for the same unit of renewable generation, the subsidy equivalent estimate for each policy was included in the analysis.

It should be noted that for some policies, only a portion of the total outlay was counted toward the subsidy equivalent. This is the case where policies provide a subsidy to generation that would have occurred in the absence of any policy intervention (such as a subsidy to pre-existing hydroelectricity under some REC schemes). This portion of the subsidy is essentially a transfer and does not contribute to the resource costs of the policy, although such payments will involve real economic costs being imposed on consumers or taxpayers, depending on who has to pay. (Hence, transfers are counted in the analysis of electricity price uplifts.)

To account for these transfers, the Commission estimated how much additional generation can be credited to each policy through an assessment of the policy design and changes in the use of low-emissions generation since the introduction of the policy.

Estimates of the subsidy equivalents for the various policies were added to derive an estimate of the total subsidy equivalent for each country.

Estimating abatement

The Commission also estimated the abatement attributable to the set of policies that were analysed for each study country. In many cases, policy overlaps meant that it was not possible to attribute abatement to individual policies. Instead, to avoid double counting, in many cases the Commission estimated the abatement that arose in each country through different technologies (for example wind or solar power).

Abatement was estimated against a counterfactual of no policy intervention. That is, what would greenhouse gas emissions have been if the policy were not in place? To do this, it was necessary to identify the source of electricity that would have been used in the absence of the subsidised low-emissions generator. Abatement is reported in tonnes of CO_2 (t CO_2), rather than tonnes of CO_2 equivalent (CO_2-e), because in most cases the available estimates of greenhouse gas emissions from electricity generation only included CO_2. Other gases (such as methane and nitrogen oxides) were not included. However, CO_2 generally accounts for 98 per cent of greenhouse gas emissions from fossil fuel combustion (or higher), so excluding these gases is not likely to have had material effects on the overall results.

Implicit abatement subsidies

The estimated implicit abatement subsidy for a policy, technology or the electricity generation sector of a country as a whole is calculated by dividing the subsidy equivalent by the abatement induced. This gives an indication of the cost effectiveness of the abatement options being pursued. (The higher the implicit abatement subsidy, the less cost-effective a measure or set of measures is likely to be.)

Demand-side effects

The Commission estimated the effects of the policies on electricity prices, consumption costs and greenhouse gas emissions in the study countries (section 4.4). These estimates are assumption-driven and should be regarded as illustrative.

Sensitivity analysis

Estimates of subsidy equivalents and abatement attributable to policies were based on assumptions about the characteristics of the electricity generation sectors in the study countries, the cost of capital and some other variables. Where such assumptions played an important role, estimates were subjected to sensitivity analysis — systematically varying parameter values to demonstrate the effects of changes. The results are reported in a range that reflects the sensitivity analysis.

4.2 Subsidy equivalents and abatement compared

This section presents the results for the supply side of the electricity generation sector, including international comparisons of abatement and total subsidy equivalents, comparisons of the cost effectiveness of various technologies, and detail on the results for each study country.

Comparing abatement across countries

For each study country, abatement was estimated for the set of policies that were analysed. While the analysis was restricted to a subset of the emissions-reduction policies in each country, for most countries those that were assessed are likely to have captured the majority of the subsidised low-emissions generation. Analysing additional policies in most countries would not be expected to lead to significantly higher estimates of total electricity sector abatement in the years of analysis.

Differences in the characteristics of the study countries mean that estimates of total abatement are not directly comparable in absolute terms. One reason is the size of the countries — in proportionate terms one tonne of abatement represents less 'effort' for a large country than for a small one. A second issue is that each of the study countries has different natural resource endowments and patterns of energy use. This means that achieving a given amount of abatement requires different levels of effort for each country. For example, if all countries applied the same policy measure (such as a production subsidy of A$50 per megawatt hour (MWh) for wind power), the abatement from that policy would be expected to differ among countries.

One way to make cross-country comparisons more meaningful is to scale the estimates according to what the country's total electricity-sector greenhouse gas emissions would have been in the absence of the policies (table 4.1, figure 4.1). The results show that, relative to total electricity-sector emissions, the policies that were analysed for Australia were estimated to have led to less abatement than in the United Kingdom and Germany, and more abatement than the policies analysed for South Korea, Japan, China and the United States.

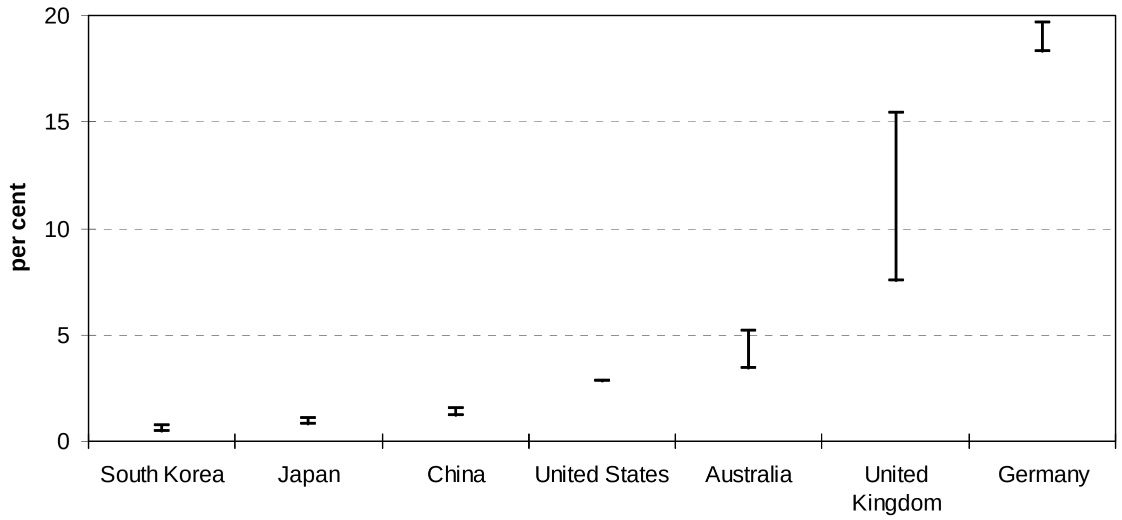
Table 4.1 **Estimates of policy-induced abatement**

Country	*Total electricity sector emissions*	*Estimated abatement*	*Abatement as a percentage of counterfactual electricity-sector emissions*[a]
	Mt CO_2	Mt CO_2	%
Australia	196	7–11	3–5
China[b]	3 370[c]	41–52	1–2
United States	2 270	67	3
United Kingdom	151[d]	12–27	8–15
Germany	299[d]	67–73	18–20
Japan	396[e]	3–4	<1
South Korea	191[e]	1	<1

[a] Counterfactual emissions are calculated as the sum of actual electricity-sector emissions and estimated abatement. [b] Results for China do not include the 'Large Substitute for Small' program. [c] Productivity Commission estimate of China's electricity-sector emissions in 2010. [d] 2009 data. [e] 2008 data.

Sources: Appendixes D–K.

Figure 4.1 **Abatement as a proportion of counterfactual electricity sector emissions[a]**



a Lines show the Commission's lower and upper-bound estimates of electricity generation sector abatement for each country. Results for China do not include the 'Large Substitute for Small' program.

Source: Productivity Commission estimates.

Comparing total subsidy equivalents across countries

The estimates of the subsidy equivalents of each policy were added to derive a total subsidy equivalent for each country. This shows the outlays that countries are making to 'buy' abatement. As with the estimates of abatement, estimates of total subsidy equivalents are more meaningful when put into context, reflecting the characteristics of the study countries. For this reason, the estimates are reported in dollar values, and as a proportion of GDP (table 4.2, figure 4.2).

The results suggest that, as a proportion of GDP, the estimated total subsidy equivalent for electricity sector policies in Australia is somewhat larger than for the policies that were analysed for Japan, the United States, South Korea and China, and significantly less than for the United Kingdom and Germany.

In interpreting these estimates, it should be noted that some of the policies that were not included in the analysis could have had a material effect. In particular, for the United States, the analysis included two large federal-level programs and 13 state-level programs. However, there are numerous state-level programs that were not included in the analysis because of time and data constraints. It is likely that some of these policies provide material subsidies to low-emissions generators.

Excluding these policies from the analysis will underestimate the total subsidy equivalent.

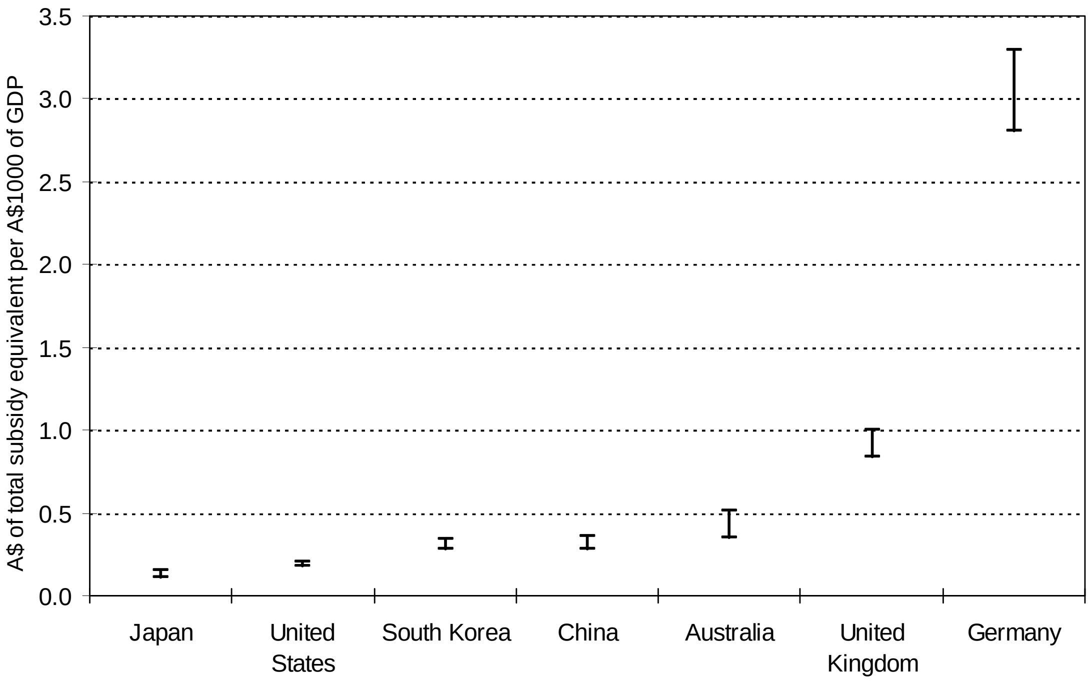
Table 4.2 **Estimates of total subsidy equivalents**

Country	*GDP*	*Total subsidy equivalent*	*Total subsidy equivalent as a percentage of GDP*
	A$b (2010)	A$m (2010)	% GDP
Australia	1 343	473–694	0.04–0.05
China	6 402[a]	1 835–2 309	0.03–0.04
United States	15 936	2 886–3 339	0.02
United Kingdom	2 437	2 042–2 433	0.08–0.10
Germany	3 572	10 019–11 947	0.28–0.33
Japan	5 959	669–940	0.01–0.02
South Korea	1 101	313–379	0.03

a GDP figure for China does not include Hong Kong.

Source: Appendixes D–K.

Figure 4.2 **Total subsidy equivalents as a proportion of GDP[a]**



a Lines show the Commission's lower and upper-bound estimates of electricity generation sector total subsidy equivalents for each study country.

Source: Productivity Commission estimates.

Comparing implicit abatement subsidies across countries

The implicit abatement subsidy for each country's electricity generation sector is the total subsidy equivalent divided by total abatement. The results are reported in A$/t CO_2, and can be interpreted as an upper-bound estimate of the average resource costs of a tonne of abatement. The implicit abatement subsidy is not a 'carbon price'. Rather, as noted in chapter 3, it gives an indication of the cost effectiveness of the set of policies that were analysed for each country in achieving abatement.

Two factors have a particularly significant influence on the implicit abatement subsidy estimates. The first is the emissions intensity of each country's electricity generation sector. Specifically, for a given total subsidy equivalent, the implicit abatement subsidy will be lower in countries where renewable energy sources displace emissions-intensive sources. For example, a given total subsidy equivalent to renewable energy in a country where renewables displace coal will yield a lower implicit abatement subsidy than the same total subsidy equivalent in a country where renewables displace gas, other things being the same.

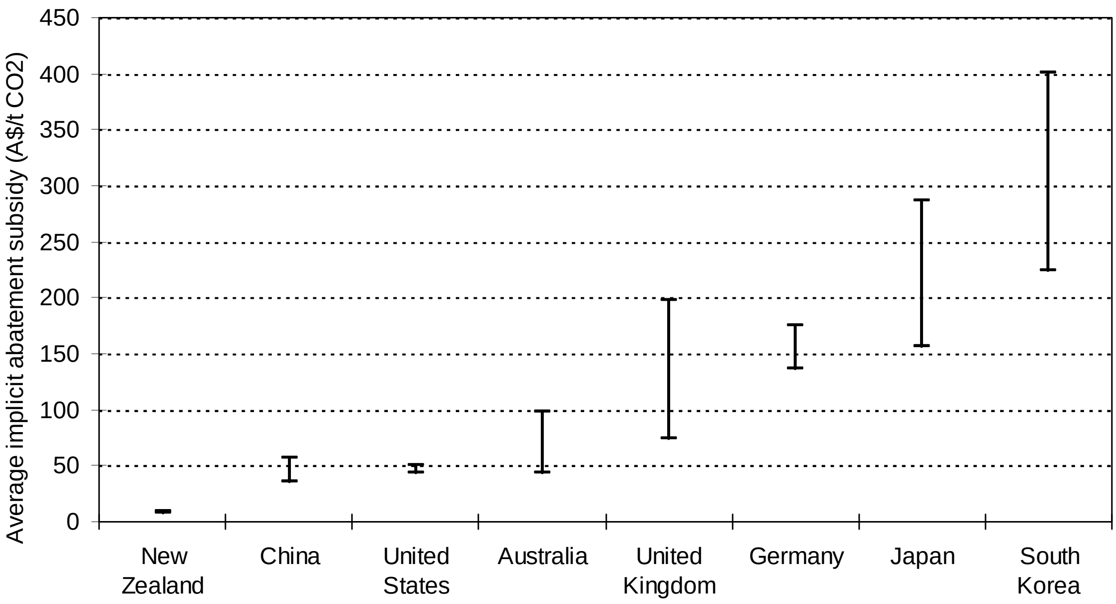
A second relevant factor is the rate of the production subsidy provided to renewables. The higher the production subsidy (expressed in A$/MWh), the higher the implicit abatement subsidy, other things being equal. Production subsidy rates tend to be related to the costs of technologies, and reflect decisions to favour particular technologies.

Bearing in mind the difficulties in making cross-country comparisons, it is reasonable to draw the following conclusions from the results (figure 4.3):

- The lowest implicit abatement subsidy estimate internationally is for New Zealand, for which only one electricity sector policy was analysed — the recently-introduced New Zealand ETS.
- Despite their participation in the European Union ETS, the estimated implicit abatement subsidies for Germany and the United Kingdom are relatively high because of the generous subsidies that the two countries provide to renewables.
- Policies analysed in Japan and South Korea achieved relatively low levels of abatement, but at a relatively high cost (mainly because of large production subsidies paid to high-cost solar photovoltaic (PV)).
- The implicit abatement subsidy range estimated for Australia (A$44–98) is lower than for some countries, but high relative to the New Zealand and European Union Emissions Trading Schemes (discussed further below).

For reasons set out in the section on subsidy equivalent estimates, the implicit abatement subsidy for the United States should be regarded as a lower-bound estimate.

Figure 4.3 **Implicit abatement subsidies[a]**



[a] Lines show the Commission’s lower and upper-bound estimates of electricity generation sector implicit abatement subsidies for each country.

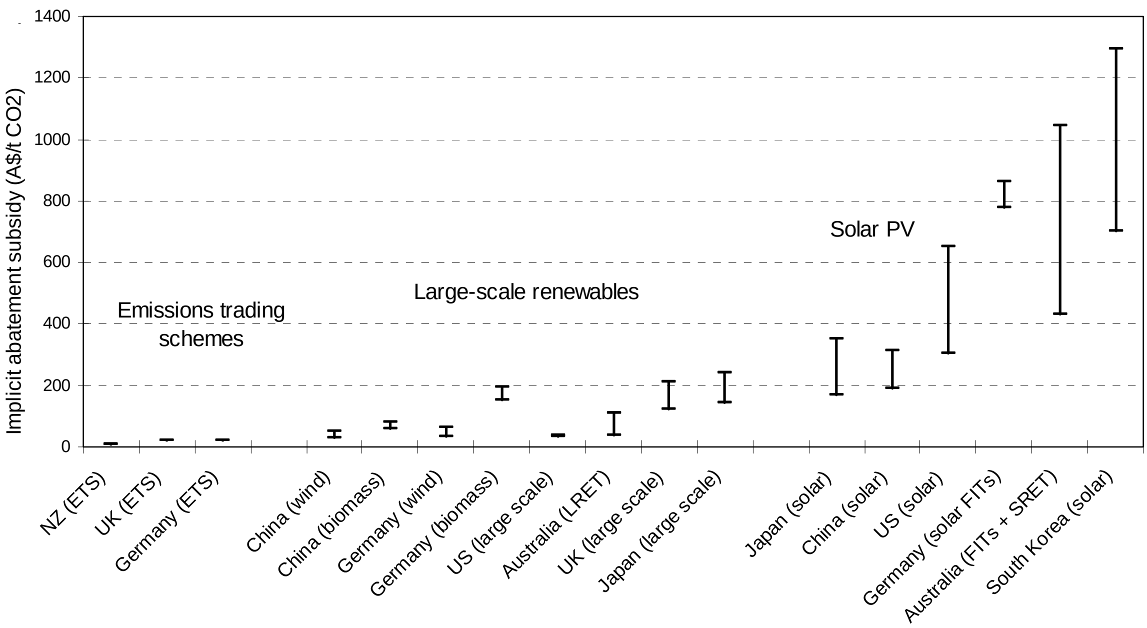
Source: Productivity Commission estimates.

Comparing emissions-reduction technologies

In some cases, it was possible to estimate the implicit abatement subsidies associated with individual policies. Where these policies support a particular technology, the results can be used to compare the cost effectiveness of using different technologies to achieve emissions reductions (figure 4.4). The results support some significant conclusions.

First, emissions trading schemes are found to have been the most cost-effective instruments identified. The European Union ETS appears to be leading to abatement by encouraging a switch from coal to gas. The effects are more pronounced in the United Kingdom than in Germany, because Germany had less surplus gas-fired generation capacity in the year of analysis. Sources of abatement under the New Zealand ETS are not yet clear, because the scheme has only applied to electricity generation since 2010, and current transition arrangements mean that the scheme has probably not yet had a significant effect on the day-to-day production decisions of New Zealand electricity generators. Moreover, around three-quarters of electricity generation in New Zealand is already from renewables (mainly hydroelectricity, geothermal and wind power), with most of the remainder coming from gas. This suggests that there are limited opportunities for New Zealand to further reduce the emissions intensity of its electricity generation sector, compared to other countries that rely more heavily on fossil fuels.

Figure 4.4 **Implicit abatement subsidies — technologies and policies**[a,b]



a Lines show the Commission's lower and upper-bound estimates of electricity generation sector implicit abatement subsidies for each country, broken down by technology. Only a subset of the policies could be broken down by technology. Where a data point is labelled 'large scale', the policy applies to numerous large-scale renewable technologies, and the effects could not be disaggregated any further. In most cases, the majority of large-scale renewables are wind and biomass. **b** For Australia, 'LRET' refers to the large-scale component of the Renewable Energy Target. 'SRET' refers to the small-scale component. Both components were analysed for 2010.

Source: Productivity Commission estimates.

A second clear finding is that solar PV is currently a relatively costly abatement option. Solar PV is a high-cost technology (box 4.1), and hence subsidy rates for solar PV need to be high to make it competitive at prevailing market prices. Furthermore, subsidy rates for solar PV often have been set at excessive levels, essentially providing windfall benefits to households that install solar PV. In Australia in 2010, the combined effect of the Renewable Energy Target and state and territory FITs was estimated to have provided a subsidy equivalent to solar PV of A$149–194 million. Abatement from solar PV through these policies was estimated to be 0.2–0.3 Mt CO_2, which implies implicit abatement subsidies for solar PV of A$432–1043/t CO_2 — some of the highest identified in this study.

Box 4.1 **The costs of electricity sources**

The levelised cost of electricity (LCOE) is a widely-used measure of the cost of electricity generation technologies. Estimates of the LCOE are sensitive to assumptions about factors such as capital costs, the useful life of assets and the technical efficiency of generation technologies. As such, they should be treated as an indicative guide to the relative costs of various technologies.

The Electric Power Research Institute (2010) reported estimates of the LCOE of various sources of electricity in Australia, including:

- coal-fired electricity (without carbon capture and storage) — A$78–91/MWh
- combined-cycle gas turbines (without carbon capture and storage) — A$97/MWh
- wind — A$150–214/MWh
- medium-sized (five megawatt) solar PV systems — A$400–473/MWh.

Smaller domestic PV systems are likely to have higher costs again. The high LCOE for solar PV is one of the reasons that policies that subsidise solar PV have high implicit abatement subsidies.

Source: Electric Power Research Institute (2010).

The results for large-scale renewables are less clear. The implicit abatement subsidies are higher than for ETS-induced coal-gas switching, and generally lower than for solar PV. However, there is significant variation in the implicit abatement subsidy estimates. Some of this is accounted for by differences in the costs of renewables in the study countries. Another factor is the different instruments used to subsidise renewables. The two most common are renewable energy certificate (REC) schemes and feed-in tariffs (FITs).

REC schemes work by setting an overall target for the use of renewables. Under a REC scheme, all renewables receive the same subsidy per MWh, and the market determines the mix of renewables that will meet the target at the lowest cost. FITs operate by setting a guaranteed payment for electricity from renewable energy sources that is fed into the electricity transmission grid. FITs are generally set at different rates for different technologies. Inevitably, FIT rates are set at higher levels than would be necessary to induce the least-cost mix of renewables, and the overall resource cost of using a particular level of renewables will be higher than under a REC scheme.

4.3 Results for each country

The following sections set out the results for each country that have been drawn on above. Key drivers of abatement, total subsidy equivalents and implicit abatement subsidies for each country are explained, and significant policies are described in greater detail. Full explanations of how subsidy equivalents and abatement were estimated for each policy are provided in appendixes D–K (available on the Commission's website).

Australia

A large number of emissions-reduction measures apply to Australia's electricity generation sector. The quantitative analysis was restricted to a subset of measures that were considered likely to have had a material effect on the total subsidy equivalent and/or total abatement estimates in 2009 or 2010 (the years of analysis). Specifically, the analysis included:

- the large and small-scale components of the Renewable Energy Target (RET)
- state and territory solar PV FITs
- the NSW and ACT Greenhouse Gas Reduction Scheme (GGAS)
- the Queensland Gas Scheme.

It should be emphasised that the estimate of the abatement attributable to the Queensland Gas scheme is an upper-bound estimate. It is likely that some of the gas generation that has been subsidised by the scheme would have been in service even without the incentives provided under the scheme.

A number of federal, state and territory capital subsidy programs (such as the Solar Flagship program, various Solar Schools programs, the Victorian Large Scale Solar Project, and the Low Emissions Energy Development Fund) were not included in the analysis as they were not considered likely to have led to material abatement or to have had significant resource costs in 2010.

In proportionate terms, Australia's total abatement and total subsidy equivalent were the third highest of the study countries (behind only Germany and the United Kingdom) (table 4.3). The average implicit abatement subsidy is lower than for South Korea, Japan, Germany and the United Kingdom, and higher than for the United States, China and New Zealand.

Table 4.3 **Effects of emissions-reduction policies, Australia**

2009, 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Renewable Energy Target	REC scheme	335–556	4.3–8.0	42–129
Large-scale component		283–459	4.1–7.6	37–111
Small-scale component		52–98	0.2–0.3	152–525
State and territory solar feed-in tariffs	FITs	96	–[a]	..
New South Wales		43	–[a]	..
Victoria		22	–[a]	..
Queensland		21	–[a]	..
Western Australia		2	–[a]	..
South Australia		6	–[a]	..
ACT		2	–[a]	..
GGAS (New South Wales and ACT)	Emissions offsets scheme	3	0.6	5
Queensland Gas Scheme	Target for gas-fired electricity	38	2.1[b]	18
Total for solar PV[c]		149–194	0.2–0.3	431–1 043
Total		**473–694**	**7–11**	**44–99**

[a] No abatement is attributed to the state and territory solar FITs, because in 2010 the schemes overlapped fully with the RET (box 4.2). [b] Abatement estimates for the Queensland Gas Scheme should be treated as an upper bound, as they probably include some gas-fired generation that would have been brought into service even if the scheme was not in place (appendix D). [c] Combined effects of the small-scale component of the RET and the state and territory FITs. **–** Nil or rounded to zero. **..** Not applicable.

Source: Appendix D.

A key finding from the analysis is that subsidising the installation of small-scale solar PV systems significantly increases the average implicit abatement subsidy and hence the resource costs of abatement. The implicit abatement subsidy for the programs that subsidise solar PV (the small-scale component of the RET and the state and territory FITs) was estimated to be in the range of A\$431/t CO_2–A\$1043/t CO_2. If these policies did not exist, it is likely that there would have been much less small-scale solar PV installed, and the electricity sector average implicit subsidy would have been around 25–30 per cent lower (A\$31–73/t CO_2 rather than A\$44–99/t CO_2). Furthermore, because the state and territory FITs overlapped completely with the RET in 2010, they did not lead to any additional abatement, and only added to the total financial costs of meeting the target (box 4.2). In fact, due to a peculiar effect of the RET scheme in 2010, the

FITs could have actually led to higher emissions than if there had been no FIT schemes.

Subsidies for large-scale renewables under the RET were responsible for more than half of the estimated abatement. The large-scale component of the RET was less costly than subsidies for solar PV, but its implicit abatement subsidy was still high relative to more cost-effective policies (such as the European Union ETS).

It is worth noting that the Commission’s implicit abatement subsidy estimates for individual policies are broadly comparable to estimates by others of the costs of abatement of the policies (box 4.3).

Box 4.2 **State and territory solar FITs — high cost and minimal abatement**

All states and territories in Australia offer FITs for solar PV. In 2010, the state and territory FITs overlapped completely with the national RET, as each MWh of electricity subsidised through FITs in 2010 was also eligible for subsidies under the RET. Given that the RET set a binding target for the use of renewables, each MWh of solar electricity simply offset abatement from other renewable sources, and hence the FITs did not lead to any additional abatement.

In fact, the Commission’s analysis found that if the state and territory FITs increased the installation of solar PV systems, the result could have been a net increase in emissions in 2010. The reason is that owners of solar PV were granted five RECs for every MWh of electricity generated. Therefore, each ‘solar-generated REC’ was equivalent to only 0.2 MWh of renewable electricity. Other renewable generators received only one REC per MWh. Hence, each ‘solar-generated REC’ that was surrendered in 2010 would have reduced the net generation from renewables by 0.8 MWh, leading to higher total emissions than if the solar PV system had not been installed. This anomaly was addressed through changes to the RET scheme in 2011.

Box 4.3 **Other estimates of the cost of abatement**

The Renewable Energy Target

The Commission's estimate of the implicit abatement subsidy of the large-scale component of the RET (A$37–111/t CO_2) is in a similar range to other published estimates of the cost of the RET, including:

- Grattan Institute (Daley and Edis 2011) — A$30–70/t CO_2 (depending on the certificate price)
- Ministerial Council on Energy (2002) — A$44–73/t CO_2
- Electricity Retailers Association of Australia (ERAA 2005) — A$60–80/t CO_2.

Queensland Gas Scheme

The Grattan Institute estimated that the cost of abatement under the Queensland Gas Scheme has been in the range of A$20–A$40/t CO_2. The Commission's estimate is slightly lower than the lower bound of this estimate. This appears to be due to the lower permit price in 2009.

Greenhouse Gas Reduction Scheme

Estimates of abatement induced by GGAS vary, due to differing assumptions regarding the additionality of the scheme. For example, DCC (2010) reported 'induced' abatement of 4.7 Mt CO_2. This was revised to 0.7 Mt CO_2 in DCCEE (2011e). The Commission's estimate was based on the most recent DCCEE estimate.

Sources: Daley and Edis (2011); DCC (2010); DCCEE (2011e); ERAA (2005); Ministerial Council on Energy (2002).

China

Six measures were analysed. Five provide incentives for renewables in the form of capital subsidies or FITs. The sixth, the 'Large Substitute for Small' (LSS) program, targets the efficiency of China's coal-fired electricity generation.

A number of policies were not included in the analysis, as research suggested that they were not likely to have been material relative to the policies that were analysed (appendix E). However, some other policies that were excluded from the analysis on data grounds may have material effects. Overall, it is likely that the policies that were analysed capture a large proportion of the types of measures being pursued in China's electricity generation sector in 2010, the subsidies they provided to low-emissions generation, and the abatement achieved.

Relative to counterfactual electricity-sector emissions, the estimate of total abatement from the Chinese policies analysed is the third lowest of the study countries, and the total subsidy equivalent is estimated to be the fourth lowest relative to GDP. Most of the subsidies paid (and abatement achieved) are attributed to wind power. Biomass contributes some abatement, and solar PV a negligible amount (table 4.4).

Table 4.4 **Effects of emissions-reduction policies, China**
2009, 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
FITs for large-scale renewables				
Wind FITs	FITs	1 346–1 731	35–45	30–49
Biomass FITs	FITs	353–397	5–6	58–81
Solar PV programs[a]				
Jianagsu Solar PV feed-in tariffs	FITs	83	0.2	356–435
Golden Sun Subsidy Scheme	Capital subsidy	43–81	0.3	124–285
Subsidies for solar PV in buildings	Capital subsidy	10–18	0.1	72–168
‘Large Substitute for Small’	Generator upgrades	0–1 251[b]	119–174	0–11
Total (not including LSS)		**1 835–2 309**	**41–52**	**35–57**
Total (including LSS abatement)[c]		**1 835–2 309**	**159–226**	**8–15**

[a] Due to overlap between the Jiangsu FITs and the solar PV capital subsidies, the Commission assumed that 20 per cent of the abatement from the capital subsidies overlaps with the abatement attributed to the Jiangsu FITs. [b] The lower-bound estimate of the subsidy equivalent for the LSS program was estimated to be less than zero. However, because negative numbers are not meaningful, the lower bound is reported as zero. [c] Does not include the subsidy equivalent for the LSS.

Source: Appendix E.

The LSS program appears to be financially cost effective, with the savings in operating costs that come from using large, modern power plants outweighing the capital costs of the new plants under most assumptions (box 4.4). The implication is that if production and investment decisions in China’s electricity sector were based on market incentives, it is likely that the smaller plants would have been replaced by more efficient plants without government intervention. In other words, the abatement achieved through the LSS program would have been achieved anyway. For this reason, the estimates of the impacts of the LSS program are reported here, but the program is excluded from the international comparisons. This is consistent with how cost-effective improvements in the efficiency of generators in other countries have been treated.

Box 4.4 The ‘Large Substitute for Small’ Program

The ‘Large Substitute for Small’ program (LSS) aims to decommission small inefficient thermal power plants and replace them with larger, more advanced plants. Since its introduction in 2006, the LSS has resulted in the closure of around 71 gigawatts (GW) of small thermal plants. According to data from the International Energy Agency, over the same period, around 569 GW of new coal power plants have been built (IEA 2010c).

It appears that the program has been pursued for a number of reasons, including increasing the efficiency of the electricity supply system, energy security, reducing greenhouse gas emissions and other environmental reasons.

The LSS program involves financial costs (the capital costs of the investment in new plants) and benefits (the operating cost savings from using more efficient technologies). Taking these into account, the Commission estimated that, under most assumptions about parameter values, the LSS program delivers a net financial benefit — the estimated savings in operating costs exceed the annualised capital costs of new plants

Improvements in the efficiency of coal-fired generation were estimated to deliver emissions reductions in the range 119–173 Mt CO_2. However, this is not included when making cross-country comparisons of abatement in this study, because the LSS program does not impose a cost on the Chinese economy (relative to the counterfactual of not upgrading China’s coal-fired plants). In order to be consistent internationally, such ‘no regrets’ measures have not been counted.

Source: IEA 2010c; Appendix E.

Even with abatement associated with the LSS program excluded from the total, the lower-bound implicit abatement subsidy estimate for China (A$35/t CO_2) is the lowest of all the study countries apart from New Zealand. This is partly due to the high emissions intensity of China’s electricity generation sector, which leads to a relatively high amount of abatement when renewables are used. It also reflects the relative cost effectiveness of large-scale wind and biomass, which account for over 90 per cent of the total subsidy equivalent.

Under the twelfth Five Year Plan (2011–2015), the Chinese Government has committed to energy and emissions intensity targets that may have an effect on the electricity generation sector. There is little detail available on how these targets will be achieved, although the twelfth Five Year Plan establishes a goal of ‘gradually establish[ing] a carbon trading market’ (Pew Center on Global Climate Change 2011, p. 2). Media reporting also suggests that the Chinese Government is proposing to trial the introduction of some form of emissions trading scheme in six provinces before 2013 and nationwide by 2015 (Reuters 2011).

United States

The analysis covered two federal renewable energy policies (a production subsidy and a capital grant), nine state-based renewable portfolio standards (which set targets for renewables), and a range of Californian subsidies for solar power. Overall, the estimates account for most large-scale renewable energy in the United States (through the federal schemes) and around 70 per cent of US solar generation (through the Californian schemes).

The US abatement estimate is high in absolute terms, but below those of Germany, the United Kingdom and Australia as a proportion of counterfactual electricity sector emissions. As a proportion of GDP, the total subsidy equivalent estimate is lower than all study countries except Japan (table 4.5).

However, the total subsidy equivalent estimate for the United States is likely to be an underestimate. This is because, due to time and data constraints, many state and federal policies could not be included in the analysis (appendix K). In aggregate, it is likely that many renewable generators that received subsidies through the policies that were analysed also received additional subsidies through policies that were not included in the analysis. These unaccounted subsidies are likely to play an important role in the investment and production decisions of renewable generators, and as such their exclusion from the analysis is likely to understate the resource costs of using these technologies. On the other hand, because the renewable generators are likely to have been included through the analysis of other policies, most of the abatement associated with the policies that were excluded from the analysis is probably already captured. Any underestimation of the total subsidy equivalent would flow through to the implicit abatement subsidy.

Subsidies for renewables in the United States range from relatively modest (the federal production tax credit offers a A$24/MWh subsidy to wind, compared to the subsidy offered under Australia’s RET of around A$40–60/MWh) to very generous (the Californian capital subsidies for solar PV, which equate to a subsidy of around A$200–250/MWh). However, the aggregate effect of the solar subsidies is relatively minor, because they constitute a small proportion of the total subsidies for renewables. The relatively low subsidies to large-scale renewables provide a further explanation for the relatively low implicit abatement subsidy.

Table 4.5 **Effects of emissions-reduction policies, United States**
2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Federal policies and renewable portfolio standards		2 684–3 047	66	41–46
Renewable Electricity Production Tax Credits	Tax credit	1 708	.. [a]	..
Treasury grants	Capital subsidy	418–782	.. [a]	..
State renewable portfolio standards	REC schemes	557	.. [a]	..
Californian capital subsidies		202–292	0.4–0.7	305–651
Californian Solar Initiative		125–148	.. [b]	..
New Solar Homes		2–4	.. [b]	..
Self Generation Incentive Program		42–78	.. [b]	..
Emerging Renewable Program		33–62	.. [b]	..
Total		**2 886–3 339**	**67**	**43–50**

[a] Due to overlaps between the federal policies and the state renewable portfolio standards, the Commission estimated abatement and implicit abatement subsidies for these policies as a group. [b] Due to overlaps between the Californian subsidies for solar PV, the Commission estimated abatement and implicit abatement subsidies for these policies as a group. **..** Not applicable.

Source: Appendix K.

As well as the subsidies for renewable energy, there is one regional ETS that is currently operating in ten north-eastern states, and another ETS that is scheduled to begin in 2012 (box 4.5). These schemes are not currently leading to significant abatement, although this may change in future years as the emissions caps tighten.

Another measure that could have significant effects on emissions from the US electricity generation sector is the US Environmental Protection Agency's emissions standards for large emitters of greenhouse gases (chapter 2). Under these standards, large emitters will have to hold permits to continue to operate. Eventually, the requirements could apply to around 70 per cent of US greenhouse gas emissions (US EPA 2011b).

Box 4.5 **Emissions trading schemes in the United States**

The Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative covers the electricity sector in ten north-eastern states. The objective of the scheme is to reduce electricity-sector emissions in these states to 10 per cent below 2009 levels by 2018.

The initial cap was set to stabilise electricity-sector emissions in these states at 171 Mt CO_2 annually until 2014. This cap does not appear to be binding, as emissions in 2009 were approximately 112 Mt (NYSERDA 2010b), and as such the ETS cannot be credited with any supply-side abatement. This observation is supported by the permit price, which was at the minimum reserve price throughout much of 2010 (US$2.05/t CO_2 (A$2.23)). As the cap begins to tighten, the permit price may rise, leading to some supply-side abatement in the future.

In May 2011, the Governor of New Jersey announced that the state would withdraw from the scheme, leaving nine states remaining (AP 2011).

The Western Climate Initiative

The Western Climate Initiative is an agreement to implement an ETS in seven US states and four Canadian provinces in 2012. The WCI (2010a) has recommended that the initial cap on emissions be set at the level of projected business-as-usual emissions. Therefore, it is expected that, if implemented, the permit price and abatement will initially be close to zero. As the cap tightens, the scheme could lead to significant abatement. The Californian Air Resources Board (CARB (US) 2010) projected that the permit price in California in 2020 will be in the range of US$25–US$162/t CO_2 (A$27–176), depending on the extent of complementary policies in place.

Currently, it appears that only California is fully committed to implementing an ETS in 2012. Arizona and Utah pulled out of the scheme in 2010, New Mexico in early 2011, and as yet Oregon, Washington and Montana have not passed enabling legislation.

Sources: AP (2011); CARB (US) (2010); NYSERDA (2010b); WCI (2010a).

United Kingdom

The analysis for the United Kingdom covered four policies: the European Union ETS; the Renewables Obligation (a REC scheme); the Climate Change Levy (a differential electricity tax with lower rates for electricity from renewable energy sources); and the Offshore Wind Capital Grants Scheme. These policies cover the main technologies leading to abatement in the United Kingdom — gas, combined heat and power, and renewables. However, there are significant interactions between the policies, and thus attributing abatement and an implicit abatement subsidy to each policy was not possible (appendix J). Instead, implicit abatement subsidy estimates for the United Kingdom are attributed to technologies.

Relative to the other countries, estimates of total abatement (as a proportion of counterfactual electricity sector emissions) and the total subsidy equivalent (as a proportion of GDP) are high in the United Kingdom — behind only Germany, and around double that of the next highest country (Australia) (table 4.6).

Around half of the abatement was estimated to have come from the incentive that the European Union ETS gives electricity generators to switch from coal to gas. The resource cost of this abatement is relatively low (the implicit abatement subsidy is equal to the European Union ETS permit price, which was around A$29/t CO_2 in 2009-10). The estimates of the subsidy equivalent and abatement are reported in a relatively wide range (A$115–A$403 million and 4–14 Mt CO_2 respectively). This reflects uncertainty about the extent of fuel switching in the United Kingdom. The estimates were based on academic literature that suggests that the European Union ETS has increased the use of gas-fired generation by between 5 and 20 per cent.

Most of the rest of the abatement was attributable to subsidies paid to renewable energy — primarily through the Renewables Obligation (a REC scheme). This scheme also accounts for the majority of the total subsidy equivalent estimate. The Renewables Obligation mainly appears to subsidise wind, biomass and waste, which are generally relatively low cost. However, the Renewables Obligation target has not been met, and as such the permit price is driven by the ‘fine’ for not surrendering a certificate. This leads to a relatively high implicit abatement subsidy for large-scale renewables in the United Kingdom. (The relatively low emissions intensity of the counterfactual electricity source also plays a role in elevating the implicit abatement subsidy.)

An important factor to take into account when assessing the UK results is that because the United Kingdom participates in the European Union ETS, any abatement in the electricity sector that is achieved through subsidies to renewables or combined heat and power will simply be offset by higher emissions elsewhere in the European Union. This is because the European Union ETS sets a binding cap on total European Union emissions from a number of sectors (including electricity generation). If the UK Government chooses to subsidise high-cost abatement through renewables, this simply reduces the burden on other countries. Overall, European Union emissions will ultimately be determined by the ETS cap.

Table 4.6 **Effects of emissions-reduction policies, United Kingdom**
March 2009 – April 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Coal–gas switching				
European Union ETS	ETS	115–403	4–14	29
Subsidies to combined heat and power				
Climate Change Levy	Differential electricity tax	30–38	2	21–26
Subsidies to renewable energy		1 897–1 993	7–12	160–294
European Union ETS	ETS	278	.. [a]	..
Renewables Obligation	REC scheme	1 508–1 573	.. [a]	..
Climate Change Levy	Differential electricity tax	105–131	.. [a]	..
Offshore Wind Capital Grants Scheme	Capital grants	6–11	.. [a]	..
Total		**2 001–2 258**	**12–27**	**75–198**

[a] Policy overlaps meant that it was not possible to estimate the abatement attributable to individual policies that provide subsidies to renewable energy sources. **..** Not applicable.

Source: Appendix J.

Germany

The analysis covered three policies: the European Union ETS, FITs for renewables, and production subsidies for combined heat and power. Of all the countries analysed, Germany has the highest total subsidy equivalent estimates (both in absolute terms and as a proportion of GDP), and the highest abatement relative to counterfactual electricity sector emissions (table 4.7).

In Germany, the European Union ETS has led to some relatively low-cost abatement through fuel switching (from coal to gas). The implicit abatement subsidy is equal to the European Union ETS permit price (around A$20/t CO_2 in 2010). However, in the year of analysis (2010), Germany had relatively little surplus gas-fired generation capacity. This placed a constraint on the ability of German generators to increase their use of gas in the short term, and meant that abatement through coal-gas switching was less than in the United Kingdom in the same year. In the longer term, the European Union ETS gives electricity generators an incentive to invest in more gas-fired capacity, which would be expected to lead to emissions reductions.

Table 4.7 **Effects of emissions-reduction policies, Germany**

2009, 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Renewable Energy Sources Act	FITs	8 104–9 789	59	137–166
Combined Heat and Power Act	FITs	399	7–10	40–55
European Union ETS	ETS			
Switch from coal to gas		15–80	1–4	20
Interaction with feed-in tariffs		1 365	.. [a]	..
Indirect subsidy to combined heat and power		136	.. [b]	..
Total		**10 019–11 769**	**67–73**	**137–178**

[a] Abatement was attributed to the Renewable Energy Sources Act. [b] Abatement was attributed to the Combined Heat and Power Act. **..** Not applicable.

Source: Appendix F.

At the other end of the scale, Germany's FIT regime is relatively costly. Implicit abatement subsidies were estimated to be as high as A$864/t CO_2 (for solar PV) (appendix F). Furthermore, because Germany participates in the European Union ETS, this abatement is offset completely by an increase in emissions from other sectors, and from other countries that participate in the scheme. For example, Traber and Kemfert (2009) found that Germany's FIT-induced electricity-sector emissions reductions would be offset by higher emissions from electricity generators in Spain and Italy. This could be described as 'intra-Europe carbon leakage'. German electricity consumers face higher electricity prices to pay for the FITs, but any emissions reductions in Germany are entirely offset by higher emissions in other countries that do not impose the same burdens on their consumers.

Japan

Seven policies were analysed — the Renewable Portfolio Standard, two capital subsides for wind, the Petroleum and Coal Tax, and three measures relating to solar PV. The results suggest that Japan achieved relatively little abatement through these policies in the year of analysis (ahead of only South Korea in proportionate terms), and had the lowest total subsidy equivalent as a proportion of GDP (table 4.8).

The total subsidy equivalent is likely to be somewhat underestimated because the Commission was unable to estimate the full effects of two national-level capital subsidies for renewable energy that have been in operation since 1997 (appendix G). Including these policies in the analysis would likely increase the total subsidy equivalent and abatement estimates. However, since 2002, the

Renewable Portfolio Standard has covered the majority of renewable energy generation in Japan. Thus, abatement from renewable generators installed after this period is likely to have been covered in the estimates.

Moreover, the relatively little abatement that Japan achieved through these policies was delivered at relatively high cost (the average implicit abatement subsidy was estimated to be in the range A$156–A$287/t CO_2 — among the highest of the study countries). Japan's high implicit abatement subsidy is explained by two factors. First, the relatively low emissions intensity of the electricity that is displaced by renewables. Second, subsidies to solar PV are high, relative to its contribution to total abatement.

Table 4.8 **Effects of emissions-reduction policies, Japan**

April 2009 – March 2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Policies that support renewables other than solar		429–541	2–3[a]	145–239[c]
Renewable Portfolio Standard	REC scheme	300	..	..
Program for Promoting the Local Introduction of New Energy[b]	Capital subsidy	19–35	..	..
Project for Supporting New Energy Operators[b]	Capital subsidy	110–206	..	..
Solar PV programs		225–354	1[c]	170–349[d]
National PV subsidies	Capital subsidy	147–274	..	..
New Buyback Program	FIT	76	..	..
Tokyo PV subsidies	Capital subsidy	2–4	..	..
Petroleum and coal tax	Fuel tax	13–39	..	..
Total		**669–940**	**3–4**	**156–287**

a Due to overlaps between the Renewable Portfolio Standard, the Program for Promoting the Local Introduction of New Energy, and the Project for Supporting New Energy Operators, abatement could not be attributed to individual measures. Therefore, the Commission estimated abatement and the implicit abatement subsidy from these measures as a group. **b** The Commission was only able to obtain data on the wind component of these capital subsidies. **c** Due to overlap between the three solar programs, the Commission estimated abatement and the implicit abatement subsidy from these measures as a group. **..** Not applicable

Source: Appendix G.

No abatement was attributed to the Petroleum and Coal tax because at the current level of the tax it was considered unlikely to have resulted in any fuel switching between fossil-fuel sources (although the tax does provide a small subsidy to renewables by increasing the price of electricity).

The Japanese Government has also foreshadowed the introduction of an ETS and a system of FITs that would replace the existing RPS. Little information is available on these measures at this time. However, if they were to be introduced, they could have a large effect on emissions, subsidies for low-emissions generation, and the implicit abatement subsidy estimate for Japan's electricity generation sector.

South Korea

As is the case for Japan, the policies that were analysed for South Korea appear to have achieved relatively little abatement at relatively high cost (table 4.9). This is largely a result of the focus of the South Korean policies on solar PV generation. Overall, approximately 85 per cent of the estimated total subsidy equivalent was provided to solar. The policy with the largest impact on the total subsidy equivalent estimate — the FITs — offered rates of approximately A$555/MWh to solar, compared to around A$15/MWh for wind generation.

The abatement estimate for the South Korean policies was the lowest out of the study countries (in proportionate terms), while its implicit abatement subsidy is by far the highest.

In contrast, the Korea Certified Emission Reductions (KCERs) scheme had an implicit abatement subsidy that is 50 to 100 times lower than that of the FITs. The scheme appears to be achieving abatement mainly through increasing the use of gas-fired generation and efficiency improvements in existing generation. However, this scheme is relatively small compared to the FITs, and thus it did not have a large impact on the estimated average implicit abatement subsidy for South Korea.

While the analysis included those emissions-reduction policies that were both material and in operation over the study period, South Korea has committed to a number of other policies that may lead to additional abatement in the future. However, the subsidies these policies would provide to lower-emissions generation are unclear. The policies include:

- a REC scheme commencing in 2012 that will replace the FITs, and will set a target for 2 per cent of electricity to be sourced from renewable generation in 2012, rising to 10 per cent by 2022
- a system of mandatory emissions-reduction agreements, including agreements covering 36 electricity generators commencing in 2012.

In addition, the South Korean Government has proposed an ETS for introduction in 2015. However, at this stage details of the policy are unclear.

Table 4.9 **Effects of emissions-reduction policies, South Korea**
2010

Policy name	*Policy type*	*Subsidy equivalent*	*Abatement*	*Implicit abatement subsidy*
		A$m (2010)	Mt CO_2	A$/t CO_2
Korean Feed-in Tariffs	FITs	255	0.6–1	261–435
Korea Certified Emission Reductions	An offset scheme directed at non-renewable electricity	1	0.3	5
General Deployment Subsidy Scheme	Capital subsidy	5–10	0.0	275–518
Regional Deployment Subsidy	Capital subsidy	20–38	0.1	301–564
One Million Green Homes	Capital subsidy	16–29	0.0	617–1 156
Loan Incentive Program	Low-interest loans	15–45	..[a]	..[a]
Total		**313–379**	**1.2–1.4**	**225–401**

[a] Due to overlaps with other policies, abatement and the implicit abatement subsidy for preferential loans were not estimated. **..** Not applicable.

Source: Appendix I.

New Zealand

Only one policy was analysed for New Zealand: its ETS. This has been in place since 2008, with electricity being covered by the scheme since 2010. During the transitional period, firms with ETS obligations are only obliged to surrender one permit for every two tonnes of emissions, and have the option of paying NZ$25 (A$19) rather than purchasing a permit. The net effect is that the implicit abatement subsidy under the scheme is capped at NZ$12.50/t CO_2 (A$10). Permit prices in 2011 have been around NZ$19–21 (A$14–16), meaning that the implicit abatement subsidy has been around A$7–8/t CO_2.

The Commission did not estimate how much abatement is being achieved under the ETS. Emissions are not capped under the scheme and international permits or offsets may be used for compliance. As a result, the permit price is low and it is likely that supply-side abatement is currently modest. However, this could change in the future depending on the policy settings and their impact on the permit price.

Emissions from New Zealand's electricity sector are currently relatively low due to the fuels used. In 2010, around 74 per cent of electricity in New Zealand was generated using renewables (mainly hydro, geothermal and wind). This suggests that New Zealand has fewer opportunities to switch fuels than is the case in countries that use more fossil fuels. However, the New Zealand Ministry of Economic Development (2010b) has forecast that, as a result of the ETS, the country's only coal-fired power plant will close by around 2021, and that future growth in electricity demand will be met by increased use of renewables.

4.4 Demand-side abatement

The previous section quantified the extent to which policies lead to supply-side abatement (abatement due to generators shifting to less emissions-intensive technologies). Emissions-reduction policies can also lead to demand-side abatement by electricity consumers (abatement due to lower electricity consumption) if the policies raise electricity prices.[1]

Given data and other constraints (discussed below), the Commission was not able to precisely quantify the extent to which policies increase electricity prices and thereby lead to demand-side abatement. Instead, this section presents illustrative estimates of demand-side abatement based on a number of simplifying assumptions. The consumption cost — defined as the consumer valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with the diverted expenditure — is also illustrated by using simplifying assumptions.

The impact of emissions-reduction policies on retail electricity prices has been a prominent issue in recent debate about Australia's actions to address climate change, and is likely to continue to be so under current regulatory arrangements (Sims 2010). For example, the NSW electricity-market regulator (IPART 2011a) recently issued a draft decision that would allow retailers to raise regulated tariffs by around 18 per cent on 1 July 2011. Most of this increase (10 per cent) was to cover a rise in network costs (transmission and distribution of electricity). However, much of the remaining increase (6 per cent) was to cover the cost of changes made to the RET in January 2011.[2] This would be in addition to the cost previously allowed for the pre-existing RET, which MMA (2010) estimated would have raised retail electricity prices by around 4 per cent at a national level from 2010 to 2015.[3] Feed-in tariffs and other emissions-reduction policies — such as the NSW

1 Demand-side abatement can also result from policies that encourage consumers to increase their energy efficiency at a given electricity price. As noted in chapter 3, energy-efficiency policies are not included in this study's quantitative analysis due to uncertainty about their impacts.

2 About a month after IPART released its draft decision, the Australian Government (Combet and Dreyfus 2011) announced adjustments to the 'solar credits' used for the small-scale component of the RET, which it claimed would reduce the cost to electricity users by around half in 2012.

3 MMA (2010) estimated that, if the RET that applied in 2010 had remained unchanged, it would have increased retail electricity prices by 4.0 per cent over 2010–2015, provided the Carbon Pollution Reduction Scheme (CPRS) had started in 2013. The estimated price increase was 4.2 per cent if the CPRS started in 2014.

Greenhouse Gas Reduction Scheme — have also been argued to have contributed to the growth of electricity prices in recent years (Garnaut 2011).

Estimation approach and interpretation

Details about the approach and data used to quantify demand-side abatement and consumption costs are provided in appendix L. In summary, the Commission estimated a range within which demand-side abatement might occur, given the total subsidy equivalent estimates from the supply-side analysis, and the bounds within which the own-price elasticity of demand appears to lie.[4]

The resulting estimates should be considered illustrative, or at best only indicative, rather than being a definitive assessment of demand-side abatement and final consumer-price impacts. This is because it was necessary to make various simplifying assumptions to complete the task within the time and data constraints faced by the study. These include the following:

- It was assumed that the cost borne by electricity generators due to emissions-reduction policies was passed through the value chain and ultimately on to consumers, unless it was clear that the policy was explicitly funded by taxpayers. This provides an upper-bound estimate of the actual increase in electricity prices, since no account was taken of factors — such as retail-price regulation and competitive pressures — that can limit producers' scope to pass cost increases on to their customers.
- Differences in policy coverage and electricity prices between different groups of customers — such as residential, commercial and industrial — were factored into the calculations where possible. However, the resulting estimates are unlikely to be as accurate as those generated by industry models that more accurately capture differences between customer groups, including their responsiveness to price changes.
- No account was taken of the compensation that governments sometimes provide to consumers to cushion the price impacts of emissions-reduction policies. Thus, the estimates could overstate the reduction in electricity demand, associated demand-side abatement, and consumption costs.

4 The own-price elasticity of electricity demand measures the proportional change in electricity consumption in response to a unit change in the price. Estimates of this elasticity are typically in the range of -0.2 to -0.7 (appendix L). On this basis, two alternative elasticities were used to quantify demand-side abatement: -0.2 and -0.7. This provided a range within which the true demand response seems most likely to occur, given the empirical evidence on elasticities.

- For a given country, it was common for one or more variables used in the calculations to be unavailable for the same year as the estimated total subsidy equivalent. In such cases, a mixture of data for adjacent years had to be used. Data constraints also led to inconsistent time periods across countries. Thus, the estimates should only be viewed as being illustrative of recent impacts, rather than a precise quantification of those in a specific year.

The supply-side estimates presented earlier in this chapter excluded implicit subsidies that do not induce abatement. This was necessary in order to approximate the resource cost of abating emissions. In contrast, the demand-side estimates presented here include all implicit subsidies associated with a given policy, regardless of whether any abatement is induced. This is done on the grounds that, while no abatement may be achieved, there is a cost and, if it is not explicitly funded by taxpayers, it will be passed on to consumers as higher electricity prices.[5]

Illustrative estimates

The illustrative demand-side estimates are provided in table 4.10. In summary, they would suggest that demand-side abatement may have been relatively minor in percentage terms in most of the analysed countries. This is due to average implicit abatement subsidies and ETS revenues being relatively insignificant when spread across a country's total electricity consumption.

The exceptions are Germany and the United Kingdom, where the estimates suggest that emissions-reduction policies may have raised electricity prices in the range of 12 to 17 per cent, and reduced emissions by 3 to 19 per cent. For Germany, more than half of the price uplift was due to FITs, and almost all of the remainder was due to the European Union ETS. For the United Kingdom, the price uplift was largely due to four policies — the Climate Change Levy, Carbon Emissions Reduction Target, Renewables Obligation, and the European Union ETS.

5 The cost of levying taxes to fund the administration of emissions-reduction policies, and to finance taxpayer-funded abatement subsidies, could be passed on to electricity consumers through means other than electricity prices. The Commission has not estimated this in its demand-side analysis.

Table 4.10 Illustrative estimates of demand-side impacts for electricity[a]

	Unit	Australia[b] Low	Australia[b] High	China[c] Low	China[c] High	Germany Low	Germany High
Change in:							
retail electricity price	A$/MWh	3	4	1	1	25	28
electricity consumption	GWh	- 479	-3 772	-4 216	-28 771	-14 982	-64 968
emissions	Mt CO_2	–	-5	-3	-29	-8	-71
Percentage change in:							
retail electricity price	%	1	2	1	1	12	14
electricity consumption	%	–	-2	–	-1	-2	-10
emissions	%	–	-2	–	-1	-3	-19
Consumption cost:[d]							
total amount	A$m	1	7	2	11	184	900
per tonne of abatement[e]	A$/t CO_2	3	2	–	–	23	13

	Unit	Japan Low	Japan High	New Zealand Low	New Zealand High	South Korea Low	South Korea High
Change in:							
retail electricity price	A$/MWh	3	3	1	1	–	–
electricity consumption	GWh	-2 050	-10 482	- 62	- 483	–	–
emissions	Mt CO_2	-1	-6	–	–	–	–
Percentage change in:							
retail electricity price	%	1	1	1	2	–	–
electricity consumption	%	–	-1	–	-1	–	–
emissions	%	–	-1	-1	-4	–	–
Consumption cost:[d]							
total amount	A$m	3	14	–	–	–	–
per tonne of abatement[e]	A$/t CO_2	3	2	1	1	–	–

	Unit	United Kingdom Low	United Kingdom High	United States Low	United States High
Change in:					
retail electricity price	A$/MWh	28	28	–	–
electricity consumption	GWh	-13 260	-50 949	-1 288	-9 741
emissions	Mt CO_2	-5	-35	-1	-9
Percentage change in:					
retail electricity price	%	17	17	–	–
electricity consumption	%	-3	-12	–	–
emissions	%	-3	-19	–	–
Consumption cost:[d]					
total amount	A$m	185	711	–	1
per tonne of abatement[e]	A$/t CO_2	35	20	–	–

[a] Monetary amounts are in Australian dollars, based on the following exchange rates for A$1: CNY 6.21; €0.70; ¥79.37; NZ$1.30; £0.54; and US$0.92. [b] Australian estimates understate current impacts because they are based on 2010 RET certificate prices, which were low due to an oversupply of certificates. [c] Chinese estimates overstate impacts because they overlook the fact that electricity prices are often set below costs. [d] Consumers' valuation of forgone electricity consumption, less the valuation of other goods that can be purchased with diverted expenditure. [e] This is typically greater for the 'low estimate' because the consumption cost is spread across a smaller reduction in emissions. – Nil or rounded to zero.

Source: Productivity Commission estimates.

In absolute terms, the estimates also suggest that there may have been a large amount of demand-side abatement in China (emissions reduction in the range of 3–29 Mt CO_2). However, this is likely to significantly overstate Chinese demand-side abatement because it assumes that electricity generators always pass on their costs, including those linked to emissions-reduction policies, to consumers. In practice, it appears that Chinese retail electricity prices are often set below the cost of production, particularly for coal-fired generators, and this has led to significant losses for many producers (China Securities Journal 2011; EIU 2011; Lan 2010).

For Australia, the estimates suggest that the price increase from all analysed policies was in the range of 1 to 2 per cent in 2010. It is possible that this national estimate conceals significant differences between states and territories.

Most of the estimated price increase for Australia was due to the version of the RET analysed in this chapter — the (expanded) RET that existed up until the end of 2010. In comparison, MMA (2010) forecast that that version of the RET would increase electricity prices by around 4 per cent over 2010 to 2015. It appears that MMA's higher estimate can be largely explained by the retail prices and REC prices it used in its calculations:

- MMA based its estimates on a REC price of around A$55 to A$70 over 2010 to 2015, whereas the Commission used REC prices that ranged from A$37 to A$60.
- MMA estimated its percentage price change relative to an expected retail price of around A$115/MWh for 2010 to 2015, which was lower than the prices observed by OTTER (2010) and used by the Commission in its calculations (A$163/MWh and A$283/MWh).

Using the same REC and retail prices as MMA, the Commission's approach would result in an estimated retail price increase of up to 3.4 per cent in 2010 for the RET alone, which is closer to MMA's results.

Recent changes to the RET are likely to mean that the price increases estimated by MMA are more representative of the RET's future impacts.[6] The RET scheme was changed significantly in January 2011 by splitting it into small and large-scale components. This was done in response to concerns that 'the inclusion of small-scale technologies and their impact on the renewable energy certificate (REC) market [was] delaying investment in large-scale renewable energy projects' (Australian Government 2010, p. 6; ECALC 2010, p. 2). The number of RECs created in 2010 was far greater than what had to be surrendered in that year. This

6 MMA (2010) estimated that, with the recent changes, the RET would raise retail electricity prices in the range of 4.2 to 4.4 per cent over 2010 to 2015.

placed downward pressure on REC prices, to the extent that it raised concerns that the RET did not provide a sufficient incentive to invest in large-scale renewable generation (ECALC 2010). As noted above, IPART (2011a) has proposed a 6 per cent increase in NSW regulated tariffs to cover the cost of the changes made to the RET.[7]

[7] This is more than the average national increase in retail electricity prices that MMA (2010) estimated over 2010 to 2015 for the most recent version of the RET (4.2 to 4.4 per cent). However, previous estimates by MMA (2009) suggest that the RET causes a higher percentage increase in retail electricity prices in New South Wales than in other states.