Australian Government
Productivity Commission

Carbon Emission Policies in Key Economies

Productivity Commission
Research Report

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The Productivity Commission

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

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

Further information on the Productivity Commission can be obtained from the Commission's website (www.pc.gov.au) or by contacting Media and Publications on (03) 9653 2244 or email: maps@pc.gov.au

Foreword

The Australian Government commissioned this report to help it, and the Multi-Party Climate Change Committee, assess the extent to which key economies are taking action to address climate change. It provides a stocktake of the large number of policy measures in the electricity generation and road transport sectors of the countries studied. And it provides estimates of the burdens associated with these policies in each country and the abatement achieved. While the results are based on a robust methodology, data limitations have meant that some estimates could only be indicative.

In conducting the study, the Commission consulted with government agencies responsible for emissions-reduction policies in China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom and the United States, as well as Australia. The Commission received information and data from a number of expert bodies internationally, including the Institute of Energy Economics in Japan. The Department of Foreign Affairs and Trade and its overseas embassies provided invaluable assistance in facilitating contact with governments and organisations in the study countries. The Commission also hired a number of firms in Australia and internationally to assist with the acquisition of information on emissions-reduction policies.

The timeframes and the nature of the exercise precluded the wide community involvement typical of the Commission's public inquiries. That said, the Commission was able to obtain a range of input and feedback on both the methodology and data through a workshop, exposure drafts sent to experts and study countries, and various meetings with stakeholders during the course of the study. The Commission is very grateful to all those who provided information and analytical input.

The study was prepared by a research team from the Commission's Melbourne office, headed by Paul Belin. In overseeing the project, I was assisted by Commissioner Warren Mundy.

Gary Banks AO
Chairman
May 2011

Terms of reference

Study into Emissions Reduction Policies in Key Economies

Productivity Commission Act 1998

I, Bill Shorten, pursuant to Parts 2 and 4 of the Productivity Commission Act 1998 hereby request the Productivity Commission to undertake a research study on effective carbon prices that result from emissions and energy reduction policies in place or committed in Australia and other key economies.

This work is intended to provide accurate and timely information on the extent of climate action in key economies and sectors.

Context

Reducing greenhouse gas emissions to mitigate the worst effects of climate change is a global challenge. Various mitigation policies are available, though not all impose explicit carbon prices on businesses and households. While some policies such as carbon taxes or emissions trading schemes will involve explicit carbon prices others, such as direct regulation of technologies, renewable energy targets, or subsidies for low emissions technology, impose less transparent carbon prices.

Given this, comparing the impact of different policies on a given sector across economies can be difficult as their scope can vary considerably and their impacts are not always clear. In this context it is important to develop a methodology for aggregating sectoral impacts across policies, and for making comparisons across key economies.

Against this background, the Commission is requested to provide advice on the effective carbon prices that result from emissions reduction and other relevant policies in key economies, where effective carbon prices include both explicit carbon prices, such as taxes or emissions trading schemes, and implicit carbon prices.

Scope of the Study

The Commission is requested to:

- examine and detail emissions reduction policies, either in place or committed in Australia and in other key economies such as the UK, the USA, Germany, New Zealand, China, India, Japan and South Korea

- estimate the effective carbon price per tonne of CO2-e 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.

Key Considerations

In conducting the study and making recommendations the Commission would:

- consult with the business sector, government agencies and other interested parties as appropriate in Australia and internationally

- draw on credible evidence both nationally and internationally, including by utilising local research expertise in economies being examined.

The Commission is to report to the Government by the end of May 2011. The report will be published.

Bill Shorten

Assistant Treasurer

[Received 15 November 2010]

Contents

The following appendixes are not included in this report. They are available on the Commission's website (www.pc.gov.au/projects/study/carbon-prices)

Abbreviations

ACT	Australian Capital Territory
AEMO	Australian Electricity Market Operator
CAFE	Corporate Average Fuel Economy
CARB	California Air Resources Board
CARD	Center for Agricultural and Rural Development
CCL	Climate Change Levy
CCS	Carbon capture and storage
CER	Certified Emissions Reductions
CFGS	Cleaner Fuels Grants Scheme
CHP	Combined heat and power
CHP Act	Combined Heat and Power Act
CNY	Chinese Yuan
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CSI	California Solar Initiative
DCCEE	Department of Climate Change and Energy Efficiency
DECC	Department of Energy and Climate Change (UK)
E10	Mixture of 10 per cent ethanol and 90 per cent petrol
E85	Mixture of 85 per cent ethanol and 15 per cent petrol
EIA	Energy Information Administration (US)
EPBB	Expected performance-based buydown
EPG	Ethanol Production Grants
ERI	Energy Research Institute (China)
ERP	Emerging Renewables Program

ETS	Emissions trading scheme
EUA	European Union Allowance
FIT	Feed-in tariff
FY	Fiscal year
g	Gram
GDP	Gross Domestic Product
GEC	Gas Electricity Certificate
GGAS	Greenhouse Gas Reduction Scheme
GSI	Global Subsidies Initiative
GST	Goods and Services Tax
GW	Gigawatt (equal to one thousand megawatts)
GWh	Gigawatt hour (equal to one thousand megawatt hours)
IEA	International Energy Agency
IEEJ	Institute of Energy Economics, Japan
ISO	Independent system operator
ITC	Investment Tax Credit
KCER	Korea Certified Emission Reduction
KEEI	Korean Energy Economics Institute
KEPCO	Korean Electric Power Corporation
kt	Kilotonne (equal to one thousand tonnes)
KRW	South Korean Won
kW	Kilowatt (equal to one thousand watts)
kWh	Kilowatt hour (equal to one thousand watt hours)
L	Litre
LCA	Life-cycle assessment
LEC	Levy Exemption Certificate
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
LRMC	Long-run marginal cost
LSS	Large Substitute for Small

MAC	Marginal Abatement Cost
MED	Ministry of Economic Development (New Zealand)
MEPS	Minimum energy performance standards
MMA	McLennan Magasanik Associates
MPCCC	Multi-Party Climate Change Committee
Mt	Megatonne (equal to one thousand kilotonnes)
ML	Megalitre
MJ	Megajoule
MW	Megawatt (equal to one thousand kilowatts)
MWh	Megawatt hour (equal to one thousand kilowatt hours)
NDRC	National Development and Reform Commission (China)
NEDC	New European Drive Cycle
NEM	National Electricity Market
NGAC	NSW Greenhouse Abatement Certificate
NSEP	National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles
NSHP	New Solar Homes Partnership
NSW	New South Wales
NYSERDA	New York State Energy Research and Development Authority
NZU	New Zealand Unit
OECD	Organisation for Economic Co-operation and Development
PBI	Performance-based incentive
PC	Productivity Commission
PTC	Production Tax Credit
PV	Photovoltaic
REC	Renewable Energy Certificate
RES	Renewable Energy Standard
RES Act	Renewable Energy Sources Act
RET	Renewable Energy Target
RFS	Renewable Fuel Standard

RGGI	Regional Greenhouse Gas Initiative
ROC	Renewable Obligation Certificate
RPS	Renewable Portfolio Standard
RTC	Renewable Tax Credit
RTFO	Renewable Transport Fuels Obligation
RTO	Regional transmission operator
SGIP	Self Generation Incentive Program
t	Tonne
TGP	Terminal gate price
TWh	Terawatt hour (equal to one thousand gigawatt hours)
USEPA	United States Environmental Protection Agency
VAT	Value-added Tax
VIU	Vertically-integrated utility
W	Watt
WCI	Western Climate Initiative
WEP	Wholesale electricity price

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.

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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**

Price
($/MWh)

p_R

S_R D

A

Subsidy
Equivalent
= A+B+C

Consumption
cost

B

p

C

p_{BL} S_{BL}

D

q q q_1 Output (MWh)
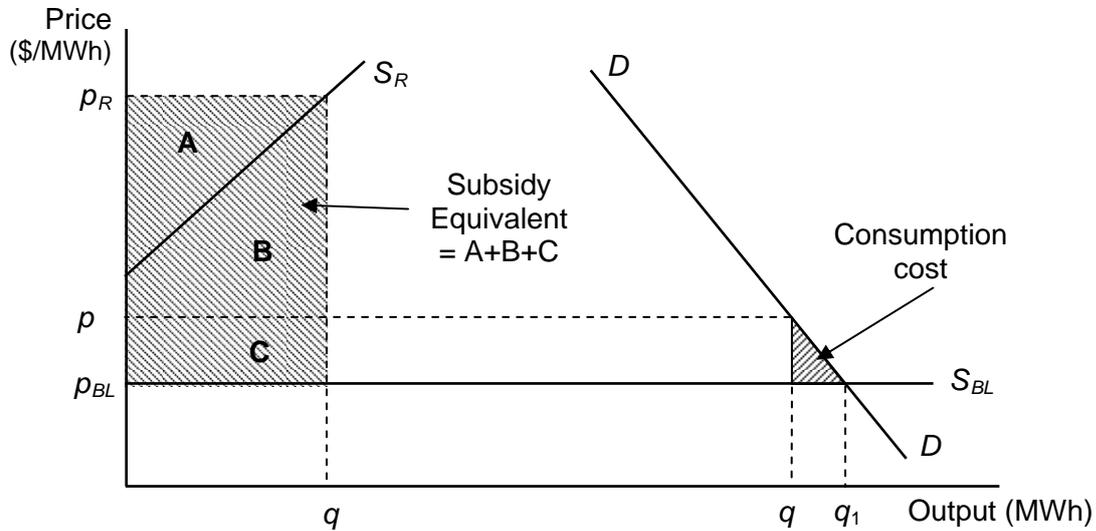
This figure is a stylised representation of an electricity generation market, with emissions-intensive, baseload electricity being provided at a constant unit cost equal to price p_{BL}, pre-intervention. Total consumption is q_1. Introducing a mandatory renewable energy target will induce abatement 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
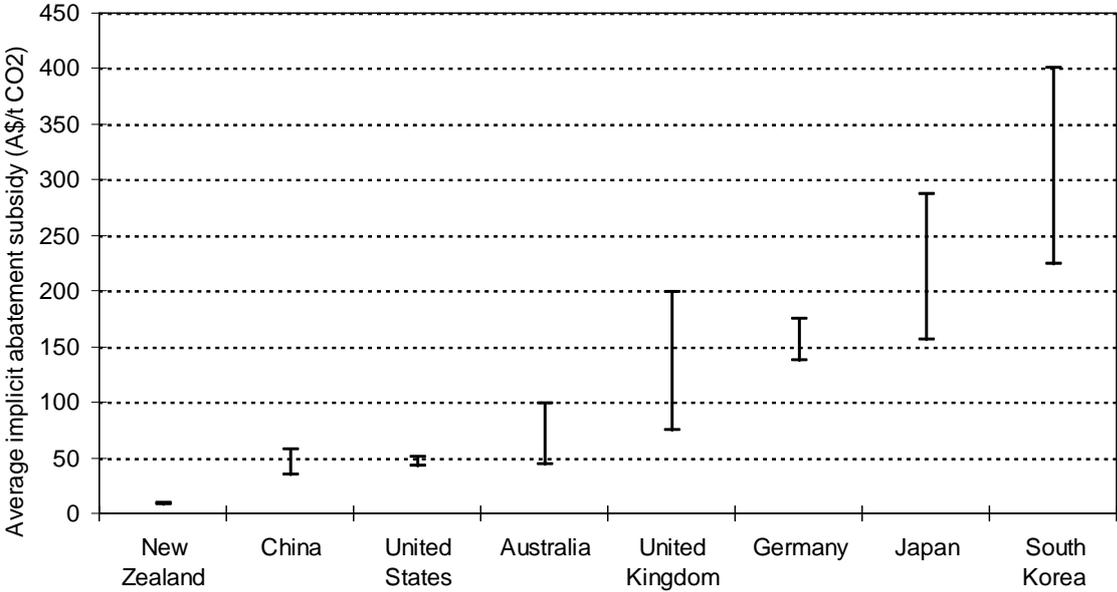
- Although the United Kingdom and Germany achieved more abatement than Australia (in absolute terms and relative to electricity sector emissions), they did so at a substantially higher cost, both absolutely and relatively. For example, using the lower bound estimates, Germany achieved around 67 Mt of 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
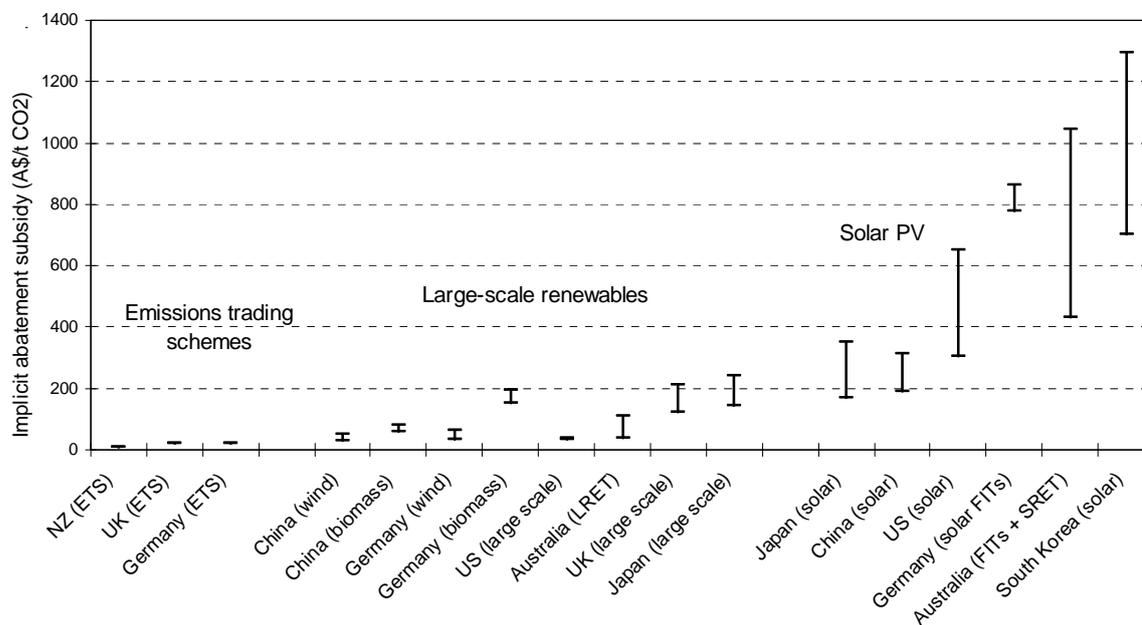
The estimated impact of emissions-reduction policies on electricity prices and thus on consumption costs varies considerably across countries. For most countries, the estimated impacts are small. This is partly because the renewable energy generation induced by the policy measures is a small proportion 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)

Country	Total subsidy equivalent			Total abatement			Total abatement as a percentage of counterfactual road transport emissions			Implicit abatement subsidy		
	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
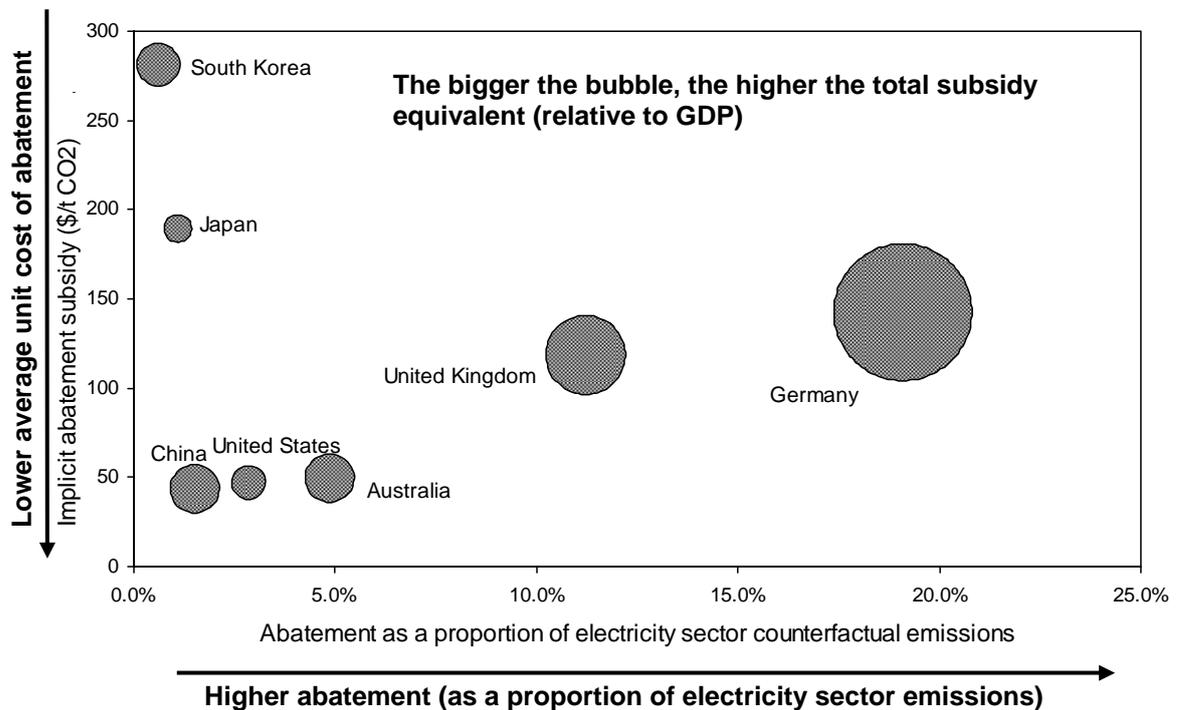
The United Kingdom and Germany stand out as having invested substantial amounts in achieving abatement. Germany achieved substantially more abatement than the United Kingdom but at a slightly higher average cost. The extent to which

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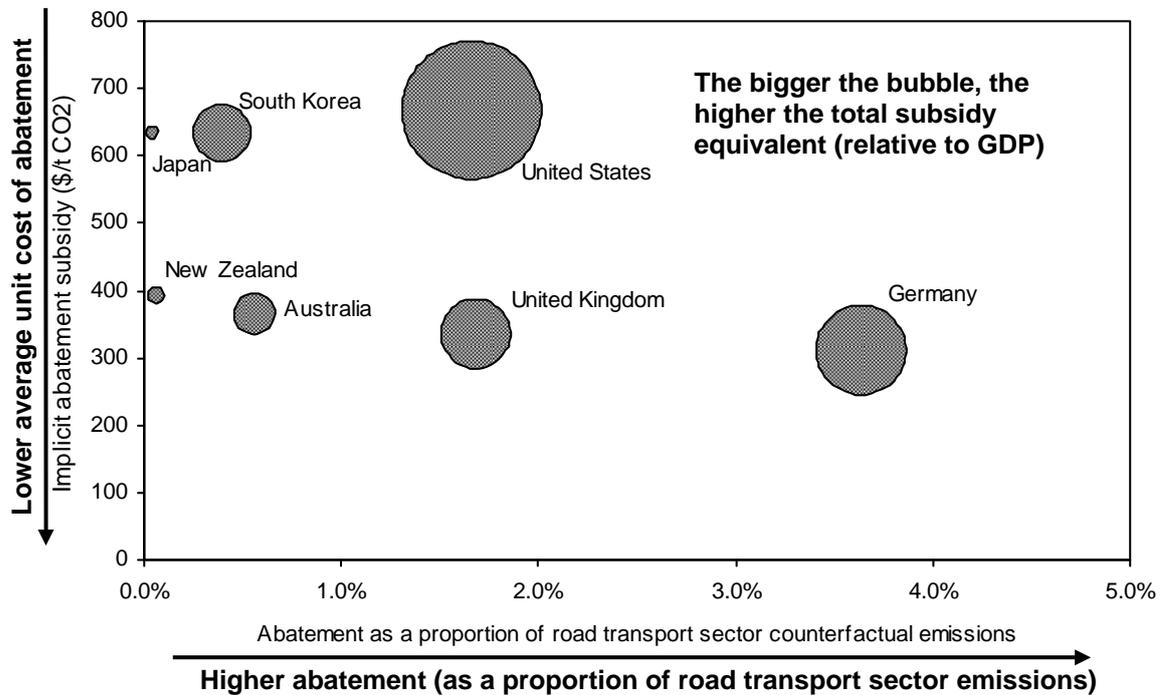
Nevertheless, to provide some indication of the cost effectiveness of actual policy measures, the Commission undertook some highly stylised modelling for Australia, using an 'off-the-shelf' version of the MMRF model.

- 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.

1   Introduction

This study documents the policies used by Australia and other selected economies to reduce greenhouse gas emissions, and provides comparative estimates of their costs and associated abatement. The study was commissioned by the Australian Government to 'provide accurate and timely information on the extent of climate action in key economies and sectors' (terms of reference).

1.1   The Commission's task in brief

The terms of reference essentially ask the Commission to:

- examine and detail key emissions-reduction policies either in place or committed in Australia and other key economies, such as China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom, and the United States

- estimate the effective carbon price per tonne of carbon-dioxide equivalent (CO_2-e) 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.

Estimating 'effective carbon prices' involves difficult conceptual and practical issues. The key conceptual challenge relates to how diverse policies that do not involve the explicit pricing of carbon emissions can be captured in a common price-related metric. Various carbon-price equivalents have been suggested, but none can replicate all impacts of an abatement subsidy scheme. The strongest conceptual basis for comparative purposes involves estimation of abatement costs associated with different policies, and this study has accordingly focused on these. Nevertheless, at a practical level, it has often been difficult to assemble robust data and some of the results are no more than indicative. These issues are covered in depth in chapters on methodology (chapter 3) and some specific sectors (chapters 4 and 5).

1.2   Background to the study

The Australian Government commissioned this study in order to 'help inform the Government's plan to introduce a carbon price in Australia' (Combet, Swan and Shorten 2010). That plan is being formulated with the assistance of the Multi-Party Climate Change Committee (MPCCC), which was established by the Australian Government to 'explore options for the implementation of a carbon price' and to 'help to build consensus on how Australia will tackle the challenge of climate change' (DCCEE 2010c). The MPCCC comprises senior members of the Government (including the Prime Minister) and the Australian Greens, as well as two independent Members of Parliament.

When the Government announced the formation of the MPCCC, it noted that the Committee would be informed by various individuals and agencies, including:

- three independent experts — Ms Patricia Faulkner, Mr Rod Sims and Professor Will Steffen — who would regularly advise the MPCCC on their areas of expertise[1]

- Professor Ross Garnaut, who would also act as an independent expert adviser to the MPCCC, provide an update of his 2008 Climate Change Review (box 1.1), and give advice on pricing carbon

- the Australian Academy of Science, Bureau of Meteorology, Climate Change Commission, CSIRO, and eminent scientists to provide up-to-date assessments of the relevant science

- an 'expert body' tasked with calculating the carbon-price equivalent of measures taken by other countries (DCCEE 2010d).

In November 2010, the Government assigned the latter task to the Productivity Commission. The Government noted that this study would help inform debate about:

- the extent to which Australia was taking action on climate change relative to the efforts of other countries (sometimes referred to as 'comparable effort')

- how the introduction of a carbon price would affect the international competitiveness of Australia's emissions-intensive trade-exposed industries (Combet 2010b, 2010c; Combet, Swan and Shorten 2010).

A proposed carbon-price mechanism was announced by the Government in February 2011. The proposal involves a fixed carbon price to commence on

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[1]   Mr Rod Sims stood down from his role as an expert advisor in May 2011 due to his nomination as Chairman of the Australian Competition and Consumer Commission.

1 July 2012, which after three to five years could transition to an emissions trading scheme. The starting level of the carbon price was to be the subject of future discussions in the MPCCC.

Box 1.1   Update of Garnaut Climate Change Review

In September 2008, the Garnaut Climate Change Review — led by Professor Ross Garnaut — reported to the Australian, State and Territory Governments on recommended medium to long-term policy options to address human-induced climate change. The recommendations were based on an assessment of the likely impacts of climate change on Australia in the absence of effective international efforts to cut emissions; and the climate and economic impacts on Australia of various potential international and Australian policy interventions.

In November 2010, Professor Garnaut was commissioned by the Australian Government to update elements of his 2008 review, where significant changes had occurred, or the sum of expert knowledge had increased, and these would have significant implications for the key findings and recommendations of the review.

A series of publicly-released papers was to be prepared between November 2010 and March 2011, and a final report presented to the Government by 31 May 2011.

Sources: Combet (2010a); Garnaut (2008).

Given the methodological and practical issues the Commission has encountered when seeking to estimate carbon prices, and some expectations about how this study's results might be used, considerable attention has been given throughout this report to explaining the basis for the results and how they should be interpreted.

This study has some similarities to a report prepared by Vivid Economics (2010) for the Climate Institute (2010). However, that exercise was largely confined to a subset of policies that supported 'low-carbon' electricity generation, such as wind and solar. In comparison to Vivid Economics' earlier work, the key extensions in this study include a broader coverage of policies and sectors, and the use of a more extensive set of data sources and expertise. The Commission's methodology also differs from that used by Vivid Economics in important respects (chapter 3).

1.3   Scope of the study

A threshold consideration for the study has been what countries, sectors and policies to include, particularly for estimation purposes. Expectations that the study would contribute to debate about 'comparable effort' and international competitiveness

was factored into this consideration, along with other issues such as data availability.

As previously noted, the terms of reference mentioned eight countries in addition to Australia; namely, China, India, Japan, Germany, New Zealand, South Korea, the United Kingdom, and the United States. They include the world's largest emitters (figure 1.1) and Australia's most important trading partners. While a case could be made for including additional countries such as Canada — on the grounds that it has a similar economic structure to Australia — or other major trade competitors, this would not have been feasible within the timeframe for this study.

Figure 1.1   **Share of global greenhouse gas emissions by country[a]**
2005

Share of global emissions (per cent)
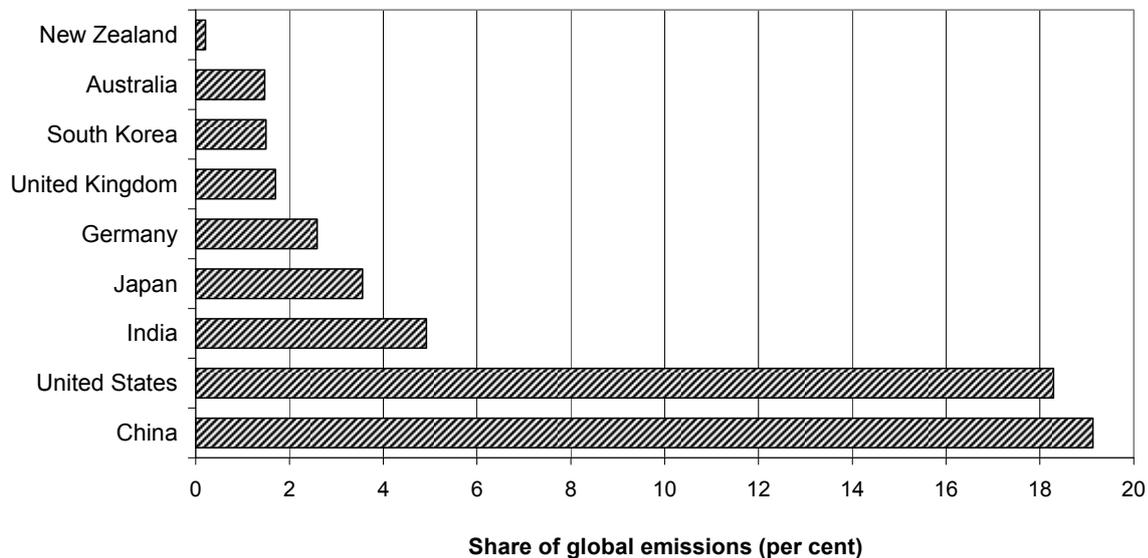
a Excludes land-use change. Emissions are measured in terms of carbon-dioxide equivalents. Comprehensive emissions data that include all six Kyoto gases (CO_2, CH_4, N_2O, PFCs, HFCs, SF_6) for developed and developing countries are not currently available beyond 2005.
Source: WRI (2011).

With respect to sector and policy coverage, a distinction has to be made between the study's stocktake of policies and the quantitative analysis. For the stocktake, the Commission sought to document key emissions-reduction policies in each country regardless of the sector to which a policy applied. In contrast, a narrower coverage of sectors and policies was needed to make the quantitative analysis feasible, given the significant data requirements and time-intensive nature of that task.

The scope of the study was also influenced by the degree to which governments in the covered countries provided assistance to the Commission. This varied

considerably. However, only in the case of India, which chose not to participate, was the Commission unable to obtain adequate information to conduct analysis.

Sectors included in the quantitative analysis

The terms of reference required effective carbon prices to be estimated for the electricity-generation sector, and suggested that they also be estimated for selected industries drawn from the manufacturing and transport sectors, 'where relevant and data permitting'. The Commission interpreted the term 'relevant' as meaning closely connected to the Government's and MPCCC's consideration of an Australian carbon price. As noted above, this encompasses the issues of 'comparable effort' between countries, and international competitiveness.

The Commission considered that the study was more likely to provide information relevant to assessing comparable effort if it concentrated on sectors that were significant emitters and had been targeted extensively by abatement policies.[2] With respect to concerns about international competitiveness, the most relevant coverage would appear to be emissions-intensive trade-exposed industries.

The emissions processes associated with electricity generation and transport account for around half of Australia's emissions (figure 1.2). Manufacturing industries are associated with a range of emissions processes, and so the relative significance of their emissions can only be determined by disaggregating the data by economic sector.[3] In doing so, it is useful to distinguish between the direct emissions that manufacturers generate, and their indirect emissions from the use of electricity.

In 2009, direct emissions from Australian manufacturing amounted to around 67 Mt (table 1.1). That was equivalent to about 12 per cent of total Australian emissions in 2009 (DCCEE 2011c). In comparison, direct emissions from Australian electricity generation were around 207 Mt (DCCEE 2011d). However, almost one-third of the direct emissions from electricity generation were associated with electricity use in manufacturing. As a result, manufacturing's indirect emissions from electricity use (63 Mt) were nearly as large as its direct emissions (67 Mt).

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[2] An important qualification here is that carbon prices can be a misleading indicator of comparable effort. As noted in chapter 3, inefficient policies could be given greater credit than those that achieve the same abatement at a lower cost. Moreover, a high carbon price does not necessarily indicate that a country experiences a greater proportionate impact on its economy or emissions.

[3] For example, direct emissions from aluminium production are included in 'industrial processes', while fuel combusted for energy in the production process is included in 'stationary energy excluding electricity' (DCCEE 2010b).

Figure 1.2   Australian greenhouse gas emissions by emissions process[a]
2009-10
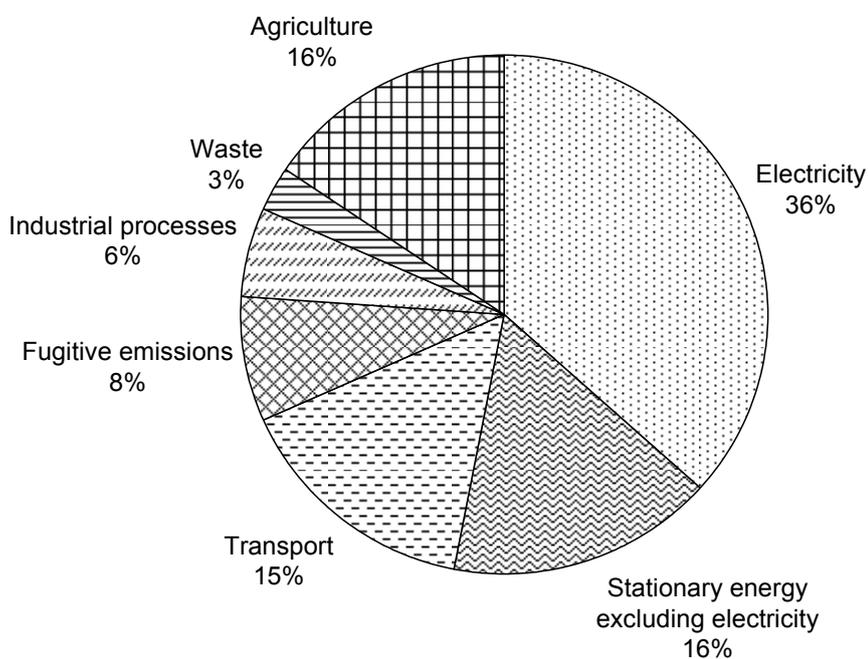
a Excludes land use, land-use change, and forestry. Emissions are measured in terms of carbon-dioxide equivalents.

Source: DCCEE (2010b).

The relative importance of indirect emissions will vary among specific industries within manufacturing, but data are not available from the National Greenhouse Accounts to assess this. Nevertheless, the data for manufacturing as a whole suggest that, by analysing policies that target electricity generation, the study would also cover a significant proportion of abatement policies relevant to manufacturing. This would particularly be the case for emissions-intensive trade-exposed industries that have a high reliance on electricity, such as aluminium production.

The Commission found that policies targeting direct emissions from manufacturing tended to have a narrower coverage of the sector than those for electricity generation, reflecting the manufacturing sector's greater heterogeneity. This raised the prospect of having to estimate carbon prices for a wide range of disparate policies across manufacturing industries, which collectively appear to be less significant (in terms of emissions covered or abatement achieved) than the key policies targeting electricity generation.

Heterogeneity is also a feature of the transport sector. For example, it would be difficult to attribute emissions abatement and costs associated with policies targeting international aviation and shipping to specific countries. For this reason,

and as a result of certain international agreements, emissions abatement in these sectors is being pursued through international, rather than domestic, policy-development processes. In contrast, land transport has a much stronger linkage to a specific country. Over 90 per cent of Australia's land-transport emissions come from road transport (DCCEE 2011c).

Table 1.1 **Greenhouse gas emissions associated with Australian manufacturing**
2009

Economic sector[a]	Emissions
	Mt CO_2-e
Direct emissions[b]	
Food, beverages, tobacco	3.85
Textile, clothing, footwear and leather	0.39
Wood, paper and printing	2.35
Petroleum, coal and chemical	17.34
Non-metallic mineral products	11.47
Metal products	30.65
Machinery and equipment	0.49
Other manufacturing	0.02
Total manufacturing	66.56
Indirect emissions from purchased electricity[c]	**62.97**

a Sector definitions are those used in the Australian and New Zealand Standard Industrial Classification. **b** Direct emissions are produced from sources within the boundary of an organisation and as a result of that organisation's activities. **c** Purchased electricity is defined as electricity that is purchased or otherwise brought into the organisational boundary of the entity.

Sources: DCCEE (2010a, 2011c, 2011d).

In light of the above, and given the time frame of the study, the Commission therefore decided only to analyse policies directly targeting electricity generation and road-transport fuels (those used in road freight and private vehicle use).

Policy coverage

As noted above, this study's policy stocktake covered a wider range of policies than the quantitative analysis. However, even for the stocktake, the Commission considered it necessary, in order to make the task feasible, to apply a 'filter' to screen out less significant measures. Thus, for example, the policies of local governments tended to be excluded, on the grounds that their impact on national abatement was limited. On the other hand, it was considered important to include policies that, while not having an explicit objective to reduce emissions, did appear

to have a material impact on emissions. Further detail on the approach used to select policies for the policy stocktake is provided in chapter 2.

An overarching issue for both the policy stocktake and quantitative analysis was the inclusion, as requested in the terms of reference, of 'committed' policies that are not yet in place. In broad terms, the Commission considered a policy to be committed if it had a high probability of being implemented. In practice, this required a degree of judgement based on a range of information, including whether a policy had reached an early stage of enactment, such as being tabled in the country's legislature, where relevant. A further criterion was that the necessary details required to describe and analyse the policy had been announced. It should also be noted that governments in all of the relevant countries were given an opportunity to provide feedback on the policies documented and analysed in the study.

A range of criteria were used to select the subset of policies in the stocktake for which abatement costs were estimated. The criteria included that the selected policies penalised emissions or subsidised abatement, and accounted for a sizeable share of emissions reductions or abatement costs in the relevant sector. Some types of policies — such as energy-efficiency initiatives, R&D subsidies, education campaigns and voluntary schemes — were excluded on the grounds that any associated emissions abatement was highly uncertain, and may not occur until far into the future.

1.4   Conduct of the study

The terms of reference for this study were received from the Assistant Treasurer on 15 November 2010, with the Commission being given about six months to complete its report to the Government.

Given the timeframe for the study, and that it was largely a technical exercise, the Commission proceeded somewhat differently from most other studies and inquiries it undertakes. For example, it did not call for public submissions. Nor was it feasible to publish a formal draft report.

Nonetheless, the Commission endeavoured to remain as accountable and transparent as possible, and to draw on a sufficiently wide range of expertise. In summary, this involved:

- keeping interested parties informed about progress of the study, including by publicly releasing a background paper on study processes and a working paper on the proposed methodology for the quantitative analysis

- consulting a wide range of interested parties in Australia and the other study countries, including through face-to-face meetings, a roundtable on methodology, briefings to industry forums, and overseas phone calls and correspondence

- obtaining information from expert bodies in the study countries, including the Energy Research Institute of the Chinese National Development and Reform Commission, and energy agencies in Japan and South Korea

- hiring contractors in Australia and other countries to assist with the acquisition of information on emissions-reduction policies and the data required to calculate carbon prices

- providing draft results to governments and other relevant experts in the study countries for comment

- making as much of the data and contractor reports used in the study as publicly available as possible.

Further details are outlined in box 1.2. The parties who assisted the study — including those that participated in meetings, provided comments on draft results, and acted as contractors — are listed in appendix A.

The Commission is grateful to all those who participated in meetings and roundtables, and provided data and other assistance. The Commission also thanks staff in Australia's overseas embassies, who facilitated contact with governments and experts in the study countries. The assistance provided by governments in China, Germany, Japan, New Zealand, South Korea, the United Kingdom and the United States, as well as in Australia (including the states and territories), is also appreciated.

The remainder of this report is structured as follows. The next chapter summarises the stocktake of emissions-reduction policies for each country. Chapter 3 outlines the methodology used for the quantitative analysis. Chapters 4 and 5 summarise the resulting estimates for the electricity-generation and road-transport sectors respectively. Finally, chapter 6 wraps up the report by drawing together the key messages from the policy stocktake and quantitative analysis.

The report is supported by a number of appendices. Three of the appendices are provided in printed form at the end of this document. These list the parties that participated in the study (appendix A), summarise the emissions-reduction policies analysed in chapters 4 and 5 (appendix B), and describe energy-efficiency policies in the study countries (appendix C).

Box 1.2 **Consultations and expert input**

As requested in the terms of reference, the Commission consulted with the business sector, government agencies and other interested parties, and utilised research expertise in the economies that were examined. The relevant parties are listed in appendix A. In summary:

- Shortly after receiving the terms of reference, the study was publicised on the Commission's website, a background paper was released, and interested parties were invited to register their interest.

- The Commission held meetings with a cross-section of interested parties in Australia, including government agencies, representatives from the electricity-generation sector, and Professor Ross Garnaut. Aspects of the study were also discussed, by telephone and in writing, with parties in other countries who had relevant expertise.

- The Commission initiated consultations with Australia's Department of Foreign Affairs and Trade (DFAT) at an early stage in the study. DFAT facilitated contact with parties in other countries, and provided comments on early drafts of the policy stocktakes for individual countries.

- The Chairman of the Productivity Commission wrote to the heads of relevant government agencies in all of the study countries seeking their assistance.

- A roundtable was held with an expert group in Melbourne on 1 December 2010 to explain the study process and obtain input on what data and methodology to use. The participants came from government, industry, private consulting firms, and universities.

- The Chairman of the Productivity Commission made presentations at three industry forums in March 2011 to brief interested parties on progress of the study and elicit their feedback.

- A paper outlining the methodology to be used for the quantitative analysis was publicly released in March 2011 (PC 2011). Drafting of the paper had benefited from written comments by individuals who had attended the December roundtable.

- Contractors in Australia and other countries were hired to assist with the acquisition of information on emissions-reduction policies in the study countries, and the data required for a quantitative analysis of policies in the electricity and transport sectors. A single consortium of contractors covered all countries apart from Australia. Other contractors with specific country or industry expertise were hired to provide supplementary information for a subset of the study countries.

- Excerpts of this report, and the associated policy stocktakes and quantitative results, were circulated in draft form to relevant experts in Australia and overseas for comment. This included national governments in each country covered by the study.

The remaining appendices are available on the Commission's website. They provide the detailed information and analysis on which this document is based. In particular, there are detailed policy stocktakes for each study country, and in-depth descriptions of the quantitative analysis for the electricity-generation and road-transport sectors.

2   Emissions-reduction policies

Key points

- There is a large number and diverse range of emissions-reduction policies in place, and in the process of being implemented, in nearly all of the nine countries studied — the Commission has identified more than 1000 policies in total.

- Some countries use cross-sectoral policies.
  - Germany, the United Kingdom and New Zealand operate multi-sector — but not yet economy-wide — emissions trading schemes (ETSs). (ETSs are under consideration or proposed in Australia, China, Japan, South Korea, and the United States.)
  - The United States is in the process of setting economy-wide emissions standards for all large emitters of greenhouse gases.

- Most countries have adopted sector-specific policies, primarily targeting electricity generation and road transport and, to a much lesser extent, agriculture and forestry. Few policies specifically target other sectors (such as resources or manufacturing).

- In the electricity generation sectors of the countries studied:
  - renewable energy targets (using certificate schemes) and feed-in tariffs (often supported by capital subsidies) are the primary emissions-reduction policies
  - subsidies and preferential loans to support the construction of renewable generation capacity are common
  - technology standards (regulating generation technology and emissions levels) are also used
  - electricity-specific ETSs are in use in the United States (across ten states) and Australia (in New South Wales). The cross-sectoral EU and NZ ETSs also apply.

- In the transport sectors of the countries studied:
  - policies predominantly target fuels and vehicles. Fuel taxes, government assistance to biofuels (such as fuel content mandates and excise exemptions), and vehicle fuel efficiency standards are the primary emissions-reduction policies
  - tax exemptions and subsidies for lower-emissions vehicles are common
  - policies such as investment in public transport and freight infrastructure, that may less directly reduce emissions, are widely used.

- A wide range of energy efficiency policies targeting households and businesses are in place in all the countries studied.

This chapter summarises the emissions-reduction policies of the nine countries covered by this study — Australia, China, Germany, India, Japan, New Zealand, South Korea, the United Kingdom, and the United States. Specific details of the policies analysed in chapters four and five are in appendix B, and a full stocktake of policies can be found on the Commission's website (appendix P).

2.1 Approach

The Commission used three main criteria in determining whether to include policies in its stocktake. Generally, policies were included if they:

- are in place or committed — where 'committed' means the policy not only has a high probability of being implemented, but specific details have also been released (for example, the policy is in the process of enactment)

- have the explicit intent, or the effect, of reducing emissions (for example, fuel excises are often considered to be road-user charges or general taxation but they also have the effect of reducing emissions)

- operate at the national or state/provincial level (policies at the local government level were generally not included because they are not likely to be material to cross-country comparisons).

The Commission used two further criteria to identify the smaller number of policies analysed in chapter 4 (electricity generation) and chapter 5 (road transport). Generally, policies were analysed if they:

- penalise emissions or give an incentive for abatement (which covers explicit or implicit taxes and subsidies, and regulations, but not voluntary codes)

- have a material impact on a country's emissions in a sector and/or impose significant total costs.

The stocktake was compiled by the Commission through a combination of its own research, utilisation of existing stocktakes of emissions-reduction policies[1], consultation with government agencies in each of the study countries, and assistance from specialist consultants. Governments in each of the study countries were given the opportunity to comment on a listing of their country's policies, while in draft form.

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[1] Datasets include those published by the International Energy Agency, the United Nations Framework Convention on Climate Change and the Department of Climate Change and Energy Efficiency (Australia).

The Commission's stocktake identified over 1000 policies across the nine countries, with large numbers in nearly all of the countries studied (table 2.1).

Table 2.1   **Number of policies in the stocktakes, by country**

	Australia	China	Germany	India	Japan	NZ	South Korea	UK	US	Total
Number	237	82	131	68	67	31	69	104	307	1096

The stocktakes include the key policies analysed in chapters 4 and 5, as well as other policies identified in each country. However, it is unlikely to be exhaustive for all countries. For example, given time and resource constraints, research for the United States necessarily focused on federal government policies, similar policies used in multiple states, schemes in which multiple states participated, and other state government policies in the five states with the largest greenhouse gas emissions.

Emissions-reduction policies were classified into specific categories using a taxonomy based loosely on one developed by the International Energy Agency (IEA 2011b). The Commission's taxonomy has six broad categories and 33 policy types (table 2.2).

Table 2.2   **Taxonomy of 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

For the purposes of presentation in this chapter, most policies were also grouped by sector. In particular, they were divided into those that have cross-sectoral coverage and those that are specific to electricity generation, transport, forestry and agriculture. This was done so that the documentation of key policies here aligns with the sector-specific analysis in chapters 4 and 5.

The one exception to this sectoral approach was energy efficiency policies. The main types of energy efficiency policies are summarised in the last section of this chapter, with more detailed discussion on select policies in appendix C.

A number of industries (such as resource extraction, processing and manufacturing) are not presented separately by sector in this chapter. Generally, this is because there are few emissions-reduction policies that are specific to these industries in the countries studied. Their emissions are covered (to varying degrees) through:

- cross-sectoral policies (such as emissions trading schemes (ETSs), carbon taxes or emissions standards that apply to sources of emissions across an economy)

- energy efficiency policies (that target large users of energy, including electricity oil, gas, coal and biomass).

Emissions in these industries are also indirectly covered to the extent that they use an input covered by other policies (such as electricity or transport policies). For example, while there are few policies specifically targeting manufacturing emissions in Australia, approximately half of the sector's total emissions are from electricity that is already subject to a range of emissions-reduction policies (chapter 1).

Details on individual policies analysed in chapters 4 and 5 are provided in appendix B, and a full stocktake of policies can be found on the Commission's website (appendix P).

Copenhagen Accord commitments

In 2010, each study country made an international commitment to reduce or limit the growth in their emissions by a 2020 deadline as part of the Copenhagen Accord (table 2.3). However, the commitments are expressed in ways that are not directly comparable. The 2020 targets for Australia, Germany, Japan, New Zealand, South Korea, the United Kingdom and the United States are expressed as a percentage reduction in emissions relative to the level of emissions in a base year. Base years vary from 1990 (for Germany, Japan, New Zealand and the United Kingdom), to 2000 (for Australia), to 2005 (for the United States). Commitments for China and

India are expressed as a reduction in emissions per unit of GDP (emissions intensity) against the base year 2005.

McKibbin, Morris and Wilcoxen (2010) attempted to convert the various countries' commitments into common terms — a percentage change in emissions relative to a standard base year.[2] They used the G-Cubed model of the global economy to estimate emissions under a 'no policy action' scenario (business as usual), and emissions resulting from a stylised implementation of the Copenhagen targets. The authors used these two scenarios to reformulate the original Copenhagen targets into equivalent targets with common base years of 1990, 2000, 2005 and 2020.

Table 2.3 **Emissions-limitation commitments under the Copenhagen Accord, by country**

Country	Commitment to limit emissions by 2020, relative to various base years
Australia	5 per cent to 25 per cent below 2000 level Moving above 5 per cent is conditional on a global, comprehensive agreement.
China	40 per cent to 45 per cent cut to 2005 emissions intensity level[a] Increase the proportion of non-fossil fuels used in primary energy consumption to 15 per cent, and increase forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic metres relative to 2005.
Germany	20 per cent to 30 per cent below 1990 level Moving above 20 per cent is conditional on a global, comprehensive agreement for the period beyond 2012.
India	20 per cent to 25 per cent cut to 2005 emissions intensity level[a]
Japan	25 per cent below 1990 level Conditional on all major economies joining a 'fair and effective international framework with ambitious targets'.
New Zealand	10 per cent to 20 per cent below 1990 level, conditional on a global, comprehensive agreement.
South Korea	30 per cent below business as usual level
United Kingdom	20 per cent to 30 per cent below 1990 level Moving above 20 per cent is conditional on a global, comprehensive agreement for the period beyond 2012.
United States	17 per cent below 2005 level[b]

[a] An 'endeavour' to reduce emissions intensity. [b] 'In the range of' 17 per cent.

Source: DCCEE (2010c).

McKibbin, Morris and Wilcoxen (2010) found that varying the base year used to express a commitment can significantly affect its apparent stringency. They also note that expressing emissions-reduction targets relative to a given base year gives little useful information about the actual size of the reduction required by 2020 compared to a business as usual scenario. For example, Australia's 2020

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[2] Where commitments are conditional or given as a range, the lower-bound levels were used.

Copenhagen commitment to an unconditional emissions reduction of 5 per cent on 2000 levels is estimated to be equivalent to a 30 per cent increase in emissions on 1990 levels, an 18 per cent reduction relative to 2005 levels, and a 35 per cent reduction against business as usual emissions levels in 2020.

When expressing Copenhagen commitments in terms of reductions against business as usual projections by 2020, McKibbin, Morris and Wilcoxen (2010) estimated that Japan has committed to the largest reduction (48 per cent), Australia's commitment is in line with that of Europe (36 per cent) and the United States (33 per cent), while China's commitment is smaller (22 per cent). India's commitment is estimated to result in an increase in emissions of 0.4 per cent by 2020, compared with business as usual.[3]

2.2   Cross-sectoral policy measures

Most of the policy measures in the countries studied apply to a particular sector. But there are some cross-sectoral policies that target emissions more broadly. The most widely applied cross-sectoral policies are emissions trading schemes. Carbon taxes are not currently used, but are under consideration in Japan and South Korea. The United States is in the process of introducing greenhouse gas emissions standards for all large stationary emitters.

Emissions trading schemes

ETSs are the only policy type that involve an explicit market price on emissions. The most common form of ETS is a cap-and-trade scheme that sets a limit on the amount of emissions, with permits issued that allow holders to emit greenhouse gases up to a quantitative cap. Permits can be traded, thus establishing a market 'price' for emissions.

Among the countries studied, the United Kingdom and Germany participate in the European Union's cap-and-trade ETS. The scheme applies to multiple sectors covering around 40 per cent of EU emissions. New Zealand operates a national ETS that is currently in a transition phase — there is no binding cap on total emissions and the government has effectively capped the price of emissions certificates. The New Zealand ETS covers a range of sectors accounting for around 45 per cent of the country's emissions. A cap-and-trade ETS is planned for a group of western

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[3] McKibbin, Morris and Wilcoxen (2010) did not report estimates for South Korea and New Zealand.

states in the USA, although it is likely that the scheme will only cover California by 2012 (box 2.1).

The Australian Government has announced that it is planning to introduce an ETS in July 2012, with a fixed price on emissions permits for the early years of the scheme (chapter 1). Japan and South Korea have also proposed the introduction of an ETS, although implementation has been delayed (Reuters 2010). China is considering trialling a pilot ETS in some of its provinces (Reuters 2011). Japan, South Korea and China currently operate voluntary ETSs of limited scope. ETSs that apply exclusively to electricity generation are discussed in section 2.3.

Carbon taxes

A carbon tax is an alternative mechanism for effectively putting an explicit price on emissions. Carbon taxes have generally not been used to date in the countries studied. However, some governments have taxed the use of fossil fuels. For example, the UK Climate Change Levy (introduced in 2001) is a tax on energy used by business and the public sector (including electricity, gas and coal). The tax rate depends on the energy content of the fuel rather than emissions. The Japanese Government has announced that the Petroleum and Coal tax — a pre-existing (revenue) tax on crude oil and petroleum products — will be increased in stages over the next four years based on the 'emissions content' of fossil fuel inputs. South Korea is considering introducing a carbon tax from 2012. In its early years, Australia's fixed price ETS would be equivalent to a carbon tax.

US greenhouse gas emissions standards

An 'emissions standard' places restrictions on the type and quantity of emissions that can be released into the atmosphere from a specified source. The US Environmental Protection Agency (USEPA) has the power to regulate greenhouse gas emissions under the *US Clean Air Act 1963*. In January 2011, the USEPA progressively began requiring large stationary greenhouse gas emitters to hold a permit to continue emitting. Initially, permits are being required only for the largest emitters (covering fossil fuel electricity generators and petroleum refineries). Eventually, they will be required for any type of stationary installation emitting more than 50 000 tonnes of greenhouse gases per year (covering approximately 70 per cent of US emissions).

European Union

The European Union Emissions Trading Scheme (ETS) commenced in 2005 and operates in 30 countries (including Germany and the United Kingdom). It covers CO_2 emissions from power stations, combustion plants, oil refineries, iron and steel works, and factories making cement, glass, lime, bricks, ceramics, pulp, paper and board. Transport fuels, agriculture and forestry are not covered. Aviation fuels will join the scheme in 2012 with the petrochemicals, ammonia and aluminium industries and additional greenhouse gases to be covered in 2013. Covered emitters are obliged to surrender one European Union Allowance (EUA) for each tonne of CO_2 emitted. The total number of EUAs issued is capped at a level consistent with the target for EU-wide emissions, and permits are traded. Offset credits obtained under the Kyoto Protocol Clean Development Mechanism can be used to meet obligations under the European Union ETS. From 2013, the emissions cap will decline annually to achieve a 21 per cent reduction relative to 2005 levels by 2020. In May 2011, the spot price was around €16–17 (A$22–23).

New Zealand

The New Zealand ETS commenced in 2008. It covers forestry, electricity generation, transport fuels (including domestic aviation and coastal shipping) and industrial processes. Waste and synthetic gases are scheduled to be covered from 2013, and agriculture from 2015. Emissions include CO_2 from liquid fossil fuels, and CO_2 and methane from electricity. By 2015, all sectors of the economy will be covered. Covered emitters must surrender New Zealand Units (NZUs) to cover emissions. Currently, the number of NZUs that can be issued is not capped. In the transition phase (July 2010 to December 2012), firms with ETS obligations are only required to surrender one permit for every two tonnes of emissions. Emitters may pay NZ$25 (A$20) instead of surrendering a NZU, effectively capping the per-tonne price at NZ$12.50 (A$10). Offset credits obtained under the Kyoto Protocol Clean Development Mechanism can be used to meet obligations under the New Zealand ETS. From 2013 onwards, one permit will be required for each tonne of CO_2-e. Early 2011 spot prices for NZUs have ranged from NZ$19–21 (around A$14–16).

United States

The Western Climate Initiative was intended to cover seven US states (California, New Mexico, Washington, Oregon, Montana, Utah and Arizona) and four Canadian provinces (British Columbia, Ontario, Québec and Manitoba). The initiative aims to reduce emissions to 15 per cent below 2005 levels by 2020. Currently, it appears that only California is fully committed to implementing an ETS by 2012. The Western Climate Initiative has recommended that the 2012 cap be the same as projected emissions for that year. Therefore, it is likely that the permit price and abatement will be close to zero in 2012.

Sources: Appendixes B, F, H, J, K.

The USEPA is in the process of establishing the first industry-specific greenhouse gas emissions standards that will apply to permit holders. Draft emissions standards for electricity generation are scheduled for release in July 2011, and for petroleum refineries in December 2011. The mechanisms that will be used to meet the new standards are still unclear at this point. In the case of electricity generation, the EPA has indicated the types of abatement technologies that may be used. These include fuel switching (from coal to gas), carbon capture and storage (CCS), and improvements in generation efficiency (USEPA 2011a; 2011b). Technology standards that apply specifically to electricity generation and transport are discussed in sections 2.3 and 2.4 respectively.

2.3   Policy measures specific to electricity generation

Renewable energy targets (using certificate schemes) and feed-in tariffs (supported by capital subsidies and preferential loans for renewable generation) are the most widely applied policies targeting electricity generation in the countries studied. Technology standards and ETSs have been adopted to varying degrees. Fossil fuel taxes, differential electricity taxes, and direct tax incentives are used to a lesser extent (table 2.4).

Renewable energy targets

A renewable energy target — a type of technology standard — requires that a quantity or proportion of electricity be generated using specified renewable technologies over a given period of time. In some countries targets are aspirational. Targets can be met through renewable energy certificate schemes or various other policy instruments (such as feed-in tariffs).

Table 2.4 **Emissions-reduction policies specific to electricity generation, by country**

The jurisdictional coverage of a policy may be national (N), sub-national (S) or European Union (EU).

	Australia	China	Germany	India	Japan	NZ	South Korea	UK	US
Feed-in tariffs	S[a]	N,S	N	N,S	N		N	N	S
Renewable energy certificate schemes	N			S[b]	N		N[c]	N	S[d]
Other technology standards	S[e]	N						N	N,S[f]
Capital subsidies	N,S	N,S	N,S	N,S	N,S	N	N	N,S[g]	N,S
Preferential loans		N	N,S	N			N	N	N
Emissions trading schemes	S[h]	S[i]	EU[j]		N[k]	N[j]	N[l]	EU[j]	S[m]
Fossil fuel taxes					N	N			
Differential electricity taxes								N	
Tax incentives	S	N		N			N	N	N

[a] Each state (apart from Tasmania) operates its own policy. [b] A certificate trading scheme is under development. [c] From 2012. [d] Mandatory in 36 states; most of these states use certificate schemes. [e] Queensland Gas Scheme. [f] From January 2011, the US Environmental Protection Agency began the regulatory process for setting national emissions standards for all stationary installations that emit more than 50 000 tonnes per year. At least 6 states have their own current emissions standards. [g] In Scotland, Wales and England. [h] NSW and ACT Greenhouse Gas Reduction scheme (baseline and credit). [i] Several Chinese cities have implemented voluntary emissions trading schemes (including Beijing, Tianjin and Shanghai). [j] Cross-sectoral ETS that also applies to electricity generation. [k] Japan operates a small voluntary ETS. It appears that introduction of a national ETS has been delayed. [l] South Korea operates a small voluntary baseline and credit ETS. A national ETS is scheduled for 2015 although it appears that this has been delayed. [m] Ten states participate in the Regional Greenhouse Gas Initiative. The Western Climate Initiative is a framework to establish a cross-sectoral ETS, and intends to cover seven western US states and four Canadian provinces. Only California has committed to implementation by 2012.

Sources: Appendixes B, D–K.

Renewable energy certificate schemes are the most common instruments for implementing mandatory renewable energy targets among those countries studied. Under such schemes, tradable certificates are issued to renewable electricity generators for the units of electricity they produce. An obligation is placed on generators or electricity retailers to surrender these certificates to a regulator to meet the renewable energy target. Renewable generators receive the market price for the electricity they produce, and earn an additional subsidy by selling the certificate to a retailer or generator with obligations under the scheme. The rules governing how renewable electricity is certified vary between schemes, altering which renewable generation technologies are eligible for a subsidy, as well as the level of subsidy received per megawatt hour of electricity.[4]

Mandatory renewable energy targets of varying magnitude and using different instruments have been adopted in Australia, the United Kingdom and Germany (under European Union mandates), Japan, South Korea, and in a majority of US and Indian states. China has adopted an aspirational renewable energy target with sub-targets for different renewable generation technologies. New Zealand has an aspirational target (table 2.5).

Other technology standards

Diverse other technology standards are applied in the electricity sectors in the United States, the United Kingdom, China and Queensland. Generally, technology standards place requirements or restrictions on the construction or operation of generation technologies.

In the United States, a number of states place limits on the emissions intensity of new electricity generators. In the case of California, the emissions standard effectively prohibits new coal-fired power stations without CCS. In the United Kingdom, any new coal-fired power station with a capacity of over 300 megawatts (MW) is required to be 'carbon capture ready'. Cross-sectoral emissions standards being implemented by the USEPA are discussed in section 2.2.

China's Large Substitute for Small policy is a unique technology standard that requires the decommissioning of small, inefficient thermal power plants to allow the construction of larger, more economically efficient and less emission-intensive

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[4] Rules can govern: tethering — the type of generation technology eligible for certification; banding — the number of certificates created per megawatt hour of electricity; or carve outs — a mandate that a percentage of the renewable energy target must come from a designated technology.

electricity generation. Up to 2011, the policy focused on closing small plants (below 50 MW capacity), larger older plants (less than 100 MW and in operation for over 20 years), and plants of less than 200 MW that have reached the end of their design life. Between 2011 and 2020, more plants between 100 and 200 MW will be closed.

Table 2.5   **Renewable energy targets, by country**

Country	Target	Instrument for meeting the target
Australia[a] (National)	20% by 2020 Mandate	A tradable certificate scheme (the Large-scale Renewable Energy Target) covering large-scale renewable energy projects (such as wind and solar farms, and hydroelectricity schemes).
China (National)	15% by 2020 Aspirational	Various instruments including capital subsidies and feed-in tariffs for wind, biomass, solar and hydroelectricity. Individual targets are set for each source of generation.
Germany (National)	20% by 2020 EU Mandate	Feed-in tariffs.
India (At least 21 states)	From less than 1% to 14% by 2010-11 to 2015-16 Mandate	Renewable energy certificate trading is under development. Eligible technologies differ across states. Separate targets are set for solar and non-solar generation.
Japan (National)	Around 1% Periodic mandate	The government imposes a periodic obligation on electricity retailers to use a certain amount of renewable electricity. Eligible technologies include solar photovoltaic, wind, biomass, small hydroelectricity and geothermal.
New Zealand (National)	90% by 2025 Aspirational	To be implemented by removing 'unnecessary regulatory barriers' faced by renewable energy generation.
South Korea (National)	10% by 2020 Mandate	From 2012 companies with power generation facilities of more than 500 MW (currently 13) will be required to purchase renewable energy up to the target.
United Kingdom (National)	20% by 2020 EU Mandate	Tradable certificate scheme — different technologies receive different levels of support depending on their cost.
United States[b] (At least 41 States)	Varies by state Mandate and aspirational	Most states have renewable tradable certificate schemes. Some states use feed-in tariffs. Eligible technologies differ across states.

a Australia also operates the Small-scale Renewable Energy Scheme (SRES). This rewards owners of small-scale renewable generation such as heat pumps and solar water heaters, which receive Small-scale Technology Certificates. Electricity retailers are required to purchase a number of certificates each year. **b** Thirty-six states have mandated targets and five states have aspirational targets.

Sources: Appendixes B, D-K.

In Australia, the Queensland Government operates the Queensland Gas Scheme. The scheme requires electricity retailers to source a minimum percentage of their electricity from eligible gas-fired generation. The mandatory target increased from

13 per cent in 2008 to 15 per cent in 2010. By 2020, the target will rise to 18 per cent.

Feed-in tariffs

Feed-in tariffs pay a guaranteed tariff for electricity produced with prescribed technologies (generally renewable sources such as solar photovoltaic (PV) and wind generation). FITs are available for larger-scale generation (such as wind farms, biomass and biogas) and smaller-scale generation (such as domestic solar PV). Tariffs can be calculated on a net or gross basis. A net approach pays a tariff for surplus energy that is exported to the grid and not consumed on-site. A gross approach pays a tariff on all electricity produced. These tariffs are often higher than those paid by general consumers.

Feed-in tariffs apply at a national level in Germany, Japan, South Korea, and the United Kingdom, and at a state level in Australia. China and India operate national and sub-national schemes (figure 2.1). FITs 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 target obligations. New Zealand does not use FITs.

The types of renewable technology eligible for FITs vary by country. South Korea and Germany offer FITs for hydroelectricity, biomass, biogas, wind and solar PV, while Australia and Japan offer FITs only for solar PV. FIT rates also vary between generation technologies. The level of FITs is highest for solar PV and lower for more established technologies such as wind, hydroelectricity and biomass. Average FITs are above average annual wholesale electricity prices in each study country, except for non-solar PV generation in South Korea.[5]

Capital subsidies

Capital subsidies are direct financial transfers from governments to households or firms investing in low-emissions electricity generation (such as solar PV cells or wind farms). Capital subsidies can have multiple objectives in addition to greenhouse gas reduction, such as addressing barriers to the adoption of energy efficiency measures and providing industry assistance. Capital subsidies are

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[5] South Korean average FITs for hydroelectricity, biomass and biogas are below the average South Korean wholesale electricity price. Average Korean FITs were calculated using fixed tariffs that appear to be below the average wholesale electricity price and a variable tariff often set above the wholesale electricity price.

typically offered by all levels of government in the countries studied. Subsidies are 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. In many cases, subsidies are provided in addition to other financial incentives for renewable generation, such as feed-in tariffs and renewable energy certificates.

Figure 2.1 **Average feed-in tariffs for different technologies, by country[a]**
A$ (2010)
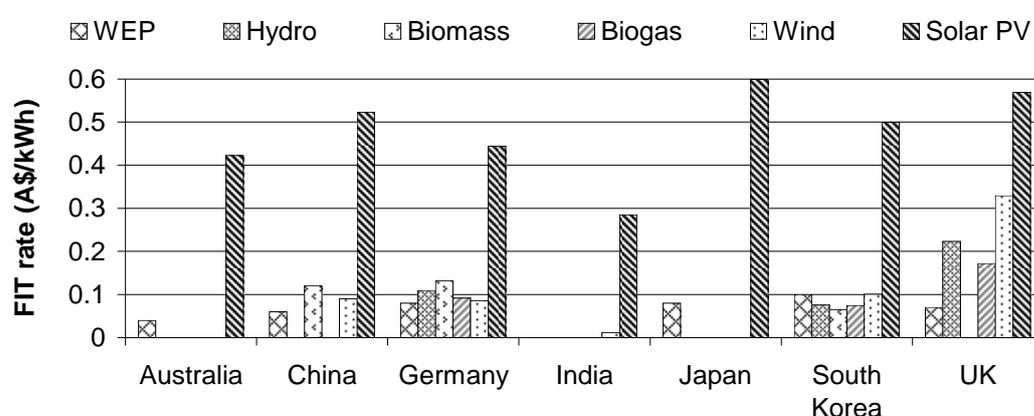
a Where multiple FITs exist for a given generation technology, unweighted averages have been calculated. Average FITs were not adjusted for net and gross differences and have been converted to 2010 Australian dollars. The wholesale electricity price (WEP) is an estimate of the 2010 average annual price per kilowatt hour paid to non-renewable generators. The Australian WEP is the unweighted average price for each National Electricity Market state. The Chinese WEP is for November 2010. The Indian WEP was not available. The South Korean WEP is for the year to 31 March 2010. South Korean average FITs were calculated using a mixture of fixed tariffs that appear to be below the average WEP and a variable tariff often set above the WEP. **WEP** Wholesale electricity price. **PV** photovoltaic. **FIT** feed-in tariff.

Sources: Appendixes B, D–G, H–J.

Preferential loans and guarantees

Preferential loans reduce the cost of borrowing to invest in low-emissions generation technologies. These can be in the form of low or zero interest rate loans, or loan guarantees where the government takes on the default risk.

A wide range of preferential loan schemes operate at the national or sub-national level in most of the study countries. These can provide small-scale support (such as the Indian Government's Off-grid and Decentralised Solar program that provides low interest loans for small solar power generation), or large-scale assistance (such as the US Government's Loan Guarantee Program for emissions-reduction projects with total costs over US$25 million).

Low-interest loans and loan guarantees may appear to increase the availability of capital for low-emissions generation projects. However, they do represent costs to government. The difference between the market cost of borrowing and the preferential interest rate is financed by the taxpayer. In cases where guaranteed loans are not repaid, governments may incur large liabilities.

Emissions trading schemes

Two study countries have implemented ETSs that are specific to their electricity sectors. Ten US states are party to a regional cap-and-trade ETS that applies solely to electricity generation. In Australia, the New South Wales Government operates a baseline and credit ETS for emissions in the electricity sector above a benchmarked target (box 2.2). Cross-sectoral ETSs in Germany and the United Kingdom (through the European Union ETS), and New Zealand, also cover electricity generation (section 2.2).

Box 2.2   Emissions trading schemes specific to electricity generation

US Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative is a state-based cap-and-trade emissions trading scheme (ETS) covering ten north-western US states (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island and Vermont). The Regional Greenhouse Gas Initiative commenced in 2009, and aims to reduce CO_2 emissions by 10 per cent below 2009 levels by 2018. Generators larger than 25 megawatts (capacity) in the participating states must purchase an allowance for CO_2 emissions. The scheme caps CO_2 emissions until 2014, after which the cap will be reduced by 2.5 per cent per year until 2018. The 2011 permit price currently sits at around US$2.05/t CO_2 (A$2.20).

NSW Greenhouse Gas Reduction Scheme

The NSW Greenhouse Gas Reduction Scheme is a baseline and credit ETS for emissions in the electricity sector above a benchmarked amount. The scheme has operated since January 2003. It requires electricity retailers and other buyers or sellers of electricity in New South Wales to meet mandatory emissions benchmarks based on the size of their share of the electricity market. Parties that emit CO_2 at a rate higher than their benchmark targets are required to purchase offsets (a NSW greenhouse abatement certificate) from eligible abatement projects or pay a penalty of A$12.00/t CO_2. The spot price of an abatement certificate over 2010 was around A$5.00/t CO_2. A similar scheme operates in the Australian Capital Territory.

Sources: Appendixes B, D, K.

Fossil fuel taxes

India and Japan impose taxes on fossil fuels, including fossil fuels used to generate electricity. These taxes raise the cost of production (and the retail price) of electricity generated from these energy sources. The taxes implicitly subsidise untaxed sources of electricity generation.

In India, the Clean Energy Tax imposes a levy of Rs.50 (A$1.20)[6] per tonne of coal, lignite or peat, which are domestically produced or imported. The tax revenue is hypothecated to a National Clean Energy Fund established to fund research and development in clean energy technology and environmental remediation programs.

Japan imposes a tax on petroleum and coal products. The tax rates are ¥2040 (A$25.50) per kilolitre of oil, ¥1080 (A$13.50) per tonne of natural gas or petroleum gas, and ¥700 (A$8.75) per tonne of coal. Japan is proposing to progressively lift these tax rates between 2013 and 2015 as part of its environmental tax reform. The rates are expected to rise by 37 per cent for oil, 72 per cent for gas and 96 per cent for coal.

Differential electricity taxes

Electricity taxes may be imposed at rates that depend on the generation technology (for example, lower-emission electricity generation incurs a lower tax rate or an exemption). These types of policies are not widely applied in the study countries. One exception, is the United Kingdom's Climate Change Levy that taxes non-residential users of electricity (fossil fuels such as gas and coal are also taxed but road transport fuels are not). Electricity generated from renewables (such as solar and wind) and approved cogeneration schemes do not pay the tax.

Direct tax incentives

Direct tax incentives provide tax credits for investment in renewable generation, or for the production of renewable electricity. These policies are not widely used in the study countries.

In the United States, national investment tax incentives offer tax credits that provide up-front payments for installed renewable capacity. A production tax incentive also offers renewable generators up to US$0.022 (A$0.024) for each kilowatt hour

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[6] Conversion of foreign currency values to Australian Dollars (A$) in this chapter used average exchange rates over January to April 2011 (RBA 2011).

produced. In China, a national scheme offers a reduced valued-added tax rate for electricity generated from renewables (including wind, small hydroelectricity and biomass).

Research and development

All countries studied fund a wide range of programs that subsidise the research, development and commercialisation of renewable electricity generation technologies. For example, the UK Marine Renewables Deployment Fund provides £50 million (A$84 million) to support research into wave and tidal technologies, and the demonstration of these technologies.

Most countries also fund the research and development of clean coal technologies. For example, the Australian Government funds the National Low Emissions Coal Initiative — a program that subsidises low-emissions coal research and the construction of demonstration projects. Governments in Germany, India, the United Kingdom and the United States fund a range of similar programs.

Research and development programs for carbon capture and storage operate in Australia, China, Germany, South Korea, the United Kingdom and the United States. In addition, the Australian Government has established the Global Carbon Capture and Storage Institute that aims to accelerate the development of industrial-scale CCS projects internationally. The European Union has committed to funding up to 12 demonstration CCS plants in EU countries (including Germany and the United Kingdom). Some of these programs also fund CCS research in other energy-intensive sectors (such as resource extraction and manufacturing).

2.4   Policy measures specific to transport

Emissions-reduction policies in the transport sectors of the countries studied predominantly relate to road transport. The most widely applied policies concern fuels, and passenger and light commercial vehicles (summarised in table 2.6). Policies targeting heavy vehicles (such as freight transport) tend to be less widely used. There is also a range of transport-related policies that may less directly reduce emissions (such as public transport and freight infrastructure policies). Few countries have policies targeting domestic maritime and aviation emissions. Regulation of international emissions falls under the jurisdiction of the International Civil Aviation Organisation, the International Maritime Organisation, and the United Nations Framework Convention on Climate Change. There are currently no binding agreements on reducing these emissions although negotiations are ongoing

(ICAO 2011; IMO 2011). In the absence of an international agreement, some countries have committed to unilateral action to regulate international emissions. For example, the European Commission has committed to including domestic and international aviation in the European Union ETS from 2012 (EC 2011a).

Fuel policies (road transport)

Fuel policies are taken to include any measure that taxes, subsidises or regulates road transport fuels (such as petrol, diesel and liquid petroleum gas). Fuel taxes and government assistance to biofuels are the most widely applied emissions-reduction policies covering road transport fuels in the study countries.

Fuel taxes

Historically, fuel taxes have been imposed for a variety of reasons unrelated to emissions reductions (such as to fund road construction and maintenance, to fund public transport, or simply to raise revenue for general government purposes). However, fuel taxes can also serve to reduce greenhouse gas emissions by reducing demand for fuel.

All study countries impose fuel taxes at the point of consumption — as an excise amount per litre of fuel or a consumption tax set at a percentage of the value of fuel sales. There are marked differences in tax rates (table 2.7). Generally, broadly based consumption taxes (such as value added taxes and goods and services taxes) are also imposed on transport fuels.

Some countries also impose fuel taxes on the production of fuels. For example, Japan imposes a Petroleum and Coal Tax on imported crude oil and refined petroleum products used to produce transport fuels, while the New Zealand ETS applies to transport fuels and is paid by fuel producers.

Recently, some governments have introduced taxes directly linked to emissions from road transport fuels. For example, the New Zealand ETS applies to transport fuels in addition to the already existing fuel excise (the European Union ETS does not). The Japanese Government has announced an increase in its Petroleum and Coal Tax based on the emissions content of the fuel category. The California Cap-and-Trade ETS (expected to commence in California in 2012 as part of the Western Climate Initiative) will cover transport fuels from 2015. South Korea is considering imposing an economy-wide carbon tax that may apply to transport fuels.

Table 2.6 **Emissions-reduction policies specific to road transport (passenger and light commercial vehicles), by country**

The jurisdictional coverage of a policy may be national (N), sub-national (S) or European Union (EU).

	Australia	China	Germany	India	Japan	NZ	South Korea	UK	US
Fuel policies									
Fuel taxes	N	N	N	N,S	N	N	N	N	N,S[a]
Biofuel policies									
fuel content mandates	S[b]	S[c]	N	N			N[d]	N	N,S[e]
production subsidies (fuel tax exemptions)	N	N	N	N	N	N	N		N
capital subsidies for fuel producers	S[f]				N				N
Vehicle policies									
Fuel efficiency/emissions standards	N[d]	N	EU		N	N[d]	N	EU	N
Vehicle fuel efficiency labelling	N	S[g]	N	N	N	N	N	N	N
Vehicle technology mandates			EU					EU	N
Differentiated vehicle taxes	N,S[h]		N	N	N		N	N	N
Subsidies for vehicle purchase		N	N	N	N		N	N	N,S[i]
Capital subsidies for lower-emissions vehicle research and manufacture	N[j]		N				N	N	N

a Fuel taxes are levied in all 50 US states, the District of Columbia and at the federal level. **b** *The Biofuels Act 2007 (NSW)* sets a mandate for ethanol and biodiesel content in New South Wales. **c** The National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles mandates a 10 per cent blend of ethanol in petrol in five provinces (Heilongjiang, Jilin, Liaoning, Henan and Anhui), and cities in Hubei, Shandong, Hebei and Jiangsu provinces. **d** Voluntary scheme. **e** Fuel content mandates operate in nine US states and at the federal level. **f** Victoria provides infrastructure grants for biofuel facilities through the Biofuels Infrastructure Program. **g** Covers ten provinces including Beijing, Tianjin, Hebei, Shanxi, Inner Mongolia and Shandong. **h** NSW, the ACT and Victoria offer discounted car registration and Queensland and the ACT offer discounted stamp duty for lower-emissions vehicles. The Australian Government's luxury car sales tax is imposed at a higher threshold for lower-emissions vehicles. **i** California· **j** The Australian Government's Green Car Fund closed in January 2011.

Sources: Appendixes B, N, O.

Table 2.7   **Transport fuel tax, by country[a]**

At the point of consumption, excluding broad-based consumption taxes, A$ (2010)

	Petrol	*Diesel*	*LPG*
	A$/L	A$/L	A$/L
Australia	0.38	0.38	..
China	0.16	0.13	..
Germany	0.94	0.67	0.14
India	(7.5% plus) 0.68	(7.5% plus) 0.19	(5%)
Japan	0.67	0.40	0.12
New Zealand	0.45	0.003	0.08
South Korea	0.70	0.49	0.21
United Kingdom	0.96	0.96	0.27
United States[b]	0.11	0.12	0.10

a Rates are current as at March 2011 and have been converted to 2010 Australian dollars. **b** Rates are the sum of federal-level fuel excise and the weighted average state-level volumetric tax rate, as of December 2010. **..** Not applicable.

Sources: Appendixes B, O.

Some countries have policies that can counteract the effect of fuel taxes. Fuel subsidies (or fuel-price regulation) provide a subsidy (either on production or consumption) to encourage the production and use of fossil fuels. These policies aim to reduce the cost and expand access to fuels. For example, India and China operate retail-price controls on some fuels, which set the price of fuel paid by consumers. The US Government provides subsidies for the production of compressed natural gas, liquefied natural gas and other fossil fuel products. In Australia, the Fringe Benefits Tax on employer-provided vehicles applies to a reduced taxable value the further a vehicle is driven. A recent government review found that the policy may encourage individuals to travel unnecessary distances, increasing pollution and road congestion (Henry et al. 2010). The Australian Government has since announced it intends to amend the tax to apply a flat tax rate independent of the distance travelled (Swan 2011).

Biofuel policies

The two main biofuels used for road transport are ethanol and biodiesel. Biofuel policies may have objectives in addition to reducing greenhouse emissions (such as regional development and agricultural assistance). The most common biofuel policies in the study countries are fuel content mandates, and fuel production subsidies (usually in the form of fuel excise exemptions). Capital subsidies for fuel refineries are used to a lesser extent.

Fuel content mandates are requirements for a minimum percentage of specified 'low emissions' fuels to be blended with petrol or diesel. For example, in 2010, Germany had a biofuel quota of 3.6 per cent for petrol and 4.4 per cent for diesel (measured by energy content). All study countries, except New Zealand and Japan, use fuel content mandates (table 2.8).

Table 2.8 **Transport fuel content mandates, by country**
(2009, 2010)

Country	Mandate	Biofuel type	Application	National/ sub-national	Voluntary/ mandatory
Australia	4 per cent (petrol) 2 per cent (diesel)	All	Per cent of total fuel consumption	NSW	Mandatory[a]
China	10 per cent	Ethanol	Per cent blend in petrol	Provincial	Mandatory
India	5 per cent	All	Per cent blend in all fuels	National	Mandatory
Japan	..	..	..	..	..
Germany	3.6 per cent (petrol) 4.4 per cent (diesel)	All	Per cent of total fuel consumption[b]	National	Mandatory
New Zealand	..	..	..	..	..
South Korea	3 per cent	Biodiesel	Per cent blend in diesel	National	Voluntary
United Kingdom	3.25 per cent	All	Per cent of total fuel consumption	National	Mandatory
United States	8 per cent[c]	All	Varies by jurisdiction	National and state	Mandatory

a In practice, exemptions to the mandates have been granted where producers could not meet the required fuel content level using domestically produced biofuels. **b** By energy content. **c** National 2011 Renewable Fuel Standard across petrol and diesel. Additional mandates also apply in several states. **..** Not applicable.

Sources: Appendixes B, N.

Production subsidies provide assistance to biofuel producers in various ways. Assistance most commonly takes the form of an excise exemption on the tax rate paid per litre of standard petrol or diesel for fuels containing biofuel. For example, India provides a full excise exemption on ethanol (up to 5 per cent blends) and on biodiesel (up to 20 per cent blends). In Australia, ethanol and biodiesel are subject to the full fuel excise but producers receive grants that reduce the effective excise

rate to zero.[7] Some countries pay direct subsidies to producers per litre of biofuel. For example, New Zealand pays biodiesel producers up to NZ$0.45 (A$0.35) per litre for biodiesel. All study countries, except the United Kingdom, provide biofuel subsidies or tax exemptions to biofuel producers (table 2.9).

Capital subsidies for fuel refineries that produce 'low-emissions' fuels are less widely applied. Government subsidies may take the form of direct payments, loan guarantees or preferential loans for fuel refineries. For example, the Biorefinery Assistance Program in the United States provides loan guarantees for the development, construction and retrofitting of commercial-scale bio-refineries to produce 'advanced biofuels' (such as cellulosic ethanol).

Table 2.9   **Biofuel production subsidies, by country**

Country	Policies
Australia	Biodiesel and ethanol are subject to the fuel excise but producers receive grants reducing the effective excise rates to zero (changes are proposed from December 2010).
China	Subsidies, tax reductions and/or exemptions of the Value Added Tax are provided to ethanol producers. Subsidies differ by province.
Germany	Fuel tax exemption for biofuels.
India	National excise exemption on ethanol (up to 5 per cent blends with petrol) and on biodiesel (up to 20 per cent blends on diesel).
Japan	Fuel tax exemption for ethanol and biodiesel.
New Zealand	Ethanol is exempt from most fuel taxes compared to unleaded petrol. Grants to biodiesel producers based on value of production.
South Korea	Fuel tax exemption for biodiesel.
United Kingdom	..
United States	A range of national and state tax credits for the production of ethanol. Various payments to biofuel producers at federal and state levels.

.. Not applicable.

Sources: Appendixes B, N.

Governments in all countries studied also subsidise the research and development of biofuels, and fund demonstration production projects to varying degrees. For example, the Australian Government funds the Australian Biofuels Research Institute, which coordinates research and development activities, and subsidises the demonstration and commercialisation of biofuel technologies.

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[7] The Australian Government has proposed phasing out this arrangement from December 2011, and gradually increasing the effective tax rates on biofuels.

Vehicle policies

Fuel efficiency standards are the most widely applied emissions-reduction policy targeting passenger and light commercial vehicles in the countries studied. Differential vehicle taxes, and subsidies for the purchase of lower-emissions vehicles, are also used in many of the countries. Policies targeting heavy vehicles (such as freight transport) tend to be less widely applied.

Fuel efficiency standards

Historically, fuel efficiency standards have been linked with objectives other than greenhouse gas emissions reductions. For example, the first fuel efficiency standards were introduced in the United States in the 1970s as an energy security measure in response to the first oil shock (Energy Policy and Conservation Act 1975 (US)).

Fuel efficiency standards impose a limit on the average amount of fuel that can be consumed by a vehicle for a specified distance travelled. An alternative approach used by some countries to limit fuel use is emissions standards. These impose a limit on the average quantity of CO_2-e a vehicle can emit per distance travelled. (Emissions standards have also been imposed to reduce pollutants that are harmful to human health or the environment, such as lead and sulphur dioxide.) Fuel and emissions standards may apply to individual vehicles or as an average across a manufacturer's fleet. Heavy vehicles are generally not covered under vehicle fuel efficiency or emissions standards. (One exception is the United States, which has introduced standards for heavy vehicles that will apply from 2014.)

All study countries, except Australia, New Zealand and India, impose mandatory vehicle fuel efficiency or emissions standards (figure 2.2). Australia[8] and New Zealand have voluntary emissions standards. The Indian Government has announced an intention to introduce mandatory fuel efficiency standards in the near future.

Study countries have a range of vehicle policies related to fuel efficiency and emissions standards. For example, all study countries have adopted, or are implementing, fuel efficiency labelling of new vehicles. Some countries use vehicle technology mandates that aim to reduce vehicle emissions in different ways. For example, Germany, the United Kingdom (under European Union mandates) and the United States have tyre standards designed to reduce fuel consumption. The United

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8 The Australian Government is considering the introduction of a mandatory scheme (ATC/EPHC Vehicle Fuel Efficiency Working Group 2009).

Kingdom and Germany (also under European Union mandates) limit the use of synthetic greenhouse gases in vehicle air conditioning systems.

Figure 2.2   **Vehicle emissions standards, by country[a,b]**
Grams of CO_2 per kilometre travelled
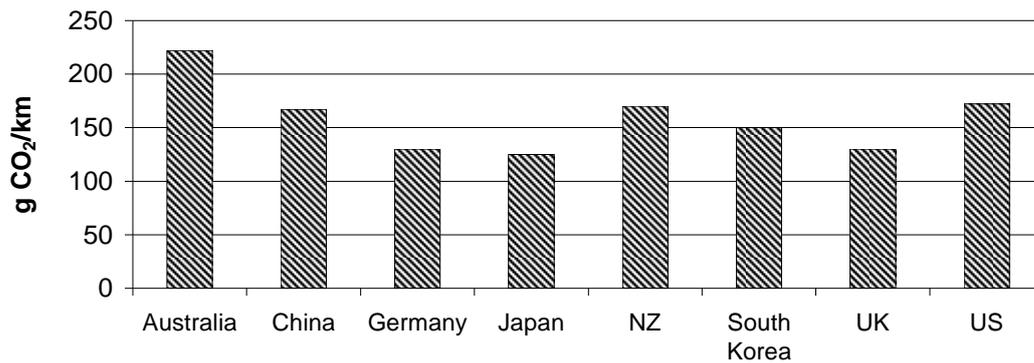
a Each country's fuel efficiency or emissions standard has been converted grams of CO_2 per kilometre travelled on the New European Drive Cycle. **b** Australia has a voluntary 2010 target for average emissions for all new light-duty vehicles. China has committed to a 2015 target for average passenger vehicle fuel efficiency. The European Union (including Germany and the United Kingdom) has a 2012 target for average fleet emissions with a commitment of 95 gCO_2/km by 2020. Japan requires average fleet fuel efficiency of 16.8 km/L (equivalent to 125 g CO_2/km New European Drive Cycle). New Zealand has a voluntary 2015 target for average emissions for new and used light vehicles. South Korea has committed to a 2015 target for average fuel efficiency with offset credits of up to 10 g CO_2/km available for implementing tire pressure monitoring systems, low-rolling resistance tyres, and gear shift indicators. The United States has committed to a 2016 target for average fleet emissions or fuel efficiency. India does not currently have a fuel efficiency or emissions standard.

Sources: ICCT (2011); Appendixes B, C.

Vehicle taxes

All study countries impose some forms of vehicle taxes. Generally, these take the form of once-off sales taxes and annual vehicle registration fees.

Vehicle taxes have been in place in study countries for a number of years without being explicitly linked with emissions-reduction objectives. However, the level of vehicle taxes often varies with vehicle characteristics that are correlated with emissions (such as engine size, weight or fuel efficiency). For example, most states in Australia set annual car registration fees based on engine size or vehicle weight.

Some vehicle taxes more directly relate to the level of a vehicle's CO_2 emissions. For example, the US Gas Guzzler Tax — introduced in 1978 to discourage the production and purchase of fuel inefficient cars — requires producers or importers

to pay a dollar amount on passenger vehicles with fuel efficiency rating below 22.5 miles per gallon. The tax increases as vehicle fuel efficiency falls — from about US$1000 (A$1090) for 22 miles per gallon (9.4 kilometres per litre) up to a maximum of US$7700 (A$8370) for vehicles of less than 12.5 miles per gallon (5.3 kilometres per litre).

More recently, other study countries have introduced differentiated vehicle taxes based on a vehicle's emissions. For example, Germany and the United Kingdom charge annual vehicle taxes based, in part, on a vehicle's emissions intensity. In Germany the tax rises by €2/g CO_2/km (A$2.70) in excess of 120 g CO_2/km. In the United Kingdom, annual vehicle registration taxes are calculated on average emissions per kilometre. Germany, India, Japan, South Korea, and the United States offer lower sales tax rates or exemptions for electric or lower emissions vehicles. Some states in Australia offer discounted car registration (NSW, ACT and Victoria) and/or discounted stamp duty (Queensland and ACT) for lower emissions vehicles. The Australian Government's luxury car sales tax is imposed at a higher threshold for lower emissions vehicles.

Vehicle subsidies

An alternative approach to reducing taxes on lower-emissions vehicles is to subsidise their purchase. Subsidies can be offered to consumers that purchase specific vehicle types, such as hybrid or electric cars. For example, the UK Government offers a 25 per cent subsidy up to £5000 (A$8380) when purchasing a low-emissions vehicle. China, Germany, Indian, Japan, South Korea, the United Kingdom and the United States also offer such subsidies.

Some study countries encourage the supply of lower-emission vehicles through capital subsidies to vehicle manufacturers (either for the production of particular vehicle types or for research, development and deployment activities). Government subsidies (in the form of grants or loans) can reduce the development or production costs of lower-emissions vehicles. The effect of these types of subsidies on emissions is difficult to discern. They also have the effect of supporting domestic car production and can be seen as a form of industry assistance or trade protection policy.

Among the countries studied, the US Government operates the Advanced Technology Vehicle Manufacturing Loan Program, which funds projects that help vehicles manufactured in the United States meet higher fuel efficiency requirements. The Australian Government's Green Car Fund — closed in January 2011 — subsidised research, development and commercialisation of lower-emission vehicle technologies and their uptake. Major grants provided under the scheme

include A$149 million to General Motors Holden to build the four cylinder car 'Cruze', A$35 million toward Australian production of the Hybrid Camry, and A$42 million to develop a more fuel efficient engine for the Ford Falcon. Germany, South Korea and the United Kingdom also subsidise the development or production of lower-emissions vehicles.

Government fleet policies

Government fleet policies — guidelines or rules on government vehicle purchases and leasing — can include fuel efficiency targets, or quotas for particular vehicle types or fuels. Most countries studied use these types of policies. For example, the US Federal Fleet Management Guidance sets a target to reduce vehicle fleet petrol and diesel consumption by 2 per cent annually, and to increase the use of 'alternative fuel' (biofuels and gaseous fuels) by 10 per cent annually to 2015 (from a 2005 baseline). It also includes mandates for using 'alternative fuel' vehicles and hybrid electric vehicles.

Other land transport-related policies

There are a range of other land transport policies that may less directly result in emissions reductions. Many of these policies have other explicit objectives, and complex and indirect impacts on emissions, making it difficult to attribute emissions reductions to them (chapters 3 and 5). Policies of this kind include:

- *investment in passenger and freight transport infrastructure,* including:
  - *high-speed rail.* For example, China, India, South Korea, the United Kingdom and the United States are investing in new high-speed passenger and/or freight networks connecting large population centres and heavy freight corridors. The Australian Government has commissioned a feasibility study into a high-speed rail network on the east coast of Australia (including consideration of a Newcastle to Sydney 'spine', northward links to Brisbane and southwards links to Canberra and Melbourne (DIT 2011.)
  - *transport infrastructure to encourage modal shifts to lower-emissions forms of transport.* For example, new subway projects are under construction or planned in the Indian cities of Delhi, Chennai, Kolkata and Bangalore. The city of Sydney operates a bus corridor program that has established priority bus lanes on existing roads and bus-only roadways such as the Liverpool-Parramatta T-way rapid transit line. In 2009, the South Korean Government enacted a law expanding the construction of bicycle only lanes.

The UK Government is subsidising the construction of a public plug-in network for electric vehicles.

– *lower emissions public transport infrastructure.* For example, the UK and US Governments are funding the electrification of fossil fuel powered rail networks. The ACT Government is progressively changing over the Territory's bus fleet to compressed natural gas.

- *'intelligent transport systems'.* For example, Japan is rolling out a national traffic control and information sharing system to reduce congestion and vehicle emissions. The Queensland Government's FreightSmart program encourages alternative freight delivery systems that reduce urban congestion and vehicle emissions.

- *road pricing and road use policies*, including:

– *congestion pricing.* For example, the city of London charges a fee for vehicles entering central London between 7 am and 6 pm weekdays. Toll charges on the Sydney Harbour bridge rise during morning and afternoon peak periods, and fall overnight and during the day.

– *road tolls based on fuel efficiency and distance travelled.* For example, Germany charges a truck toll for freight vehicles based on the distance travelled, the size of the truck and its emissions category.

– *rationing and auctioning of vehicle licences.* For example, the city governments in Beijing and Shanghai cap the number of new vehicle licences issued in a month and auction them off.

– *high-occupancy lanes and/or low-emissions vehicle-only lanes.* For example, Melbourne's Eastern Freeway has a high occupancy vehicle lane during morning peak times. In some US states, low-emissions vehicles are permitted to use high occupancy vehicle lanes with only one person in the car.

Aviation and maritime policies

There are currently no multilateral agreements covering international aviation and maritime emissions. Negotiations (between national governments, the International Civil Aviation Organisation, the International Maritime Organisation, and the United Nation Framework Convention on Climate Change) on how international transport emissions will be counted, and what steps may be taken to reduce them, are ongoing (ICAO 2011a, IMO 2011).

In the absence of an international agreement, the International Maritime Organisation has developed a range of technical and operational energy efficiency

measures for new and existing ships designed to reduce emissions, and is negotiating with member countries to make the measures mandatory (IMO 2011). The International Civil Aviation Organisation is coordinating a range of voluntary measures to reduce aviation emissions (such as increased fuel efficiency of aircraft, the development of aviation biofuels and offset markets for aviation emissions, and improvements to air navigation practices (ICAO 2011a)).

Some of the countries studied have taken policy action to reduce domestic aviation or maritime emissions. For example, the New Zealand ETS covers transport fuels used for domestic flights and shipping (fuel used by international aviation and marine transport is exempt). The Japanese Government has imposed a Petroleum and Coal Tax on imported crude oil and petroleum used to make transport fuels (including aviation and maritime fuels). This tax is to be progressively increased from 2013 to 2015 (although petrol, light oils and jet aviation fuels will initially be exempt).

Some countries have taken unilateral policy action to cover international emissions that otherwise would have been be covered under multilateral agreements. These policies are examples of businesses being subjected to the policies of foreign governments. For example, the United Kingdom imposes an air passenger duty (charged to the carrier) on flights departing the United Kingdom. The rate of the duty increases with the distance flown. The European Commission has committed to including domestic and international aviation (covering aircraft that arrive or depart from EU airports) in the European Union ETS from 2012 (EC 2011a). The European Commission has also publicly stated that the European Union will bring all international shipping visiting EU jurisdictions into the ETS if there is no global agreement on maritime emissions by the end of 2011 (EC 2011b).

There is a range of policies in the countries studied that support research and development in relation to aviation biofuels. For example, the US Federal Aviation Administration (in partnership with the aviation industry) funds the Continuous, Lower Energy, Emissions and Noise Reduction Program to develop aviation biofuels. The US Air Force is undertaking tests with private sector companies to meet a goal of certifying all of its aircraft as able to use aviation biofuel blends, and to be able to obtain 50 per cent of its aviation fuel needs from biofuels by 2016. The US and Chinese Governments have signed a series of research partnerships between the Boeing Company, US government agencies, and Chinese research institutions and state companies to undertake aviation biofuels research (ICAO 2011b). The European Union funds a range of aviation biofuel research programs, including Sustainable Way for Alternative Fuels and Energy for Aviation (SWAFEA 2011).

2.5 Forestry and agriculture

Forestry

Many of the study countries have made public commitments to emissions-reduction policies in the forestry sector. Some policy commitments appear be aspirational targets to increase the land area covered by forest or to increase forest stock. Other policy commitments involve the use of financial incentives and land-use regulations to increase forestry coverage and reduce emissions from land clearing.

For example, the National Mission for a Green India program — one of the eight programs under the National Action Plan on Climate Change — aims to increase forest cover on a total of 10 million hectares of land, and to increase CO_2 sequestration in forests by 50 – 60 Mt per year by 2020. It is currently unclear how these targets will be achieved. The Indian Government has allocated A\$2.72 billion to a Compensatory Afforestation Fund Management and Planning Authority to fund programs for the conservation, regeneration and management of existing forests and wildlife habitats. Details on how the money will be used are currently unclear.

China has adopted an aspirational target to increase forest cover by 40 million hectares, and forest stock volume by 1.3 billion cubic metres by 2020 from 2005 levels. It is unclear how these targets will be achieved.

The Australian Government offers a tax deduction to businesses that plant forests for the purpose of absorbing CO_2 from the atmosphere. Some state government policies also encourage the expansion of forestry coverage (such as Victoria's Carbon Tender which pays landholders to permanently revegetate a portion of their land) or emissions reductions through changes to land management practices (such as Queensland's *Vegetation Management Act* (1999) that regulates land clearing).

New Zealand has three main schemes that subsidise afforestation and the maintenance of existing forests. The East Coast Forestry Project subsidises the planting of commercially productive forest (up to 200 000 hectares by 2020). The Afforestation Grants Scheme provides finance to smaller landholders for planting new forests. The Permanent Forest Sinks Initiative encourages the establishment of permanent forests on previously unforested land by granting landholders tradable offset credits that they can sell on the domestic or international carbon markets.

The United Kingdom operates a number of schemes (such as the Woodland Grant scheme and the Environmental Stewardship scheme) that provide financial incentives for landowners wanting to create new woodland or improve land management practices.

The US Government and some state governments operate a range of policies that provide financial incentives and technical assistance for voluntary sequestration of emissions by private land owners.

Forestry sectors in some of the countries studied are covered by ETSs. The New Zealand ETS has applied to forestry since its inception in 2008. The owners of eligible forests can receive emission permits for increases in the carbon stock of their forest and can trade these on the domestic emissions market or convert them to Kyoto units to be traded overseas. Forest owners are required to surrender New Zealand Units to the Government if carbon stocks fall (for example if a forest is harvested). Units earned from forestry sequestration can be traded internationally to meet obligations under the Kyoto Protocol. In addition, the US Western Climate Initiative cap-and-trade scheme, in principle, will permit offsets from forestry activities. The European Union ETS does not currently cover forestry.

Agriculture

Agricultural food production (including cereals, grains, meat and dairy) can be a significant source of a country's overall greenhouse gas emissions. Currently, it appears there are few emissions-reduction policies that apply to the agricultural sectors of the countries studied.

China and South Korea have announced policies to reduce emissions from rice growing. However, there is little detail on how these targets will be achieved.

A number of countries fund research into reducing agricultural emissions. For example, Australia and New Zealand have a range of policies that fund research into reducing emissions from various farming activities. The UK Government funds research into reducing methane emissions from dairy cattle. Japan operates a national program studying potential uses for biomass from the agriculture and forestry sectors. A draft law before the Japanese legislature would set targets for the proportions of biomass (such as cattle excrement, food waste, wood waste and forestry residue) to be re-utilised by 2020.

Existing ETSs deal with agricultural emissions in different ways. The New Zealand ETS will require the agriculture sector to report emissions from 2012 (with agriculture scheduled to be covered from 2015). Agriculture will receive uncapped permit allocations on an output intensity basis. Agricultural activities cannot currently earn New Zealand Units for sequestration of emissions. The Western Climate Initiative cap-and-trade scheme, in principle, will permit offsets for agricultural activities. The European Union ETS does not cover agriculture.

The Australian Government has introduced legislation to parliament to establish a national Carbon Farming Initiative — a voluntary scheme that would enable farmers, forest growers and other landholders to earn carbon credits for saving or storing greenhouse gases through eligible sequestration activities (DCCEE 2011b).

2.6 Energy efficiency

All study countries use a wide range of policies designed to increase energy efficiency, many of which are promoted as contributing to emissions reductions. Energy efficiency policies apply to households, businesses and government operations in the countries studied. Appendix C discusses some of the major energy efficiency policies in electricity consumption and road transport in more detail. Further information on specific energy efficiency policies is provided in the country stocktakes on the Commission's website (appendix P). Energy efficiency policies that relate to road transport are also discussed in section 2.4.

The most widely applied policies aim to reduce household and commercial energy consumption through:

- *information provision.* All study countries operate energy efficiency labelling schemes for certain electrical appliances (such as energy efficiency star rating labels on household appliances). Some countries also operate energy efficiency rating schemes for residential and commercial buildings that require disclosure of the building energy efficiency rating prior to rental or sale.

- *minimum standards.* All study countries set minimum energy efficiency standards for specific electrical appliances. Generally, appliances that do not meet these standards can not be sold in the country. Study countries also set energy efficiency related building standards for residential and commercial buildings through their respective building codes and regulations (covering areas such as insulation, heating, cooling and lighting).

- *direct financial assistance.* Governments may provide zero or low interest loans, or product subsidies and rebates, to encourage the purchase of energy-efficient electrical appliances and the installation of energy efficiency building measures.

- *market-based schemes.* Governments can require electricity retailers to meet energy savings targets by encouraging the uptake of energy efficiency measures by residential customers or by purchasing offset certificates.

Study countries also operate a range of energy efficiency policies that specifically target energy use by businesses. Primarily, these policies relate to electricity use,

but can include other energy sources such as oil, gas, coal and biomass. Policies fall into three broad categories.

- *Information and financial assistance to small and medium businesses to reduce energy use.* Voluntary programs can offer information and subsidies to encourage the uptake of energy efficiency measures by businesses. For example, the UK Carbon Trust and Low Carbon Australia are non-profit companies established with seed funding from their respective governments. They provide information and advice to businesses and the public sector on how to reduce energy use, and subsidise the uptake of energy-efficient technologies. All countries studied offer a range of these policies.

- *Partnership programs for 'large' energy users.* These policies can include voluntary or mandatory energy (or emissions) reporting, energy audits of business operations, and the uptake of energy efficiency measures. Australia, China, Japan, South Korea and the United States operate these types of programs.

- *Market-based mechanisms for 'large' energy users.* Market-based mechanisms usually set a cap on energy use or an energy efficiency target for businesses, then impose a penalty for not achieving targets (such as a fine or requirement to buy an offset certificate). A number of countries have implemented, or are considering, these types of schemes (box 2.3).

Study countries also target energy efficiency in government operations. This can be through energy audits to identify energy efficiency opportunities, the mandating of energy efficiency targets, and government procurement policies which set minimum energy efficiency standards for government purchases of goods and services (such as minimum fuel efficiency standards on car fleet purchases). All study countries have incorporated energy efficiency objectives into aspects of their government procurement policies.

Box 2.3   **Market-based energy efficiency schemes for business**

In the countries studied, a range of market-based schemes that aim to improve energy efficiency in business operations are in use or about to be implemented.

- *The Tokyo Metropolitan Government's baseline and credit trading scheme.* The mandatory scheme (commenced in 2010) covers emissions from the energy consumption of approximately 1400 office buildings and 300 factories (about 20 per cent of Tokyo's emissions). The scheme aims is to reduce emissions by 25 per cent by 2020 from 2000 levels. Covered installations are set emissions targets based on energy consumption and must buy offsets or pay a fine for energy consumption above the target. Saitama Prefecture operates a similar scheme.

- *The Indian Perform, Achieve and Trade scheme.* The scheme (to commence in April 2011) requires approximately 700 of the most energy intensive industrial units and power stations in India to reduce their energy intensity by a specified percentage (depending on the current level of efficiency). Energy users that achieve reductions above their mandated amount receive Energy Savings Certificates that can be traded. The firms included in the scheme are responsible for around half of India's emissions.

- *The South Korean Greenhouse Gas and Energy Target Management Scheme.* The scheme (to commence in 2012) is a system of mandatory agreements covering companies producing at least 25 000 metric tons of emissions a year (470 companies, including 36 power generators). The agreements would set energy savings and emissions-reduction targets for each emitter. Emitters who would have to buy offsets or pay a fine for not meeting a target.

- *The NSW Energy Savings Scheme.* The scheme (commenced in 2009) is a mandatory energy efficiency scheme for electricity retailers who are required to meet energy savings targets. Electricity retailers meet their targets by implementing energy saving activities (with households and business customers) or by purchasing energy savings certificates from companies with recognised energy reductions.

Source: Appendix P.

3   Methodology

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Key points

- What all emissions-reduction policies have in common is that they generally impose costs that someone must pay in order to reduce emissions. It is in this sense that the Commission has interpreted 'effective' carbon price loosely to mean the cost of reducing greenhouse gas emissions. This applies both to individual emission-reductions policies and in aggregate.

- The Commission has adopted a partial equilibrium, comparative static approach that compares, in the latest year for which data are available, a snapshot of the post-policy situation to the counterfactual snapshot of no policy. Ideally the impacts would be measured in terms of changes in economic welfare, taking into account influences on both the supply and demand sides, divided by the abatement achieved.

- On the supply side, the Commission has estimated subsidy equivalents as proxies for resource costs. The subsidy equivalent is the amount of explicit or implicit subsidy provided for low-emission products.

  – While it overstates the resource costs involved, this measure provides some basis for comparing the cost-effectiveness of different policies within and across countries.

  – Subsidy equivalents are also useful indicators of the resources that respective governments are prepared to devote to encouraging abatement, either directly through explicit financial subsidies or indirectly through higher prices paid by consumers.

- On the demand side, the Commission has also endeavoured to estimate the overall product price 'uplift' that results from the various supply and demand-side interventions in each sector for each country, and using this information make some inferences about consumption costs and demand-side abatement.

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The terms of reference for this study essentially ask the Commission to capture the various emissions-reduction policies being applied in a number of countries in a single metric — an 'effective' carbon price. This would be a relatively straightforward task if all countries applied economy-wide carbon taxes or quota schemes.

In that case, the carbon 'price' would be observable and comparable. But, as chapter 2 has illustrated, none does, eschewing broadly-based explicit pricing for a myriad of less transparent, more narrowly-focused interventions designed to assist the production and consumption of selected, less emissions-intensive technologies, or penalise particular emissions-intensive products and processes. Even those countries that have carbon pricing schemes apply them only to a limited range of emitting activities. This fragmented approach increases the cost of achieving any given level of abatement, but it also makes comparable measurement problematic.

This chapter discusses the methodology used in this study. Section 3.1 outlines how emissions-reduction policies work and section 3.2 looks at measurement issues. Section 3.3 then considers summary measures. Some key terms used in this study are outlined in box 3.1.

Box 3.1   **Subsidy equivalent, abatement and cost terminology**

- *Production subsidy equivalent* — the assistance provided per unit of output through a particular policy measure (implicitly or explicitly) to suppliers of low-emissions, but high cost, products to enable them to be competitive with high emission but low cost products.

- *Subsidy equivalent* — the production subsidy equivalent multiplied by output.
  - The *total subsidy equivalent* is the sum of the subsidy equivalents at the sectoral level.

- *Abatement* — a reduction in greenhouse gas emissions. In this study abatement has been calculated by comparing the emissions of the low-emissions product or technology supported by a policy measure with the emissions of the counterfactual high-emissions product or technology.
  - *Total abatement* is the sum of abatement from all policies at the sectoral level.

- *Implicit abatement subsidy* — the subsidy equivalent divided by the amount of abatement. An indicator of relative cost effectiveness.
  - The *average implicit abatement subsidy* is the total subsidy equivalent divided by total abatement.

- *Resource costs* — the value of labour, capital and other primary factors of production used directly and indirectly in the production of a good or service.

- *Consumption costs* — households' valuation of the goods that they give up as a result of a price rise, less their valuation of other goods that are purchased with the diverted expenditure. (When a tax on a good increases its price, households use less of the good than they would otherwise prefer and divert more expenditure to other, less-preferred goods.)

3.1　How emissions-reduction policies work

Understanding how different policies operate is an important first step to measuring and aggregating their effects.

'Carrots and sticks'

Despite the variety of policy instruments, all policies designed to promote lower greenhouse gas emissions essentially must either provide incentives to abate or disincentives to emit greenhouse gases, or both. Broadly speaking, all policies can be classified as those that:

- encourage substitution of low-emissions technologies and products (for example, renewable electricity and biofuels) for higher-emissions technologies and products (such as coal-generated electricity and fossil fuels) — these policies essentially focus on the production or supply side

- discourage consumption of products that generate emissions, either through price increases of those products and/or non-price induced decreases in demand for emissions-intensive products — these policies work through the demand side.

But whichever side of the market policies target, they will have implications for the other. Policies that effectively tax one commodity implicitly subsidise others. Effective subsidisation of a commodity implicitly taxes others. Put another way, to achieve their objective, policies that seek to reduce greenhouse gas emissions must alter relative prices to favour products that involve low emissions and to discourage products with the opposite characteristics.

Carbon taxes and quotas

It is generally recognised that the most direct and, consequently, most efficient way of implementing the 'relative price' change required to discourage consumption of high-emission products in favour of low-emission ones, is through a global, broadly-based carbon tax or quota scheme (emissions trading scheme). Placing a 'price' on emissions through these mechanisms means that an additional cost must be taken into account in all decisions involving production and consumption of competing products that have varying amounts of emissions embodied in them or which emit varying amounts of carbon in their use. Production of emissions-intensive products will decline as consumers reduce their purchases in response to higher prices, and as producers switch to comparatively cheaper, low-emission production technologies and intermediate inputs. Because these adjustments can be made on the basis of consumer and producer assessments of

relative costs and benefits to them, any given amount of abatement will be achieved at least cost.[1]

Emissions trading schemes (ETSs) limit the total quantity of emissions, but in effect work in a similar fashion to taxes, by directly raising energy prices to consumers and implicitly subsidising producers of 'clean' products. Therefore, any ETS has a 'tax equivalent' that would deliver precisely the same amount of abatement from the same sources for the same resource cost. Assuming perfect compliance, the two approaches also would have identical distributional impacts, delivering the same revenues to government, if permits were auctioned.

However, no country currently imposes an economy-wide tax on greenhouse gas emissions or has in place an economy-wide ETS. Of the study countries, the United Kingdom, Germany, some parts of the United States and New Zealand have emissions trading schemes operating — but these apply only to particular sectors, such as electricity generation. In some cases too the imposition of generous caps, combined with the impacts of economic recession, have meant that, at least in the early years, the caps have not been binding to any great extent and prices of emission permits have been low (for example, the Regional Greenhouse Gas Initiative in the United States).

Emissions trading schemes or taxes that focus on the electricity sector alone nevertheless work in the same way as more broadly-based taxes and quotas, though the potential abatement options are more limited. They increase the price of non-renewable energy and reduce energy consumption overall (assuming some price sensitivity of demand).[2] At the same time, they implicitly subsidise lower emissions-intensity energy production, because they raise the price that renewable energy producers can charge energy buyers (and still compete with other producers). Non-renewable energy production will thus be squeezed on two 'margins' — by lower demand for energy overall, and by the increased competitiveness of renewable energy production.

An emissions tax in the electricity sector effectively taxes consumption of *all* energy. The revenue raised from taxation of high emissions-intensity energy production accrues to government, and the revenue from higher prices for low

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[1] This presumes that the tax or quota scheme is costless to implement. In practice, the costs of administration and compliance would make it uneconomic to attempt to cover all goods and services in all situations, and hence price effects will differ. However, to the extent that such exemptions are based on marginal benefits and costs, the resulting consumption patterns would be optimal from the community's perspective.

[2] Reductions in energy consumption could be countered by compensation payments, particularly arrangements linked to energy use, such as rebates rather than lump-sum income supplements.

emissions-intensity energy production accrues to producers as an effective subsidy (box 3.2). The rate of subsidy, or producer 'price uplift', for renewable production is equal to the rate of tax on emissions-intensive production.

### *Subsidies, renewable targets or mandated production standards*

Chapter 2 sets out an extensive range of policies that subsidise the production or consumption of particular 'clean' technologies, or that mandate targets for the use of these technologies by producers.

Regulations or schemes that set quotas, standards or targets for renewable energy, or which mandate prices for generating certain types of renewable energy (such as solar feed-in tariffs), implicitly subsidise their production (box 3.3). In this case, the subsidy rate is equal to the producer price uplift required to induce the amount of renewable energy set by the target or quota. The 'subsidy equivalent' of a policy will equal this subsidy rate times the quantity of renewable energy produced.

Except for explicit, taxpayer-funded subsidies, such schemes must also 'tax' consumers to pay for the higher cost of supplying energy from renewable technologies. Higher energy prices in turn will induce some reduction in overall energy use, leading to some additional abatement. To the extent that energy consumers were compensated for the additional energy cost, this additional source of abatement could be diminished, depending on the nature of the compensation payment.

It is important to note, however, that even if the full costs of implicit production subsidies are passed on to energy consumers, the resultant increase in the price of energy will not have the same effect as imposing a tax on emissions that led to the same uplift in consumer prices. Such a tax would induce different, lower-cost abatement and, almost certainly, would generate different levels of abatement (higher or lower) than the renewable target.

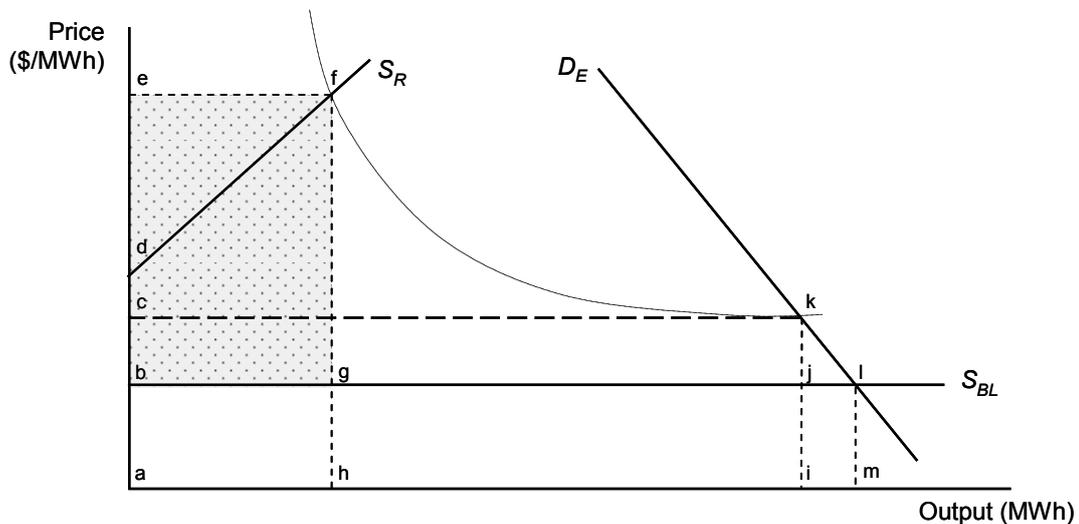Box 3.2   **How emissions taxes and permits work**
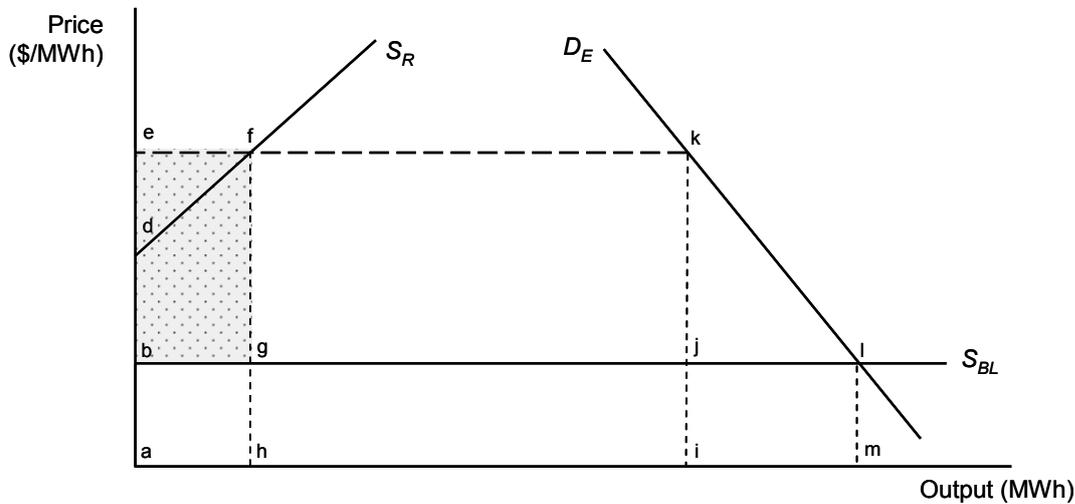
This figure presents a stylised market for electricity generation with non-renewable baseload electricity being provided at a constant unit cost equal to price *ab*, and no renewable electricity generation (represented by the supply curve S_R). A carbon tax is then imposed, driving up the price of electricity from *ab* to *ae*.

This higher price will have two effects. One, household and business demand for energy falls (from *am* to *ai*) (they use less energy either through adopting more energy efficient processes or by curtailing activities and production that use energy). Two, at the same time, provided the tax is high enough, energy generated from renewable or less emissions-intensive sources will come on line in response to the higher consumer price for energy from non-renewable sources (as drawn, supplying *ah*).

Amount *hi* is still supplied from non-renewable energy sources. Tax revenue collected from non-renewable energy production is represented by area *gfkj*. A quota or permit scheme that only allowed total emissions consistent with this output from non-renewable sources would have the same price and abatement effects as the tax, but the distribution of the revenue represented by area *gfkj* will depend on whether permits or quota entitlements are given away or sold.

Shaded area *befg* represents the 'subsidy equivalent' to renewable energy producers, paid by consumers of energy. The economic costs of the scheme are the additional *resource cost* of producing renewable energy (area *bdfg*) plus the *consumption cost* (the loss of consumer surplus represented by triangle *jkl*). Consumers, however, not only curtail their energy consumption, but pay more for what they continue to consume — in total, area *bekj*, which comprises tax payments to government (or payments for permits) and the 'subsidy' to producers of renewables.

This figure again depicts a stylised electricity generation market, with non-renewable baseload electricity being provided at a constant unit cost equal to price *ab*, pre-intervention. Total consumption is *am*. A mandatory renewable energy target is introduced that is assumed to induce supply from low-cost (for example, biomass), medium-cost (wind) to high-cost (solar) sources. The supply curve for these options is shown as S_R. If the renewables target is set at quantity *ah*, the price required by marginal generators will be *ae*.

- The implicit subsidy paid per MWh to renewable producers is *be*, and the total subsidy equivalent (*TSE*) the shaded area, *befg*. Total abatement would be equal to the difference in emissions intensities of the baseload generator and the renewable generators, multiplied by the amount of renewable electricity *ah*.

- Part of the *TSE*, area *def*, is producer surplus to renewable suppliers — the size of this depends on the excess of the price received over their costs of production. The remainder (area *bdfg*), is the additional resource cost of supplying *ah* (that is, additional to the cost of the baseload generation being replaced).

The renewables target will increase the average cost of generating electricity and lead to an increase in the electricity price from *ab* to *ac* (as drawn, the full cost of the subsidy is passed on to consumers so area *befg* is the same as area *bckj*). This will induce a reduction in consumption of energy and some additional abatement. If the subsidy to renewable energy producers was paid by taxpayers instead, the consumer price of electricity would not change, but the average cost of producing energy would still rise.

Biofuel policies

There are a range of assistance measures designed to increase the production of biofuels and displace the consumption of cheaper but more emissions-intensive

conventional fuels (petrol and diesel). These include production subsidies as well as fuel content mandates that specify a minimum percentage of biofuel in the volume of petrol or diesel sold. The mandated increase in demand allows biofuel producers to sell at a higher price than conventional fuels (adjusted for energy content) and thus provides an implicit subsidy for their production (box 3.4).

Fuel taxes

Fuel taxes raise the price of fuel and therefore reduce fuel consumption and greenhouse gas emissions from fuel use. Thus they result in abatement on the demand side. As with supply-side abatement there is a cost, but in this case it is less obvious than the additional resource costs that are involved in supply-side abatement. With demand-side abatement, consumers end up driving less and diverting more of their expenditure to other goods than they otherwise would prefer. Measurement of this consumption cost requires assumptions about the demand curve and how responsive consumers are to increases in fuel prices.

Energy efficiency measures

In addition to policies that increase prices of energy products, there are many policies designed to compel or encourage consumers and firms to invest in more energy-efficient durable products, such as fuel-efficient cars and energy-efficient appliances. The switch to such products is intended to reduce the demand for energy and, hence, emissions. However, the ultimate impact on emissions will also be a function of the level of their use. Because the energy operating costs are reduced, 'rebound' effects can mean usage can increase, offsetting some of the initial savings. Further, the effect on abatement in some instances will depend on the emissions intensity of energy or fuel production displaced — higher-cost renewable products could be displaced instead of cheaper but more emissions-intensive products.

There are substantial difficulties in evaluating these programs and calculating their effects. There are resource costs in producing the additional energy-efficient durables, but there are also expected future savings in resource costs from using less energy (box 3.4). And both the additional production costs and the expected future cost savings are difficult to measure.

Box 3.4   **How fuel content mandates work**
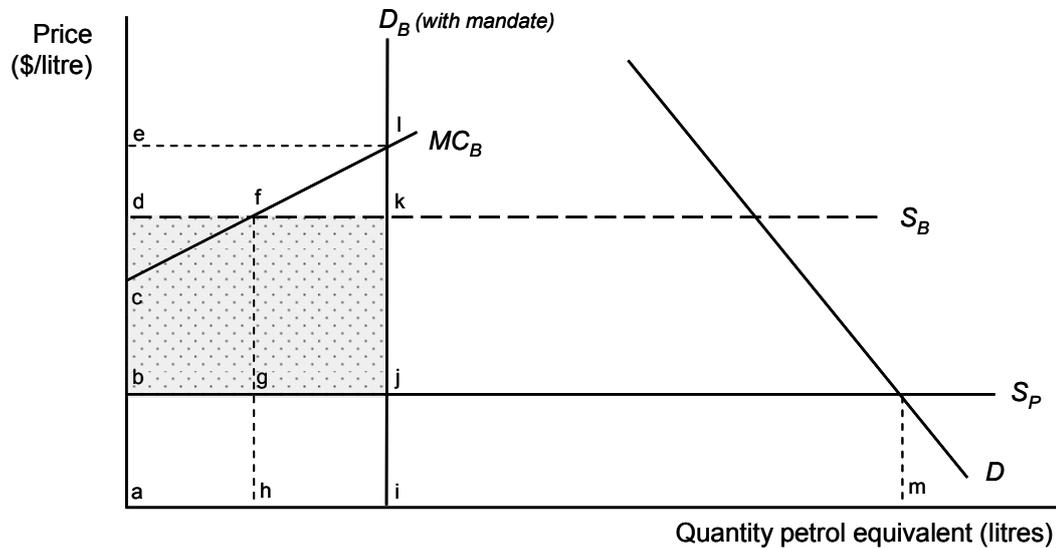
This figure depicts a market where both petrol and biofuel can be supplied by imports at world prices *ab* and *ad* and the two are considered to be perfectly substitutable in use after adjusting for energy content. Without intervention, *am* litres of petrol are consumed and no biofuel is consumed as it is not competitive with petrol.

Consider the introduction of a binding fuel content mandate that requires demand for biofuel to be *ai* and allows this to be met by imports or domestic production. The domestic biofuel price is set by the world price and the quantity of domestic production depends on its marginal costs MC_B. At price *ad* domestic production of biofuel is *ah* and imports are *hi*. The additional costs required to replace petrol with biofuel are *bcfkj* which are the additional resources used in producing domestic biofuel *bcfg* and to purchase the biofuel imports *gfkj*. The subsidy equivalent of the biofuel mandate is the shaded area *bdkj*, which is greater than the additional resource costs by the value of producer surplus *cdf*.

In contrast, where imports are not permitted to meet the mandate *ah*, the price that domestic biofuel producers receive will reflect domestic costs of production. That is, the price will be determined by domestic producers' marginal cost at the mandated quantity of biofuel. In this case, with domestic biofuel price *ae* domestic production of biofuels is *ai*, the total subsidy equivalent is *belj*, the additional resource costs are *bclj* leaving producer surplus *cel*.

Although not shown in the figure, the fuel mandate also increases the price of the petrol-biofuel blend and thus also has demand-side effects.

The difficulty in measuring production costs of additional energy efficiency is that energy efficiency products generally do not exist on their own. Instead, energy efficiency attributes are embodied in durable products along with other attributes.

Measuring the expected decrease in future energy costs is also difficult, because it depends on whether investors underestimate the benefits of energy savings

(box 3.5). The 'energy paradox' is that there appears to be a reluctance to invest in seemingly cost-effective energy-efficient durables. Why this is so is contentious. The net result depends on whether the apparent reluctance reflects investor misperceptions, or whether it reflects some unobserved cost of additional energy efficiency (such as search costs, high borrowing costs, or a preference for product attributes other than energy efficiency).

Therefore, the net costs of efficiency standards depend critically on assumptions regarding investor perceptions. For example, Parry, Evans and Oates (2010) provided estimates suggesting that in the United States, the marginal costs of using auto standards to reduce economy-wide emissions by several percent can vary from roughly −US$100 to +US$100 per US (short) ton of CO_2.

3.2 Measurement issues

The crux of the challenge for this study is how disparate, limited policies of selective application can be measured and aggregated in a useful way. If all greenhouse gas emissions were 'priced' directly, comparing prices across countries would be meaningful. Even so, any differences in carbon prices would not reveal whether some were too high or some too low — that would require an assessment of the desirable level of abatement globally. Some differences would also occur where the coverage of schemes differed.

In the absence of explicit carbon prices or taxes being imposed on all emissions in an economy, the total economic (welfare) costs of individual policies and their associated abatement effects ideally need to be estimated.[3] Measurement of total costs and abatement would allow calculation of average costs per tonne of CO_2 abated *under the schemes analysed*, which in turn would allow comparison of the cost-effectiveness of the various policies.

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[3] Price and quantity adjustments induced in markets will also likely generate real adjustment costs involving capital write-offs and labour relocation. Implementation and ongoing administration and compliance costs should also be taken into account but are difficult to measure.
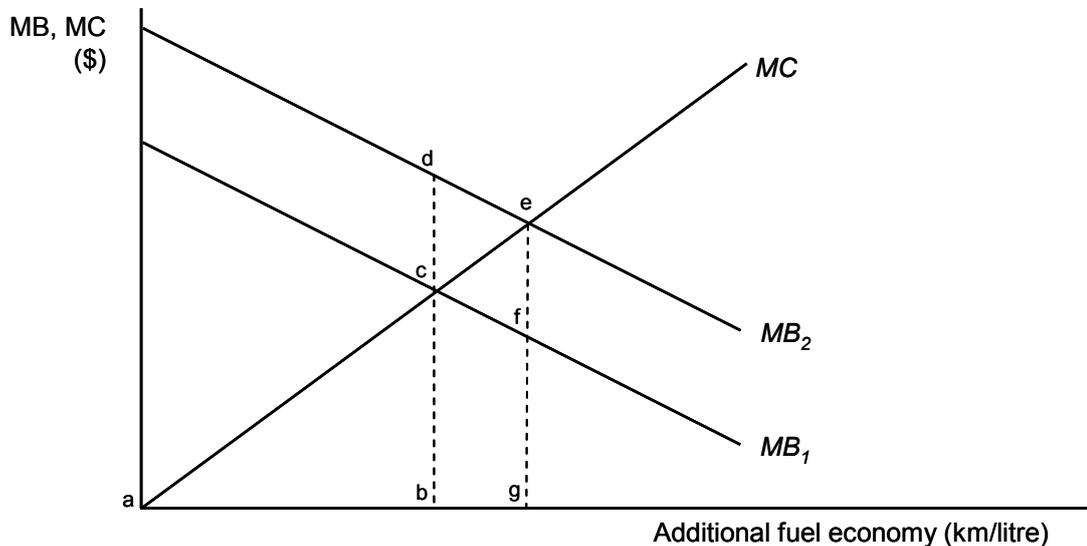
A large number of policies promote the production of and investment in more energy-efficient durable products, buildings and equipment, with the objective of reducing the demand for energy. The above figure is a stylised representation of the marginal benefits and costs of investing in a durable product (a car) that gives greater fuel economy. Marginal costs represent the resource costs used in producing the product, whereas the marginal benefit to investors depends on the value of expected future fuel savings discounted over the product lifespan (less any other transaction costs).

Expected fuel costs are the discounted value of the expected distance travelled in each future year, multiplied by the expected price of petrol divided by the fuel economy (km/litre). Marginal benefits are the change in fuel savings (that is, the negative of the change in expected fuel costs) from a change in fuel economy. With higher petrol prices, greater distance travelled and/or a lower discount rate, there are larger marginal benefits.

Many studies have suggested that buyers seemingly undervalue increased fuel economy. That is, marginal benefits are perceived to be MB_1 rather than the 'true' MB_2 and actual investment ab is less than the desirable level ag. This 'energy paradox' could result from imperfect information or excessive discounting. In this case, a mandatory vehicle fuel economy standard ag is seen as achieving the desired production level and net benefits — the increase in production costs $bceg$ is less than fuel savings $bdeg$ giving net benefits cde.

However, if investors correctly evaluate fuel savings, then marginal benefits are represented by MB_1 and a mandated fuel economy standard ag results in additional production costs $bceg$ less fuel savings $bcfg$. In this case, the vehicle fuel economy standard leads to over-investment in fuel economy with net costs cef. Thus, the costing of mandated energy efficiency standards such as fuel economy is particularly problematical and depends critically on the assumption about the extent to which investors may misperceive costs and benefits (to themselves).

An inherent difficulty of these measurements is that they involve comparing an existing situation with an unobserved 'counterfactual'. Calculating the effects of an existing or committed policy requires an assessment of what would have happened in the absence of the policy. This requires assumptions about, or estimates of, the supply and demand responses to the policy. Yet there is often considerable uncertainty about these responses, and the underlying models that are used to measure them can be quite different (and are sometimes only implicit). Some models are based on engineering estimates with little behavioural response, whereas others allow for behavioural supply and demand responses.

These considerations are especially important when attempting to construct comparable measures across diverse policies and countries. In some cases, sophisticated models allow consistent measurement across policies in a single country,[4] but for most there are no available models, and also significant data limitations. Costs of a policy derived from even a fully-specified model in one country will not be comparable to those calculated from more ad-hoc methods in another.

For policies that assist producers of low-emission products, the value of the assistance ('subsidy equivalent') is more easily calculated than their resource costs and is more comparable across policies and countries. These production subsidy equivalents[5] are of interest in themselves, because they capture the often hidden transfers to producers. Also, they are indicative of the true (resource) costs, though they generally will overstate them.

Measuring economic costs and subsidy equivalents

A (relatively) simple case: explicit production subsidies for low-emissions products

Measurement is simplest in the case of production of low-emission products such as renewable energy and where it is assumed that:

1. there is an explicit subsidy paid for each unit of production of the low-emissions product

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[4] For the United States, a comprehensive and consistent measurement of the economic cost effectiveness of a wide range of energy policies has been produced by Resources for the Future and National Energy Policy Institute using a version of the US Energy Information Administration's National Energy Modelling System (NEMS) (Krupnick et al. 2010).

[5] The OECD (2010) uses the terminology 'producer support estimates' for these measures in relation to agricultural assistance policies.

2. it is assumed that there would be no production of the low-emissions product without the assistance policy

3. consumers consider the low-emissions product (for example, electricity generated from renewable sources) to be perfectly substitutable for a higher-emissions product (such as electricity generated from coal)

4. the higher-emissions product is produced at constant marginal costs.

In this case, the subsidy equivalent from government — the production subsidy equivalent multiplied by annual production — provides additional revenue to low-emissions producers that is used to pay for the additional resource costs of producing their output[6] and, depending on costs, leaves some producer surplus.

On the basis of the commonly-used approximation that the marginal costs of producing the low-emissions product is linear, the additional resource costs will be greater than one-half of the subsidy equivalent and at most equal to the subsidy equivalent. To split the subsidy equivalent into additional resource costs and producer surplus, the marginal cost of producing low-emissions products is needed[7], but is generally unknown. For this reason, it is necessary to rely on an estimate of the subsidy equivalent as a proxy for the additional resource cost, even though it will generally overstate it.

More complicated cases

In addition to explicit production subsidies (assumption 1) there are a large number of other less transparent policies that assist the production of low-emissions products and thus implicitly subsidise them. In these cases, it is necessary to estimate the production subsidy *equivalents*.

This is straightforward with renewable energy certificate schemes, where the certificate price is equivalent to a production subsidy. And the production subsidy equivalent of a feed-in tariff is the tariff rate less the wholesale price of electricity.

In other cases, estimation of production subsidy equivalents is less straightforward. With input subsidies, for example, it is necessary to convert them to a per unit of output basis to make them equivalent to a production subsidy. Up-front lump sum capital subsidies have to be converted to an annual basis to determine the production subsidy equivalent. With an ETS, the production subsidy equivalent for

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[6] These resource costs of producing the low-emissions product are those additional to the cost of producing the higher-emission equivalent.

[7] This can be seen in boxes 3.1 and 3.2 where the subsidy equivalent is area *befg,* additional resource costs are area *bdfg* and producer surplus is area *def*.

a low-emissions producer is equal to the permit price times the difference between their emissions intensity and that of higher-emissions producers.

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

More measurement difficulties arise where high-emissions and low-emissions products are imperfect substitutes (assumption 3 does not hold). For example, biofuels are not perfect replacements for their conventional fuel counterparts. In these cases measurement is difficult because in principle it is necessary to know the supply and demand of the low-emissions product and how these change in response to the policy. In practice, with biofuels it has been assumed that, after adjusting for energy content, they are perfectly substitutable with conventional fuels (chapter 5).

There are further issues if assumption 4 is relaxed and there are increasing marginal costs of producing the high-emissions substitute. This has implications for the breakdown of the low-emissions product's subsidy equivalent into additional resource costs and producer surplus. Nonetheless, it remains the case that (with linear marginal costs) the additional resource costs for low-emissions production will be half or more of its subsidy equivalent.

Measuring price uplifts and consumption costs

Any policy that raises product prices to consumers will reduce their consumption and impose costs on them. However, rather than considering the consumption costs of each individual supply-side policy in a sector, the Commission has estimated the price uplift for all policies combined and then made some illustrative estimates of consumption costs.

The price uplift depends on who pays the subsidy equivalents. Where these are paid for entirely by consumers, the uplift will equal the sum of the subsidy equivalents for the sector divided by post-policy consumption (box 3.3). However, where it is known that the subsidy equivalents were funded by taxpayers, they have been excluded from the price uplift estimates. Where the subsidy equivalents are paid by consumers, the price uplift is estimated using the subsidy equivalent on all

production, not just the subsidy equivalents on policy-induced production (which are used as a proxy for resource costs).

The consumption cost is a measure of the value to consumers of foregone consumption of a good, minus the value of other goods that can be purchased instead.[8] In chapter 4, consumption costs are approximated by taking one half of the product of the change in quantity and price uplift. This commonly-used approximation (based on the demand curve being linear) is best for small price changes. For the larger fuel price changes considered in chapter 5, consumption costs have been calculated assuming a constant elasticity of demand.

It is also important to note that there are also costs if the subsidies are paid by taxpayers and not consumers. Because additional taxes further distort individual decision-making, they reduce efficiency and thus introduce an additional excess burden or welfare cost on the broad economy. However, no estimates have been made of these costs.

Measuring abatement

In addition to measuring the subsidy equivalents of individual policies, it is necessary to calculate the abatement brought about by each policy. The difficulty again is that this requires a counterfactual; namely, how much abatement would have happened in the absence of the policy?

Another issue is that policies aimed at supply-side abatement can also generate demand-side abatement if they raise product prices by reducing the quantity demanded and thus emissions. However, it is more convenient to consider first the supply-side abatement of individual policies, and to introduce later the effects of all the sectoral supply-side policies on the demand for the sector's product and emissions.

Supply-side abatement

A simple case is a policy that encourages production of a low-emissions product that then replaces production of a higher-emissions product. In this case, abatement is the additional quantity of the low-emissions product multiplied by the difference in carbon intensities between the high-emissions and low-emissions products.

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8   In boxes 3.2 and 3.3, the consumer valuation of the foregone consumption is *iklm*, while *ijlm* would be diverted to the consumption of other goods and reflects the valuation of those other goods. This leaves the consumption cost, that is, a net loss, of *jkl*.

Nonetheless, identifying the counterfactual can be complicated where the marginal operator varies depending on the circumstances (for example, peak-load electricity), and this can have a substantial impact on the amount of abatement that might reasonably be attributed to a policy. In the case of electricity generation, it is conceivable that at certain times some types of renewable electricity production replace (relatively low emissions) hydro or gas-fired electricity rather than (relatively high emissions) coal-fired electricity, for example.

It is even more complicated when a number of piecemeal, seemingly independent, policies interact. Here, the unintended consequence can be that the abatement impacts of the policies are not additive. One policy may increase the production of a zero-emissions product such as electricity from solar, but it may act to displace another zero-emissions product such as electricity from wind generation.[9]

Furthermore, it is necessary to measure *net* abatement in cases such as biofuels which, by replacing conventional fuels, reduce emissions, but in their production use fossil fuels, which increases emissions. This necessitates using a life-cycle approach to measuring emissions.

Demand-side abatement

Demand-side abatement is important for policies that push up the price of products that embody emissions. These policies obviously include explicit carbon taxes, ETSs and fuel taxes. In addition, to the extent that subsidies increase the prices to users — and demand elasticities are not zero — this will provide an additional source of abatement and, ideally, should be taken into account. In this study the Commission has used estimates of the elasticities of demand for electricity and transport fuels to make some inferences about the likely short-term abatement that the policy measures might achieve, presuming that all costs are passed through to consumers.

Other measurement issues

The timeframe

Ideally, emissions-reduction policies would be assessed over multiple years. This is because:

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9   In these cases, as abatement from one policy goes to zero then abatement costs per tonne of CO_2 for that policy goes to infinity. Nonetheless, the combined abatement and costs from the two policies would be included in the sectoral averages.

- policies are often designed to induce capital investments, such as the building of renewable electricity generation, which can take years to complete and result in abatement over many years

- it is common for policies to be phased in over a period of years, such as an increasingly stringent target for the share of electricity generated from renewable sources.

However, this can add considerable complexity, and so its advantages have had to be weighed against the time constraint on the study. In measuring the costs and abatement of policies, the Commission has adopted a partial equilibrium, comparative static approach that compares, in the latest year for which data are available, a snapshot of the post-policy situation to the counterfactual snapshot of no policy.

This is not to say that longer-term issues cannot be accommodated in the framework. For example, a capital subsidy that encourages investment in low-emissions generation, has a one-off upfront cost, but may contribute to abatement over many years. To account for this divergence in costs and benefits, the value of the subsidy can be amortised over the life of the project and expressed on an annualised basis. This can also be done for previous years' capital subsidies, as some of these previous up-front payments also contribute costs today when considered on an annualised basis. Similarly, the costs of policy measures that bring forward investment that might reasonably be assumed to have occurred in the future can be approximated in similar ways by use of appropriate discount rates (chapter 4).

'Additionality'

Some policies promote other domestic objectives (such as revenue raising or reducing local pollution), while having the 'by-product' effect of achieving emissions reductions. (This issue is more likely to arise for policies that are not explicitly intended to target greenhouse gas emissions, such as fuel excise.) Where such policies deliver domestic benefits and would have been undertaken regardless of their impact on greenhouse gas emissions, the marginal costs of any associated abatement will be negligible. Given that policies can have multiple objectives and that it in most cases it is not possible to decompose abatement estimates (or for that matter costs), it is arguable how much can or should be attributed to abatement objectives.

Sensitivity analysis

Given the measurement challenges just outlined, it is inevitable that there will be a degree of uncertainty associated with estimating abatement costs. The Commission has accordingly produced a range of estimates, rather than a single number, for different policies and for each sector in each country. This involved sensitivity analysis, with key assumptions varied within plausible ranges.

3.3   Adding it up

Ideally, the full economic costs and abatement of the various interventions in the study countries would be measured. Given the measurement challenges, for each policy measure, a subsidy equivalent (as a proxy measure of resource costs), and where possible, an implicit abatement subsidy (cost per tonne of CO_2 abated) have been reported. Implicit abatement subsidies could not be estimated for every measure, because,, as noted earlier, in some cases it has not been possible to isolate the abatement effects of individual policies.

Although these proxy measures will typically overstate resource costs, to the extent that they do so consistently across countries, they provide some basis for comparing the *cost effectiveness* of different measures within and across countries in these sectors. They will also be useful indicators of the resources that respective governments are prepared to devote to encouraging abatement, either directly through explicit financial subsidies or indirectly through higher prices paid by consumers.

As far as possible, the Commission has also endeavoured to estimate the overall product price increase or 'uplift' that results from the various interventions in each sector for each country. This information has been used to make some inferences about consumption costs and demand-side abatement. It has been done only after aggregating the subsidy equivalents for each sector. But given the large degree of uncertainty about demand elasticities, estimates of consumption costs can only be illustrative.

The Commission's approach to estimating the sectoral price uplift resulting from the various policies is essentially the same as that followed by Vivid Economics (2010) in a report it undertook for the Climate Institute. Vivid Economics weighted its estimates of the costs of each policy by the share of electricity generation to which that policy applied, to give the price uplift (box 3.6). Vivid Economics referred to this as the sectoral 'implicit carbon price' by expressing it per tonne of CO_2.

Box 3.6   **Issues in 'implicit carbon prices'**
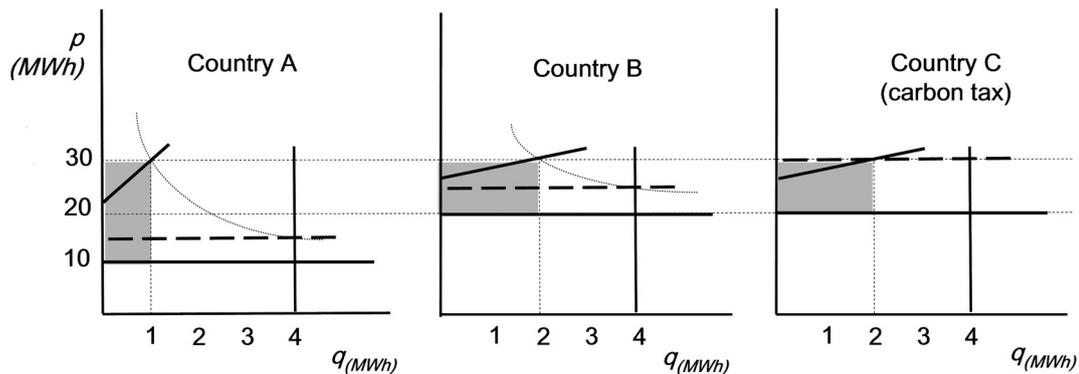
In its report for the Climate Institute, Vivid Economics calculated the cost of abatement for each policy measure, weighted these results by the proportion of electricity generation to which that measure applied, and then summed them. The result was termed the 'implicit carbon price' for that country's electricity-generation sector.

This weighting system is appropriate for calculating electricity price uplifts (when all costs are passed on to consumers). However, it will give a different result for countries that are identical in abatement and costs, but which differ in their cost and emissions intensity of baseload electricity. The result also depends on whether the assistance provided to renewable generators comes via direct intervention or by imposition of a carbon tax or ETS.

Take three countries, each of which devotes the same amount of resources (as proxied by the total subsidy equivalent, and shown as the shaded area in each diagram above) to supporting renewable generators. In country A the quantum of assistance provides one unit of renewable electricity, and in country B it provides two units. This is because in country A, baseload is half the cost in country B, and twice as much subsidy is required to induce the renewable technology supported by country A's intervention. (To simplify the figure, country A and B are assumed to target different technologies hence the different cost functions, but this does not affect the outcome.)

If baseload electricity in country A is assumed to be twice as emissions-intensive as in country B (2 t CO_2/MWh compared with 1 t CO_2/MWh), each country achieves the same amount of abatement at the same additional cost (and hence would have the same implicit abatement subsidy). But Vivid Economics' weighting would mean that country A's assistance would be weighted by a factor of 0.25 (one unit of renewable electricity in four units in total) and country B's would be weighted by 0.5. In other words the 'implicit price of carbon' in country B would be twice that of country A, despite both having the same amount of abatement and the same cost of abatement per tonne of CO_2.

Box 3.6 (continued**)**

Now let country C (which has the same characteristics as country B) impose a carbon tax instead of a technology-specific regulation or subsidy. In this example, the carbon tax provides the same uplift in the prices received by renewable generators, and the same total subsidy equivalent. But because the Vivid Economics approach gave the carbon tax (for its estimate of the United Kingdom) a weighting of 1.0, it contributes more again to the implicit price.

In summary, the abatement subsidy is $10/t CO_2 for all three countries and they all achieve the same abatement, but the implicit prices that would be derived from the Vivid Economics' approach are $2.50, $5.00 and $10.00/t CO_2 for countries A, B and C respectively.

This is a highly stylised example that uses large hypothetical differences in emissions intensity and cost, but it serves to illustrate some of the issues in interpreting a single measure of costs that is weighted by shares of generation.

These three scenarios can also be used to illustrate what would happen to electricity prices if the full amount of the tax equivalent was passed through to customers. The tax equivalent for countries A and B is equal to the subsidy equivalent, but in country C the total tax equivalent equals the full revenue from the carbon tax, some of which accrues to renewable generators as a subsidy and some to government. For both country A and country B the price uplift would be $5/MWh, but because of the different cost base this would represent a 50 per cent increase in country A and a 25 per cent increase in country B. Full pass-through of the carbon tax in the case of country C would result in a $10/MWh rise in electricity prices, a 50 per cent increase. Thus, in this example, country A with the lowest 'implicit carbon price' has the (equal) highest percentage increase in electricity prices.

This example also illustrates that the Vivid Economics 'implicit carbon price' can be interpreted as (and is equivalent to) the price uplift per MWh divided by the baseload emissions intensity. That is, dividing the price uplift for each country ($5, $5 and $10/MWh for A, B and C respectively) by their emissions intensity (2.0, 1.0 and 1.0 t CO_2/ MWh) gives the country's 'implicit carbon price' ($2.50, $5 and $10/ t CO_2). Thus, all else the same, the higher the emissions intensity, the lower the 'implicit carbon price'.

To demonstrate this, the Commission has calculated from Vivid Economics' published figures that their average abatement subsidies for Australia and the United States would be US$15.27 and US$15.38/t CO_2, respectively. Using Vivid Economics weighting, these translate into electricity price uplifts in the two countries of US$2.45 and US$4.80/MWh. Based on emissions intensities for the two countries (1.05 and 0.95), their 'implicit carbon prices' are US$2.34/t CO_2 and US$5.05/t CO_2.

Finally it is important to note that these 'implicit carbon prices' cannot be compared to *explicit* carbon prices of the same value. In the above example as drawn if country B converted its 'implicit carbon price' of $5 into an explicit carbon tax of $5, it would achieve no abatement and have no abatement costs (with demand unresponsive to price) while raising $20 in revenue.

The Commission's estimates of price uplift are expressed per unit of output and comparisons are made across countries of the percentage increase in output prices as a result of the emissions-reduction policies examined. While these price uplifts are one important metric in cross-country comparisons of the effects of carbon policies, it is necessary also to compare abatement achieved and the economic costs incurred. Countries could have similar abatement and costs with different price uplifts or vice versa (box 3.6).

It is also important to note that the estimated price uplift is not a *carbon price* equivalent. That is, the imposition of an economy-wide carbon price that would result in the same price uplift would not achieve the same abatement as the existing sectoral policies, nor would it have the same costs of abatement.

Conceptually, there are a number of different economy-wide carbon prices that are equivalent to existing sectoral policies in a *single* aspect of their impacts but not others (box 3.7). The imposition of an economy-wide carbon price that would result in the same amount of abatement as existing policies would not involve the same cost nor would it achieve the same price uplift. Or the imposition of an economy-wide carbon price that imposed the same costs as existing policies would not result in the same abatement. In other words, there is no single economy-wide carbon price that would bring about precisely the same level, type and cost of abatement as a scheme that assists a narrow subset of abatement options.

Box 3.7   **The elusive 'implicit' carbon price equivalent of a subsidy**

There are a number of different carbon price equivalents that could capture a particular aspect of the impacts of a subsidy scheme.

First, it would be possible to estimate the carbon price or 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 taxpayers). But this carbon price would be too low to support the level of renewable production that the subsidy brings forth and, indeed, too low to generate much abatement from any other low-emissions technology. Moreover, for any given abatement cost, this particular carbon price will be lower, the greater the emissions intensity of baseload generation.

Second, there will generally be a carbon price level or rate of tax capable of inducing the *same amount of renewable energy* as a renewables subsidy. Indeed, that carbon price or tax would need to equal the (explicit or implicit) unit subsidy. But unlike the subsidy scheme, this level of carbon price or tax would also lead to additional abatement by increasing consumer prices and reducing consumption of electricity overall, and by encouraging other production technologies (for example, gas-fired generation). (And the broader the base of the carbon price or tax, the greater the abatement for any given price.)

Third, there will be a carbon price or tax that would generate the *same costs* as the subsidy scheme, but this carbon price will be lower than the unit subsidy and would also likely generate greater abatement from different sources to the subsidy scheme (again depending on the coverage of the carbon price scheme).

A fourth approach would be to calculate the carbon price or tax that would deliver that *same total amount of abatement* as the renewables subsidy, from the most efficient (lowest-cost) sources. While this would be equivalent to the subsidy in that particular respect, the resulting abatement would not come from the same sources or occur at the same cost. That said, such a calculation would usefully highlight to governments the relative cost effectiveness of the mitigation policies they have in place. (But these 'efficient' carbon price equivalents, assuming they could be estimated for each country, would still provide little guidance as to whether countries should undertake more or less abatement.)

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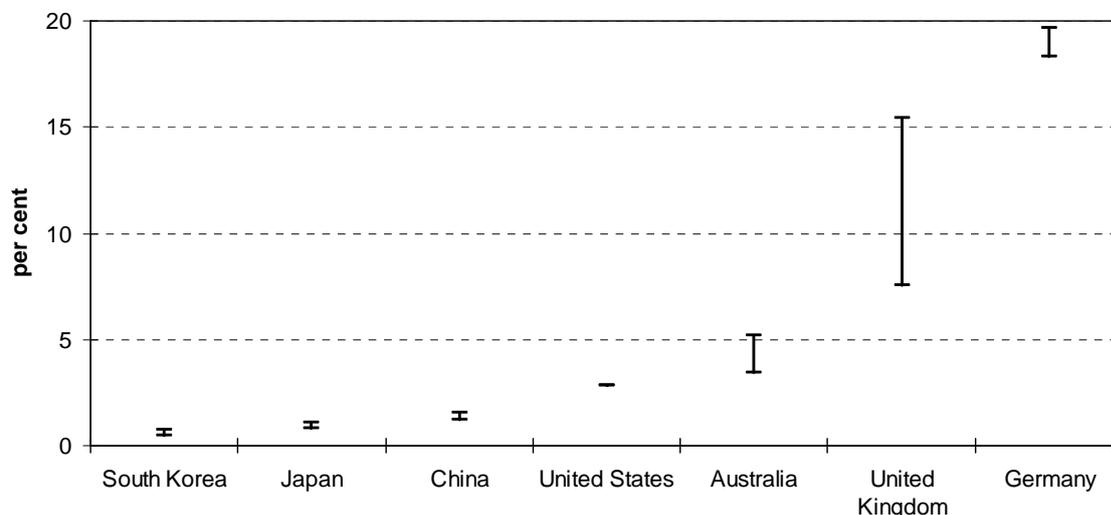
[a] Lines show the Commission's lower and upper-bound estimates of electricity generation sector abatement for each country. Results for China do not include the 'Large Substitute for Small' program.

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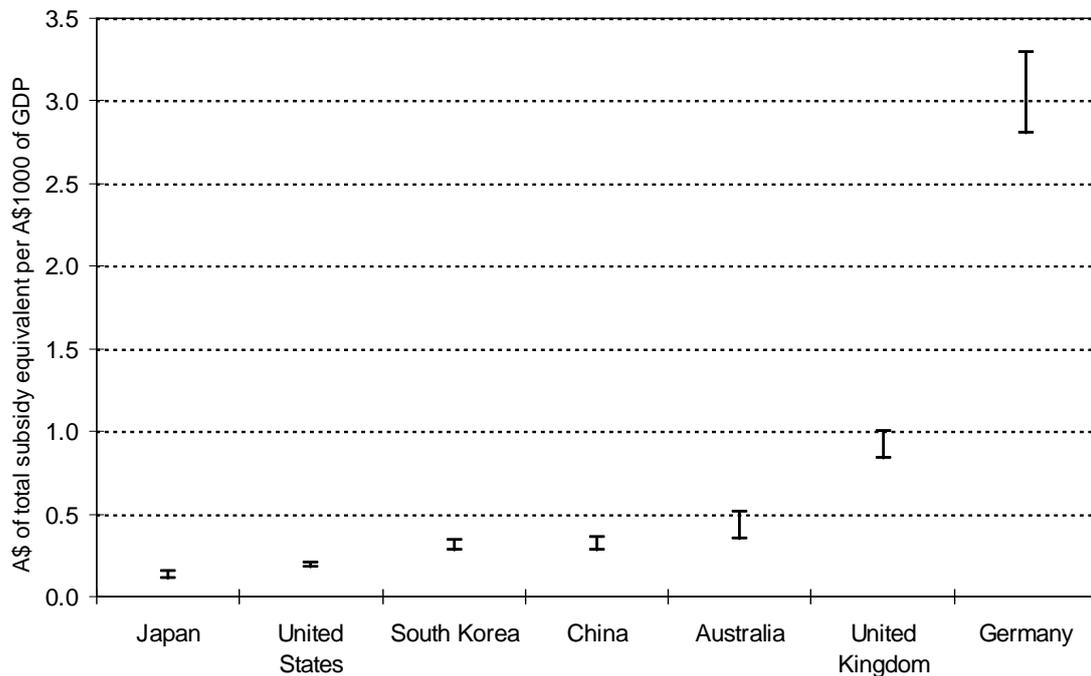
a Lines show the Commission's lower and upper-bound estimates of electricity generation sector total subsidy equivalents for each study country.

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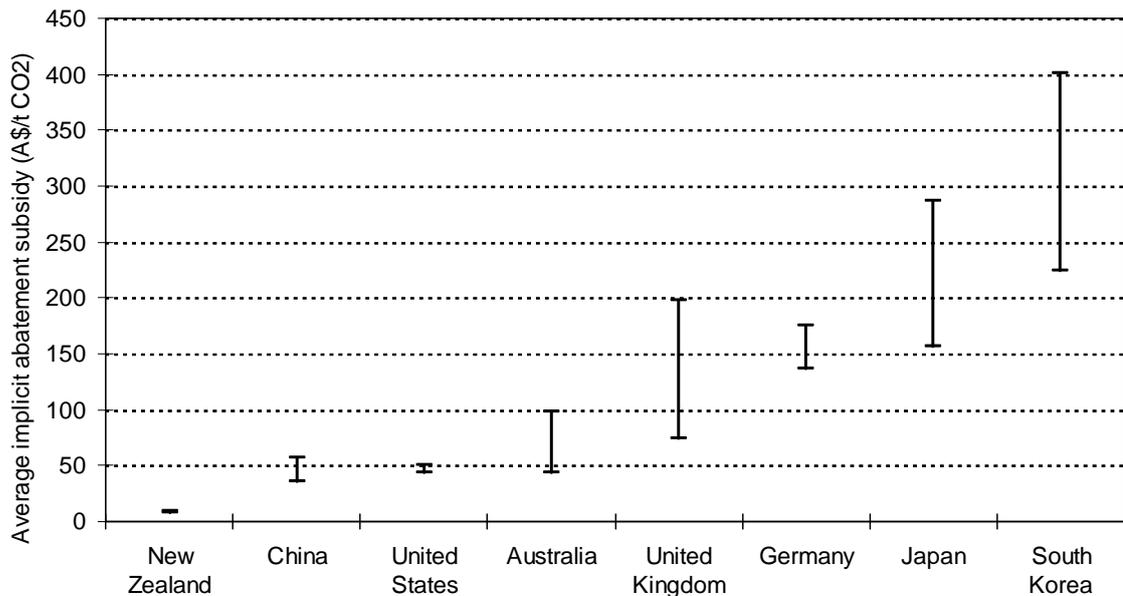
[a] Lines show the Commission's lower and upper-bound estimates of electricity generation sector implicit abatement subsidies for each country.

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]**
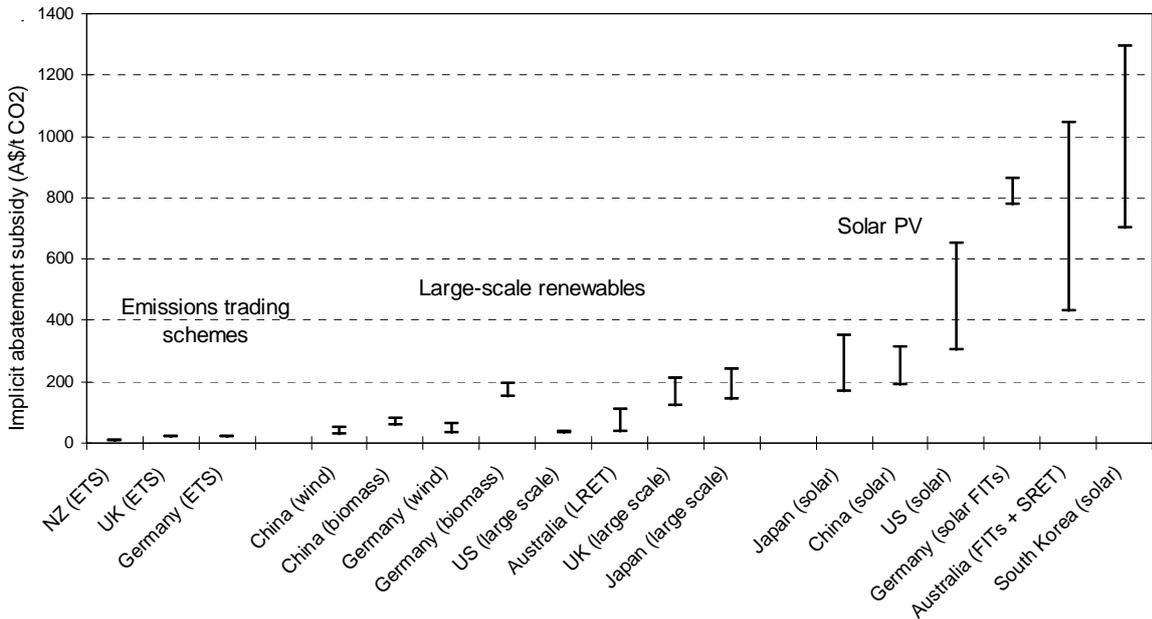
a Lines show the Commission's lower and upper-bound estimates of electricity generation sector implicit abatement subsidies for each country, broken down by technology. Only a subset of the policies could be broken down by technology. Where a data point is labelled 'large scale', the policy applies to 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.

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).

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

90   CARBON EMISSION
       POLICIES IN KEY
       ECONOMIES

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

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[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.

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[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.

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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

		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	–	–

		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

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[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]

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[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.

5　The road transport sector

Key points

- The Commission has analysed the costs and abatement for a selection of road transport fuel policies (fuel taxes and biofuel policies).
  - This analysis provides an illustration of the challenges in estimating abatement costs in sectors other than electricity.
  - However, the limited coverage of the analysis means that the results do not reflect all relevant policy-induced costs and abatement in the study countries.
- Both fuel taxes and biofuel policies often have multiple objectives.
  - Where policies are primarily in place for other reasons, reductions in emissions could be seen as an incidental outcome, at low or zero cost.
- In general, policies targeting greenhouse gas emissions from road transport that are broad in scope are likely to reduce emissions more efficiently and cost effectively than policies that target specific technologies or activities.
- Across all study countries, biofuel policies make a small contribution to abatement in the road transport sector at a relatively high cost.
  - These policies are narrow in scope (and can be even narrower where preference is given to particular biofuel feedstocks).
  - The abatement from biofuel policies is highly sensitive to the feedstock used, taking into account life-cycle emissions.
  - Australia's biofuel policies in 2010 led to abatement of 0.6 per cent of counterfactual road transport sector emissions at a cost of A$364 per tonne of CO_2-e abated.
- Fuel taxes are a broad based policy (within road transport) and can potentially have a large impact on sectoral emissions at relatively low cost.
  - However, fuel taxes are levied for a range of other purposes and it is difficult to attribute the costs of fuel taxes to the abatement achieved.
  - The average cost per tonne of abatement is higher in countries that have higher fuel taxes.
  - In 2009-10, fuel taxes reduced emissions from road transport by 8 to 23 per cent in Australia at an average cost of around A$57–59 per tonne of CO_2-e.

This chapter presents the Commission's quantitative analysis of abatement and costs for a selection of road transport policies. The first two sections discuss the scope of the quantitative analysis and the approach used to estimate abatement costs. The final section presents results by country on both the supply side and demand side.

5.1   Reducing emissions from road transport

The road transport sector includes all transportation of passengers and freight by road, such as commercial and private vehicles, on-road public transport (for example, buses), small and large commercial goods vehicles and government fleet vehicles. Road transport represents a significant proportion of total greenhouse gas emissions in all study countries, ranging from 5 per cent in China to 26 per cent in New Zealand (figure 5.1). By focusing on road transport, the Commission's analysis covers the majority of emissions in each study country's transport sector. Further analysis of emissions and road transport fuel use is provided in Appendix M (available on the Commission's website).

A range of policy tools are being used by governments to reduce transport emissions. For example, governments tax or subsidise fuels and vehicles based on their greenhouse gas emissions intensity. Chapter 2 provides an overview of the types of policies that study countries use to reduce emissions more generally in the transport sector.

The scope of quantitative analysis

The Commission has identified over 100 policies that apply to the road transport sectors of the study countries, and has selected a subset for more detailed analysis. The quantitative analysis was restricted to road transport policies that:

- penalise emissions or provide an incentive for abatement

- have a material impact on a country's emissions and/or impose significant total costs

- have a reasonably direct impact on greenhouse gas emissions.

A further issue was whether it was *feasible* to quantify the costs and abatement of policies — some policies met the criteria in principle, but could not be included due to a lack of suitable data, or high levels of uncertainty regarding abatement or cost.

Figure 5.1　**Road transport greenhouse gas emissions as a percentage of total national emissions[a,b]**

2008 (or most recent year available)

Road Transport ▨ Other Domestic Transport
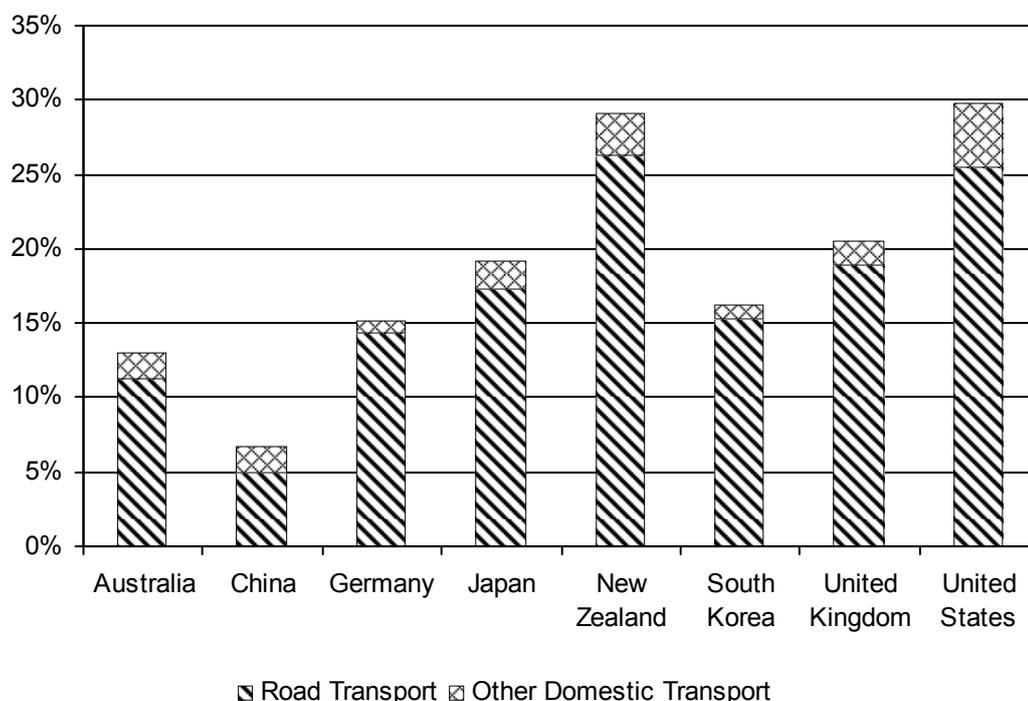
a 'Other domestic transport' includes emissions from fuel used for domestic civil aviation, railways, domestic water-borne navigation, pipeline transport, fishing, off-road transport and other non-specified domestic transport emissions. Excludes emissions from fuel sold for use in aircraft or marine vessels engaged in international transport. **b** As China and South Korea do not have official reporting obligations under the Kyoto Protocol, national emissions are 2007 estimates from WRI (2010) and exclude emissions from land use change and forestry. Road transport and other domestic transport emissions for China and South Korea are 2008 estimates from the IEA (2010a).

Sources: IEA (2010a); UNFCCC (2011a); WRI (2010).

Road transport fuels

One group of policies that satisfied the Commission's criteria targets road transport fuels (figure 5.2), comprising biofuel policies and fuel taxes.

- The analysis of biofuels covers several types of policy, including tax exemptions, production subsidies and fuel content mandates (where material, and sufficient data were available).

  – Some policies, such as fuel content labelling requirements, were not analysed as the extent to which these policies led to abatement is uncertain and the linkages to greenhouse gas emissions too indirect (chapter 3).

- The analysis of fuel taxes covers all taxes that specifically target fuels (such as excise), but not broad-based consumption taxes, which usually do not provide differential treatment of transport fuels.

  – It also includes explicit carbon prices that cover transport fuels, as these are typically levied on fuel suppliers in a similar way to fuel excise (at present, of the countries studied only the New Zealand Emissions Trading Scheme (ETS) covers transport fuels).

Figure 5.2   **Road transport policies**
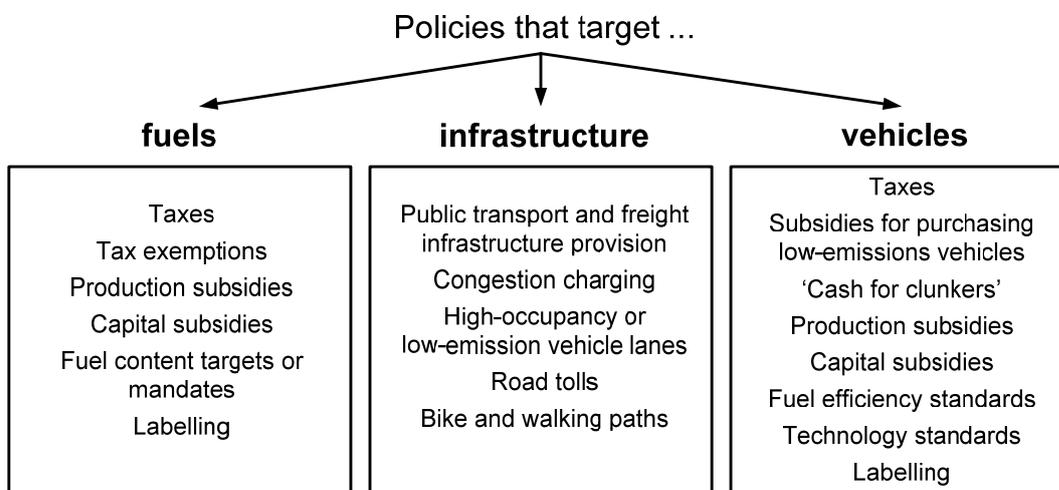
Not all transport-fuel policies can be considered primarily climate change measures. For example, fuel taxes — which are in place in every study country — are levied to meet a range of objectives, such as to fund road provision and maintenance, reduce congestion or to raise general revenue. These taxes may have net benefits where they address other objectives.

However, fuel taxes raise the price of fuel, and in so doing, reduce fuel demand and greenhouse gas emissions. Some study countries, such as Japan, have raised (or committed to raise) their fuel taxes with an explicit objective of reducing greenhouse gas emissions (chapter 2). Although a relatively direct measure, fuel taxes do not specifically target greenhouse gas emissions where they are levied as a flat rate on each litre of fuel. Nevertheless, since fuel taxes clearly provide an incentive for consumers to use less fuel — and thereby have a significant impact on emissions — they have been included in the analysis.

Where policies meet other objectives, reductions in greenhouse gas emissions may be an incidental outcome and thus any resulting abatement may occur at low or zero cost. (However, it is difficult to separate the impacts and costs of multiple

objectives of policies.) For example, biofuel policies often have a range of objectives in addition to greenhouse gas mitigation, such as promoting regional development or improving energy security. The Commission has not attempted to apportion abatement by the objectives of a policy and thus the estimates provide an 'upper bound'.

Other road transport policies

Applying the criteria for policy selection to other policy types in the road transport sector led to a large number of policies being excluded from the analysis. One excluded category is transport infrastructure policies, such as the development of public transport systems or road tolling. These are adopted by governments for various purposes other than reducing greenhouse gas emissions. However, these policies may have significant impacts on greenhouse gas emissions over long time periods. For example, infrastructure and urban planning policies can affect the range of transport modes available to individuals and thus can shape the ways in which people respond to changes in fuel prices over time. In doing so, infrastructure and urban planning policies have complex links to greenhouse gas emissions and can interact with other policies, such as fuel taxes. These impacts are difficult to measure.

Policies that target vehicles according to their fuel efficiency or greenhouse gas emissions, such as differential vehicle registration and mandated emissions standards, have also been excluded from the analysis (box 5.1). Governments may utilise some of these policies in order to overcome deficiencies in the provision of information — where consumers are not fully informed about the potential fuel savings from purchasing more fuel-efficient vehicles — or as a way to internalise the costs imposed on others from vehicle greenhouse gas emissions. However, there are divergent views on the extent to which individuals understand the private costs and benefits of fuel efficient (lower-emissions) vehicles, with significantly different implications for the costs of these policies as a means of abatement (appendix C).

Further, policies that target vehicles are a relatively indirect measure to reduce greenhouse gas emissions. While the average emissions intensity or fuel efficiency of a vehicle can be observed, this is only one factor among several that can determine the emissions from a vehicle over its lifetime. Total vehicle emissions will also depend on the distance the vehicle is driven, the type of fuel used, road conditions, where the owner lives and his or her driving style. Moreover, many vehicle policies (such as fuel efficiency standards) apply only to new vehicles. Thus, they affect the national vehicle fleet incrementally over long time periods.

While the Commission has therefore not estimated cost and abatement for vehicle policies, discussion of their likely impacts is provided in appendix C.

Box 5.1   Key transport terms used in this study

- Biodiesel — a form of diesel fuel that is derived from plant or animal matter.

- Conventional fuels — the two most widely used road transport fuels, petrol and diesel.

- Diesel — a middle distillate derived from a petroleum refining process (also referred to as light fuel oil, distillate fuel oil or automotive gas oil in some countries).

- Ethanol — ethyl alcohol, most commonly derived from biomass and used as a vehicle fuel.

- Ethanol-blended fuel — a mixture of petrol and ethanol. The name used in some countries refers to the proportion of ethanol (for example, E10 is 10 per cent ethanol and 90 per cent petrol).

- Export parity price — the price that fuel producers could receive by selling fuel for export rather than selling fuel domestically.

- Import parity price — the cost of importing fuel (including transport and import costs).

- LPG — liquefied petroleum gases used as vehicle fuel.

- Petrol — automotive gasoline distilled from petroleum (this includes 'regular unleaded' and 'premium unleaded' in Australia).

- Petrol equivalent — a measure to compare fuel volumes (for example biofuels or diesel) consistently by energy content. It is the volume of petrol that has the same energy content as one litre of a given fuel.

- Petroleum — liquid hydrocarbons as extracted from the earth (often called oil or crude oil).

- Terminal gate price — the advertised price of fuel for sale at the terminal gate of refiners or importers, which is often used as a reference to determine actual wholesale prices to customers.

What this means for the scope of the road transport analysis

While emissions-reduction strategies in the road transport sector clearly extend well beyond biofuels and fuel taxes, the focus has been restricted to these policies. This narrowing of scope was necessary because other policies in the sector either do not provide costs or incentives that are sufficiently closely linked to greenhouse gas emissions, or result in costs and levels of abatement that are particularly difficult to assess. This means that reported estimates do not fully capture the costs of

emissions-reduction policies in the road transport sector nor the policy-induced abatement.

An analysis of road transport fuels provides a useful illustration of the difficulties in estimating abatement costs in a sector other than electricity. For one thing, the methodological approach (chapter 3) cannot be applied to the road transport sector in the same way. There are some key differences between these sectors which affect the process required to estimate abatement and costs. In particular, the transport sector does not involve one homogeneous product. Also, fuels are commonly traded on international markets.

It is important that estimates for road transport fuels are viewed in this context, and not interpreted as necessarily representative of abatement costs, or levels of abatement being achieved, in the road transport sector more broadly.

What the Commission has estimated

There are a range of biofuel assistance measures and fuel taxes in place in all study countries (table 5.1). The approach taken to estimating abatement costs for these policies differs for the two broad policy types, and also across individual policies.

Biofuel policies

All eight study countries provide some form of support to biofuels and often utilise several policy instruments for this purpose (table 5.1). To the extent that they are effective, biofuel policies can induce an increase in domestic biofuel consumption and displace consumption of more emissions-intensive conventional fuels (such as petrol and diesel) (box 5.1). This abatement occurs on the supply side of the fuel market.

The biofuel analysis focuses on the two main fuel markets in each country (petrol and diesel) for which there are biofuel substitutes (ethanol and biodiesel). The analysis was conducted separately for these two fuel markets.

Table 5.1   **Coverage of fuel policies[a]**

| Country | Biofuel policies | | Fuel taxes |
	Subsidies	Fuel content mandates[b]	
Australia	Ethanol, biodiesel	..	Petrol, diesel
China	Ethanol, biodiesel	Ethanol	Petrol, diesel
Germany	Biodiesel, vegetable oil[c]	Ethanol, biodiesel	Petrol, diesel, LPG
Japan	Ethanol	..	Petrol, diesel, LPG
New Zealand	Ethanol, biodiesel	..	Petrol, diesel, LPG[d]
South Korea	Biodiesel	..	Petrol, diesel, LPG
United Kingdom	..	Ethanol, biodiesel	Petrol, diesel, LPG
United States	..	Ethanol, biodiesel	Petrol, diesel, LPG[e]

a Only policies that were included in the quantitative analysis are listed in the table. Biofuel policies that are not expected to lead to additional biofuel consumption have not been included. **b** Only mandatory schemes were included in the analysis (this does not include the mandate in New South Wales). **c** Pure vegetable oil is used in some vehicles in Germany, and is assumed to displace diesel. **d** Fuel taxes in New Zealand include the New Zealand ETS. **e** Fuel taxes in the United States include federal and state-level taxes. **..** Not applicable.

Sources: Appendixes N, O.

In all study countries, some substitution occurs between petrol and/or diesel and biofuels (usually with a low proportion of biofuel in a blend with conventional fuel). While biofuels are not perfect substitutes for petroleum-derived fuels — there are differences in energy content and octane or cetane rating — in most cases they are used to displace these fuels. The Commission's analysis assumes that differences between fuel types — apart from energy content — do not significantly affect the demand for transport fuels. Thus, it has been assumed that in the absence of government policy, consumers will only purchase biofuels where these are price competitive with petrol or diesel. That is, the prevailing market price of biofuels is expected to equal the petrol (or diesel) price (adjusted for energy content) in the absence of policy support.

The focus of the analysis is on *consumption* of biofuels in each country. Where biofuels are imported, these are incorporated in the analysis. In contrast, biofuels that are produced domestically, but exported and consumed in another country, are excluded. This captures the costs of reducing greenhouse gas emissions through biofuels that are consumed in the country only.

Estimating costs

In order to determine the average cost of abatement of biofuel policies, the Commission has estimated their subsidy equivalents. The subsidy equivalent represents the amount of financial assistance provided directly or indirectly to the

biofuels industry under the policy. Subsidy equivalents also give an upper bound estimate of the resource costs of these policies (chapter 3).

The Commission estimated subsidy equivalents for two types of biofuel policy: production subsidies and fuel content mandates. Production subsidies provide a subsidy to producers of biofuel for each litre of fuel produced, usually in the form of an excise exemption on the tax rate paid per litre of petrol or diesel for fuels that contain biofuel. Where an exemption or a reduced excise rate is provided for biofuel, the Commission has assumed that the production subsidy is equal to the rate of excise levied on petrol (for ethanol) or diesel (for biodiesel) minus the excise rate (if any) on the biofuel. An alternative approach would have been to assume that the 'counterfactual' excise rate (that is, the excise rate on biofuel without the exemption or concessionary rate) would be equal to the excise rate for conventional fuel adjusted for energy content. However, most study countries do not adjust their fuel excise rates for energy content and it was not clear which study countries would do so in the absence of subsidies for biofuels. As such, the counterfactual excise rate for biofuel is assumed to be the excise rate for conventional fuel with no adjustment for energy content.

Fuel content mandates can be in the form of blending requirements or quotas that apply to all fuel distributors, or to particular groups (for example, government agencies as part of government procurement policies[1]). Whatever their form, mandates are likely to increase domestic consumption of biofuels where they are 'binding' — that is, where the mandate increases consumption above what it would otherwise have been. By increasing demand for their product, the mandate provides an implicit subsidy for biofuel producers. Rather than receiving the petrol price for their output (adjusted for energy content), ethanol producers receive a premium above the petrol price.

In order to estimate this price premium, estimates of country-specific terminal gate prices for each type of fuel have been used (box 5.1). The analysis assumes that no individual country has a significant influence on world prices for petrol and diesel. Further, as each study country is a net importer of either crude oil or petroleum-derived fuels, it is assumed that domestic petrol and diesel prices are largely determined on international markets and are supplied at the import parity price (that is, supply is perfectly elastic).

In countries where there is a combination of biofuel policies in place, it was more challenging to determine the costs and abatement of individual policies. In

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[1] Since government procurement schemes create a guaranteed demand for biofuels, they are conceptually the same as a quota for biofuel consumption.

particular, where fuel content mandates are used in conjunction with production subsidies, careful consideration must be given to the extent to which each policy leads to abatement in addition to that achieved by other policies. In these cases, cost and abatement were quantified by taking a whole-of-market approach — where the combined impacts of policies were examined, rather than quantifying the impacts of each policy in isolation (box 5.2).

Box 5.2   **Accounting for policy overlaps**

In four study countries a combination of overlapping policies are used to support the consumption of biofuels. This overlap can affect the approach taken to estimate resource costs and abatement, particularly where a fuel content mandate is utilised in conjunction with other policies.

Under a binding fuel content mandate, the volume of biofuel consumed in a country is set by the mandate, meaning that other policies will generally not affect the overall level of consumption of biofuel. Where this occurs, other policies can represent a transfer to producers (both domestic and foreign depending on the eligibility requirements for the subsidy) and may also increase the level of domestic biofuel production relative to imported biofuels (where the mandate is met by a mix of imported and domestic production). Where a subsidy shifts consumption towards higher cost domestic producers and away from imported biofuel, this will also lead to additional resource costs.

Where a fuel content mandate does not bind, other policies are inducing additional consumption of biofuels rather than the mandate. In this case, the total subsidy equivalent is estimated taking into account the costs of these policies.

Estimating abatement

The abatement attributed to a policy is determined by estimating the amount of greenhouse gas emissions that occur in the year of analysis (with the policy) relative to that which would have occurred without the policy (counterfactual emissions). In order to determine counterfactual emissions, assumptions must be made about the mix of fuels that would have been consumed if the policy had not been introduced and their emissions intensity. It is difficult to estimate with any precision the volume of biofuels and conventional fuels consumed in the 'counterfactual' (for example, due to uncertainty about whether any biofuel producers would be competitive in the absence of government assistance, or because data are not available). Consequently, the default assumption adopted for each country is that no biofuel would be consumed under the counterfactual scenario (box 5.3).

Box 5.3 **Consumption of biofuels without government assistance**

The costs of producing biofuel vary by country or region and depend on a range of factors including the type of feedstock used and the technology used to convert the feedstock into fuel. In most parts of the world (with Brazil being a notable exception), biofuels cost significantly more to produce than conventional petroleum-derived fuels (IEA 2006b). Consequently, consumption and production of biofuel 'has been, and continues to be shaped profoundly by government policies' (Steenblik 2007, p. 3).

In recent years, increasing oil prices combined with lower biofuel production costs have improved the cost competitiveness of biofuels with conventional fuels. However, in most countries biofuels are still not competitive with petrol and diesel without subsidies (IEA 2006b). This is partly because it is not just the oil price that matters — the opportunity cost of the feedstock is also a critical factor, and thus as feedstock prices rise the cost competiveness of biofuel is reduced.

Nevertheless, it is impossible to definitively conclude that there would be no consumption of ethanol or biodiesel in the study countries without government support. There are several reasons why this may not be the case:

- Biofuel might be used as a fuel additive, for specific purposes.

- Some consumers may be willing to pay a premium for biofuels.

- Some biofuel producers may be able to compete with suppliers of petrol or diesel when their production costs are low (for example, by producing biodiesel from recycled cooking oil) or when conventional fuel prices are high (for example, due to high world oil prices).

The potential for biofuel consumption in the absence of policy support was considered in all study countries. While it was not possible to definitively conclude either way, in most countries it appears unlikely that biofuels would be consumed at any significant level without government assistance (with the United States being one possible exception).

In some parts of the United States, ethanol is added to petrol as an oxygenate to meet air quality regulations (by reducing emissions of particulates and toxic chemicals). While ethanol is not the only chemical to be added for this purpose, it is the most commonly used. Consequently, sensitivity analysis was conducted for the United States to take into account ethanol used to meet air quality regulations in the regions where these regulations are in place. Where there is consumption of biofuel in the counterfactual scenario, this affects the level of abatement and cost attributed to a given policy, but not the implicit abatement subsidy (average cost).

Sources: IEA (2006b); Steenblik (2007).

The Commission has used life-cycle emissions intensity estimates of different fuels in its analysis, as there can be significant differences in the emissions generated during the production and distribution of fuels. In particular, life-cycle emissions can differ significantly depending on the type of feedstock used (appendix M). For

each country, an average abatement factor is estimated that takes into account the mix of feedstocks used. This indicates the average amount of life-cycle emissions per litre of biofuel consumed.

Using the average abatement factors, abatement estimates were calculated for specific policies where it was possible to separate out the impacts of a policy on biofuel consumption. In addition, 'whole of market' abatement is estimated for ethanol and biodiesel in each country. This was done by estimating how much abatement is achieved by all policy measures for each biofuel type.

A detailed discussion of the approach, assumptions and data used for each country in the biofuels supply-side analysis is provided in appendix N.

Fuel taxes

Fuel taxes — and ETSs that cover fuel — raise the price of fuel and therefore reduce fuel consumption and greenhouse gas emissions from fuel use. Thus, abatement occurs on the demand side of the fuel market. The approach to estimating costs is different to that used for biofuel policies, which focused on supply-side costs and abatement.

For example, in response to higher fuel prices, users of fuel will tend to reduce their consumption by:

- substituting between vehicle types (for example, to more fuel-efficient cars or those that run on a lower-taxed fuel, such as ethanol or LPG) or between modes of transport (for example, greater use of rail)

- travelling less

- re-organising their supply chains and/or the spatial structure of production.

The consumption cost of reduced demand for fuel can be estimated as the net cost to consumers (box 5.4).

Estimating costs

The magnitude of these consumption costs was estimated by comparing observed prices and consumption relative to a counterfactual scenario (an estimate of how much fuel would have been consumed had fuel taxes not been imposed).

The size of these costs depends on the characteristics of demand — in particular, how consumers respond to increases in fuel prices by reducing the amount of fuel they consume (appendix O). This is measured by the own-price elasticity of demand. The Commission has used low and high elasticity values of -0.25 and -0.75 respectively. (A value of -0.25 means that a one per cent increase in the fuel price leads to a 0.25 per cent reduction in fuel consumption). These values are based on estimates of long-term elasticities in the literature (appendix O). Long-term estimates have been used for this analysis, as they capture longer-term behavioural responses to fuel taxes that have been in place for a considerable period of time in most of the study countries. Long-term estimates also allow for changes in demand that result from investment decisions, such as purchases of lower-emissions (more fuel-efficient) vehicles.

Estimating induced abatement

Abatement due to a fuel tax includes the reduction in greenhouse gas emissions associated with the direct reduction in fuel consumption induced by the tax, as well as any change in emissions (positive or negative) that might occur due to consumers switching to alternative modes of travel. This first element can be estimated using the change in the level of fuel demand (the difference between the counterfactual level and the current observed level of fuel consumption) and estimates of the emissions intensity of fuels. The Commission estimated abatement over a one year period in each country. However, where fuel taxes have been in place for long

periods of time, abatement could be driven by cumulative changes in behaviour over many years.

Quantifying consumers' substitution to non-road modes of transport (supply-side abatement) and estimating the resulting change in emissions is more difficult. This would require a substantial amount of detailed information on the extent to which consumers switch between road and non-road forms of transport as fuel prices rise, as well as estimates of the emissions intensity of other modes of transport. Consequently, abatement could only be estimated on the demand side.

In order to estimate the average consumption cost of fuel taxes in each country, a cost per unit of (demand-side) abatement for fuel taxes was estimated by dividing estimated consumption costs by the estimated level of abatement.

A detailed discussion of the approach, assumptions and data used for each country in the demand-side analysis for road transport is provided in appendix O.

Interpreting the results

In its biofuel analysis, the Commission has estimated:

- a subsidy equivalent for each policy (where possible) and fuel type, and a total subsidy equivalent for each country
- abatement by policy (where possible) and fuel type, and total abatement for each country
- an implicit abatement subsidy for each policy (where possible) and fuel type, and an average implicit abatement subsidy for each country.

In its fuel tax analysis, the Commission has estimated in each study country:

- total consumption costs
- total abatement
- average consumption costs (per tonne of CO_2-e).

These estimates provide some insights into the effects of emissions-reduction policies in the study countries. However, there is no single value that can be used to measure the relative 'effort' of a country in reducing emissions or the impacts of a country's climate change policies on its emissions-intensive trade-exposed industries (chapter 6). The Commission's road transport analysis sheds little light on these issues. However, this analysis does indicate the costs that countries are bearing in order to implement biofuel policies and the potential cost-effectiveness of these policies. Further, it also provides an illustration of the potential abatement and

costs of fuel taxes. However, even then the results are only indicative and must be interpreted carefully.

Total subsidy equivalents, consumption costs and abatement are not particularly meaningful on their own. For example, high levels of abatement could come at great cost due to inefficient policies or could indicate that a country has many low-cost abatement opportunities. Further, the study countries vary significantly in size, levels of total fuel consumption and the mix of fuels used in road transport. In consequence, the results are presented with some contextual information, including total abatement as a percentage of counterfactual emissions and the total subsidy equivalent as a percentage of GDP.

The Commission has not aggregated estimates of costs and abatement for biofuel policies and fuel taxes for each country, as these will not necessarily be representative of abatement costs in the transport sector more broadly. Moreover, the different methodological approaches used to analyse fuel taxes and biofuel policies makes it difficult to directly compare results to provide an aggregate estimate for road transport fuels.

Sensitivity analysis

For some policies sensitivity analysis was conducted — particularly when there were differences across available sets of data — with the results reported in a range around a 'central' estimate. The 'central' estimate is based on the set of assumptions that the Commission considers to be the most accurate given the available data.

5.2 Supply-side results

Cross-country analysis

The Commission's analysis of the supply-side abatement costs of biofuel policies suggests that these policies are a relatively costly means of achieving abatement. In all countries except China, the average implicit abatement subsidy was estimated to be over A\$300/t CO_2-e (table 5.2). By way of comparison, this is well above both the permit price of any existing ETS in these countries and the implicit abatement subsidies estimated on the supply side for most electricity generation policies.

Table 5.2   **Average implicit abatement subsidies**
2009, 2010

	Total subsidy equivalent	Total abatement	Average implicit abatement subsidy
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Australia	144	0.4	364
China[a]			
Ethanol	1 904	-1.4–0.8	-6 105
Biodiesel	94	0.2	592
Germany	1 711	5.5	310
Japan	57	0.1	617–653
New Zealand	3	0.01	391
South Korea	196	0.2–0.5	415–831
United Kingdom	680	2.0	335
United States	12 470–17 477	19–26	604–672

a The average implicit abatement subsidy estimate for China is presented separately for biodiesel and ethanol and only a central estimate for ethanol is given due to the negative abatement result.

Source: Appendix N.

The high average implicit abatement subsidies of biofuel policies reflect both the large estimated total subsidy equivalents of these measures as well as the relatively small amount of abatement they achieve. These findings are broadly in line with those in a series of reports on assistance to biofuels by the Global Subsidies Initiative (box 5.5).

The outlier among the eight study countries is China. There is considerable uncertainty about the life-cycle emissions of ethanol in China (with abatement due to ethanol policies presented as a range from -1.4 Mt to +0.8 Mt CO_2-e) (table 5.2). It is important to note that the negative estimate of the implicit abatement subsidy for ethanol (-A$6105/t CO_2-e) is due to negative abatement — that is, induced *additional* emissions — not negative costs. While significant costs are incurred, the use of ethanol (as a replacement for petrol) is likely to increase emissions for reasons explained below (although there is significant uncertainty surrounding the estimates). At nearly A$2 billion, China's total subsidy equivalent (which comprises subsidy equivalents of A$1904 million for ethanol and A$94 million for biodiesel) is the second highest among study countries. Although this cost is small as a proportion of GDP (0.03 per cent) it is high when expressed as a unit cost (A$1.15 per litre of petrol equivalent of ethanol consumed in China) (table 5.3).

Box 5.5   **Global subsidies initiative studies into government support for biofuel**

The Global Subsidies Initiative (GSI) produced a series of reports over 2006 to 2010 addressing government support to biofuels in different countries, including Australia, China and the United States. The GSI reports identify and quantify subsidies to biofuel production, distribution and consumption as well as subsidies to producers of key inputs into biofuel production. In estimating total assistance to ethanol and biodiesel, the GSI studies have incorporated the costs of a broader range of policies than the Commission's analysis, including subsidies to agricultural producers, import tariffs and research and development funding.

The GSI's estimates differ from the Commission's primarily due to differing years of analysis (consumption of biofuel has increased and there have been changes in the number of policies and the design of specific policies since the GSI conducted its analysis) and also because the GSI included a broader range of policies in its analysis. Another key difference is that the GSI often presents abatement estimates by feedstock, whereas the Commission's results represent an average across the mix of feedstocks used in a country.

Global Subsidies Initiative estimates for ethanol

Country	Year	Total assistance (millions)	Assistance per litre	Assistance per tonne of CO_2-e[a]
Australia	2006-07	A$36.2	A$0.42	A$380 – A$790
China	2006	US$114	ne	ne
European Union	2008	€841	€0.24	€669 – €1 422
United States	2006	US$5 123 – US$6 782	US$3.97 – US$5.22	US$520

[a] Assistance per tonne of CO_2-e abated is estimated by feedstock and presented as a range across the different feedstocks used in a given country. These figures are not average assistance per tonne of CO_2-e abated like the Commission's implicit abatement subsidies. **ne** Not estimated.

Sources: GSI (2006; 2008a; 2008b; 2010)

The average implicit abatement subsidy for Australia was estimated to be around A$364/t CO_2-e. This is similar to the estimates for New Zealand, Germany and the United Kingdom. While Germany and the United Kingdom have the lowest average costs, the volume of biofuels consumed in these countries is the highest, as are the total subsidy equivalents as a percentage of GDP. In the United States, Japan and South Korea, the average implicit abatement subsidies are relatively high. This result for the United States is mainly due to a number of policy measures that have substantial subsidy equivalents but may not be contributing substantially to abatement.

There can be significant variation in the estimated costs and abatement of biofuel measures in each country, depending on the data and assumptions used

There can be significant variation in the estimated costs and abatement of biofuel measures in each country, depending on the data and assumptions used (appendix N). In order to interpret estimates of average implicit abatement subsidies, it is important to also consider total subsidy equivalents and abatement by country.

Total costs

The total resource cost of biofuel policies in each country, measured as the total subsidy equivalent, varies widely (table 5.3). This is due to differences in the amounts of biofuel that each country consumes, and differences in the level of government assistance provided per litre of biofuel consumed (measured as the production subsidy equivalent per litre of petrol equivalent).

At A$144 million, the total subsidy equivalent of Australia's biofuel policies is the third lowest of the eight study countries. This figure reflects a relatively low level of consumption (275 ML petrol equivalent in 2009-10) and a moderate production subsidy equivalent (A$0.52/L petrol equivalent). However, as a proportion of GDP, the estimated total subsidy equivalent in Australia (0.01 per cent of GDP) is the fourth highest of the study countries.

Biofuel policies in the United States have the highest estimated cost (in absolute terms and as a percentage of GDP) of all the study countries: A$17.5 billion in the central estimate (0.11 per cent of GDP), which is higher than the other countries combined. This reflects that the United States consumes the largest amount of biofuel (29 273 ML petrol equivalent in 2009) and that there is considerable government support for biofuel consumption. The implicit abatement subsidy is also high, since the production subsidy equivalents (A$0.57/L petrol equivalent for ethanol and A$1.12/L petrol equivalent for biodiesel) are relatively high.

Abatement

Total abatement was estimated by multiplying the amount of policy-induced biofuel consumption by an average abatement factor, which reflects the abatement per unit of biofuel (table 5.4). Total abatement ranged from 0.01 Mt CO_2-e (New Zealand) to 26 Mt CO_2-e (the central estimate for the United States).

Table 5.3   Estimates of total subsidy equivalents
2009, 2010

	Total biofuel consumption	Average production subsidy equivalent	GDP	Total subsidy equivalent	Total subsidy equivalent as a percentage of GDP
	ML petrol equivalent	A$/L petrol equivalent	A$b (2010)	A$m (2010)	%
Australia	275	0.52	1 343	144	0.01
China	1 731	1.15	6 402[a]	1 998	0.03
Germany	3 775	0.45	3 572	1 711	0.05
Japan	57	1.00	5 959	57	0.001
New Zealand	6	0.56	152	3	0.002
South Korea	401	0.49	1 101	196	0.002
United Kingdom	1 419	0.48	2 437	680	0.03
United States	29 273	0.54–0.62	15 936	12 470–17 477	0.08–0.11

Source: Appendix N.

For Australia, total abatement from biofuel policies was estimated at 0.4 Mt CO_2-e (an estimated reduction of 0.6 per cent from the counterfactual where there are no biofuel policies). However, the estimated reduction in greenhouse gas emissions from biofuel policies was small for all countries relative to the counterfactual level of road transport emissions. Only in Germany, the United Kingdom and the United States was abatement due to biofuel policies higher than one per cent of counterfactual emissions.

China's abatement from ethanol use was estimated to be above that of Australia at the high end, and negative at the low end. This reflects a very low (and potentially negative) average abatement factor for ethanol. Together with the high unit cost estimated, this explains the high cost of China's ethanol policies in terms of reducing emissions.

In most study countries, greater abatement per litre is achieved through policies that increase the proportion of biodiesel in the fuel mix (relative to ethanol). For example, in Australia, the average abatement factor for biodiesel (2218 g CO_2-e/L petrol equivalent) is significantly larger than that for ethanol (1081 g CO_2-e/L petrol equivalent) (table 5.5). The only country where ethanol achieves, on average, greater abatement per litre than biodiesel is Germany (which has the largest consumption of biodiesel of all study countries).

Table 5.4 Estimates of policy-induced abatement
2009, 2010

	Total road transport sector emissions	Total abatement	Total abatement as a percentage of counterfactual road transport emissions
	Mt CO_2-e	Mt CO_2-e	%
Australia	69	0.4	0.6
China[a]	334		
Ethanol	..	-1.4 to +0.8	-0.4 to +0.2
Biodiesel	..	0.2	0.05
Germany	146	5.5	4
Japan	208	0.1	0.04
New Zealand	13	0.01	0.06
South Korea	79	0.2–0.5	0.3–0.6
United Kingdom	119	2.0	1.7
United States	1 537	19–26	1.2–1.7

a Abatement for China is presented separately for ethanol and biodiesel due to the negative abatement result for ethanol.

Source: Appendix N.

The Commission has also estimated the abatement induced by biofuel policies on the demand side. This can occur when biofuel policies lead to higher fuel prices, although the abatement that results is generally much smaller than the abatement that occurs on the supply side. However, both the costs and abatement on the demand side are estimated to be relatively small (box 5.6)

Table 5.5 Average abatement factors by country
Central estimates

	Average abatement factor	
Country	Ethanol	Biodiesel
	g CO_2-e/L petrol equivalent	g CO_2-e/L petrol equivalent
Australia	1 081	2 218
China	-224	464
Germany[a]	1 593	1 416
Japan	1 576	..
New Zealand	1 277	2 033
South Korea	..	771
United Kingdom	1 594	1 442
United States	832	2 318

a In addition, an average abatement factor of 1691 g CO_2-e/L (petrol equivalent) was used for the analysis of vegetable oil in Germany. **..** Not applicable.

Source: Appendix N.

Box 5.6   **Demand-side abatement from biofuel policies**

The Commission sought to estimate the abatement induced by biofuel policies on the demand side. This can occur when biofuel policies lead to higher fuel prices, although the abatement that results is generally much smaller than the abatement that occurs on the supply side.

Illustrative estimates were calculated using the same approach used for fuel taxes, where the 'tax' or price increase is a measure of the cost that some biofuel policies can impose on consumers of transport fuels. For example, fuel suppliers may pass on the cost of meeting a fuel content mandate to consumers in the form of higher prices, which reduces demand and can induce some abatement.

Specifically, the subsidy equivalent was divided by the volume of fuel that is affected. This was done only for policies where the costs are borne by consumers rather than by governments (such as fuel content mandates). As a result, estimates were calculated only for Germany, the United Kingdom and the United States (the results are provided in Appendix O).

In all cases, the estimated total consumption cost and abatement attributable to demand-side impacts of biofuel policies are smaller than the corresponding values for the supply side. This is largely because the estimated impact on fuel prices is small (given the large volume of petrol and diesel that are consumed in most countries relative to biofuels) — approximately A$0.01/L to A$0.02/L in each country. The average cost of demand-side abatement is also relatively low in all three countries, ranging from less than A$1/t CO_2-e (for biodiesel in the United States) to A$5/t CO_2-e (for both ethanol and biodiesel in Germany).

Source: Appendix O.

Australia

Australia provides significant support to biofuel — both ethanol and biodiesel — through production subsidies. These involve payments to biofuel producers that offset the amount of fuel excise that they pay. The analysis did not include the New South Wales biofuels mandate because, during the year of analysis, the minimum sales percentages required under the Act were not enforced due to domestic supply constraints (Office of Biofuels, NSW Land and Property Management Authority, pers. comm., 15 April 2011). Hence, this mandate is not likely to have induced a significant amount of biofuel consumption in addition to the production subsidies.

Australia's biofuel policies are estimated to achieve total abatement of 0.4 Mt CO_2-e (0.6 per cent of counterfactual road transport emissions) at a total subsidy equivalent of A$144 million (table 5.6). This incorporates A$108 million for support to ethanol producers through the Ethanol Production Grants program,

and A\$35 million for support to biodiesel producers through the Cleaner Fuel Grants Scheme.

Support to ethanol producers was appreciably higher than support to biodiesel producers as the volume of ethanol consumed (275 ML) was considerably higher than the volume of biodiesel consumed (90 ML). However, the Ethanol Production Grants program did not generate significantly more abatement than the Cleaner Fuel Grants Scheme. This was because the average abatement for a given quantity of biodiesel was higher than that for ethanol.

The implicit abatement subsidies of the individual policies reflect these differences in average abatement. The implicit abatement subsidies for the Ethanol Production Grants program and the Cleaner Fuel Grants Scheme were A\$532/t CO_2-e and A\$186/t CO_2-e respectively.

However, the biofuel production subsidies are to be gradually reduced as effective tax rates are gradually increased from December 2011. The changes are likely to significantly alter the costs and abatement associated with these policies (although the changes do not affect the Commission's estimates, which are estimated for the 2009-10 financial year).

Table 5.6   **Biofuel policies, Australia**
July 2009 – June 2010

Policy	Type	Subsidy equivalent	Abatement	Implicit abatement subsidy
		A\$m (2010)	Mt CO_2-e	A\$/t CO_2-e
Ethanol Production Grants	Production subsidy	108	0.2	532
Cleaner Fuel Grants Scheme	Production subsidy	35	0.2	186
Total		**144**	**0.4**	**364**
Abatement (%)[a]		..	0.6	..

[a] Abatement as a percentage of counterfactual emissions from road transport. .. Not applicable.
Source: Appendix N.

China

The Chinese government provides significant financial and regulatory support for domestic ethanol producers. All ethanol produced and consumed in China is sourced from five authorised producers (which are majority state-owned). In contrast, biodiesel plants tend to be small, privately owned enterprises and are more numerous and geographically dispersed than ethanol plants.

Differences in the level of support for ethanol and biodiesel are reflected in the subsidy equivalents shown in table 5.7. Total support for ethanol (A$1.96 billion) dwarfs that for biodiesel (A$94 million). However, the abatement attributable to ethanol policies does not reflect the level of support provided, with the results suggesting ethanol policies actually increased emissions by 312 kt CO_2-e in 2009 (using the central estimate). In contrast, abatement due to biodiesel policies was estimated to be 158 kt CO_2-e.

Abatement estimates for ethanol policies in China must be interpreted with care. Taking into account the mix of feedstocks used, ethanol appears to have, on average, higher life-cycle emissions intensity than petrol. This suggests that any policy that increases the share of ethanol in total fuel consumption relative to petrol *increases* total greenhouse gas emissions.

The drivers of this result are the estimates for life-cycle emissions intensity for ethanol produced using maize and wheat, which are higher than those used for other countries (maize and wheat ethanol represent 90 per cent of all ethanol produced in China). This is likely to be due to high fertiliser application rates during the production of the feedstock and the relatively high level of energy that is used to refine feedstocks into fuel in China (Ou et al. 2009).

However, estimated abatement is highly sensitive to the life-cycle assessment method used and assumptions regarding the inclusion of land-use change or the treatment of recycled or waste feedstocks (appendix M). Recognising this uncertainty, sensitivity analysis was undertaken. This suggests that abatement from ethanol policies could range from -1.4 to +0.8 Mt CO_2-e.

The implicit abatement subsidy for ethanol is estimated to be -$A6105/t CO_2-e (for the central estimate) and A$592/t CO_2-e for biodiesel. The high costs and small negative central estimate for abatement from ethanol policies are the principal reason the implicit abatement subsidy for ethanol is so large and negative. It suggests that these policies are effectively acting as a substantial subsidy for emitting rather than for abating.

Table 5.7 **Biofuel policies, China**
2009

Policy	Type	Subsidy equivalent	Abatement	Implicit abatement subsidy
		A$m (2010)	Mt CO_2-e[a]	A$/t CO_2-e[a]
Tax incentives	Production subsidy	744	..	..
Flexible subsidies for loss	Production subsidy	640	..	..
National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles	Guaranteed market and production subsidy	614	..	..
Totals				
Ethanol	..	1 904	-1.4 to +0.8	-6 105[b]
Biodiesel	..	94	0.2	592
Abatement (%)[c]	Ethanol	..	-0.4 to +0.2	..
	Biodiesel		0.05	

[a] Due to the policy overlaps it was not possible to estimate abatement and implicit abatement subsidies for each ethanol policy separately. [b] The implicit abatement subsidy for ethanol is presented for the central estimate only due to the negative estimate of abatement [c] Abatement as a percentage of counterfactual emissions from road transport. .. Not applicable.

Source: Appendix N.

Germany

A large domestic market for biofuels exists in Germany, accounting for 5.8 per cent of all road transport fuel sold in 2009. This market is underpinned by fuel tax exemptions and mandates covering ethanol, biodiesel and vegetable oil used directly as a fuel for road transport.

There is significant overlap between the fuel tax exemptions and the mandates. Evidence suggests that the tax exemptions are driving consumption of biodiesel and vegetable oil, as the mandate did not bind for these fuels in 2009. However, the mandate did lead to incremental consumption of ethanol and was found to bind in 2009. Consequently, the tax exemptions are unlikely to have led to additional consumption of ethanol, in part because only a small proportion is eligible for tax relief (less than three per cent).

Due to this overlap, the Commission has not estimated costs and abatement for each policy individually, presenting subsidy equivalents, abatement and implicit abatement subsidies for each of the three fuel types and for all three fuel types combined.

In combination, the tax exemptions and mandates imposed significant costs — the total subsidy equivalent for Germany was estimated at A$1.7 billion. Support for biodiesel accounted for the largest share of this with a subsidy equivalent of A$1.1 billion (table 5.8).

Total abatement due to Germany's biofuel policies was estimated at 5.5 Mt CO_2-e, or 3.6 per cent of counterfactual emissions in the road transport sector. The Energy Tax exemption is likely to account for the majority of the abatement (and cost) as it is the main support measure for biodiesel and vegetable oil which together account for more than three quarters of total abatement.

The implicit abatement subsidy for the policies combined is estimated at A$310/t CO_2-e. Of the individual fuels, the cost of abatement was highest for ethanol, with an implicit abatement subsidy of A$444/t CO_2-e, followed by biodiesel and then vegetable oil with implicit abatement subsidies of A$275 and A$242/t CO_2-e respectively.

Table 5.8   **Whole of market estimates, Germany**
2009

Fuel type	Subsidy equivalent	Abatement	Implicit abatement subsidy
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol	533	1	444
Biodiesel	1 130	4	275
Vegetable oil	48	0.2	242
All fuels	**1 711**	**6**	**310**
Abatement (%)[a]	..	4	..

[a] Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.
Source: Appendix N.

Japan

Japan consumes only a small quantity of ethanol (0.1 per cent of petrol) and a negligible quantity of biodiesel. Consequently, only one biofuel policy was analysed — an exemption from fuel taxes for ethanol. A tax exemption for biodiesel was also considered for analysis in Japan, but eliminated on the grounds of both immateriality and insufficient information.

The ethanol tax exemption in Japan is still small in scale relative to policies in other countries. The subsidy equivalent for the policy was estimated at A$57 million.

Total abatement was also low, at between 87–92 kt CO_2-e, or around 0.04 per cent of counterfactual emissions from the road transport sector (table 5.9). Abatement is expressed as a range due to uncertainty about the share of ethanol produced from different feedstocks and the method of feedstock cultivation (both factors affect the emissions intensity of ethanol production). While this uncertainty does not lead to a wide abatement range, it does have a significant impact on the range of the implicit abatement subsidy. The implicit abatement subsidy for Japan is estimated at between A\$617–A\$653/t CO_2-e.

Table 5.9 **Ethanol fuel tax exemption, Japan**
April 2009 – March 2010

Fuel type	Subsidy equivalent	Abatement	Implicit abatement subsidy
	A\$m (2010)	Mt CO_2-e	A\$/t CO_2-e
Ethanol	57	0.087–0.092	617–653
Abatement (%)[a]	..	0.042–0.044	..

a Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.
Source: Appendix N.

New Zealand

Demand for biofuel in New Zealand is driven by a tax exemption for ethanol and a production subsidy for domestic biodiesel producers. The estimates of the total subsidy equivalent (A\$3 million) and abatement (8 kt CO_2-e) for these policies is very low in comparison to other countries, reflecting low levels of consumption. Total consumption of biofuels in 2010 was just 5.6 ML (petrol equivalent). Most of the cost and abatement was attributable to the ethanol tax exemption, with ethanol accounting for around 80 per cent of all biofuel consumed.

The average implicit abatement subsidy for New Zealand was estimated at A\$391/t CO_2-e. The implicit abatement subsidy is A\$479/t CO_2-e for ethanol compared to A\$163/t CO_2-e for biodiesel (table 5.10). These figures are in line with the results for comparable policies in Australia. As was the case in Australia, the estimates suggest that the cost of abatement for biodiesel policies is significantly lower than for ethanol policies, mainly reflecting higher average abatement per litre consumed.

Table 5.10 Biofuel policies, New Zealand
2010

Policy	Type	Subsidy equivalent	Abatement	Implicit abatement subsidy
		A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol fuel tax exemptions	Tax exemption	2.7	0.006	479
Biodiesel Grants Scheme	Production subsidy	0.4	0.002	163
Total		**3.1**	**0.008**	**391**
Abatement (%)[a]		..	0.06	..

[a] Abatement as a percentage of counterfactual emissions from road transport. .. Not applicable.

Source: Appendix N.

South Korea

South Korea is alone among the study countries in providing support only to biodiesel and not to ethanol. The absence of policy support for ethanol may reflect the relatively low proportion of petrol consumed in South Korea — petrol accounts for just 30 per cent of road transport fuel consumed (appendix M).

The main source of government support for biodiesel is through a rebate of fuel tax. The subsidy equivalent for this policy was estimated to be A$196 million and abatement at 0.2–0.5 Mt CO_2-e during 2010 (table 5.11). Abatement is estimated as a range due to significant uncertainty with regard to the emissions intensity of biodiesel consumed. Abatement due to the policy is equivalent to between 0.3 to 0.6 per cent of counterfactual road transport greenhouse gas emissions.

The implicit abatement subsidy due to the tax rebate was estimated at between A$415–A$831/t CO_2-e. At the high end of this range, this is a larger subsidy per tonne of abatement than any other study country.

Table 5.11 Biodiesel tax rebate, South Korea
2010

Fuel type	Subsidy equivalent	Abatement	Implicit abatement subsidy
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Biodiesel	196	0.2–0.5	415–831
Abatement (%)[a]	..	0.3–0.6	..

[a] Abatement as a percentage of counterfactual emissions from road transport. .. Not applicable.

Source: Appendix N.

United Kingdom

The United Kingdom provides support to biofuel producers by mandating the amount of biofuel consumed each year (as a percentage of total fuel consumption) through the Renewable Transport Fuels Obligation. The total subsidy equivalent for the Renewable Transport Fuels Obligation was estimated at A$680 million in fiscal year 2009 (April 2009 to March 2010) (table 5.12). Thus, while there is no budgeted government expenditure for support to the biofuel industry, government support for biofuels through regulation involves significant resource costs.

Table 5.12   **Renewable Transport Fuels Obligation, United Kingdom**
April 2009 – March 2010

Fuel type	Subsidy equivalent	Abatement	Implicit abatement subsidy
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol	214	0.5	424
Biodiesel	465	1.5	305
All fuels	**680**	**2.0**	**335**
Abatement (%)[a]	..	1.7	..

[a] Abatement as a percentage of counterfactual emissions from road transport. .. Not applicable.
Source: Appendix N.

The average implicit abatement subsidy was estimated at A$335/t CO_2-e, with around 2 Mt CO_2-e abated as a result of the Renewable Transport Fuels Obligation in 2009. This level of abatement is small relative to the counterfactual road transport sector emissions, representing approximately 1.7 per cent of total emissions from road transport in the United Kingdom (that said, abatement as a proportion of counterfactual emissions is larger than in many other study countries).

The implicit abatement subsidies by fuel type suggest that while ethanol achieved greater abatement for each additional litre of ethanol induced, it did so at a higher cost — with the implicit abatement subsidies for ethanol and biodiesel estimated to be A$424/t CO_2-e and A$305/t CO_2-e respectively.

United States

A large volume of biofuel — mostly ethanol produced from maize — is consumed each year in the United States. There is considerable government support for biofuel consumption, consisting of subsidies for domestic producers, concessional rates of fuel excise, fuel content mandates, government procurement regulations and an import tariff.

The total subsidy equivalent of biofuel policies in the United States was estimated at A\$17.5 billion in US fiscal year 2009 (October 2008 to September 2009), most of which can be attributed to support for ethanol (A\$16.1 billion) (table 5.13).

Table 5.13 **Total subsidy equivalent, United States**
October 2008 – September 2009

Policy	Level of government	Subsidy equivalent		
		Ethanol	Biodiesel	Total
		A\$m (2010)	A\$m (2010)	A\$m (2010)
Alcohol and Biodiesel Fuel Credits	National	5 718	922	6 640
Bioenergy Program for Advanced Biofuels	National	8	7	15
State-level excise concessions for ethanol	Sub-national	3 029	0	3 029
Renewable Fuel Standard[a]	National	7 321	472	7 793
Federal Fleet Management Guidance	National	1	0	0.8
Total	**..**	**16 076**	**1 401**	**17 477**

[a] The central estimate of the subsidy equivalent is reported for the Renewable Fuel Standard. This includes the impact of the tariff on most ethanol imports. **..** Not applicable.

Source: Appendix N.

Abatement from these policies was estimated to be around 19–26 Mt CO_2-e, which was equivalent to 1.2–1.7 per cent of road transport emissions in the counterfactual scenario (where there is no policy support for biofuels). This translates to an average implicit abatement subsidy of around A\$604–672/t CO_2-e (table 5.14).

These estimates were calculated using a 'whole of market' approach (for each of ethanol and biodiesel), due to significant overlaps between policy measures. Accordingly, the total subsidy equivalent was calculated by adding up the subsidy (explicit or implicit) that each US policy provided for the consumption of biofuel.

Table 5.14 **Whole of market estimates, United States**
October 2008 – September 2009

Fuel type	Subsidy equivalent	Abatement	Implicit abatement subsidy
	A$m (2010)	Mt CO_2-e	A$/t CO_2-e
Ethanol	11 337–16 076	16–23	617–724
Biodiesel	1 133–1 439	3	389–494
All fuels	**12 470–17 477**	**19–26**	**604–672**
Abatement (%)[a]	..	1.2–1.7	..

a Abatement as a percentage of counterfactual emissions from road transport. **..** Not applicable.
Source: Appendix N.

The amount of biofuel consumed in fiscal year 2009 was determined by the mandates in the Renewable Fuel Standard. However, ethanol and biodiesel that were used to meet this mandate could also benefit from production subsidies, excise concessions or import tariffs. While these other policies do not affect the total amount of biofuel consumed, they would be expected to increase the level of domestic production at the expense of imports. This can increase the cost of biofuels (by favouring higher-cost domestic production over lower-cost imports) and can affect the level of abatement (by changing the types of feedstocks that are used).

The range of results presented reflects different assumptions about the counterfactual level of biofuel consumption and the effect of differing wholesale prices of fuel (which were used to calculate the subsidy equivalent of the Renewable Fuel Standard). The counterfactual assumption was changed from the default (of zero consumption) to illustrate a possible alternative in which around one third of ethanol would have been consumed in the absence of biofuel policies. This is because some ethanol is specifically added to petrol in some parts of the United States to meet air quality regulations (by reducing emissions of particulates and toxic chemicals)[2], and estimates of the volume used for this purpose have been published.

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[2] Other chemicals can be added to fuels for this purpose, although some of these have been banned in parts of the United States. While it is possible that ethanol could be used in this way in other countries in the absence of policy support, estimates of the amount that would be used were not available.

5.3 Demand-side results

This section provides illustrative estimates of the cost and abatement from fuel taxes in each study country. It is important to note that this analysis estimates the abatement achieved due to the full amount of fuel tax applied in each country. Further, abatement is estimated relative to a counterfactual scenario in which there are no fuel taxes (and fuel has never been taxed). Estimated abatement does not take into account the other reasons that countries impose fuel taxes and is accordingly greatly biased upwards, as well as being very high for each country.

There are large differences in fuel tax rates across countries (table 5.15), reflected in the significant variation in estimated consumption costs and abatement (table 5.16). Countries that have higher average fuel taxes also have higher average consumption costs per tonne of CO_2-e, because higher tax rates induce a larger reduction in fuel demand, which becomes increasingly more costly the larger the reduction (all else equal). Correspondingly, the effect on consumers is larger and consumers may make bigger changes to their behaviour.

Table 5.15 Fuel tax rates and volumes consumed[a,b]

Country	Year	Petrol rate	Petrol volume	Diesel rate	Diesel volume	LPG rate	LPG volume
		A$/L	ML	A$/L	ML	A$/L	ML
United States[c]	2009	0.11	504 844	0.12	132 717	0.10	1 022
China	2010	0.16	81 554	0.13	82 989	..	na
Australia	2009-10	0.38	16 619	0.38	18 053	..	2 083
New Zealand	2010	0.45	2 505	0.0029	2 161	0.08	208
Japan	2009[d]	0.67	54 795	0.40	2 830	0.12	2 701
South Korea	2009	0.70	10 132	0.49	15 855	0.21	7 782
Germany	2009	0.94	25 562	0.67	31 174	0.14	942
United Kingdom	2010	0.96	19 982	0.96	24 678	0.27	195

a Only fuel-specific volumetric taxes that are levied directly on vehicle fuels are shown. Note that in some countries other taxes, such as road-user charges, may be levied differently (for example, diesel fuel in New Zealand). **b** Tax rates have been converted to 2010 Australian dollars and are rounded to two significant figures. **c** Tax rates for the United States include both federal and state taxes. **d** Figures for Japan are for April 2009 to March 2010 (the Japanese fiscal year). **..** Not applicable. **na** Not available.

Source: Appendix O.

China and the United States have the lowest fuel taxes of the study countries. While the total consumption costs in these countries are high relative to others, they are low in comparison to the size of each economy (around 0.01–0.02 per cent of GDP in China and 0.01–0.03 per cent of GDP in the United States). Likewise, while the absolute level of abatement is relatively high in both countries, when expressed as a

percentage of estimated road transport emissions in the absence of fuel taxes, it is at the bottom of the range.

Overall, the United States has the lowest average consumption costs, at A$19/t CO_2-e. The average consumption cost in China was estimated to be slightly higher, at A$20–A$23/t CO_2-e. This suggests that the cost of reducing a relatively small proportion of emissions in these countries may be lower than in other countries.

On the other hand, the United Kingdom has the highest average fuel taxes, followed by Germany, Japan and South Korea. In these countries total consumption costs and abatement are both high. Costs range from around 0.10 per cent to 0.33 per cent of GDP in Germany, and from 0.14 per cent to 0.46 per cent of GDP in the United Kingdom. The results also suggest that fuel taxes may have reduced emissions by around 20 to 40 per cent from counterfactual levels in both countries.

However, the average cost of this abatement — in excess of A$100/t CO_2-e in Germany, the United Kingdom and Japan — is considerably higher than for other study countries. This suggests that, at relatively high tax rates, there can be significant costs incurred reducing an additional tonne of emissions. This suggests that the marginal cost of reducing emissions becomes higher as more emissions are abated (in other words, abatement may be cheaper per tonne at lower levels of the fuel tax than are presently in place).

By contrast, the estimates for Australia and New Zealand (including the ETS in New Zealand as well as fuel excise) appear to lie in the middle of the range of countries. The results suggest that fuel taxes may have reduced emissions from road transport by around 8 to 23 per cent in Australia, and 7 to 19 per cent in New Zealand, relative to the counterfactual. For Australia, this could cost up to A$1.2 billion (0.09 per cent of GDP) each year. As a result, the average cost of abatement is around A$57–A$59/t CO_2-e in Australia, and somewhat higher in New Zealand, at A$71–A$73/t CO_2-e.

Furthermore, the estimated cost of demand-side abatement from fuel taxes (per tonne of CO_2-e) is significantly lower in most countries than the cost of supply-side abatement from biofuel policies. This reflects the broader base of fuel taxes — which cover almost all road transport fuels — and the close link between fuel consumption and emissions (although fuel taxes are also used to reduce fuel consumption to target other objectives, such as reducing congestion or urban air pollution). However, fuel taxes are generally not based on the emissions content of each fuel.

Table 5.16   **Fuel taxes**[a]

Range of estimates

Country	Average fuel tax[b]	Consumption cost	Consumption costs as a percentage of GDP[c]	Abatement	Abatement as a percentage of counterfactual road transport sector emissions	Average consumption cost[d]
	A$/L	A$m (2010)	% GDP	Mt CO_2-e	%[e]	A$/t CO_2-e
Australia	0.36	373–1 189	0.03–0.09	6–21	8–23	57–59
China	0.14	449–1 383	0.01–0.02	20–68	6–17	20–23
Germany	0.78	3 437–11 492	0.10–0.33	29–102	17–41	113–119
Japan	0.64	2 238–7 301	0.04–0.13	21–73	9–26	100–105
New Zealand	0.43	54–174	0.04–0.11	1–3	7–19	71–73
South Korea	0.50	1 046–3 432	0.10–0.33	12–41	13–34	83–87
United Kingdom	0.96	3 323–11 125	0.14–0.46	24–85	17–42	130–139
United States	0.11	1 749–5 421	0.01–0.03	92–291	6–16	19

a Values are national aggregates over petrol, diesel and LPG. **b** Average per-litre tax, in Australian dollars, over petrol, diesel and LPG (in the year of analysis), and weighted by the taxed volume of each fuel type. Averages for Australia and China are over petrol and diesel only as LPG is not taxed. Average for New Zealand is over petrol and LPG only as diesel use is mainly taxed through vehicle charges. **c** In each case, the lower figure reported for average consumption cost corresponds with the higher value of fuel-demand elasticity used (-0.75), and vice versa. **d** GDP data are from IMF (2011) and were converted to 2010 Australian dollars. **e** Abatement as a percentage of the level of counterfactual emissions in the road transport sector (that is, estimated emissions in the absence of fuel taxes). Emissions data are from IEA (2010a) for China and Korea, and the UNFCCC (2011a) for all other countries. Figures for 2008 were used as this was the latest year for which consistent data were available for the road transport sector.

Sources: IMF (2011); IEA (2010a); UNFCCC (2011a); Appendix N.

6   Conclusions and implications

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Key points

- The resources committed by different study countries to emissions-reduction policies vary as a proportion of GDP.

  – In electricity generation, Germany made the largest relative resource commitment, the United Kingdom was next and Australia, along with China and the United States, were in the middle.

  – In biofuels, the US resource commitment was substantially higher than other study countries, though Germany also devoted considerable resources to this abatement policy.

- The cost effectiveness of these actions in achieving abatement, and the amount of abatement actually achieved, also varies widely, both across programs within each country and in aggregate across countries.

  – Explicit carbon pricing in the United Kingdom appears to have been a cost-effective way of achieving considerable abatement.

  – At the other end of the scale, policies to encourage small-scale renewable generation are substantially less cost effective and have led to relatively little abatement.

- The impacts of supply-side policies on product prices appear to have been modest for most countries, with the notable exception of electricity prices in Germany and the United Kingdom, where impacts of over 10 per cent are estimated to have occurred.

- The relative cost effectiveness of a price-based approach is illustrated for Australia by stylised modelling that suggests that the abatement from existing policies could have been achieved at a fraction of the cost.

- However, the estimates in this report cannot be used to determine the appropriate starting price of a broadly-based carbon pricing scheme in Australia.

- Similarly, the estimates provide only a small subset of the data required to make assessments of what assistance would be needed to avoid undue levels of carbon leakage, and competitive disadvantage. Additional countries and relevant industries would also need to be assessed.

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This concluding chapter looks again at the approach taken and relevant caveats, summarises some key results and then draws out some implications for assessing comparative effort and competitiveness effects.

6.1   Recapping on the Commission's approach

If all greenhouse gas emissions were 'priced' directly, comparing prices across countries would be straightforward, but this approach is not common.

- The European Union emission trading scheme (ETS), covering both Germany and the United Kingdom, is one point of reference. But permit prices are influenced by the coverage of the scheme — which is still limited — and the cap on emissions.

- New Zealand has introduced an ETS, and the carbon price has been capped as an interim measure.

- Other countries are contemplating introducing explicit carbon pricing (Japan and South Korea, for example, as well as Australia), but there has been no firm indication of what the carbon prices will be.

When the analysis is broadened to include the impacts of the many non-price emissions-reduction measures, the analytical task becomes much more complicated. The idea that these impacts could be measured in price terms has broad appeal, but there is no clear definition of, or basis in theory for, such a measure (chapter 3).

What all emissions-reduction policies have in common is that they generally impose costs that someone must pay in order to reduce emissions. It is in this sense that the Commission has interpreted 'effective carbon price' loosely to mean the cost of reducing greenhouse gas emissions. This led to the conclusion that the best metric for comparing disparate policies was abatement costs, which in this study has been estimated by comparing the costs and associated emissions of each policy measure (or bundle of measures) with a counterfactual of no policy.

But the abatement cost results cannot be said to be carbon prices. This is because an explicit carbon price applied broadly to the economy would achieve abatement in quite different, and most likely much more cost-effective, ways. Thus for example, a country might be achieving some abatement through subsidising biofuel production, which has been shown to be a high-cost abatement option (chapter 5). Because a broad-based carbon tax would work on both the demand and supply sides of the economy and encourage the lowest cost abatement options to be taken up first, it would not need to be as high as the biofuel subsidy rate to achieve the same level of abatement. Thus, while it is possible to calculate a tax equivalent that will

give the same amount of abatement as the biofuel subsidy (or any other measure that gave the same abatement), application of that tax equivalent would most likely not induce abatement through biofuels.

Measuring abatement costs

Abatement costs should ideally be measured in terms of the impacts on total economic welfare. This requires estimating the costs of inducing substitution on the supply side (the additional *resource costs* of production) as well as the costs of reduced consumption on the demand side where product prices are pushed up (*consumption cost*s).

On the supply side, the Commission estimated the subsidy equivalent for all material policy measures for which data could be obtained. The subsidy equivalent is the explicit or implicit subsidy provided to suppliers of low-emission, but high-cost, products to enable them to be competitive with high-emission but low-cost products. It is indicative of the true (resource) costs, but will generally overstate them (where marginal costs are increasing). However, as long as they do so consistently — and for similar bundles of technologies, such as biomass, wind or solar photovoltaic this is a reasonable presumption — cross-country comparisons can still usefully be made. Subsidy equivalents are also of interest in their own right, because they capture the often hidden transfers to producers.

On the demand side, the Commission estimated consumption costs for those policy measures that directly impact on firms and consumers, such as carbon taxes or fuel taxes. It also estimated consumption costs for supply-side policy measures where the subsidy is effectively paid for by firms and consumers — such as where the cost of purchasing renewable energy certificates is passed on, in whole or in part, by electricity retailers in electricity prices. This necessitated using some simplifying assumptions about demand responsiveness and cost pass-through to provide indicative results in this area.

Abatement was estimated relative to the counterfactual of what emissions would have been in the absence of a given policy. This can depend on the circumstances. In the case of electricity generation, for example, the marginal generator that is replaced when renewable energy generators are dispatched can vary depending on market circumstances, and this can have a substantial impact on the amount of abatement that can be attributed to a policy.

Some limitations

It is important to be clear about the uncertainties inherent in this analysis and the assumptions that needed to be made.

- Unsurprisingly, data proved difficult to obtain for some policy measures and some technologies, particularly in the non-English speaking countries included in the study. The Commission received valuable cooperation from most governments and many research organisations, and it employed contractors to help obtain information, but some uncertainties and gaps remain.

- As noted, the 'counterfactual' scenario can differ depending on the circumstances. Sensitivity analysis was accordingly used to capture the range of possible outcomes.

- The analysis only provides a snapshot for the most recent year for which data were available. As some programs are ramping up over time, it can be expected that, other things being the same, cost and abatement will rise. While the Commission was asked to look at 'committed' policies, in most cases there was insufficient data to estimate the cost impacts of these schemes, other than to offer a qualitative indication.

- Costs and abatement are attributed to some policies that have multiple objectives and there is uncertainty about how much might reasonably be apportioned to each. Sensitivity analysis was again used to test this. Thus, for example, the analysis of fuel taxes considered the extremes of them being solely an emissions-reduction measure or not.

- The study countries provide a useful benchmark in the sense that they include many of the largest emitters, but they are not the home to the competitors of many Australian companies (competiveness issues are taken up below).

- Some policy measures work in the opposite direction by implicitly encouraging emissions. But as these may be achieving other objectives, and/or acting indirectly, it would have been very difficult to factor these in to the analysis.

6.2   Some key results

The Commission estimated the total subsidy equivalent (as a proxy for the resource costs), and the abatement attributable to the subset of policies that are having the greatest impact in each country. Dividing the former by the latter gives the average implicit abatement subsidy, which is the proxy for the unit cost of abatement. The Commission also calculated some indicative estimates of the consumption costs on the demand side.

Electricity supply side

The implicit abatement subsidies — which are also measures of cost effectiveness — varied considerably across policies and also across countries (table 6.1), depending in part on each country's policy mix.

- The lowest implicit abatement subsidy estimate was for New Zealand, for which only one electricity-sector policy was analysed — the recently-introduced ETS.

- Despite their participation in the European Union ETS, estimated implicit abatement subsidies in Germany and the United Kingdom are relatively high. This is because of the generous subsidies that the two countries provide to renewables.

- Policies analysed in Japan and South Korea achieved very low levels of abatement, at a relatively high resource cost (mainly because of high production subsidies paid to high-cost solar photovoltaic), hence the implicit abatement subsidies are high.

- The range of the estimated implicit abatement subsidy for Australia (A$44–99) was lower than for some countries, and at the low end, comparable with China and the United States.

Table 6.1 International comparison table — electricity generation policies

Country	Total subsidy equivalent	Total subsidy equivalent as a percentage of GDP	Total abatement	Abatement as a percentage of counterfactual electricity sector emissions[a]	Implicit abatement subsidy
	A$m (2010)	%	Mt CO$_2$	%	A$/t CO$_2$
Australia	473–694	0.04–0.05	7.0–10.7	3.5–5.2	44–99
China	1 835–2 309	0.03–0.04	40.7–52.1	1.2–1.5	35–57
Germany	10 019–11 769	0.28–0.33	67.1–73.1	18.3–19.6	137–175
Japan	669–940	0.01–0.02	3.3–4.3	0.8–1.1	156–287
New Zealand	..	..	..	..	8–10
South Korea	313–379	0.03–0.03	0.9–1.4	0.5–0.7	225–401
United Kingdom	2 042–2 433	0.08–0.10	12.3–27.4	7.5–15.4	75–198
United States	2 886–3 339	0.02–0.02	66.5–66.7	2.8–2.9	43–50

a 2010 for China, 2009 for United Kingdom and Germany, 2008 for Japan and Korea. **..** Not applicable.

Source: Appendixes D-K

In many cases, overlaps between policy measures makes it impossible to separately report the abatement each achieves. But where they are separable (or at least can be separated into one or more groups of policies), the implicit abatement subsidy

estimates can be used to compare the resource costs of different technologies for reducing emissions (figure 4.4) and the reliance of countries on particular policy measures (figure 6.1). Notable features include:

- Subsidies for solar-photovoltaic systems were found to be a relatively very costly way of achieving abatement and generally little abatement resulted. (These are visible as the very high thin bars in the charts for China, South Korea, the United States and to a lesser extent Japan.) Although a feature of the policy mix in Australia, solar subsidies were deemed to have overlapped with the large and small renewable energy targets, and hence abatement could not be separately identified.

- Germany obtained most of its abatement from relatively high-cost feed-in tariffs (the wide block at A\$137/t CO_2).

- The United Kingdom had a mixed outcome, achieving low-cost abatement from fuel switching through the incentives created by the European Union ETS (the low flat bar at A\$29/t CO_2) and a similar amount of abatement from its much higher cost Renewables Obligation (at A\$176/t CO_2).

- The United States obtained most of its measured abatement from a combination of three policy measures, two federal tax credits and the renewable portfolio standards operated by many states (combined these are estimated to have an implicit abatement subsidy of A\$43/t CO_2).

- China's main contributor was its wind feed-in tariff at around A\$38/t CO_2.

- Australia's suite of policies (discussed later), was dominated by the combined effects of the large and small−scale components of the renewable energy target and feed-in tariffs (giving an average implicit abatement subsidy of A\$62/t CO_2).

Figure 6.1 **Marginal abatement costs — electricity-generation sector[a]**

Graphs show the Commission's 'central' estimates of abatement (as a proportion of counterfactual electricity-sector emissions) and implicit abatement subsidies
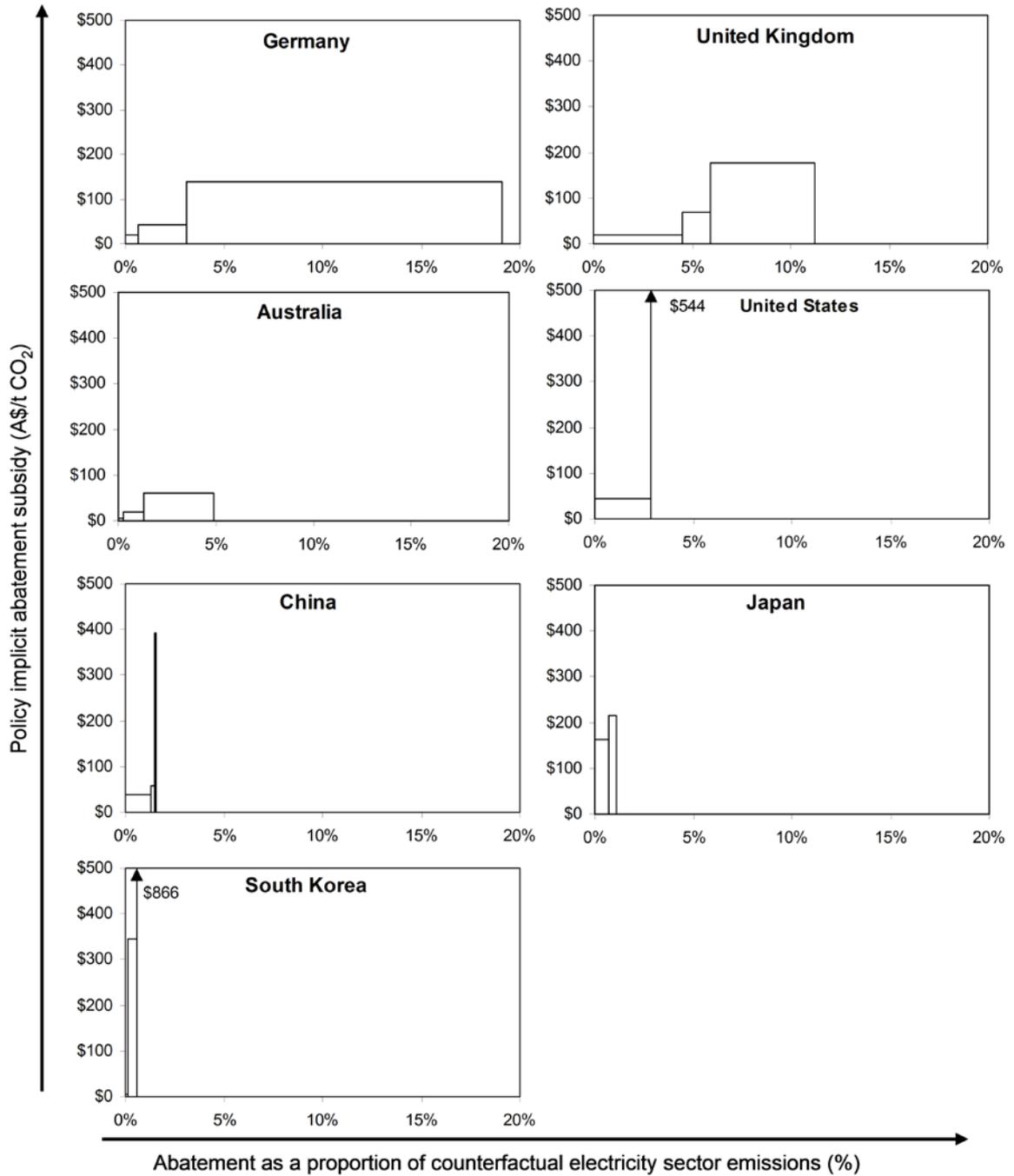
[a] The vertical axis was truncated at A$500/t CO_2. Where the estimated implicit abatement subsidy for a policy was above this level the implicit abatement subsidy estimate is shown on the graph.

Source: Productivity Commission estimates.

Road transport supply side — biofuels

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. However, costs and abatement vary widely across these countries (table 6.2).

- The United Kingdom, Germany and the United States — all with fuel content mandates — had high estimated total subsidy equivalents and abatement.

    - Germany stands out for having the highest abatement when measured against counterfactual emissions for the transport sector (3.6 per cent) at an implicit abatement subsidy of A\$310/t CO_2-e, which was at the lower end of the results for all countries.

    - The United States stands out for substantial abatement but at very high cost (the implicit abatement subsidy was estimated to be in the range A\$604–A\$672/t CO_2-e).

- New Zealand committed a very small amount of resources to biofuels and hence was achieving very little abatement.

- Japan and South Korea had relatively high cost biofuel schemes, with minimal abatement.

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

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. Cost per tonne of abatement — as measured by the implicit abatement subsidy — is typically A\$300–A\$600/t CO_2-e and possibly as high as A\$800/t CO_2-e. This cost is substantially higher than for most supply-side measures in electricity generation (though broadly comparable with solar subsidies).

Table 6.2   International comparison table — biofuel policies

Country	Total subsidy equivalent	Total subsidy equivalent as a percentage of GDP	Total abatement	Abatement as a percentage of counterfactual road transport emissions	Implicit abatement subsidy
	A$m (2010)	%	Mt CO_2-e	%	A$/t CO_2-e
Australia	144	0.011	0.4	0.6	364
China[a]	1 998	0.03	..	..	..
Ethanol	..	..	-1.4 to +0.8	-0.4 to +0.2	-6 105
Biodiesel	..	..	0.2	0.06	592
Germany	1 711	0.05	5.5	3.6	310
Japan	57	0.001	0.1	0.04	617–653
New Zealand	3	0.002	0.01	0.06	391
South Korea	196	0.02	0.2–0.5	0.3–0.6	415–831
United Kingdom	680	0.03	2.0	1.7	335
United States	12 470–17 477	0.08-0.11	19-26	1.2–1.7	604–672

[a] Results for China are presented separately for ethanol and biodiesel due to the negative abatement result for ethanol. Only a central estimate is given for the implicit abatement subsidy for ethanol; this estimate reflects negative abatement (not cost). .. Not applicable.

Source: Appendix N.

Road transport demand-side analysis

Of the biofuel policies analysed, the Commission has only explored the demand-side impact of fuel mandates because these are the only type of biofuel policy likely to affect retail prices. Fuel mandates were analysed for the United States, Germany and the United Kingdom. These mandates tend to increase fuel prices because they require petrol and diesel to be blended with more costly biofuels. However, the Commission's results suggest that the mandates appear to have had only a modest effect on prices, with at most an impact of around 1-2 cents per litre on retail prices of petrol and diesel.

By comparison, if regarded as emissions-reduction measures, the various taxes on fuel, such as excise taxes, (but excluding broad based consumption taxes) may be preventing emissions from road transport being much higher than they would otherwise. As for electricity, the Commission had to make some simplifying assumptions about demand responsiveness. In this case, these are even more speculative given the much larger tax-induced changes in price. But even if demand is only mildly responsive to price, it is likely that fuel taxes have led to substantially lower emissions relative to the counterfactual of no fuel taxes. For example, the high estimate for Germany indicated that abatement relative to the counterfactual was approximately 41 per cent. The consumption costs associated with this also appeared to be relatively modest.

But in most countries these taxes have been used for general taxation purposes and/or as quasi 'road-user charges'. Therefore, any abatement could be considered to be incidental. In some cases, such as the United Kingdom, recent adjustments to fuel taxes have 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. But if anything these results point to the added effect a carbon tax could have on top of existing fuel taxes.

6.3   Implications for 'effort'?

There is significant interest in understanding the relative effort of different countries in mitigating climate change. 'Effort' implies some sort of sacrifice that a country is making to achieve a given level of abatement. But sacrifice is difficult to define. For example, some see it as meaning that each country should reduce its emissions by the same proportion, others that countries should suffer the same proportionate losses in national income. The different commitments made by parties to the Copenhagen Accord illustrate diverse views, with some countries committing to absolute reductions from a past base year, others advocating reductions against some business-as-usual projection, and yet others advocating decreases in emissions intensity.

The economic impacts will vary according to the approach taken and the characteristics of each economy. Even if all countries had identical carbon taxes, it could not be said that each was making the same *abatement* effort.

Given the problems of defining and measuring effort, this study can only provide some circumstantial evidence of relative effort. There are two ways it does this: through an overview of the breadth and depth of the policy action each country is taking; and scaling costs and abatement achieved by GDP and (counterfactual) emissions, respectively.

Policy actions

Most study countries have adopted a large and diverse range of emissions-reduction policies. For example, the Commission identified more than 300 significant state and federal policies in the United States, and around 120 in the United Kingdom. And Australia itself has around 200 policy measures (chapter 2). These include ETSs in some countries (or regionally), and a range of less direct measures, such as mandatory renewable energy targets, feed-in tariffs, energy efficiency measures and capital subsidies for constructing or installing renewable energy technologies.

Of course, sheer numbers of policies say little in themselves about the materiality or effectiveness of the aggregate response made by governments. Australia and the United States have many policies in place partly because they are federations and their states are active in environmental policy. New Zealand, on the other hand, which has a unitary system of government and a natural endowment of hydro power, has achieved a more focused policy mix centred around explicit carbon pricing.

Some of the breadth in the policy mix can be explained by the use of complementary policies that are intended to address market failures other than the externality associated with greenhouse gas emissions (for example, energy efficiency policies that address information asymmetries). It can also be explained through the rebadging of existing policy instruments. (For example, fuel taxes are increasingly being seen as ways of discouraging fossil-fuel consumption and hence greenhouse gas emissions).

But it is also evident that there is much overlap and inconsistency in the policy mix of most countries. Different levels of government can be supporting the same project, not adding to abatement but adding to cost (for example, the US Federal Government subsidies for renewable energy and state mandatory renewable energy targets). Even at the same level of government, overlaps exist. For example, the United Kingdom and Germany are part of the European Union ETS — which covers electricity generation — yet the United Kingdom has continued to employ a mandatory renewable energy target and Germany has continued to employ very generous feed-in tariffs. Perversely, Germany's high level of support for renewable electricity reduces the emissions-reduction burden that must be borne by the rest of the European Union, lowering ETS permit prices, and leading to increases in emissions in other EU countries at Germany's expense (Traber and Kemfert 2009).

One feature of the policy mix of most countries is that they are in a state of flux. With the European Union ETS now well established and its coverage growing, New Zealand's fledgling ETS, some regional schemes in North America, and other countries such as South Korea, Japan and China intending to trial or adopt such schemes, explicit carbon pricing appears to be coming to the fore. But it is not clear if this will lead on to the rationalisation of other, more costly mechanisms.

Cost and abatement being achieved

The other way this study can shed some light on effort is by relating the cost incurred by each country in reducing emissions to the size of their economies, and comparing abatement to their sectoral emissions (table 6.1 and 6.2).

Electricity generation

When the total subsidy equivalent of each country's abatement policies was 'scaled' by expressing it as a proportion of GDP, Australia's commitment of resources (measured by the size of its bubble in figure 6.2) was much the same as for South Korea and China. But relative to South Korea, Australia's suite of measures was much more cost effective and produced proportionately more abatement, and relative to China they were about as cost effective, but achieved greater proportionate abatement. Australia achieved more proportionate abatement than the United States at about the same cost effectiveness, but devoted more of its GDP to achieving this outcome.[1] The United Kingdom and Germany are again shown to have devoted substantial resources to achieving abatement. Germany achieved substantially more abatement than the United Kingdom but at a slightly higher average cost. Japan's resource commitment was smaller than most other countries, the unit cost was high, and abatement small.

Figure 6.2 'Effort' and reward — how countries compare

Electricity generation — central estimates
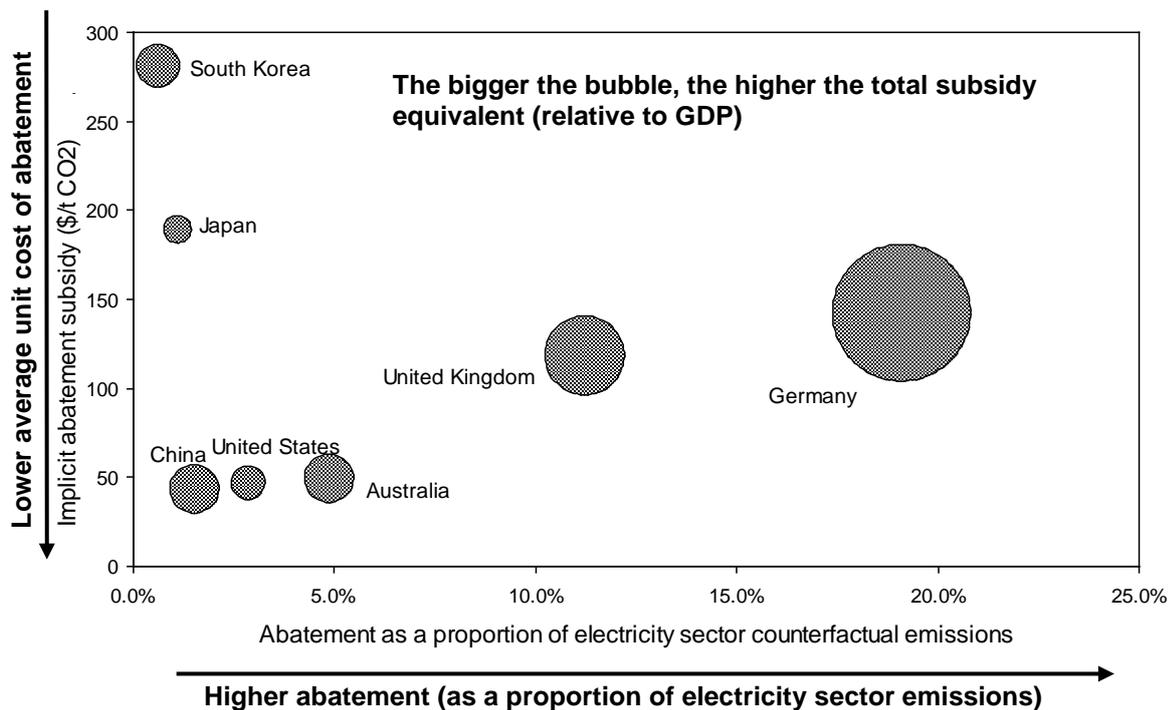
Source: Appendixes D to K.

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[1] But as noted in Chapter 4, of all study countries, the results for the United States are more likely to be underestimated due to the possible omission of other material policy interventions.

Some care needs to be taken in interpreting the data. Other things being the same, average costs of abatement would be expected to rise as abatement increases. This might be expected if policy makers have targeted assistance at the lowest-cost abatement options first. Indeed, if South Korea and Japan are excluded, the results for all other countries exhibit this trend. However, other things are clearly not the same. There are likely to be some large differences in the costs of the same renewable generation technologies, if for no other reason than that some countries will have different endowments of wind or solar resources (for example), and the different mixes of policies will influence average costs.

Biofuels

Using the same approach for biofuels reveals that, as a proportion of GDP, Australia's commitment of resources to achieving abatement is less than for most other study countries, but that cost effectiveness appears comparable to Germany and the United Kingdom, being roughly in the range of A\$300-A\$400/t CO_2-e (figure 6.3). But Australia is achieving relatively less abatement when measured as a proportion of transport-sector emissions. Germany is devoting considerable resources to biofuels, but is achieving the highest proportionate amount of abatement. The United States stands out in this analysis for having by far the highest commitment of resources relative to GDP, for only moderate proportionate abatement and hence low cost effectiveness.

Demand-side abatement and consumption costs

The demand-side abatement results discussed above could also be considered to shed some light on effort, as indicative as they are. The impacts on UK and German consumers of electricity and road-transport fuels stand out in this regard. Both countries have costly policy measures supporting low-emissions generation, which in combination with the European Union ETS, are estimated to have raised retail electricity prices by over 10 per cent. In road transport, the impacts of fuel taxes on abatement and hence consumption costs for most countries are considerable. Germany and the United Kingdom stand out, with fuel taxes of A\$0.78 and A\$0.96 per litre respectively (table 5.16), with Australia mid-range at A\$0.36 per litre.[2] But if these taxes are considered to be primarily for other purposes, such as funding roads or as a revenue-raising measure, it is not valid to attribute high-tax countries with additional effort.

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2   These are weighted averages of the rates applying to different road transport fuels.

Figure 6.3 'Effort' and reward — how countries compare

Biofuels — central estimates
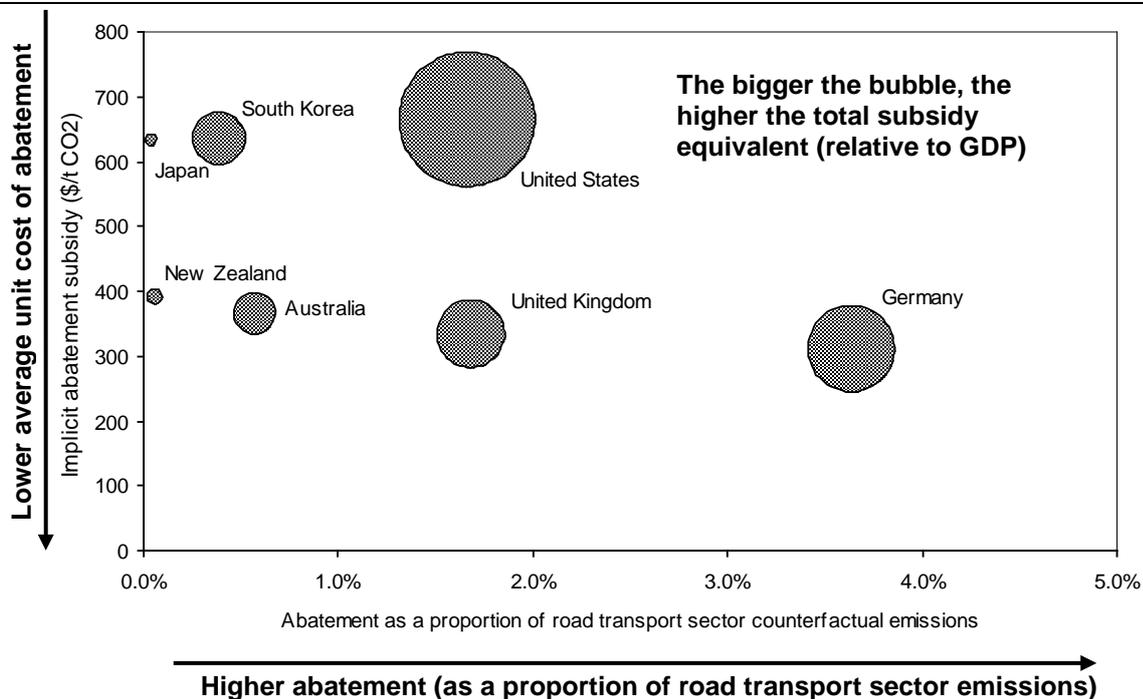
Source: Appendix N

In summary, such analysis can tell us relatively little about comparative effort per se, other than that some countries have devoted proportionately more of their national resources to achieving abatement than others, though with varying cost effectiveness. The results also illustrate the traps in using simple metrics to indicate effort.

- A relatively high implicit abatement subsidy does not necessarily indicate that a country also experiences a greater proportionate impact on its economy, or emissions, than other countries.

- A country that adopts high-cost abatement opportunities should not be given greater credit than a country that achieves the same abatement at lower cost. Indeed, the more cost effective the abatement policy, the greater the abatement that becomes possible for a given cost.

Least-cost abatement

As noted above, the cost effectiveness of a country's policy measures in aggregate can be put into perspective by estimating the explicit carbon price (from either a

carbon tax or emission permits) that would achieve the same amount of abatement when applied on an economy-wide basis.

This can be illustrated using a (hypothetical) marginal abatement cost (MAC) curve that shows all feasible abatement options in ascending order (including by reducing relatively low-value consumption) (figure 6.4).

- For various reasons, governments have found it difficult to implement the lowest-cost options first, meaning they may support a suite of relatively high-cost options (shown as the 'Policy MAC curve').

- If instead, all abatement options were considered and adopted in order of lowest to highest cost, the same amount of abatement could be achieved at a lower (marginal) cost (P_2 versus P_1).

- Conversely a much greater level of abatement could be achieved at the same (marginal) cost (A^{**} instead of A^{*}). (Note that total cost is measured by the area under the respective MAC curves, and the average cost of abatement will be less than the marginal cost.)

The abatement costs of the three existing policy measures analysed in this study for Australia have been plotted in figure 6.5 to create, in effect, an Australian 'policy MAC curve' for electricity. (The demand-side effect is shown separately and labelled 'electricity consumption costs'). The central estimates of abatement for these policies comes to around 12.5 Mt CO_2.

Stylised modelling using an 'off-the-shelf' version of the MMRF model of the Australian economy suggests that a carbon tax or ETS permit price would have achieved the same abatement at much lower cost. For example, according to the modelling, if applied only to the electricity sector, an explicit carbon price of about A\$9/t CO_2 (corresponding to P_2 in figure 6.4) is required.

This equates to about 11 per cent of the almost A\$500 million estimated cost of the existing policies. Alternatively, for the same aggregate cost, more than twice the abatement could be achieved. One of the reasons an explicit carbon price would be expected to be more cost effective at such low levels of abatement is that, as modelled, it captures a considerable amount of low-cost abatement on the demand side.

Figure 6.4 Marginal abatement cost (MAC) curves and cost effectiveness: a hypothetical illustration
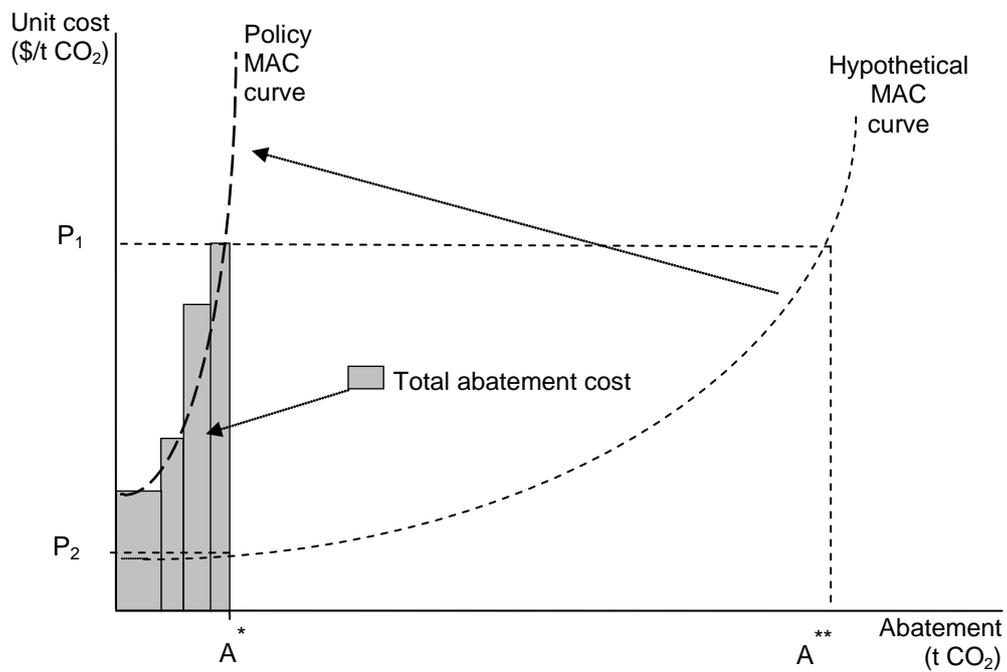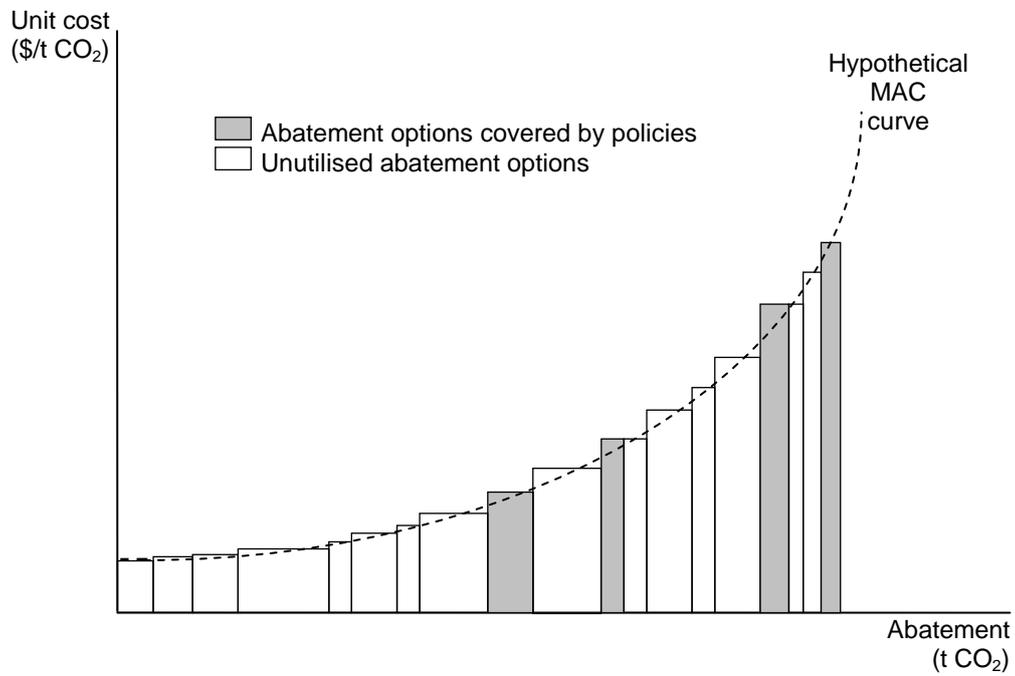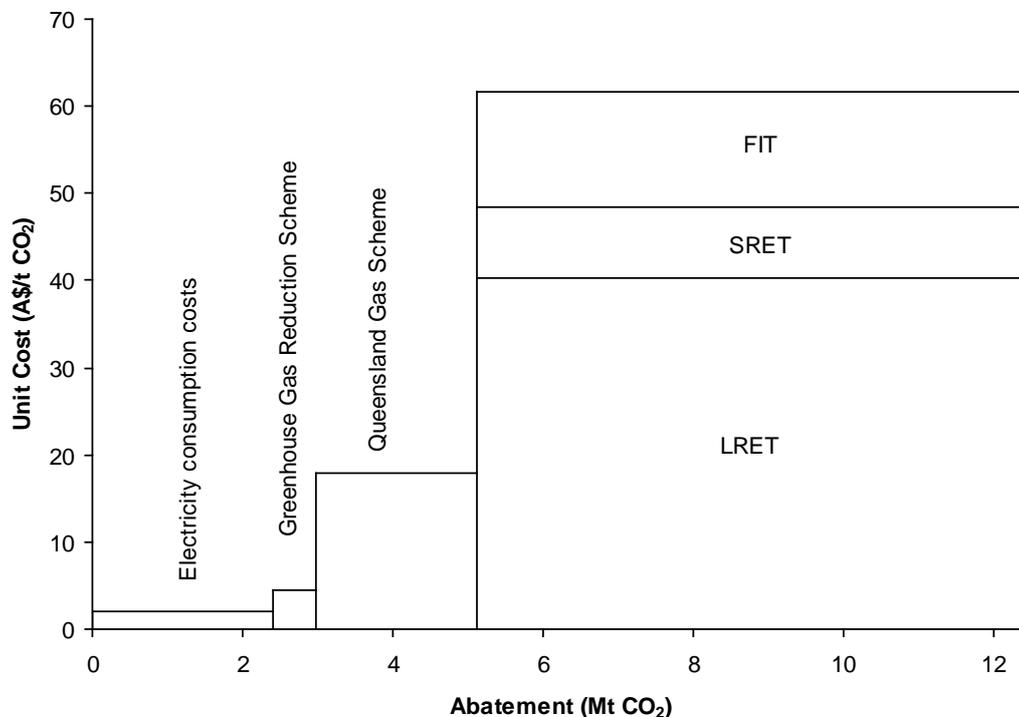
Figure 6.5 **Marginal abatement costs, Australian electricity**
'Central' estimates, 2009-10

Source: Productivity Commission estimates.

This worked example is relatively simplified and cannot be used to infer what the explicit carbon price would need to be to achieve Australia's abatement objectives (something that the Australian Treasury model is better equipped to address). But it illustrates how much more cost effective abatement can be if, in place of other more costly measures, an explicit carbon price is applied to both the demand and supply sides of a broader set of emissions-reduction opportunities within the electricity sector. Extending such a price across the economy would make it even more cost effective. By the same token, a carbon price in combination with other measures will generally be less cost effective than one operating on its own.

6.4   Implications for competitiveness?

When governments intervene to encourage the provision of low-emissions but high-cost production in place of high-emission, low-cost production, they can obviously have an effect on the competitiveness of businesses using that production as an input. The potentially more vulnerable firms will be those that are energy

intensive and trade exposed. In the context of this study, those firms would be the larger users of electricity and/or road transport fuel.

But the actual impact on a firm's costs will depend on how the government chooses to intervene.

- 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 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 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 estimated the impact of a sample of emissions-reduction policies on the retail prices of electricity and transport fuels. With the exception of taxes on road-transport fuels, the estimates are illustrative or at most indicative, for the reasons explained (section 6.1).

But even if these impacts were known with certainty, this information would still be of limited use in assessing impacts on the competitiveness of individual firms. This would require detailed information for particular firms and industries, including knowledge of the cost functions for the comparable industries in the competing countries, relative energy intensities, the net impacts of other policy measures affecting the cost of production, and the ability to pass on costs. Moreover, Australian firms may compete with firms in a wide range of countries — in many cases including countries other than those in this study — and the position would change as market conditions and exchange rates change.

The results for the electricity-generation and road-transport sectors vary considerably and need to be considered separately. In road transport, the Commission looked at support for biofuels as replacements for fossil fuels, and the impact of taxes on fuel prices.

Road-transport fuels are used widely in all economies for private consumption purposes, and as an input to business. Increases in the price of fuels could therefore have wide and diffuse impacts on the economy, with some businesses more affected than others.

- All countries impose substantial taxes on transport fuels, which can increase the cost of doing business. But the degree to which increases in fuel taxes might impair competitiveness will vary according to how much firms can claw back through tax credits or income tax deductions.

- Most biofuel policy measures are budget funded and (pre tax) fuel prices are determined in international markets and hence there are no direct effects. The only policies that do have impacts on retail prices seems to be the fuel mandates operated in Germany, the United Kingdom, and the United States, where they are binding. But even in these cases the impacts on fuel prices seem to be very modest to date (less than A$0.02 per litre).

In the case of electricity generation, the results are a little different, partly because electricity is generally not traded internationally and the industry can pass on cost increases to some extent. As this study has shown, most countries have some very costly policy measures, such as feed-in tariffs for renewable electricity, which are paid for by firms and households. The cost per unit of electricity from these schemes might be high, but to date the overall amount of electricity generated through these measures has, for most countries, been quite small. Hence, there has only been a relatively small impact on product prices to date. For example, the price impacts for Australia appear to have been of the order of 1 to 2 per cent in 2010. But there are exceptions, including Germany and the United Kingdom, where the impacts on retail prices appear to have been of the order of over 10 per cent. This would be an issue for firms in those countries that consume large amounts of electricity (and would work to the advantage of energy-intensive Australian firms competing against those firms).

The finding that average abatement costs are not particularly useful in assessing competiveness means that they are also not particularly useful for setting assistance for emissions-intensive trade-exposed firms. The analytical framework for considering assistance issues under the mixed bag of policies that apply in most countries is perhaps even more challenging than it would be under explicit carbon prices.

In summary, while the overall impacts of the policy measures analysed appears to be relatively small for most countries, the consistent finding from this study is that much lower-cost abatement could be achieved through broad, explicit carbon pricing approaches, irrespective of the policy settings in competitor economies.

A Study participants

As noted in chapter 1, for this study the Commission consulted with the business sector, government agencies and other interested parties, and utilised research expertise in the study countries. The tables below list the relevant parties and the nature of their involvement in the study.

Table A.1 **Meetings with interested parties**

Participant
AGL
Australian Energy Market Operator
Bureau of Infrastructure, Transport and Regional Economics (Australia)
Business Council of Australia
Clinton Foundation
Delegation of the European Union to Australia
Department of Climate Change and Energy Efficiency (Australia)
Department of Infrastructure and Transport (Australia)
Garnaut Climate Change Review
Independent Pricing and Regulatory Tribunal (New South Wales)
National Generators Forum
New Zealand Emissions Trading Scheme Review Secretariat
Refrigerants Australia
Rio Tinto
Treasury (Australia)

Table A.2　Participants in the methodology roundtable
Melbourne, 1 December 2010

Participant
Australian Bureau of Agricultural and Resource Economics and Sciences (Australia)
Australian Industry Greenhouse Network
Bureau of Infrastructure, Transport and Regional Economics (Australia)
Centre for International Economics
Centre of Policy Studies (Monash University)
Climate Change Institute (Australian National University)
Commonwealth Scientific and Industrial Research Organisation
Department of Climate Change and Energy Efficiency (Australia)
Department of Resources, Energy and Tourism (Australia)
Energy Supply Association of Australia
Essential Services Commission (Victoria)
Garnaut Climate Change Review
Professor Peter Lloyd (University of Melbourne)
Treasury (Australia)
Vivid Economics

Table A.3　Productivity Commission presentations to industry groups

Date	Industry group	Location
1 March 2011	National Generators Forum	Melbourne
18 March 2011	Business Council of Australia	Sydney
23 March 2011	Australian Industry Greenhouse Network	Canberra

Table A.4   **Government agencies providing data and policy information**

Agency
Bureau of Infrastructure, Transport and Regional Economics (Australia)
Chief Minister's Department (Australian Capital Territory)
Committee on Climate Change (United Kingdom)
Department of the Chief Minister (Northern Territory)
Department of Climate Change and Energy Efficiency (Australia)
Department of Energy (United States)
Department of Energy and Climate Change (United Kingdom)
Department of Environment and Conservation (Western Australia)
Department of Foreign Affairs and Trade (Australia)
Department of Innovation, Industry, Science and Research (Australia)
Department of Premier and Cabinet (New South Wales)
Department of Premier and Cabinet (Victoria)
Department of the Premier and Cabinet (Queensland)
Department of the Premier and Cabinet (South Australia)
Department of Premier and Cabinet (Tasmania)
Department of Resources, Energy and Tourism (Australia)
Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Germany)
Ministry for the Environment (New Zealand)
Ministry of Economy, Trade and Industry (Japan)
Ministry of Environment (Japan)
National Development and Reform Commission (China)
Treasury (Australia)
United States Environmental Protection Agency

Table A.5   Contractors providing data and policy information

Contractor	Coverage	
	Countries	Sectors
Energy Research Institute (National Development and Reform Commission)	China	Electricity generation and road transport
Frontier Economics	Australia, Germany and United Kingdom	Electricity generation
Korean Energy Economics Institute	Korea	Electricity generation and road transport
Resources for the Future	United States	Electricity generation and road transport
Vivid Economics, AEA Technology and Covec (consortium)	Australia, China, India, Japan, Germany, New Zealand, South Korea, United Kingdom and United States	Electricity generation and road transport

Table A.6   Other organisations providing assistance

Organisation
Institute of Energy Economics, Japan

Table A.7   **Government agencies invited to provide feedback on data**

Country	Agencies
Australia	Chief Minister's Department (Australian Capital Territory) (stocktake only)
	Department of the Chief Minister (Northern Territory) (stocktake only)
	Department of Environment and Conservation (Western Australia) (stocktake only)
	Department of Infrastructure and Transport
	Department of Climate Change and Energy Efficiency
	Department of Innovation, Industry, Science and Research
	Department of Premier and Cabinet (New South Wales) (stocktake only)
	Department of Premier and Cabinet (Victoria) (stocktake only)
	Department of the Premier and Cabinet (Queensland) (stocktake only)
	Department of the Premier and Cabinet (South Australia) (stocktake only)
	Department of Premier and Cabinet (Tasmania) (stocktake only)
	Department of the Prime Minister and Cabinet
	Department of Resources, Energy and Tourism
	Garnaut Climate Change Review
	Treasury
China	National Development and Reform Commission
Germany	Embassy of the Federal Republic of Germany (Canberra)
	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
	German Emissions Trading Authority
India	Ministry of Environment and Forests (stocktake only)
	Ministry of New and Renewable Energy (stocktake only)
	Ministry of Power (stocktake only)
Japan	Ministry of Economy, Trade and Industry
	Ministry of Environment
New Zealand	Ministry for the Environment
South Korea	Ministry of Environment
	Ministry of Knowledge Economy
	Presidential Committee on Green Growth
United Kingdom	Committee on Climate Change
	Department of Energy and Climate Change
United States	United States Department of Energy
	United States Environmental Protection Agency

B   Policies selected for analysis

This appendix provides brief descriptions of the emissions-reduction polices that have been quantitatively analysed in chapters 4 and 5. Policies are presented for the electricity generation and road transport sectors in each study country (excluding India, which chose not to participate in the study). Descriptions of all policies identified by the Commission are provided in the country stocktakes, which are available on the Commission's website.

Table B.1   Electricity generation, Australia

Policy type	Jurisdiction	Policy name	Description
Renewable energy certificate scheme	National	Large-scale Renewable Energy Target	Wholesale purchasers of electricity (retailers and large users) are required to purchase large-scale renewable energy certificates (RECs) to achieve annual targets for the overall amount of renewable energy generation. Annual targets increase over time from an initial level of 10 400 GWh of large-scale renewable energy in 2011. Between 2020 and 2030 the annual target is 41 000 GWh.
Renewable energy certificate scheme	National	Small-scale Renewable Energy Scheme	Electricity retailers are required to purchase a certain number of RECs from owners of eligible small-scale renewable energy installations (such as micro-generation, heat pumps and solar water heaters). The scheme does not have an overall general target and the small-scale technology percentage required to be purchased is set each year.
Solar feed-in tariffs	New South Wales	Solar Bonus Scheme	Owners of solar photovoltaic (PV) systems (up to 10 kW) are paid A$0.60/kWh or A$0.20/kWh for all electricity generated (depending on when the system was installed).
Solar feed-in tariffs	Victoria	Premium Feed-in Tariffs	Owners of solar PV systems (up to 5 kW) are paid up to A$0.60/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	Queensland	Queensland Government Solar Bonus Scheme	Owners of solar PV systems (up to 10 kW) are paid A$0.44/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	South Australia	Solar Feed-in Tariffs	Owners of solar PV systems (up to 10 kW) are paid A$0.44/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	Western Australia	Feed-in Tariff	Owners of solar PV systems (up to 10 kW) are paid A$0.40/kWh for excess electricity exported to the grid.
Solar feed-in tariffs	Australian Capital Territory	Feed-in Tariff Scheme	Owners of solar PV systems (up to 30 kW) are paid A$0.40–A$0.50/kWh (depending on the time of year the system was installed) for all electricity generated.

Table B.1 (continued)

Policy type	Jurisdiction	Policy name	Description
Emissions trading scheme – baseline and credit	New South Wales	Greenhouse Gas Reduction Scheme	Electricity retailers must meet mandatory emissions-reductions targets that are based on their market share, and must develop and encourage activities that offset emissions. Scheme participants must purchase NSW Greenhouse Abatement Certificates to meet their benchmark — each certificate represents a one tonne reduction in CO_2 emissions.
Electricity supply or pricing regulation	Queensland	Queensland Gas Scheme	Electricity retailers must source a minimum percentage of their electricity from eligible gas-fired electricity. Requirements must be met by surrendering Gas Electricity Certificates that are created for each MWh of electricity produced by eligible gas generators. The mandatory target was 15 per cent of generation in 2010 and will rise to 18 per cent by 2020.

Table B.2   Road transport, Australia

Policy type	Jurisdiction	Policy name	Description
Production subsidy	National	Ethanol Production Grants	A subsidy of A$0.38/L (2009-10) is provided to eligible ethanol producers to offset the amount of fuel excise. This subsidy is to be gradually phased out from December 2011 with the introduction of taxes based on the energy content of biofuels.
Production subsidy	National	Cleaner Fuels Grants Scheme	The Cleaner Fuels Grants Scheme provides a payment of A$0.38/L (2009-10) to producers and importers of biodiesel and renewable diesel to offset the amount of fuel excise paid. This scheme is to be abolished in December 2011 with the introduction of taxes based on the energy content of biofuels.
Fuel tax	National	Fuel excise	Australia levies excise on petrol, diesel and most biofuels at the rate of A$0.38/L (with rebates for off-road use), but does not currently tax liquefied petroleum gas (LPG) or other gaseous transport fuels (changes to these arrangements are scheduled to take effect from December 2011).

Table B.3   Electricity generation, China

Policy type	Jurisdiction	Policy name	Description
Feed-in tariff	National	Feed-in Tariff for Wind Turbines	Feed-in tariffs for wind generation that vary according to the 'zone' that generators are located in. Rates vary from CNY 0.51/kWh to CNY 0.61/kWh.
Feed-in tariff	National	Feed-in tariff for Biomass	Feed-in tariff of CNY 0.75/kWh for electricity generated from biomass.
Feed-in tariff	Local	Jiangsu Feed-in Tariff for solar PV	Feed-in tariffs for solar PV farms (CNY 1.4/kWh), solar PV rooftop projects (CNY 2.4/kWh) and building-integrated solar PV systems (CNY 2.9/kWh) (rates are for 2011). The target for the scheme is for 400 MW of installed solar PV capacity by the end of 2011.
Capital subsidy	National	The Golden Sun Demonstration Scheme	Subsidies for selected grid-connected solar PV projects (50 per cent of the capital investment) and off-grid solar PV projects (70 per cent of the capital investment).
Capital subsidy	National	Subsidy for Solar PV in Buildings	Capital subsidy of CNY 20/W for solar PV systems of 50 kW capacity or greater that are installed in buildings.
Generator upgrades	National	Large Substitute for Small program	Replacement of small less-efficient coal-fired generators with larger, more efficient generators.

Table B.4   Road transport, China

Policy type	Jurisdiction	Policy name	Description
Tax concession	National	Fuel Excise Exemption	Biodiesel and ethanol are exempt from fuel excise and a rebate is paid to producers for the value added tax (levied at 17 per cent). These exemptions only apply to authorised ethanol producers and to biodiesel producers that use at least 70 per cent recycled vegetable oil or tallow.
Production subsidy	National	Flexible Subsidies for Loss	Subsidies are provided to authorised ethanol producers to compensate for losses made in producing ethanol for road transport. The subsidy is based on an evaluation of each individual ethanol producer's annual financial performance.
Fuel content standard	Sub-national	National Scheme of Extensive Pilot Projects on Bioethanol Gasoline for Automobiles	Petrol is required to contain 10 per cent ethanol in six provinces (Heilongjiang, Jilin, Liaoing, Henan, Guangxi and Anhui), nine cities in Hubei province, seven cities in Shandong province, six cities in Hebei and five cities in Jiangsu. Only authorised ethanol producers are able to supply ethanol under this program.
Fuel tax	National	Fuel excise	China taxes petrol and diesel at the national level through the 'Consumption Tax' at rates of CNY 1/L of petrol and CNY 0.8/L of diesel. There is no tax on LPG used as a transport fuel.

Table B.5   Electricity generation, Germany

Policy type	Jurisdiction	Policy name	Description
Emissions trading scheme	European Union member states (including Germany)	European Union Emissions Trading Scheme	Electricity generators (and firms in some other sectors) are required to surrender one European Union Allowance (EUA) for each tonne of carbon dioxide they emit. EUAs are internationally traded permits. In the second phase of the European Union ETS (2005–2008), the majority of permits were allocated to firms with ETS obligations. However, during this period around 9 per cent of Germany's allocation of EUAs were auctioned by the German Government. This is scheduled to increase to 70 per cent by the end of the third phase (2010–2020). The scheme does not currently cover road transport fuels but will cover aviation fuels from 2012, with around 85 per cent of permits to be allocated to firms in that year.
Feed-in tariff	National	Renewable Energy Sources Act	Operators of electricity grids are required to purchase and transmit all electricity that is generated from renewable energy sources and mine gas.
Feed-in tariff	National	Combined Heat and Power Act	Payments to combined heat and power generators that vary depending on the age of the plant, its size and its efficiency.

Table B.6   Road transport, Germany

Policy type	Jurisdiction	Policy name	Description
Tax concession	National	Fuel Tax Exemption for Pure and Blended Biofuels	Biodiesel and vegetable oil are partially exempt from fuel taxes, with the exemption equivalent to €0.2734/L and €0.3049/L in 2009. The ethanol component of petrol blends (that contain at least 70 per cent ethanol) and 'cellulosic ethanol' are fully exempt.
Fuel content standard	National	Biofuel Quota Act	A minimum amount of biofuel must be consumed as transport fuel each year, either neat or blended with petrol or diesel. Each year, the proportion of biofuel in conventional fuel (petrol or diesel) is set (in terms of energy content). In 2009 quotas were 4.4 per cent for biodiesel (blended with diesel), 2.8 per cent for ethanol (blended with petrol) and 5.25 per cent for all biofuels.
Fuel tax	National	Fuel excise	Germany levies fuel excise on most transport fuels, with a tax of €0.65/L of petrol and €0.47/L of diesel (tax rates are higher for fuels with sulphur content over 10 miligrams per kilogram).

Table B.7 Electricity generation, Japan

Policy type	Jurisdiction	Policy name	Description
Renewable energy certificate scheme	National	Renewable Portfolio Standard	Electricity retailers must generate or purchase a certain amount of renewable energy each year (compliance can also be achieved by surrendering RECs). The scheme covers solar PV, wind, biomass, geothermal and hydroelectricity generators (excluding hydroelectricity generators over 1 MW). RECs can be banked and borrowed across years, with some restrictions.
Feed-in tariff	National	The New Buyback Program for Solar Photovoltaic	Electricity utilities are required to purchase excess electricity from solar PV systems exported to the grid. A fixed tariff is provided for 10 years (at rates of ¥20–45/kWh for systems installed in fiscal year 2009 (¥32–42/kWh in fiscal year 2011).
Capital subsidy	National	National PV capital subsidies	Capital subsidies for the installation of solar PV systems in residential buildings. In fiscal year 2009, the subsidy was ¥70 000/kW of solar PV installed (reduced to ¥48 000/kW in 2011).
Capital subsidy	Tokyo	Tokyo PV capital subsidies	Capital subsidies for the installation of solar PV systems in residential buildings, paid at the rate of ¥100 000/kW. This subsidy is provided in addition to the national subsidies listed above.
Fossil fuel tax	National	Petroleum and Coal Tax	Tax on imported fossil fuels, including coal, petroleum and natural gas. Both refined and unrefined imports are taxed. Current tax rates are ¥700/t of coal, ¥1080/t of natural gas and ¥2010/kL of petroleum. These rates will be increased between 2013 and 2015 as part of the 'Special Provision on Taxation for Global Warming Countermeasure', with the rate of increase based on the CO_2 emissions content of each fuel.

Table B.8 Road transport, Japan

Policy type	Jurisdiction	Policy name	Description
Tax concession	National	Biofuel excise concessions	Ethanol that is blended with petrol is exempt from fuel excise.
Fuel tax	National	Fuel excise	Japan levies two taxes on petrol (the Gasoline Tax and Local Gasoline Tax), at rates of ¥48.6/L and ¥5.2/L respectively. In addition, there is a Diesel Handling Tax of ¥32.1/L and a tax on LPG of ¥17.5/kg.

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Table B.9   **Electricity generation and road transport, New Zealand**

Policy type	Jurisdiction	Policy name	Description
Emissions trading scheme	National	New Zealand Emissions Trading Scheme	The New Zealand ETS covers electricity generation, transport fuels and some other sectors (including forestry and industrial processes). In the transition phase (July 2010 to December 2012), one ETS permit (New Zealand Unit) can be surrendered by firms to cover liabilities for two tonnes of CO_2-e emissions, and firms have the option of paying NZ$25 to the Government instead of surrendering a permit. In addition, some international offsets (such as Certified Emissions Reductions certificates) can be used to meet liabilities. From 2013 one permit will be required per tonne of emissions.
Tax concession	National	Ethanol fuel tax exemption	Domestic producers and importers of ethanol are exempt from the Accident Compensation Corporation Levy on fuel.
Production subsidy	National	Biodiesel Grants Scheme	A subsidy of NZ$0.425/L (2009) for domestic producers of biodiesel with sales of 10 kL per month or more.
Fuel tax	National	Fuel excise	New Zealand levies several taxes on petrol — including excise, the Accident Compensation Corporation Levy, the Petroleum Engine Fuels Monitoring Levy and the Local Authority Petroleum Tax — at a total rate of NZ$0.59/L. Excise is levied on LPG at a rate of NZ$0.10/L. There is a small tax on diesel fuel (less than NZ$0.01/L) since diesel use is taxed primarily through a system of 'road user charges' that are based on distance travelled.

Table B.10   Electricity generation, South Korea

Policy type	Jurisdiction	Policy name	Description
Feed-in tariffs	National	Feed-in Tariffs	Feed-in tariffs are provided to wide range of new and renewable electricity sources, including wind, solar, biomass, hydro, tidal and fuel cells. The South Korean Government is planning to replace this scheme with a REC scheme in 2012.
Emissions trading scheme	National	Korea Certified Emissions Reductions	A voluntary market for emissions-reduction certificates has been in operation since 2005 for firms that reduce emissions by 500 t CO_2 annually. In practice, the government purchases most certificates at around A$4.75/t CO_2.
Capital subsidy	National	General Deployment Subsidy	Capital subsidies are provided for up to 50 per cent of the cost of installing certain renewable energy systems.
Capital subsidy	National	Regional Deployment Subsidy	Subsidies are provided for building electricity generation infrastructure (100 per cent of costs) and the installation of renewable energy systems (up to 60 per cent of the cost) in some regions.
Capital subsidy	National	1 million Green Homes	Subsidies are provided to small-scale renewable generators (including solar PV, solar thermal, wind, geothermal and biomass) with the aim of having 1 million households using renewable energy by 2020.
Preferential loan	National	Loans Incentive Program	Low-interest government loans are provided for up to 90 per cent of the cost of installing or operating renewable energy systems (with the amount reduced to 50 per cent of costs for large corporations).

Table B.11   Road transport, South Korea

Policy type	Jurisdiction	Policy name	Description
Tax rebate or credit	National	Tax rebates for biodiesel	Domestic producers and importers of biodiesel are entitled to a fuel tax rebate of KRW 528.75/L (in 2010).
Fuel tax	National	Fuel excise	Several taxes are levied on petrol and diesel: The Transportation, Energy, Environment Tax; the Education Tax; and the Motor Fuel Tax. The total tax rates are KRW 745.89/L of petrol and KRW 518.18/L of diesel. Other taxes apply to LPG which total KRW 221.06/L.

Table B.12 Electricity generation, United Kingdom

Policy type	Jurisdiction	Policy name	Description
Emissions trading scheme	European Union member states (including the United Kingdom)	European Union Emissions Trading Scheme	See table B.5 (Germany).
Fuel or resource tax	National	Climate Change Levy	The non-domestic use of fossil fuels and electricity is taxed (excluding oil, heat, steam and gaseous transport fuels). In 2010 the rate was £0.00470/kWh for electricity with fossil fuels taxed at varying rates. Renewable electricity (with the exception of large-scale hydro) and 'good quality' combined heat and power systems are exempt from the tax.
Renewable energy mandate	National	Renewables Obligation	Electricity retailers are required to purchase Renewable Obligation Certificates created by renewable generators, or alternatively pay a 'fine'. Renewable generators receive different numbers of certificates per MWh depending on the technology used.
Capital subsidy	England	Offshore Wind Capital Grants Scheme	Capital subsidies for the construction of offshore wind farms, set at 40 per cent of costs in excess of the cost of building a conventional power station.

Table B.13 Road transport, United Kingdom

Policy type	Jurisdiction	Policy name	Description
Fuel content standard	National	Renewable Transport Fuels Obligation	The Renewable Transport Fuels Obligation requires domestic refineries and importers of refined conventional fuels to ensure that a specified percentage of road transport fuels that they supply are biofuel. The target for fiscal year 2009 was 3.25 per cent by volume of fuel. This has been raised to 3.5 per cent in fiscal year 2010. The scheme includes tradeable certificates and suppliers could 'buy out' of their obligation for £0.15/L in 2009.
Fuel tax	National	Fuel excise	Excise is applied to all road transport fuels in the United Kingdom. In 2010 the rates averaged £0.57/L of petrol or diesel and £0.17/L of LPG. The United Kingdom has justified increases in rates of fuel excise as an emissions-reduction measure.

Table B.14 **Electricity generation, United States**

Policy type	Jurisdiction	Policy name	Description
Tax concession	Federal	Renewable Electricity Production Tax Credit	An annual tax credit for renewable energy production from qualified facilities for the first 10 years of their operation. The rate in 2010 for wind, closed-loop biomass, solar and geothermal was US$0.022/kWh. Other renewable energy sources received US$0.011/kWh.
Capital subsidy	Federal	Section 1603 Renewable Energy Grants (Treasury Grant)	Firms can choose to accept this tax credit or, alternatively, can choose either the Business Energy Investment Tax Credit or an equivalent Section 1603 Treasury Grant. Cash grants to eligible renewable energy investments (facility construction) that are brought into service from 2009. The grant is 30 per cent of costs for fuel cells, solar, small wind, biomass, landfill, geothermal (other than heat pumps) waste and marine, and 10 per cent for geothermal heat pumps, micro-turbines and combined heat and power. Firms can choose whether to receive this grant or, alternatively, can receive either the Business Energy Investment Tax Credit or the Renewable Electricity Production Tax Credit.
Renewable energy certificate scheme	31 states and the District of Columbia	Renewable portfolio standards	Mandatory renewable energy targets (most of which have renewable energy certificates) exist in 36 states and the District of Columbia, with voluntary schemes in an additional five states. The design of these schemes, and the renewable technologies supported, differ across states. All schemes cover wind, solar PV, hydroelectricity, biomass, biofuels and landfill gas. Obligations are placed on generators in some states, and on retailers in others. 'Alternative compliance payments' exist in some states, a penalty paid per unit of non-compliance (in effect a price cap).
Capital subsidy	California	California Solar Initiative	Subsidies for solar energy systems. These consist of upfront cash payments (the Expected Performance Based Buydown and the Single-family Affordable Solar Homes scheme) and performance based incentives (feed-in tariffs for the first five years of operation of solar PV systems).
Capital subsidy	California	New Solar Homes Partnership	Subsidies to builders of new residential properties for the installation of solar energy systems. Subsidies vary by the housing type and the expected performance of the system. The base subsidy is US$2.50/W, with higher rates for builders of multiple houses that install solar panels and those that install solar panels on 'affordable housing' projects.
Capital subsidy	California	Self-Generation Incentive Program	Payments for distributed energy systems including wind turbines, fuel cells and 'advanced energy storage' systems. Payments are US$1.50/W for wind, US$2.50/W for fuel cells using non-renewable fuels, US$4.50/W for fuel cells using renewable fuel, and US$2/W for advanced energy storage systems.
Capital subsidy	California	Emerging Renewables Program	Payments for the installation of grid-connected small wind and fuel cell renewable energy electricity generation systems (up to 50 kW). The rate paid is up to US$3/W, depending on the type and size of the system (with higher rates for 'affordable housing' projects).

Table B.15   Road transport, United States

Policy type	Jurisdiction	Policy name	Description
Tax concession	Federal	Alcohol Fuel Credit	Producers of ethanol that is used as a road transport fuel receive a tax credit of US$0.45/gallon (US$0.12/L) of ethanol produced (including the ethanol component of petrol-ethanol blends). Additional tax credits are provided to producers of 'cellulosic ethanol', such that the total rate is US$1.01/gallon (US$0.27/L). Eligible small producers can receive an additional US$0.10/gallon (US$0.03/L) over the first 15 million gallons of biofuel produced each year.
Tax concession	Federal	Biodiesel Fuel Credit	Producers of biodiesel (and renewable diesel) that is used as a road transport fuel receive a tax credit of US$1/gallon (US$0.26/L) of biodiesel produced (including the biodiesel component of diesel-biodiesel blends). Eligible small producers can receive an additional US$0.10/gallon (US$0.03/L) over the first 15 million gallons of biofuel produced each year.
Production subsidy	Federal	Bioenergy Program for Advanced Biofuels	Eligible 'advanced biofuel' producers receive payments for the production of fuel from biomass (excluding maize starch). Payment rates differ depending on the feedstocks used, the size of the facility and the total amount of funding available.. There are also different payment rates for 'base' production (equal to total production over the previous year) and 'incremental' production (additional production within the year).
Tax concession	10 states and the District of Columbia	Excise Concessions for Ethanol	Ethanol is taxed at a lower rate than petrol in some states. These tax concessions are often applied to the two ethanol-petrol blends that can be legally sold in the United States — E10 (petrol blended with 10 per cent ethanol, also called 'gasohol' in the United States) and E85 (petrol blended with 85 per cent ethanol).
Government procurement	Federal	Federal Fleet Management Guidance	Federal government agencies with 20 or more vehicles must reduce their annual consumption of petroleum-derived products by 2 per cent, relative to a 2005 baseline. In addition, agencies must increase their consumption of 'alternative fuels' (including biofuels) by 10 per cent each year until 2015 (relative to 2005).
Fuel content standard	Federal	Federal Renewable Fuel Standard	A minimum volume of biofuels that must be sold each year. In 2009 the requirement was for the consumption of 11.1 billion gallons (42 billion litres) of biofuel, of which 0.5 billion gallons (1.9 billion litres) was expected to be biodiesel (or 10.20 per cent of all petrol sold was required to contain biofuel in that year). Since 2010, both petrol and diesel must contain biofuel and mandates have been set for 'celluosic' ethanol and other 'advanced' biofuels (that is, not maize starch). Most biofuel must also meet emissions-reduction criteria to be used for scheme compliance. Fuel suppliers can meet the requirements of the scheme through the creation of Renewable Identification Number certificates, which are tradable.
Fuel tax	National	Fuel excise	Fuel taxes are levied at the national and state levels in the United States, with significant differences in tax rates and tax systems across states. Federal-level excise rates are US$0.18/gallon (US$0.05/L) of petrol and US$0.24/gallon (US$0.06/L) of diesel. State taxes averaged around US$0.21/gallon (US$0.06/L) of petrol and diesel, and US$0.12/gallon (US$0.03/L) of LPG in 2009.

C Energy efficiency policies

Energy efficiency policies are directed at reducing the amount of energy required to produce a unit of output or to achieve a particular outcome. Depending on the source(s) of energy, to the extent that greater energy efficiency decreases energy consumption, there may also be a reduction in greenhouse gas emissions per unit of output.

C.1 Introduction

Mandating or encouraging improvements in energy efficiency are increasingly seen as important components of the policy framework for reducing greenhouse gas emissions in many developed and some developing countries. Indeed a similar suite of policies are observed across many countries. A key rationale is that unrealised profitable energy efficiency gains are seen as pervasive and offering a low (or even negative) cost means of emission reduction.

For example, the International Energy Association (IEA 2009b) has postulated that most of the greenhouse gas emission reductions needed to limit the global increase in energy-related emissions by 2020 to 6 per cent over 2007 levels, could be attained through improved energy efficiency.[1]

Non-price energy efficiency policies are also often easier to implement politically than tax or price-based policies. Unlike pricing or taxation instruments, the costs of energy efficiency regulations are often not apparent to those paying them.

In a number of key policy areas, most study countries have introduced substantial regulation in both the electricity and transport sectors, although the precise policy tools and stringency differ. In addition, most countries have adopted a diverse range of smaller energy efficiency initiatives, as well as broader emissions-reduction

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[1] This would be achieved largely by additional government regulation and a cap and trade emissions trading scheme for the power and industry sectors of OECD and EU countries, starting in 2013 and reaching a carbon price of US$50/tCO$_2$ (A$48) by 2020.

policies that will also have some consequential effect on energy efficiency.[2] The range of policies tends to be greater in countries with sub-national governments.

C.2   Establishing the costs and emissions reductions from energy efficiency policies

To estimate the cost of abatement for the emissions reductions achieved through the numerous energy efficiency policies implemented by many governments, it would be necessary to determine both the abatement attributable to each of these policies and the various costs involved in achieving it. However, there are significant difficulties in making meaningful estimates of both.

Estimating abatement

For a number of reasons, it is often very difficult to estimate abatement attributable to the diverse range of regulatory and information policies that have been used to encourage greater energy efficiency.

Establishing the counterfactual

In an era of generally rising energy prices, significant technological and structural change and increasing community focus on greenhouse gas emissions, ongoing improvements in energy efficiency are likely to be observed. Particularly as new or replacement high value assets are purchased, consumers and firms will place increased emphasis on energy efficiency. If energy prices rise sufficiently, some asset replacement will be brought forward to take advantage of more energy efficient technology. Product technology also evolves to satisfy these demands. In addition, some consumers simply exhibit preferences for improved environmental outcomes and will seek energy efficient products. Some businesses also appear to be becoming more aware of their 'carbon footprint' and the corporate reputational issues attached to it and are making decisions, including investments in increasing energy efficiency, to reduce that impact.

Hence, it is often difficult to identify what improvements in energy efficiency (and the associated costs) are attributable to a particular policy over and above those that would have occurred in the absence of the policy. This is further accentuated when

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[2] A more complete listing of energy efficiency based emission abatement policies implemented in the countries under review is included in the individual country policy stocktakes published on the Commission's website.

the impact of regulatory standards on energy use is uncertain, which can be particularly important for heterogeneous assets like residential and commercial buildings and industrial machinery.

If regulated standards wholly or partly reflect what the market would have delivered anyhow, then the potential costs of overriding consumers' preferences are commensurately reduced, but the regulatory transactions costs would then be spread over a smaller amount of emissions reductions.

'Rebound effects'

By lowering operating costs of energy-using equipment — effectively making marginal energy use cheaper — improved energy efficiency can cause a secondary increase in the demand for energy. For example, more fuel efficient motor vehicles make travelling cheaper and hence provide users with an incentive to drive further and more often. This is called the energy efficiency *direct* 'rebound effect'. While the existence of rebound effects is well established, their size can be contentious.

Apart from possible direct effects, privately cost-effective energy efficiency improvements will be wealth enhancing and will stimulate growth, particularly in the sector concerned. Significantly greater indirect energy rebound effects may occur as a result. This can contribute to a potentially large *total* rebound effect.

The Breakthrough Institute (Jenkins, Nordhaus and Shellenberger 2011), in a review of the rebound effect literature, noted that in developed countries, studies had typically identified direct rebound effects in the order of 10 to 30 per cent. It argued that this was likely to be a good deal higher in emerging economies, where demand for energy services was more elastic, with much greater scope to increase demand than in developed countries. Allowing for growth-induced indirect effects significantly increased the rebound effect for cost-effective energy efficiency initiatives, often to over 50 per cent, with several studies predicting a rebound of over 100 per cent — so called 'backfire'.[3] Conversely, indirect rebound effects from policies that are not privately cost effective would be negative, as such policies would be wealth diminishing.

In sum, the potential for rebound effects makes it difficult to determine the extent of energy savings attributable to policy measures promoting energy efficiency. Energy efficiency improvements that arise in response to higher energy prices do not face

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[3] While such productivity enhancements are to be welcomed, they do call into question the emission-reduction benefits of such policies. Indeed, from a purely emissions reduction point of view, energy efficiency regulation that is not privately cost effective will tend to generate greater emissions savings, as it will decrease wealth.

these difficulties, however, because they involve an unequivocal increase in net energy costs.

Extent of abatement

For a given reduction in energy demand, the impact on greenhouse gas emissions will depend on the energy source from which the reduction is obtained. For example, if improving air conditioner energy efficiency is mandated, any electricity reduction (net of rebound effects) is likely to occur in periods of peak demand, in which case the electricity displaced may be provided by gas generation. Conversely, falls in energy demand due to more efficient home lighting will involve mostly base-load electricity, suggesting that demand for coal-fired capacity might be reduced. In some cases, however, hydro electricity may be displaced, resulting in no emissions reductions.

In an electricity industry with a mix of fossil fuel technologies and several non-emitting energy sources, it will not always be clear what power source bears the brunt of reductions in energy demand resulting from energy efficiency policies. Electricity suppliers will reduce output from the highest cost source at the time. Because energy efficiency measures do not place a price on greenhouse gas emissions, they do not necessarily influence that decision in favour of reducing fossil fuel-based generation. In a country like New Zealand, where over 70 per cent of electricity already comes from renewable sources, emissions reductions are likely to be relatively small and unit abatement costs commensurately higher.

Estimating the cost of abatement

Determining the net costs (or benefits) of energy efficiency policies is particularly problematic. The costs associated with these programs are often diffuse and difficult to identify or quantify. The size of the costs depends significantly on whether the nature and extent of the intervention is commensurate with the market failures present in the market for energy efficiency (box C.1), and on whether all costs have been considered.

The market failures are mostly information related, and intervention that addressed these directly and in a cost effective way could lead to net private and social benefits. If this was the case, the net costs would be negative and the intervention a true 'no regrets' measure. But there can be some important costs that are sometimes overlooked. These are of two broad types: transactions costs and the costs of overriding consumer preferences.

Box C.1   Potential market failures in the demand for energy efficiency

It has often been observed that apparently privately cost effective energy efficiency savings are not taken up by consumers, firms and governments. The Commission (PC 2005) identified a number of barriers and impediments that might explain this. However, only if these represented market failures might policy intervention be justified.

Information deficiencies

If consumers and producers do not have easy access to adequate information on energy efficiency performance, they may 'under invest' in energy efficiency. Of particular importance is information asymmetry, where sellers may have more information than buyers regarding energy efficiency and do not share that information. However, limited knowledge is not of itself a market failure — information is expensive to provide and to obtain and hence it will generally be efficient to have less than perfect information.

Split incentives

Differing incentives can arise when the purchaser of an energy-using product (for example, a property developer or landlord) is different from the eventual user (for example, a home buyer or tenant). This is a form of the principal–agent problem. Due to uncertainty about the returns they may receive, developers and landlords can have less incentive to provide appliances and buildings that are as energy efficient as buyers or tenants actually desire. Such problems can be magnified by information asymmetries, where builders or property owners have more knowledge about the energy efficiency of a building than buyers or renters, and are not willing to fully share that information. In principle, these issues could be dealt with in contract negotiations, but in many cases this may be too complex and expensive given the potential savings.

Positive externalities (spillovers)

These occur where a firm's actions provide benefits to others that it cannot capture. Positive externalities relevant to energy efficiency relate to research and development and demonstration effects of firms being the first to adopt energy efficient technologies.

Negative environmental externalities

The negative externalities associated with CO_2 emissions have provided significantly added incentive for energy efficiency policy. In general, firms and individuals will not take account of these impacts and will have inefficiently high consumption of emissions producing energy. Among other things, this will mean an underinvestment in energy efficiency, because the private cost of energy is less than the social cost. Governments have implemented a wide range of policies encouraging or mandating individuals, firms and government agencies to use more energy efficient products.

Transactions costs that in principle should be considered include:

- the costs of obtaining and processing information

- the opportunity cost of management or consumers' time in making decisions. When combined with the often low share of energy in firms' or consumers' costs, this may lead to simple decision rules (rules of thumb) that fail to optimise the use of energy, but economise on other scarce resources

- borrowing costs to finance investment in energy efficiency. These can be increased by the uncertainty of the costs and benefits of some energy efficiency investments (for example, in heterogeneous assets like buildings) and the capital constrained position of some consumers such as first home buyers or low income earners

- the costs of administering and complying with regulatory interventions. These costs are likely to be higher and more difficult to estimate where there are many small impact policies spread across all tiers of government. They will also generally be higher if there are inter-jurisdictional differences in policies within a country.

The cost of overriding consumer preferences is a highly contentious area. At its simplest, this can be conceived of as the loss of other valued product attributes. These might be overridden by regulation (for example, light quality of incandescent light globes) or forgone because of the higher initial capital cost of achieving greater energy efficiency. At a more complex level again, costs can depend on whether consumers and firms are correctly perceiving the costs and benefits of investing in durable goods that will save them energy relative to the counterfactual (box 3.4).

All of these costs would ideally need to be estimated in order to determine the costs of emissions reductions achieved through energy efficiency policies.

Private costs and benefits can also be difficult to identify because energy efficiency attributes are embodied in products and are difficult to disentangle from other product features.

Multiple policy objectives

In some cases, improved energy efficiency (often in conjunction with energy conservation) and the concomitant reduction in greenhouse gas emissions, is only one of a number of benefits justifying a particular policy. For example, a number of countries include improving energy security as an important objective of energy

efficiency regulations. Also many jurisdictions include achieving energy and emissions savings in transport as a consideration when framing air pollution, public transport and land use planning policies. In such circumstances, the private benefits and emissions-reduction gains, if they could be reliably estimated, could both be included in policy evaluation.

However, it is usually very difficult to disentangle the precise impacts on policy of these sometimes competing objectives, and the costs and benefits involved. Only if specific allowance were made in policy development for the value of greenhouse gas emissions savings, and that allowance led to defined additional expenditure or costs, could they be considered an identifiable and quantifiable abatement measure. For example, urban planning policies involve many competing and at times conflicting priorities, among which energy usage (and by implication emissions reductions) is only one.[4]

Whilst it is usually not feasible to precisely allocate policy costs across these various objectives, part of the costs of achieving abatement can be attributed to them.

C.3 Energy efficiency policies in electricity consumption

Chapter 4 presents a quantitative analysis of a number of measures directed at influencing the technologies used to generate electricity in favour of lower emissions sources. In addition to these measures, abatement policies in many countries have also focused on improving the energy efficiency of a wide range of household, business and government energy applications. Most of these relate to electricity. A large number of diverse policies have been used. This section provides an overview of several of the more important ones adopted in study countries.

Energy efficiency labels for appliances

There is a long history of information programs directly targeting perceived deficiencies in energy efficiency information on more energy intensive appliances and equipment. All study countries have some form of (usually mandatory) appliance labelling policy covering a range of consumer, commercial and in some

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[4] In other cases impacts on energy efficiency are a coincidental outcome of particular policies. For example fuel standards and engine design regulations to reduce urban air pollution from motor vehicles will often reduce energy efficiency.

cases industrial products. Rating standards differ somewhat between countries. Sometimes mandatory schemes are supplemented by voluntary government sponsored labels, while in some countries private organisations provide endorsements or voluntary labels for energy efficient products (for example, the Energy Saving Trust in the United Kingdom).

The *United States* introduced a labelling scheme for appliances in 1980. The mandatory scheme now covers 11 products while the voluntary Energy Star label is used on around 20 others. The *European Union* (incorporating the *United Kingdom* and *Germany*) has had a mandatory labelling scheme since 1992 now covering 10 household appliance categories and has a voluntary Eco Label scheme used on 9 more. *Japan* has had a voluntary labelling system since 2000 applying to 16 household appliances.

South Korea has operated a compulsory labelling and standards program since 1992, that now covers 24 products. There is also a government sponsored high efficiency appliance certification program covering over 40 items of commercial and industrial equipment. *China* has voluntary energy labels for over 40 products and a compulsory label which commenced in 2005 and now covers around 20 products. *India* commenced a voluntary labelling program for frost-free refrigerators and tubular fluorescent lamps in 2006. Labelling for those products is now mandatory along with air conditioners and distribution transformers. There is voluntary labelling for several other products.

Australia has had a national mandatory energy efficiency labelling scheme since 1999, following more than a decade of individual state based labels. It now covers a range of major electrical and gas household appliance groups. The IEA (2010j) noted the very high compliance rates achieved by the scheme. In addition, Australian governments have developed an energy rating web site to provide information for consumers seeking an energy efficient appliance. *New Zealand* commenced mandatory labelling in 2002 and sets its standards in conjunction with Australia.

Minimum energy performance standards (MEPS) for appliances

All study countries have implemented some form of MEPS for new appliances — in general prohibiting the sale of appliances which do not meet these minimum standards. In some countries particular product types, such as incandescent light globes are banned altogether. In all countries, the level of the standards and the number of products covered have been increasing over time, including the coverage of some products used in the commercial and industrial sectors.

The *United States* has a long record of MEPS commencing, in the 1970s when energy security first became a major concern. The first federal standards were introduced in 1987. Initially 13 household appliances were covered and the number of products (now around 40 and including some commercial sector appliances) and the minimum performance standards have both increased over time. Several states impose standards on additional products. Initially the *European Union* was inhibited in introducing MEPS by the need for EU wide agreement to avoid obstructing EU trade. However, since 2005 it has implemented a number of MEPS and is in the process of significantly increasing the minimum allowable energy efficiency performance of many appliances.

Japan has energy efficiency standards covering over 20 household and commercial products. However, rather than setting minimum standards, each manufacturer and importer is required to achieve a designated weighted average energy efficiency performance for given appliance categories by a target year. These standards are set by reference to the product with the highest energy efficiency performance ('top runner') in the market in the base year — hence individual products are not prohibited from sale. Intermittently these standards are raised to reflect rising levels of achieved energy efficiency. Penalties for failing to achieve the average standard are light, with moral suasion and negotiation being preferred. *South Korea* commenced MEPS in 1992 and they now apply to over 20 household and commercial products.

China has an extensive program of MEPS which commenced in 1989 and now covers over 20 categories of residential, commercial and industrial appliances and equipment. Zhou (2008) considered that these standards, in conjunction with product labelling, had an important impact in reducing energy consumption, but that compliance had been a major problem. *India* commenced MEPS in 2007 with standards starting at a relatively low level but gradually being ratcheted up.

Australia first introduced national MEPS for various residential and commercial appliances in 1999, many evolving from earlier state-based standards. Australia and New Zealand now adopt the same standards for around 20 electrical and gas product groups. There are plans to further increase the product coverage and minimum standards. The Prime Minister's Task Group on Energy Efficiency (2010, p. 185) noted that Australia has 'a strong reputation internationally' for its current MEPS.

Unlike many of the motor vehicle fuel efficiency standards discussed below, MEPS have often been set significantly above the performance of the lower performing products in a number of countries (including Australia) and minimum standards have been raised over time. While rebound effects will have somewhat reduced their impacts, these policies are likely to have led to significant reductions in energy

use and greenhouse gas emissions in most countries. The costs of achieving this abatement are unclear. Policy development and implementation costs for government and business, particularly of the more intrusive MEPS, are generally difficult to estimate. Further, net costs (or benefits if the standards corrected market failures) to consumers of mandatory standards — which have restricted the options available to consumers by removing some lower priced products from the market, or leading to energy efficiency technology being incorporated at the expense of other product attributes — are problematic.

Energy performance standards for buildings

All study countries regulate the energy efficiency of new residential and commercial buildings. The level and extent of standards vary between countries and for different climatic regions within countries. In some cases (for example, Australia, the United States and India) they are imposed and/or regulated by sub-national levels of government, with varying degrees of coordination at the national level. In *Australia* they can also involve water efficiency measures as well. A number of countries (including Australia, the United Kingdom and Germany) now require disclosure of the energy performance of houses and commercial buildings at the time of sale or lease, to increase the previously limited information available about a building's energy efficiency.

Mandatory building energy codes in the *United States* were initially stimulated by energy security concerns following the 1970s oil crisis. Energy efficiency regulations for houses and commercial buildings are regulated at a state and local level with significant variations between jurisdictions, partly due to climate. Over time, standards have been implemented in more states and become more stringent in an effort to reduce greenhouse gas emissions, although a number of states still have no energy standards. There are also various model standards and codes developed by the federal government and private organisations, which can be adopted by the states or used by builders to inform buyers or renters about the energy efficiency and other attributes of a building.

In 2002 the *European Union* directed member states to set standards for the energy efficiency of new buildings and to update these regularly. Individual countries have responsibility for implementing this direction but requirements must be updated at least every five years. In the *United Kingdom*, energy efficiency requirements for insulation of new homes were first introduced into building regulations in 1965 and have been tightened several times since then and expanded to cover commercial buildings. Regulations were expanded and tightened in 2006 and further increases in standards are proposed. *Germany* first introduced insulation standards for new

buildings in the 1970s with ongoing increases in the stringency and coverage of energy efficiency requirements since then. The IEA (2009c) noted that German standards for new buildings were the highest in the G8 countries and further increases of over thirty per cent over current levels were in prospect.

Japan introduced energy performance standards for commercial buildings in 1979 and housing in 1980 and these have been strengthened over time to match European and US cold region standards. Although technically voluntary, they contain 'name and shame' provisions for larger projects (more than 2000 square metres) and monetary penalties since 2008. Hong et al. (2007) report compliance rates of 32 per cent for residences and 74 per cent for commercial buildings in 2004. For smaller buildings, standards are not mandatory and there are no penalties for non-compliance. *South Korea* first implemented mandatory energy efficiency standards (insulation thickness) in 1977 and standards were gradually expanded to cover various commercial and residential buildings. It formally adopted a mandatory building energy standard for larger commercial buildings and residential complexes in 2004, based on the Japanese model.

China has a history of province-based building standards and codes to improve energy efficiency in particular provinces, starting with housing in northern China in 1986. Standards were established for tourist hotels in 1993 and later for commercial and government buildings and for retrofits. However, Kang and Wei (2005) suggested that only 6 per cent of new buildings comply with the standards. Since 2008, China has required all provincial governments to increase urban energy efficiency in buildings and public transportation to meet energy intensity goals. The central government now audits local government plans. Chmutina (2010) noted that energy efficiency performance of the Chinese commercial building stock was much poorer than in developed countries.

Until 2007 there were no national energy efficiency requirements for new buildings in *India*. Mandatory energy efficiency standards have now been introduced for larger energy using commercial buildings and these are recommended for all other buildings. As there is a significant amount of new building in both China and India, standards will apply to a relatively greater percentage of the total building stock than in developed countries. The low per capita income of both countries suggests that the non-regulated level of energy use and energy efficiency in a building is likely to be lower than in developed countries. Hence any given standard of energy efficiency would tend to require a relatively greater increase in costs compared to business as usual.

New Zealand's Building Code provides minimum standards (which are reviewed over time) for energy use for heating, ventilation and cooling and lighting of

commercial buildings and for the energy performance of homes. As with appliances, the relatively small share of fossil fuels in electricity generation will limit the abatement benefits of these standards and increase the unit costs of abatement.

In *Australia*, mandatory building energy efficiency standards for new houses were introduced into the national building code in 2003. A number of jurisdictions had previously included energy efficiency standards in their building codes. These standards have since been extended to all new residential buildings and for commercial building and for major renovations, sometimes in conjunction with water saving and other environmental measures. Standards vary between climatic regions and some jurisdictions have continued to impose additional or alternative energy efficiency regulations. Development approval is only given when compliance is proven. The standards have increased over time, with further periodic tightening likely as part of an ongoing review process.

The wide variety of climatic zones covered by the study countries makes cross-country comparisons of standards difficult. In particular, Australia has only a small proportion of its population living in areas with extended periods of extreme climate, so that investments in energy efficiency standards would generally give lower returns. Also, because of the heterogeneous nature of residential and, particularly, commercial buildings, it is difficult and potentially expensive to accurately assess the costs and benefits of energy efficiency standards. In addition, the usage patterns of individual occupants will significantly affect the outcomes. The Commission has noted previously that it is difficult to assess both the impact on emissions and the costs of energy efficiency codes (PC 2005).

Furthermore, these uncertainties would be one explanation of the apparently high discount rates consumers and firms place on some investments in building energy efficiency.

Energy efficiency reporting requirements for large energy users

In recent years, a number of countries have implemented energy efficiency regulations directed specifically at the largest energy users, often requiring large energy using companies to undertake energy efficiency audits. The objectives are usually to encourage the businesses concerned to seek out further energy efficiency improvements and to provide demonstration effects for other energy users.

Japan requires designated energy management factories (annually using more than 3000 kL of fuel or more than 12 GWh of electricity) to follow energy rationalisation guidelines, prepare an energy rationalisation plan and appoint a number of licensed

energy managers. Compulsory energy audits are also undertaken (free for smaller companies) and the results monitored. In *South Korea*, businesses with annual energy use of more than 2000 tonnes of oil equivalent must conduct an energy audit every five years. Audits for smaller and medium-sized enterprises in this group are subsidised.

China set energy saving targets for 2005 to 2010 for 1000 enterprises consuming more than 5.3 petajoules per year (Top 1000 program), based on achieving energy efficiency improvements. The chosen enterprises' average annual energy consumption was 19.6 petajoules. Energy conservation agreements were signed between the firms and local governments, with both parties being held accountable for their achievement. Agreed savings averaged around 15 per cent (Price, Wang and Yun 2008). In *India*, companies in certain energy intensive sectors provide information in their annual reports on energy use and energy savings undertaken.

Australia has an Energy Efficiency Opportunities program, that since 2006 has required large energy-using corporations (those using more than 0.5 petajoules of energy per year) in all sectors of the economy to undertake energy efficiency opportunities assessments every five years and publicly report on the outcomes including annual updates. Over 200 corporations incorporating around 1200 subsidiaries are affected. Verification of compliance is undertaken for a sample of corporations. Decisions on undertaking identified opportunities are at the discretion of the business. Some state governments also have energy auditing requirements, sometimes in conjunction with other environmental goals. For example, in Victoria, all commercial and industrial sites that use more than 100 terjoules of energy or 120 ML of water in a financial year are generally required to prepare environment and resource efficiency plans and must implement all actions that have a three year or better payback period. These firms are subject to ongoing monitoring and reporting requirements. Queensland and New South Wales both have energy efficiency audit and reporting requirements for certain large energy users.

New Zealand has far fewer large energy using firms than other study countries. It provides subsidies up to NZ$10 000 or NZ$20 000 (up to one-third of the cost) for energy efficiency audits for businesses, truck fleets and building designs where relatively large energy use is involved. Recipients must commit to developing an action plan from the audit.

Very large energy users might be expected to have already identified profitable opportunities for energy efficiency improvements in the normal course of business. However, by mandating such studies, these programs may help to identify more marginal gains or bring forward improvements that would have been identified in the future. It is problematic what part of energy savings identified by mandatory

audits could be attributed to the existence of the programs and whether these savings justify the costs involved. In countries with some form of carbon tax, additional incentive to uncover and act on energy efficiency opportunities is provided by the tax.

In summary, Australian governments at all levels have implemented a wide array of regulatory policies designed to encourage or mandate improvements in energy efficiency in the use of electricity by households, business and government. While the breadth of policies used internationally makes it difficult to make comparisons with overseas countries, this suite of programs appears to broadly match those of other developed countries and generally surpasses that of developing countries.

C.4   Road transport

Chapter 5 examined quantitatively a range of fuel policies aimed at generating emissions reduction in the road transport sector. Several regulatory policies focusing on increasing the energy efficiency of new passenger motor vehicles, along with motor vehicle ownership charges, are considered below.

Provision of fuel efficiency and emissions information

One potential cause of sub-optimal motor vehicle purchasing decisions is that buyers might not possess sufficient knowledge to make an informed choice, despite information on the attributes (including fuel efficiency) of motor vehicles being available from a wide range of sources including automobile clubs, motoring magazines and vehicle producers. Nonetheless, many countries — including all study countries — have regulation or voluntary agreements for point-of-sale display labels showing fuel consumption, and in many cases carbon dioxide emissions, for new motor vehicles.[5] Fuel and carbon dioxide emissions are estimated using designated laboratory testing procedures, which often differ between countries and have also changed over time in some countries. A number of countries (for example, the *United States*, the *European Union* and *Japan*) are introducing compulsory fuel efficiency labelling for tyres.

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[5] Several countries also have web-based facilities to assist buyers in comparing fuel efficiency between vehicles. In Australia, the Department of Climate Change and Energy Efficiency's Green Vehicle Guide provides a low cost convenient means for buyers to compare fuel efficiency and emissions performance of new passenger motor vehicles. A Truck Buyers Guide gives advice to businesses on how to choose a small truck which is more fuel efficient, while still suiting their needs. Consideration is being given to including fuel consumption and emissions data in vehicle advertisements.

These schemes are relatively low cost for government, vehicle producers and consumers and they directly address any information market failure relating to efficiency in the light vehicle market. They allow buyers to incorporate more precise comparative fuel efficiency and carbon dioxide emission information into their purchasing decision. As consumer preferences are not overridden, these measures do not generate any loss of consumer surplus. Nonetheless, there is a possibility that by providing explicit information on only energy efficiency and emissions, the labels may detract from buyers' relative consideration of other vehicle attributes. If these attributes are inversely correlated with energy efficiency, buyers may be encouraged to make sub-optimal decisions.

Australia has made similar efforts to most other developed countries in directly addressing any information deficiencies with regard to fuel efficiency, through labelling schemes and vehicle guides.

Vehicle fuel efficiency standards

Passenger motor vehicles account for a significant share of greenhouse gas emissions — globally, light-duty vehicles contribute around 12 per cent of energy-related emissions. This has led many countries to implement regulations or voluntary agreements with vehicle producers aimed at increasing the fuel efficiency of the new vehicle fleet. The major policy in this area has been establishing minimum fuel efficiency standards for the new car sales of individual motor vehicle manufacturers. The underlying engine efficiency of motor vehicles has increased significantly over the last twenty years. However, in response to consumer preferences, a trend towards vehicles with more energy-using equipment, and in some cases larger and faster vehicles, has limited the improvement in observed fuel efficiency in many countries. Australia's experience has been somewhat contrary, in that the gradual removal of very high levels of industry protection over the last 20 years has allowed smaller, more fuel efficient, imported vehicles greater access to the market and to significantly increase their market share.

The *United States* first imposed fuel efficiency regulations for new passenger vehicles and light trucks (pickups, minivans, sports utility vehicles) in 1978 for reasons of energy security. These were in the form of a common Corporate Average Fuel Economy (CAFE) target for each producer's new vehicle sales — for passenger cars starting at 18 miles per gallon (mpg) (13.1 litres per 100 km (L/100km)) in 1978 and rising to 27.5 mpg (8.6 L/100km) by 1985, where it remained largely unchanged for over 20 years. Fines apply to vehicle producers that

do not meet the standards.[6] In 2007 significantly higher standards were established for 2020.

However, new standards are now to apply from 2012 (around 33 mpg — 7.8 L/100km for cars), with the previous 2020 fleet-wide standard being brought forward to 2016 (39 mpg for cars and 30 mpg for light trucks — averaging about 35 mpg for the whole fleet). An emissions standard, largely consistent with the fuel efficiency standards, of 250 grams of CO_2 per mile for the vehicle fleet has been set for 2016. Also each model will now have a separate target, which then converts to a different sales weighted target for each producer. The inclusion of emissions as well as fuel efficiency standards should improve the cost effectiveness in achieving the abatement objectives underlying the policy.

While the standard has been surpassed for the national new fleet as a whole, some overseas producers have sometimes not met it and have paid large fines. Goldberg (1996) and Anderson et al. (2010) considered that the CAFE standards had been binding on automobile producers. However, it is not clear how significant that impact was. In the 1970s, consumers had already begun demanding more fuel efficient new vehicles in response to higher oil prices and concerns about energy security — actual new fleet fuel efficiency had risen from 13 mpg in 1973 to 20 mpg in 1978. In the meantime, standards did not increase after 1985, in which time Knittel (2009) argues that nearly all improvements in fuel efficiency technology were used by US producers to increase power and weight without sacrificing fuel efficiency, suggesting a long-running consumer preference for these features.

Costly market distortions which may have been caused by the CAFE program include favouring a shift in production of larger vehicles towards sports utility vehicles (classified as light trucks) (Anderson et al. 2010), distorting the choice between import and local manufacture of both small and large vehicles (Goldberg 1996) and possible increases in road fatalities through effects on vehicle fleet composition (Klier and Linn 2011). A variety of studies (including Green 2010, Parry, Evans and Oates 2010 and Bento, Li and Roth 2010) highlight the considerable uncertainty about whether the CAFE standards have provided net benefits to consumers.

The increases in the standards by over 40 per cent by 2016 is more likely to involve capital costs that buyers would not otherwise have incurred, but will also provide future savings in fuel expenses.

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6 US$5.50 per tenth of a mile per gallon (A$5.32) under the standard for each vehicle manufactured for that year. Since the inception of the scheme importers have paid over US$500 million in fines.

The European Union and Japan have traditionally had the tightest international vehicle fuel efficiency and lowest carbon dioxide emissions targets, partly reflecting an existing market preference for fuel efficient vehicles and smaller cars. In 1998, the European Union (including the *United Kingdom* and *Germany*) established an industry wide average voluntary target with vehicle manufacturers and importers on the emissions of new vehicles of 140 grams of carbon dioxide per kilometre ($g\,CO_2$/km) (fuel efficiency of around 6.1 L/100km) by 2008. This was not achieved — actual fleet-wide emissions were over 155 g CO_2/km (6.7 L/100km) with wide variations between manufacturers. Now a mandatory average fleet emissions target of 130 g CO_2/km (equivalent to fuel use of around 5.6 L/100km) for passenger vehicles for each producer by 2016 will be phased in from 2012.[7] The 2016 standard for light commercial vehicles is 175 g CO_2/km.

Japan first applied corporate fuel efficiency targets for new passenger vehicles from 1985. Energy security objectives were part of the rationale for the policy. The most recent targets for various models equated to around a 6.7 L/100km fleet-wide average fuel efficiency for petrol vehicles in 2010. There were substantial tax savings on vehicles exceeding the standards before the 2010 target. In 2007, targets were set for 2015, based on nine weight classes. These were based broadly on the fuel efficiency of the best vehicle in class in the base year. The various targets equate to around a 6 L/100km fleet-wide average fuel efficiency (equivalent to emissions of about 125 g CO_2/km)[8]. Targets are mandatory but monetary penalties for not meeting them are small. In 2006, Japan introduced fuel-efficiency standards for heavy trucks, requiring a 12 per cent improvement by 2015.

Following earlier voluntary programs, *South Korea* introduced mandatory corporate fuel efficiency standards for domestically manufactured new car sales in 2006 and in 2009 for importers with sales of less than 10 000 vehicles per year. Importers selling more than 10 000 vehicles were subject to US CAFE standards. The standard for vehicles under 1500 cc was about 8 L/100km and 10.4 L/100km for those over 1500 cc. Further reductions were targeted for 2012 and a 2015 corporate carbon dioxide emissions standard has now been set of 140 g CO_2/km.

In 2005, *China* became one of the first developing countries to introduce fuel efficiency standards for domestically produced new light vehicles, with standards made about 10 per cent more stringent in 2008. Standards apply for 16 vehicle

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7 Penalties apply of €5 per vehicle (A$7) for the first gram over the standard up to €95 (A$130) for the fourth gram onwards.

8 Because Japan has a much lower percentage of diesel vehicles than Europe, a given emissions target translates into a lower equivalent fuel efficiency target — diesel has both a higher energy content and carbon content.

weight classes and two transmission types and are applied to each model produced. Models not meeting the standard cannot be sold. These standards are only surpassed by the European Union and Japan. Imported vehicles which tend to be larger and more luxurious were not subject to the fuel efficiency regulations. The regulations have energy security and industry policy objectives as well as achieving emissions reductions. This adds to the difficulty in ascribing costs of the policy to carbon dioxide abatement. Oliver et al. (2009) considered that the standard did encourage producers to include more fuel efficiency technology in vehicles sold on the Chinese market but probably at somewhat higher prices.

India is developing a compulsory fuel efficiency standard for carbon dioxide emissions (in the range of 130 to 140 g CO_2/km) to be applied to the new car sales of each vehicle manufacturer and importer by 2015.

New Zealand considered a compulsory fuel efficiency standard for new and used light vehicles entering the fleet, but chose not to implement it because costs to motorists (up to NZ$1500 (A$1200) for a large car) would have outweighed the benefits.[9] However, it had set an average emissions objective for new and used vehicles entering the fleet in 2015 of 170 g CO_2/km. This objective is to be supported by information provision, incentives and capability building. New Zealand also has an emissions trading scheme that will encourage greater fuel efficiency and fuel conservation for the whole vehicle fleet.

Australia has had a voluntary industry-wide average fuel consumption target for new passenger petrol motor vehicles since 1978, when measured fuel consumption of the new fleet averaged around 11 L/100km. Various gradually reducing voluntary targets were negotiated over time with the industry, the latest being 6.8 L/100km by 2010.[10] In 2005, the vehicle industry committed to its own voluntary 2010 carbon dioxide emissions target of 222 g CO_2/km averaged across all new vehicles under 3.5 tonnes. The target was achieved in 2009. The government has now announced that a mandatory fleet-wide carbon dioxide emissions target will be set for 2015 with individual vehicle producers being given regulated targets. Carbon dioxide emission levels of 190 g CO_2/km by 2015 and 155 g CO_2/km by 2024 have been given as the starting point for further consultation with stakeholders. A Regulatory Impact Statement is to be prepared examining the implementation of this standard.

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[9] Conversion of foreign currency values to Australian Dollars (A$) in this appendix used average exchange rates over January to April 2011 (RBA 2011).

[10] Changes in test procedures and vehicle coverage in 2003 significantly increased measured fleet fuel consumption by over 10 per cent and, along with the failure to proceed with the anticipated introduction of more energy efficient petrol, have made the 2010 target redundant.

Historically, outcomes have been generally slightly over the targets. Although average fuel efficiency of the new vehicle fleet has increased substantially (around 33 per cent) over the last 30 years, the Australian Transport Council (ATC 2009) found no evidence that the targets have had any influence on this. As the targets were voluntary and no individual producer was responsible for achieving them, there seems little incentive for individual producers to deviate from their 'business as usual' plans for fuel efficiency. Some of the improved fuel efficiency technologies incorporated in new vehicles sold in Australia may have been stimulated by overseas regulatory standards.

Until recent years, Australia's regulation of new motor vehicle fuel efficiency appears to have been in line with the relatively non-intrusive approach of a number of other study countries, although the fuel consumption targets were higher than in the (previously voluntary) European and (light-handed) Japanese schemes. However, the significant cross-country variations in scheme design, specification of standards and testing methods, and the difficulty in establishing non-regulatory counterfactuals would make any comparisons of 'relative effort' particularly imprecise. A number of countries, including Australia, have now announced significant increases in their fuel efficiency targets for 2015 and beyond, with a trend towards focusing on carbon dioxide emissions.

The effective stringency of standards expressed in fleet-wide terms, will depend partly on underlying consumer preferences in the country concerned. In European countries and Japan, which have high petrol taxes and are densely populated, with high levels of urban traffic congestion in many cities, preferences tend to be towards smaller, fuel efficient vehicles. Similar preferences exist for less wealthy countries like China, India and South Korea. In large, wealthy and less densely populated countries with relatively low petrol taxes, like the United States and Australia, bigger and more powerful cars have a much higher market share.[11] Hence, any given fleet-wide fuel efficiency standard will be more difficult and costly to attain and will generate relatively more emissions reduction in such countries.

Also, in the absence of substantial market failures, the cost of abatement imposed by fuel efficiency standards for new vehicles can be unnecessarily high. All of the abatement burden is placed on new vehicles — no ongoing incentives are in place to improve fuel efficiency of older vehicles, to update to more fuel efficient

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[11] The Federal Chamber of Automotive Industries (FCAI 2010) noted that the combined small/medium vehicles sector held similar market shares in Australia as in Germany and the United Kingdom. However, large cars held nearly a quarter of the market in Australia compared to 8 per cent in Germany and 5 per cent in the United Kingdom. Conversely, the share of light vehicles was much lower in Australia.

vehicles, use less polluting fuels or reduce kilometres travelled.[12] Also, by further increasing the up front capital cost of new vehicles, higher fuel efficiency standards can discourage upgrading to new (usually already more fuel efficient) vehicles thereby increasing emissions. Hence achieving emissions reductions by simply emulating increasing overseas fuel efficiency standards may involve unnecessarily high costs. For example, *New Zealand* has chosen not to implement fuel efficiency standards for new motor vehicles, but rather will achieve transport emission abatement more efficiently by including transport fuel in its emissions trading scheme.

Vehicle charges related to fuel efficiency

Some taxes on vehicle ownership have provided incentives (often coincidentally with primary policy objectives) to purchase more fuel and/or emissions efficient vehicles, although often the relationship is only loose via vehicle weight or engine size. A number of governments have now more closely aligned these taxes to fuel efficiency or emissions.

- Since 1978 the *United States* has had a 'gas-guzzler tax' which is an excise on manufacturers of new passenger cars that fail to meet a minimum fuel efficiency standard (currently 22.5 mpg). The tax increases as tested fuel efficiency decreases. However, it does not apply to light trucks including sports utility vehicles. Vehicle registration fees (usually annual) are charged on a state and even county basis. Some are flat fees, while others vary with a vehicle's weight, age or value.

- In the *United Kingdom*, first year registration tax and annual vehicle tax are both based on a vehicle's rated CO_2 emissions (13 steps from 100 to over 255 g CO_2/km). First year registration ranges from zero to £950 (A$1489) and annual fees from zero to £435 (A$682).

- *Germany* has annual ownership taxes for vehicles based on a combination of engine size and rated carbon dioxide emissions — the latter increasing in a continuous fashion once emissions go over 120 g CO_2/km.

- In *Japan*, the vehicle acquisition tax rises step wise with engine size, as does an annual automobile tax, while there is also an annual tonnage tax per 500 kilograms of vehicle weight.

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[12] The United States and Germany both introduced a temporary 'cash for clunkers' program in 2009. These schemes provided subsidies for scrapping older vehicles to purchase new ones, in order to stimulate the economy during the global financial crisis. Such a scheme was also proposed for Australia, but was abandoned prior to being implemented.

- In *South Korea*, vehicle taxes are based on engine size, but consideration is being given to switching to a fuel efficiency or carbon dioxide emissions-based system.

- Excise rates on new vehicles in *China* vary in a step-wise fashion with engine displacement. In addition, vehicles with engine displacement of 1.6 litres or less, and which meet fuel efficiency standards, received a subsidy of CNY 3000 (A$443).

- *India* levies excise on vehicles, which varies by vehicle class, and a special duty which increases in three steps with engine displacement.

- *New Zealand's* initial registration fee and annual vehicle licences are largely invariant to vehicle size or fuel efficiency. However, New Zealand includes transport fuels in its emissions trading scheme.

- In *Australia*, annual registration fees and stamp duty on vehicle purchase are imposed by the States and Territories and are generally levied on the basis of weight, engine capacity or number of cylinders. In some cases, registration fees for passenger vehicles are fixed amounts while in others they vary with vehicle weight. Stamp duty varies with the price of the vehicle, usually with some broad stepwise rate increases for higher prices. In addition, the Australian Government applies a 'luxury car' tax (33 per cent) to the GST-exclusive price of a vehicle over a threshold value (around A$57 000). It does not apply to vehicles with rated fuel consumption below 7L/100km, which cost below A$75 375.

Some countries have taxes on vehicle purchase and ownership that vary directly with fuel or emissions efficiency while in others (including Australia), there is only a rather indirect (in varying degrees) relationship, via vehicle size or price. Australia's passenger motor vehicle manufacturing industry is more concentrated in the medium to larger cars, which tend to be less fuel efficient. Hence, vehicle taxes which favour more fuel efficient vehicles will tend to disadvantage domestic production.

Varying vehicle taxes according to estimated fuel efficiency or carbon dioxide emissions is an indirect and hence generally less cost-effective means of achieving emissions reductions. Unlike fuel taxes they do not provide incentives for abatement through mechanisms such as reduced vehicle use, more efficient driving practices and better vehicle maintenance. However, as the higher taxes are aggregated into relatively large up-front and annual lump sums, consumers may be more responsive to them.

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