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

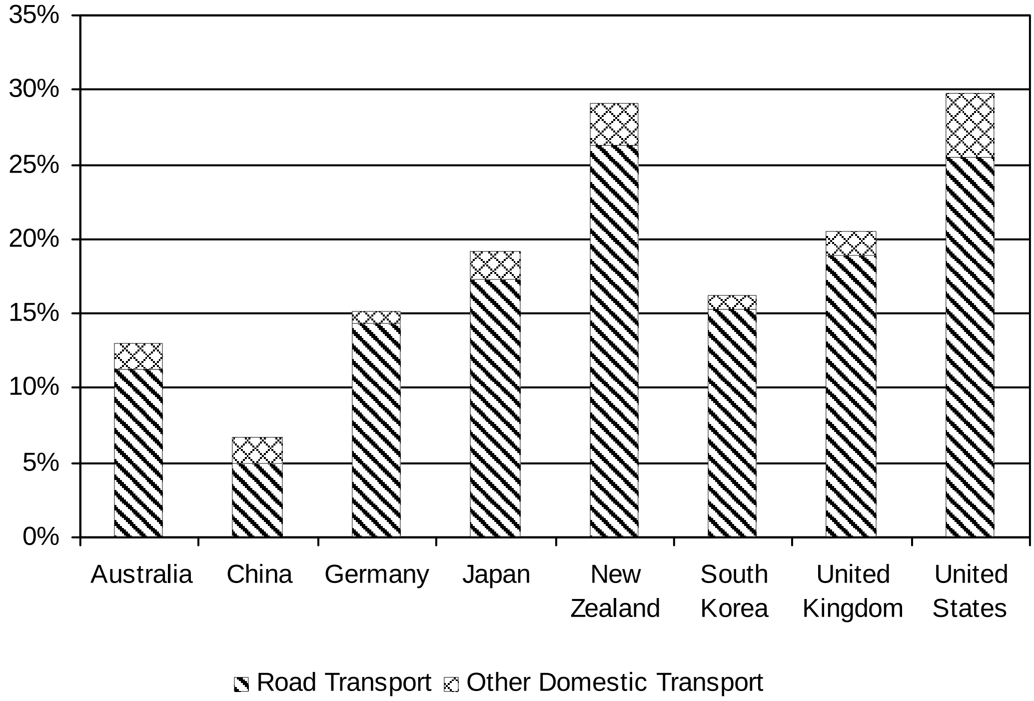
The Commission has identified over 100 policies that apply to the road transport sectors of the study countries, and has selected a subset for more detailed analysis. The quantitative analysis was restricted to road transport policies that:

- 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)



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).

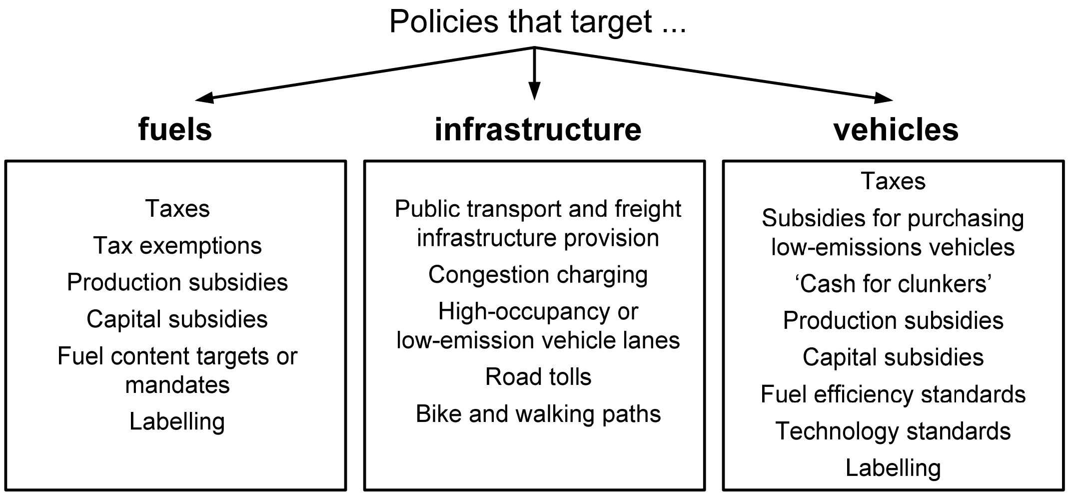
Road transport fuels

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]

	Biofuel policies		
Country	*Subsidies*	*Fuel content mandates*[b]	*Fuel taxes*
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

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 5.2).

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).

Box 5.4 **The economic cost of fuel taxes**

By raising the price of fuel, fuel taxes discourage consumption. Induced reductions in consumption of fuel come at an economic cost. This economic cost is not the amount of tax paid. Rather, it incorporates two kinds of costs (that are more difficult to quantify):

- Loss of the greater enjoyment or utility a consumer would have received using the fuel, for example by driving to work or going on a road trip.
- The costs of switching to different modes of transport (that use less fuel) but may not have the same valued attributes as a consumer's usual car.

Fuel taxes may also increase the amount of money that consumers spend on fuel, which means they must forgo consumption of other goods or services.

These consumption costs can be estimated by quantifying the decrease in 'consumer surplus' (less any transfers to the government through tax revenues) due to the imposition of a fuel tax (appendix O). Consumer surplus is a concept used in economics to measure the welfare effects of price and income changes.

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 (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

		Subsidy equivalent		
Policy	*Level of government*	*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.

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]**

		Petrol		*Diesel*		*LPG*	
Country	*Year*	*rate*	*volume*	*rate*	*volume*	*rate*	*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.