J The United Kingdom's electricity generation sector

The Commission has estimated the subsidy equivalent for four policies in the United Kingdom: the European Union Emissions Trading Scheme (ETS), the Renewables Obligation, the Climate Change Levy (CCL) and the Offshore Wind Capital Grants Scheme.

In addition, the Commission has estimated the implicit abatement subsidies arising from the feed-in tariff (FIT) scheme that commenced in April 2010 (but has not estimated abatement or a subsidy equivalent). Several other policies were considered, but preliminary analysis suggested that the effect of these policies on emissions iwas unlikely to be material in comparison to the other policies analysed, and accordingly the subsidy equivalent and abatement were not estimated.

Subsidy equivalents and abatement were estimated for the 2009-10 financial year (1 April 2009 to 31 March 2010). Subsidy equivalents and implicit abatement subsidies are reported in both UK pounds and Australian dollars, with currency conversion rates based on the average exchange rate for the period April 2009 to March 2010 (£1 = A$1.86). (One exception to this is the FIT scheme, for which the estimate was based on the 2010 calendar year average exchange rate — £1 = A$1.68. This is because the policy did not commence operation until April 2010.)

For the four policies that were analysed in detail, the Commission carried out sensitivity analysis. The results of the sensitivity analysis are reported in comparison to the Commission's 'central' estimate. The 'central' estimate is based on the set of assumptions that the Commission considers to be most consistent with its approach to estimating subsidy equivalents and abatement.

References in this appendix to Frontier Economics refer to unpublished data supplied to the Productivity Commission by that contractor.

J.1 Electricity generation in the United Kingdom

This section is broken into two parts. The first describes the structure of UK electricity markets, while the second reports some key statistics.

Structure of UK electricity markets

Electricity generation, transmission and retail in the United Kingdom are mostly privately-owned (with the exception of some nuclear generators). There are essentially two weakly-linked electricity markets in the United Kingdom. A single market operates in Great Britain. Northern Ireland is not a part of this market, but operates in a single market with the Republic of Ireland. The Great Britain and Northern Ireland wholesale markets will be discussed separately. The other major components of their electricity systems — transmission and retail — are not described. Some remote communities (such as some Scottish Islands) are not connected to the national grid, and rely on imported fossil fuels (such as diesel) and increasingly, renewable sources. These communities constitute a relatively small proportion of total UK electricity generation, and are not assessed separately.

Great Britain wholesale electricity market

The Great Britain market was liberalised throughout the 1990s, and electricity dispatch operates under a market system whereby generators sell electricity to retailers and other large buyers. Most of the UK electricity generation sector is privately-owned, aside from a small amount of nuclear power (IEA 2006). Wholesale electricity is traded in 30 minute blocks. Wholesale trade is decentralised, in contrast to central pool arrangements common in many other electricity markets. Market players are free to trade as they wish, and contracts can be brokered on over-the-counter markets or via exchanges.

National Grid, the entity that operates the UK transmission system, plays a role in balancing demand and supply across 30 minute blocks. This is done by accepting bids to increase or decrease generation or consumption. In the case of additional generation, participants bid the price they would be willing to sell the electricity for, and successful participants receive the price they bid for their electricity (as opposed to other electricity markets including the National Electricity Market in Australia, where all participants receive the highest market clearing bid). According to ELEXON (2011), 98 per cent of trading is done via forward and future markets, with only 2 per cent via this balancing mechanism.

Northern Ireland wholesale electricity market

In 2007, Ireland and Northern Ireland combined to form the Single Electricity Market. Unlike the Great Britain electricity market, the Single Electricity Market is a mandatory pool market — all electricity bought and sold in Ireland must be transacted through the central pool. Generators and suppliers place bids through the central pool and the generators that are scheduled to supply electricity receive the highest market clearing bid.

The Single Electricity Market also features payments to generators for providing reserve capacity to the market. Revenue to make the payments is raised through reserve capacity charges on purchasers of electricity.

Electricity transfers

The electricity system in Great Britain is connected to Northern Ireland through the Moyle interconnector, which has an export capacity of around 450 MW (from Great Britain) and an import capacity of around 80 MW (into Great Britain). The interconnector with France has a capacity of around 2000 MW. Connections are also being constructed with the Republic of Ireland and the Netherlands. There are a number of connections between Northern Ireland and the Republic of Ireland (EirGrid 2011). The United Kingdom was a small net energy importer between 2005 and 2009 (DECC (UK) 2010a).

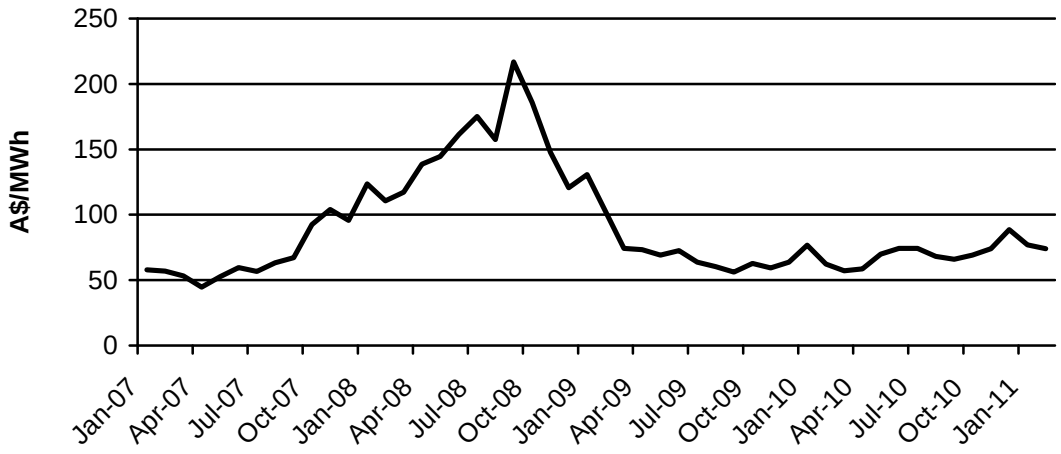
Key statistics

Electricity prices

The average monthly wholesale price of electricity in Great Britain rose significantly in 2008, before falling in 2009 to around A$58/MWh. It has remained at around this level since mid-2009 (figure J.1). The lowest average monthly price was observed in April 2007 at around A$44/MWh. The highest average monthly price was observed in September 2008 at around A$216/MWh. The most recent data available show an average monthly price of around A$80/MWh in early 2011.

Figure J.1 **Monthly average wholesale electricity prices**

Great Britain, Nominal prices, 2007–2011



Source: Frontier Economics (unpublished data).

Electricity generation

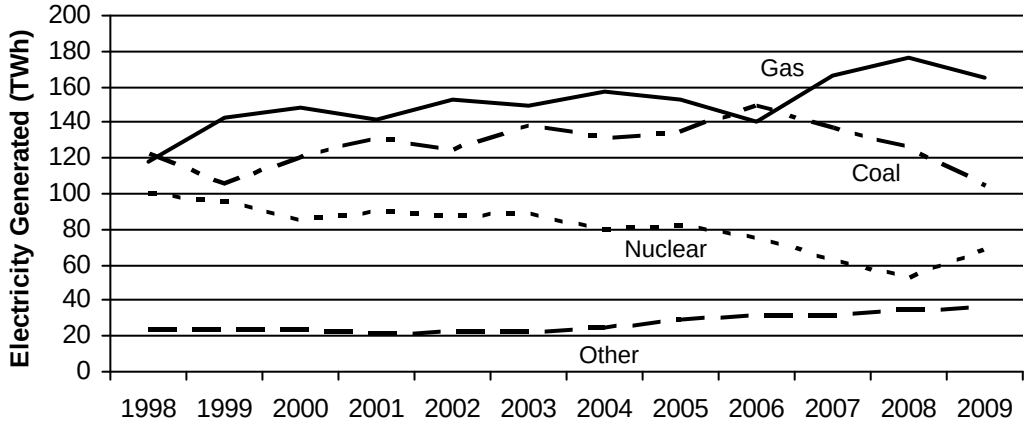
The UK electricity sector has been dominated by three energy sources — coal, gas and nuclear (figure J.2). The share of electricity generated using gas has increased in recent years, and was responsible for around 44 per cent of UK generation in 2009. Renewables (which make up a large proportion of the 'other' category in figure J.2) have also increased their share to around 8 per cent of UK generation in 2009. Biomass is the largest source of renewable generation in the United Kingdom accounting for around 11 TWh of electricity in 2009 (table J.1). Wind generated around 9 TWh of electricity in that year, and is the next largest source of renewable generation. The amount of wind power has increased rapidly in recent years.

Emissions

Emissions from the UK electricity generation sector have fallen since the early 1990s (figure J.3). This is in large part due to the increased use of renewable energy and gas at the expense of coal (which is relatively emissions intensive — table J.2). In 2009, carbon dioxide emissions from the UK electricity generation sector were around 150 Mt.

Figure J.2 **Electricity generated by fuel type[a]**

United Kingdom, 1998–2009



a 'Other' includes hydroelectricity (natural flow and pumped storage), wind, 'other renewables', oil and 'other fuels'.

Source: DECC (UK) (2010c).

Table J.1 **Renewable generation[a]**

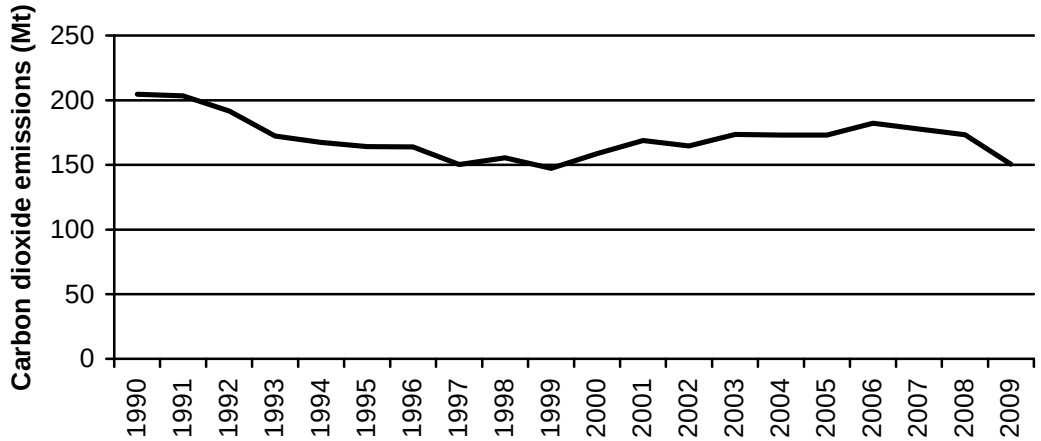
United Kingdom, 2009

Renewable	*Generation (GWh)*
Onshore wind	7 564
Offshore wind	1 740
Solar photovoltaic	20
Hydroelectricity (small scale)	598
Hydroelectricity (large scale)	4 664
Biomass	
Landfill gas	4 952
Sewage sludge digestion	638
Municipal solid waste combustion	1 511
Co-firing with fossil fuels	1 806
Animal biomass	620
Plant biomass	1 109
Total biomass	10 636
Total renewable generation	25 222

a Does not include non-biodegradable waste.

Source: DECC (UK) (2010a).

Figure J.3 **Emissions for the UK electricity generation sector[a]**
United Kingdom, 1990–2009



a Estimates for 2009 are preliminary.

Source: DECC (UK) (2010c).

Table J.2 **Emissions intensity of power generation**
United Kingdom, 2009

Electricity source	*Emissions intensity*
	t CO_2/MWh
Coal	0.915
Oil	0.633
Gas	0.405
Fossil fuels (weighted average)	0.598
All sources (weighted average)	0.452

Source: DECC (UK) (2010a).

J.2 Estimating abatement in the United Kingdom

In order to estimate 2009-10 abatement for each policy, assumptions were made about the source (and emissions intensity) of electricity that has been replaced by the new renewable or lower emissions technology.

The Commission has attempted to identify the marginal generator displaced by the new renewable or low-emissions source in order to estimate the marginal emissions factor. For the United Kingdom, the Commission has considered three approaches to identify the marginal source:

- Frontier Economics — the 'merit order' approach
- Hawkes (2010) — an empirical approach

- the UK Department of Energy and Climate Change (DECC) — the 'build margin' approach.

The Commission's preferred approach — Frontier Economics

Using data on the costs of various plants (or types of plants) to construct a 'merit order', and actual demand during each period, it is possible to identify the marginal plant for each period. This can be used to estimate what the subsidised lower-emissions electricity is replacing during each time period. This is the Commission's preferred approach to estimating the abatement achieved by UK policies.

According to Frontier Economics (unpublished data), the marginal generator in the United Kingdom is generally either coal or combined-cycle gas turbines. Which one is marginal for any given time period depends on costs (in particular fuel prices) and the demand for electricity. In addition, at very high levels of demand, open-cycle gas turbines or oil may become the marginal generator. Therefore, the marginal generator can differ depending on the time of day and year.

Based on the UK merit order and historical demand, Frontier Economics (unpublished data) estimated the average marginal generation source in the 2009-10 financial year to have an emissions intensity of 0.565 t CO_2/MWh. This intensity is higher during the winter, and also during the day (table J.3).

Table J.3 **Emissions intensity of the marginal generator**
United Kingdom, 2009-10, by time of day and year

Time of year	*Day*	*Night*
	t CO_2/MWh	t CO_2/MWh
Summer	0.593	0.412
Winter	0.717	0.538

Source: Frontier Economics (unpublished data).

As the emissions intensity of the marginal generator differs by the time of day and year, it is possible to estimate the emissions intensity displaced by some renewable sources:

- Poyry (2010) suggests that both offshore and onshore wind produce more electricity during the winter than during the summer. In addition, in the case of onshore wind, generation is higher during the night. Based on this, the average emissions intensity of generators displaced by wind was estimated to be slightly

higher than the average emissions intensity of generators displaced by other sources (table J.4).

- Solar photovoltaic (PV) only produces electricity during the daytime and produces more during summer than winter. Frontier Economics estimated the emissions intensity of generators displaced by solar PV to be slightly higher than the average emissions intensity of generators displaced by other sources (table J.4).

Table J.4 **Average emissions intensity displaced by various generation sources**

United Kingdom, 2009-10

Source	*Counterfactual emissions intensity*
	t CO_2/MWh
Offshore wind	0.582
Onshore wind	0.587
Solar PV	0.610
All other	0.565

Source: Frontier Economics (unpublished data).

For other generation sources (biomass, landfill gas, hydroelectricity, sewage gas, tidal and wave, and combined heat and power (CHP)) the average marginal generator has been used as the counterfactual.

Hawkes (2010)

As an alternative to the merit order approach, Hawkes (2010) employed an empirical approach to estimate marginal emissions factors in Great Britain. This approach is based on the idea that a precise merit order is not always observed in practice. More specifically, Hawkes states that:

> The logistics of plant operation, transmission constraints, plant availability, and the vertically integrated nature of many utilities could all provide incentives or constraints that encourage operation in contravention of what is suggested by merit order. (Hawkes 2010, p. 5979)

To address these issues, Hawkes performed regression analysis using historical operating data on the observed dispatch of generators (aggregated into fuel/technology types) in the British electricity system over the period 2002 to 2009. This analysis yielded an average marginal emissions factor of 0.69 t CO_2/MWh — compared to a average grid emissions intensity of 0.51 t CO_2/MWh. The analysis also showed that the marginal emissions factor was lower late at night and early in the morning and higher during peak times.

Department of Energy and Climate Change (DECC) (UK) (2010)

The UK Government uses a long-run emissions factor in calculating abatement estimates — that is, what plant would be 'built or retired in response to policies that result in long-term changes to electricity demand or supply' (DECC (UK) 2010e, p. 9). While not consistent with the Commission's estimation of subsidy equivalents in a single year, the counterfactual emissions intensity from this analysis is included for sensitivity analysis.

The DECC (UK) has predicted, based on a model of the energy sector, that closed-cycle gas turbine plants will be the marginal generation plant built until 2025, and will replace any existing thermal plants that are retired. According to the DECC (UK) (2010e), combined-cycle gas turbine generation has an emissions intensity of 0.39 t CO_2/MWh.

J.3 Policy overlaps

The Commission has made estimates for four UK policies — the Renewables Obligation, the CCL, Offshore Wind Capital Grants and the European Union ETS. However, there is considerable overlap and interaction between these policies:

- Most firms receiving Renewable Obligation certificates (ROCs) are also eligible to receive an exemption under the CCL. These firms also receive a benefit from the European Union ETS. Offshore wind farms can receive a capital grant in addition to these three subsidies.
- There are some renewable generators receiving the CCL exemption that do not receive ROCs (or are not counted by the Commission as leading to additional abatement under the Renewables Obligation).
- CHP generators only receive a benefit under the CCL.
- A coal–gas switch is induced through the European Union ETS.

In order to account for these overlaps and interactions, the Commission has not estimated abatement separately for all policies. Instead, the Commission:

- has reported abatement and implicit abatement subsidies for the Renewables Obligation
- has attributed abatement to the renewables component of the CCL (though an implicit abatement subsidy was not calculated), as some abatement covered under the CCL was not covered under the Renewables Obligation

- has not reported abatement or implicit abatement subsidies for the Offshore Wind Capital Grants Scheme and the renewable energy component of the European Union ETS
- has estimated abatement and implicit abatement subsidies for the CHP component of the CCL, and the coal–gas switch induced by the European Union ETS (because generators receiving these subsidies were already covered under the Renewables Obligation).

It should be noted that while much of the renewable energy abatement was attributed to the Renewables Obligation, this is not necessarily the case in practice. In reality, the abatement was likely to be caused by a combination of the policies. For example, a wind farm may need the subsidies it received through the Renewables Obligation, the CCL and the European Union ETS to be financially viable. Implicit abatement subsidies for the renewable energy schemes combined are reported in section J.9.

J.4 The Renewables Obligation

The Renewables Obligation is a renewable energy certificate scheme operating in the United Kingdom. Eligible generation (including landfill and sewage gas, wind, solar, hydroelectricity, biomass, tidal geothermal, wave and 'energy crops') creates certificates (ROCs) that must be purchased by electricity retailers. The Renewables Obligation commenced in 2002 in England, Wales and Scotland, and in 2005 in Northern Ireland.

In 2009-10, the target was for over 30 million ROCs to be surrendered (corresponding to approximately 30 TWh of renewable generation). However, this target was not met (around 21 million ROCs were surrendered (Ofgem (UK) 2011b)), and in general, the renewable target has not been met in prior years. Instead, many retailers opt to pay a buy-out price (set at £37.19 per ROC in 2009-10). The money raised from this is mostly recycled back to retailers (called the recycle fund), in proportion to the number of ROCs surrendered.

Since April 2009, generators do not all necessarily create one ROC per MWh. Generators installed after this date create differing numbers of ROCs, depending on the technology used — for example, solar PV creates two ROCs per MWh, whereas sewage gas creates 0.25 ROCs per MWh.

In addition, as of April 2010, small-scale generation has been moved into the Feed-in Tariffs scheme (section J.8).

Estimating the subsidy equivalent

The subsidy equivalent of a renewable certificate scheme is simply the certificate price, multiplied by the number of certificates issued to additional generation.

An estimate of the 'value' of a ROC can be calculated based on the buyout price, and the value of the recycle fund. In 2009-10, the buyout price was £37.19, and £15.17 was recycled back to retailers for each ROC surrendered. Therefore, the value of a ROC (or the certificate price for which a retailer will be indifferent between surrendering a certificate or paying the buyout price) will be £52.36.

In the most recent period for which data were available (covering April 2009 to March 2010), 21.2 million ROCs were issued to renewable generators. The total value of these ROCs was estimated to be £1.1 billion (A$2.1 billion).

However, the Commission is interested in the additional generation induced by the policy — the subsidy to pre-existing generation is simply a transfer payment, and should not be included in the estimates. Therefore, the number of ROCs received by generators installed prior to 2002 was 'netted out'.

The amount of eligible renewables (not including large-scale hydroelectricity, as pre-2002 hydroelectricity was not eligible to receive ROCs) existing in 2001 is shown in table J.5. Using data on the number of ROCs received per MWh by each energy source, and assuming that pre-2002 plants are generating at 2001 levels, the number of ROCs received by pre-existing generation was estimated to be 5.1 million. Therefore, an estimated 16.1 million ROCs were received by post-2001 generators.

The subsidy equivalent to these generators was estimated to be £845 million (A$1.6 billion) (table J.6).

Abatement

The abatement attributable to a policy is the amount of low-emissions electricity induced by the policy, multiplied by the difference between the emissions of the subsidised source and the emissions intensity of the counterfactual generator.

Of the 20..3 TWh of renewable generation receiving ROCs in 2009-10, 4.8 TWh was estimated to be produced by generators that already existed in 2001. This leaves a total of 15.5 TWh of 'induced' generation.

Table J.5 **Generation in 2001 by source[a]**

United Kingdom, 2001

	Generation	*ROCs per MWh*	*ROCs*
	GWh	ROCs/MWh	No.
Wind	965	1	965 000
Solar	2	2[b]	4 000
Small-scale hydroelectricity	210	1.002	210 421
Landfill gas	2 507	1.074	2 692 803
Sewage digestion	363	1.074	389 790
Animal biomass	542	1.074	582 170
Plant biomass	234	1.074	251 343
Total	4 823		5 095 533

a Based on the banding for solar PV. Other estimates were based on data in Ofgem (UK) (2011b). **b** Note that these values are likely to represent an over-estimate of the number of ROCs received by pre-existing generation, as some of these sources may have shut down, or not be eligible for ROCs. However, it represents the best available estimate of the ROCs received by pre-existing generators.

Sources: DECC (UK) (2010d); Ofgem (UK) (2011b).

Table J.6 **Subsidy equivalent, Renewables Obligation**

United Kingdom, April 2009 – March 2010

	Value
Number of certificates issued to post-2001 generators	16.1m
Estimated ROC price	£52.36
Subsidy equivalent	£845m (A$1.6b)

Sources: Ofgem (UK) (2011b); Productivity Commission estimates.

Of this additional generation, 6.3 TWh was onshore wind, 2.1 TWh was offshore wind, and an estimated 3.4 GWh was solar PV (based on the number of ROCs received by solar PV, and the banding for solar PV).

Based on the counterfactual emissions intensity estimated by Frontier Economics, as outlined in section J.2, the abatement achieved by the Renewables Obligation was estimated to be 8.9 Mt CO_2 (table J.7).

Implicit abatement subsidy

Based on the above calculations, the implicit abatement subsidy was estimated to be £95/t CO_2 (A$176).

Table J.7 **Abatement, Renewables Obligation**

United Kingdom, April 2009 – March 2010

Source	*Amount of 'induced' generation*	*Counterfactual emissions intensity*	*Abatement*
	GWh	t CO_2/MWh	Mt CO_2
Offshore wind	2 089	0.582	1.2
Onshore wind	6 273	0.587	3.7
Solar PV	3	0.610	–
Other	7 147	0.565	4
Total	15 512		8.9

– Nil or rounded to zero.

Sources: Ofgem (UK) (2011b); Productivity Commission estimates.

Sensitivity analysis

Two parameters were altered during sensitivity analysis — the ROC price and the counterfactual emissions intensity.

Varying the price of ROCs

In reality, the ROC price may be higher or lower than the estimate used above. e-ROC (2011) is an online auction for ROCs, that contains actual data on permit prices. (Note that over the 2009-10 period, this reflects a limited subset of the ROC market — just over 500 000 ROCs, out of 21.2 million ROCs created). The average ROC price for these auctions over the 2009-10 period was £50.20.

Using this value as the certificate price, the subsidy equivalent was estimated as £810 million (A$1.5 billion), and the implicit abatement subsidy was £91/t CO_2 (A$169).

Altering the counterfactual

As noted in section J.2, two alternate counterfactual scenarios have been considered.

- In the first scenario, based on a regression analysis by Hawkes (2010), the counterfactual emissions intensity was estimated to be 0.69 t CO_2/MWh. Using this counterfactual, the implicit abatement subsidy was estimated to equal £79/t CO_2 (A$147).
- The second scenario was based on the 'build margin' (what would be built in the long run in the absence of the policy) estimated by the UK Government, and

uses a counterfactual emissions intensity of 0.39 t CO_2/MWh. This results in an implicit abatement subsidy of £138/t CO_2 (A$257).

Summary

The results of the Renewables Obligation estimations are in table J.8. The estimated implicit abatement subsidy ranges from approximately £79–£138/t CO_2 (A$147–A$257).

Table J.8 **Summary, Renewables Obligation**
United Kingdom, April 2009 – March 2010

Scenario	*Subsidy equivalent (UK pounds)*	*Subsidy equivalent (Australian dollars)*	*Abatement*	*Implicit abatement subsidy (UK pounds)*	*Implicit abatement subsidy (Australian dollars)*
	£b	A$b	Mt CO_2	£/t CO_2	A$/t CO_2
'Central'	0.9	1.6	8.9	95	176
Alternate ROC price	0.8	1.5	8.9	91	169
Hawkes (2010) counterfactual	0.9	1.6	10.7	79	147
'Build margin' counterfactual	0.8	1.6	6.1	138	257

Source: Productivity Commission estimates.

J.5 The Climate Change Levy (CCL)

The CCL is a 'single-stage' sales tax on electricity supplied to non-domestic customers.[1] A number of supplies are excluded or exempt from the levy, including electricity from renewable sources, and good-quality CHP.[2]

1 In addition to electricity, the levy is applied to the supply of the following fossil fuels used for lighting, heating and power: natural gas; petroleum and hydrocarbon gas in a liquid state; coal and lignite; coke, and semi-coke of coal or lignite; and petroleum coke.

2 Relevant electricity generation related exemptions for the CCL are as follows: supplies for domestic use, and for the non–business use of charities; small quantities of fuel and power (assumed to be for domestic use); supplies not for burning or consumption in the United Kingdom; supplies to electricity producers (other than self supplies); supplies to certified CHP schemes; electricity from renewable sources (except for hydro-power over 10 MW); supply of electricity to consumers with a climate change agreement (reduced rate).

In the UK fiscal year 2009-10, electricity was subject to a CCL rate of £4.70/MWh (HM Revenue and Customs (UK), 2010).

In order for suppliers of renewable electricity and good-quality CHP to qualify for exemption from the CCL, they must surrender levy exemption certificates (LECs). LECs are issued to accredited renewable electricity and CHP generators (by the UK Office of Gas and Electricity Markets (Ofgem)) for each MWh of electricity produced from renewable or CHP sources. The generators then sell these LECs to suppliers, who use them to claim exemption from the CCL for the supply of non-domestic electricity from renewable or CHP sources.

Estimating the subsidy equivalent

Differential taxes provide implicit subsidies to exempt sources of electricity. Under the CCL, exempt sources are electricity from renewables and good-quality CHP. Therefore, the production subsidy equivalent of the CCL is equal to the CCL rate per MWh, and the subsidy equivalent is the CCL rate per MWh multiplied by the 'induced' production of subsidised electricity.

Under the CCL, the amount of subsidised electricity is equal to the number of LECs created. The intrinsic value of a LEC is equivalent to the CCL on electricity (£4.70/MWh). This is the amount of the CCL that the supplier would have to charge the non-domestic consumer if the electricity were not exempted.

The estimation of the subsidy equivalent of the CCL was therefore similar to the estimation approach used to calculate the subsidy equivalent of renewable energy certificate schemes — the certificate price was multiplied by the number of certificates to estimate the subsidy equivalent (section J.4).

For the UK financial year 2009-10 (April 2009 to March 2010) 41 million LECs for electricity from renewable and CHP were issued to UK generators. This includes generation from renewable sources that existed prior to the commencement of the CCL in 2001, but does not include LECs issued to generators in neighbouring countries (about 18 per cent of LECs in 2009-10).[3]

The total value of CCL was therefore 41 million multiplied by £4.70/MWh, which was equal to £194 million (A$362 million). However, as noted above, a proportion of the LECs issued in 2009-10 were for generators that existed prior to the

[3] It also excludes LECs from Northern Ireland, which were not available separately for CHP and renenewables. Total LECs from Northern Ireland make up around 2 per cent of total UK LECs. Therefore their exclusion does not have a material effect on the Commission's estimates.

introduction of the CCL. For the estimation of the subsidy equivalent, this amount of generation has been excluded (table J.9).

Table J.9 **Renewable generation receiving LECs by technology[a,b]**
United Kingdom, April 2009 – March 2010

Technology	*Generation in 2009-10 receiving LECs*	*Generation in 2000*	*Additional generation in 2009-10*
	GWh	GWh	GWh
Biomass	3 190	487	2 703
Small hydroelectricity	568	214	354
Landfill gas	5 617	2 188	3 429
Municipal and industrial waste	1 163	840	323
Offshore wind	1 919	0	1 919
Onshore wind	6 815	946	5 869
Solar PV	0.3	0[c]	0.3
Sewage gas	696	367	329
Wave power	0.04	0	0.04
Total renewables	19 968	5 042	14 926

a Pre-existing generation includes total generation for each renewable technology — a small proportion of which may not have been eligible for the CCL exemption had it existed at the time. As such, it may represent an overestimate of the level of pre-existing generation, and as a consequence, 'additional' generation may be slightly underestimated. This is not expected to be significant. For example, in 2009-10, 19 968 GWh of renewable generation received LECs compared to a total of 20 558 GWh of renewable electricity generation. **b** The estimates of 'additional' generation in 2009 assume that for each renewable source, the amount of generation per unit of capacity installed in 2000 (the capacity factor) was the same as in 2009. **c** Only a small proportion of solar PV generation was provided with LECs in 2009-10 (0.337 GWh compared to generation of 20 GWh). Therefore the Commission has assumed that of the 1 GWh of solar PV generated in 2000 none would have been provided with a LEC.

Sources: Ofgem (UK) (2010a); DECC (UK) (2010a); Productivity Commission estimates.

For CHP, the Commission was unable to obtain information on the amount of CHP generation in 2000 that was 'good quality' and that would be eligible for the CCL exemption — as only total CHP data are available. Moreover, data from DECC (UK) (2010b) suggest that since 2000, electricity generation used for CHP has become more efficient. This is reflected in the decline in the heat to power ratio for CHP generation in the United Kingdom. Therefore, the Commission has used the following approach to estimate the amount of pre-existing good quality CHP:

- In 2009, there was 5.57 GW of installed CHP electrical capacity compared to 4.45 GW in 2000 (DECC (UK) 2010b). This suggests that 1.12 GW of additional CHP capacity was added over the time-frame in which the CCL has been in operation.
- In 2009, 5.57 GW of CHP capacity generated 27.7 TWh of electricity. This implies a capacity factor of 57 per cent. Based on this capacity factor, the

1.12 GW of additional CHP capacity contributed 5.6 TWh of CHP. This figure is likely to be an overestimate of the amount of additional CHP (for the purposes of the CCL analysis), as it does not distinguish between good quality CHP and other CHP.

- In 2009, 21.4 TWh of CHP electricity received LECs, out of a total of 27.8 TWh of CHP. This implies that 77 per cent of total CHP electricity was 'good quality'.
- Applying this proportion to the amount of additional CHP output in 2009 (5581 GWh) gives an estimate of additional good quality CHP in 2009 of 4.3 TWh.

Adding this amount of additional CHP to the estimate of additional renewable output from above gives an estimate of the total level of additional generation receiving the CCL exemption in 2009 of 19 TWh. Based on this level of generation, the subsidy equivalent of the CCL exemption was estimated to be £90 million (A$168 million) (table J.10).

Table J.10 **Subsidy equivalent, Climate Change Levy**
United Kingdom, April 2009 – March 2010

Variable	*Value*
Production subsidy (£/MWh)	4.70
New renewable generation (TWh)	14.9
New CHP generation (TWh)	4.3
Subsidy equivalent (excluding pre-existing renewables and CHP) (£m)	90
Subsidy equivalent (excluding pre-existing renewables and CHP) (A$m)	168

Sources: Ofgem (UK) (2010a; 2010b); Productivity Commission estimates.

Abatement

The Commission has not estimated abatement from the CCL scheme as a whole due to overlap between the CCL and the Renewables Obligation. For the renewable component of the CCL, almost all eligible renewable generation was covered by the Renewables Obligation. There are two exceptions:

- municipal waste and landfill gas installed since 2001
- additional renewable capacity installed in 2001 (prior to the introduction of the Renewables Obligation).

Abatement from these two components is estimated below. However, the Commission has not separately estimated the implicit abatement subsidy for this component of the CCL, as it was only a small component of total renewable

electricity covered under the CCL. Its effects are included in the average implicit abatement subsidy for the UK electricity generation sector as a whole.

CHP does not overlap with any other measures, hence abatement and the implicit abatement subsidy of CHP have been estimated.

Abatement from renewables

Municipal waste and landfill gas not covered by the Renewables Obligation, but covered by the CCL, was as follows (table J.11):

- 323 GWh of municipal and industrial waste (installed since 2001) was covered under the CCL, but not the Renewables Obligation.
- 1092 GWh of landfill gas (installed since 2001) was covered under the CCL, but not the Renewables Obligation.

Therefore, a total of 1.4 TWh of generation from these two sources was covered under the CCL estimates, but not the Renewable Obligation estimates.

In addition, Once large-scale hydroelectricity (which is not covered under the CCL), solar (which does not appear to be widely covered by the CCL) municipal waste and landfill gas (which have already been accounted for above) are excluded, an additional 301 GWh of renewable generation was generated in 2001 (of which 19 GWh was wind). It was assumed that this increase was as a result of capacity installed in 2001, and generates at the same level in 2009-10.

Therefore, a total of 1716 GWh of renewables are covered under the CCL, but not the Renewables Obligation. Using the counterfactual emissions intensity outlined in section J.3, abatement is estimated to be 959 kt CO_2 (table J.11).

Table J.11 **Renewables covered by the CCL**

United Kingdom, April 2009 – March 2010

	Units	*Renewable energy covered under the Renewables Obligation*	*Renewable energy exempted under the CCL*	*Renewables exempted under the CCL but not the Renewables Obligation*
Landfill gas	GWh	2 337	3 429	1 092
Municipal and industrial waste	GWh	0	323	323
Additional 2001	GWh	..	..	301
Total generation	GWh	..	..	1 716
Abatement	Mt CO_2	..	..	0.96

.. Not applicable.

Sources: Ofgem (UK) (2011a; 2011b); Productivity Commission estimates.

Abatement from good quality CHP

CHP captures the heat generated in the production of electricity and uses it for other productive purposes, such as heating, hot water or other industrial processes. Therefore, the abatement attributable to exempt CHP under the CCL was dependent on how much energy was saved through CHP and the emissions intensity of the source of energy that would otherwise have been used to generate heat. This was difficult to determine, as CHP uses a variety of fuels and technologies across a range of different applications, and as a consequence, displaces a range of fuels and technologies.

The DECC (UK) (2010a) provides various statistics on CHP in the United Kingdom. The Commission has used these statistics to derive estimates of abatement for the CHP component of the CCL exemption.

DECC (UK) (2010a) estimated that in 2009, CHP saved 9.5 Mt CO_2 in total or 1.7 Mt CO_2 per 1000 MW of installed capacity (p. 163). This implies an abatement factor of 0.34 t CO_2/MWh of electricity generated through CHP.[4]

Applying this abatement factor to the amount of additional CHP generation in 2009-10 gives abatement of 1.5 Mt CO_2 (table J.12).

Table J.12 **Abatement, Climate Change Levy (CHP)**
United Kingdom, April 2009 – March 2010

Variable	*Value*
Additional CHP generation	4.3 TWh
Abatement factor (t CO_2/MWh)	0.34
Abatement from CHP	1.5 Mt CO_2

Sources: Ofgem (UK) (2010a; 2010b); DECC (UK) (2010a; 2010c); Productivity Commission estimates.

Implicit abatement subsidy (CHP)

Based on the subsidy equivalent and abatement calculations above, the implicit abatement subsidy of the CCL was estimated to be £14/t CO_2 (A$26).

4 Calculated as follows: 1000 MW x 24 hours x 365 days x 57% (capacity factor) gives 4 984 440 MWh of output per year per 1000 MW of installed capacity. Based on this the DECC (UK) (2010a) figure can be expressed as 1.7 Mt of abatement per 4 984 440 MWh, which gives an abatement factor of 0.34t CO_2/MWh.

Sensitivity analysis

The Commission varied two key parameters to perform sensitivity analysis — the price of the LEC and the emissions intensity of the counterfactual source of electricity displaced by renewable electricity.

Alternative LEC price

LECs are not traded in a market, and as such it was not possible to observe a price. Rather, LECs are 'bundled' with electricity that is sold to suppliers by LEC-eligible generators. The Commission has based its estimates of the subsidy equivalent for this policy on the assumption that the value of a LEC was equal to the prevailing rate of the CCL. However, anecdotal evidence suggests that the implicit price that electricity suppliers pay for LECs was sometimes less than 100 per cent of the CCL rate. This could be because the purchasers (electricity retailers) have a degree of market power, or because of the transaction costs associated with purchasing and surrendering LECs.

To demonstrate the effects of this assumption on the final results, the Commission has carried out a sensitivity analysis using the assumption that the value of the LEC was 80 per cent of the rate of CCL for electricity (£3.76). Based on this LEC value, the subsidy equivalent of the CCL to renewable and CHP generators was £72 million (A$135 million), and the implicit abatement subsidy for CHP was estimated to be £11/t CO_2 (A$21).

Alternative abatement assumptions

For subsidised renewable electricity generation, two alternative counterfactual scenarios were considered.

The first assumes a higher emissions intensity of 0.69t CO_2/MWh based on Hawkes (2010). Using this higher emissions intensity, abatement from exempt renewables under the CCL was 1.2 Mt CO_2.

The second was based on the DECC (UK)(2010a) 'build margin' average emissions intensity of 0.39 t CO_2/MWh. Using this lower emissions intensity, abatement from exempt renewables under the CCL was estimated to be 669 kt CO_2.

Summary of estimates

Table J.13 provides a summary of the Commission's estimates of the subsidy equivalent, abatement, and implicit abatement subsidy for the CCL. These estimates imply an implicit abatement subsidy for CHP in the range of £11–£14/t CO_2 (A$21– A$26).

This range will be affected by future increases in the CCL rate. As of 1 April 2011, the CCL rate for electricity increased to £4.85/MWh. This will have the effect of increasing the value of the subsidy to exempt sources.

Table J.13 **Summary of estimates, Climate Change Levy**
United Kingdom, April 2009 – March 2010

	Units	*Low*	*'Central'*	*High*
Subsidy equivalent				
Renewables	£m	70	70	70
Renewables	A$m	131	131	131
CHP	£m	21	21	21
CHP	A$m	38	38	38
Abatement				
Renewables	Mt CO_2	0.7	1.0	1.2
CHP	Mt CO_2	1.5	1.5	1.5
Implicit abatement subsidy (CHP)	£/t CO_2	14	14	14
Implicit abatement subsidy (CHP)	A$/t CO_2	26	26	26
Alternative LEC price				
Implicit abatement subsidy (CHP)	£/t CO_2	11	11	11
Implicit abatement subsidy (CHP)	A$/t CO_2	21	21	21

Source: Productivity Commission estimates.

J.6 The Offshore Wind Capital Grants Scheme

The Offshore Wind Capital Grants Scheme offers an upfront grant of up to 40 per cent of the costs incurred over and above those that would be incurred from building a conventional power station. The scheme aims to contribute £107 million to the construction of offshore wind farms.

Many firms have recently repaid their capital subsidies from this scheme. This is because offshore wind farms are now eligible to receive two ROCs under the Renewables Obligation for every MWh they produce, and under European Union state aid rules, any wind farm that receives a capital subsidy is not eligible for the additional ROCs. A total of £49.6 million worth of grants were repaid, and are not

considered in the estimates (NAO (UK) 2010). (Note however, those that did not repay are still eligible to receive one ROC/MWh under the Renewables Obligation.)

Plants that received grants prior to July 2006 did not have the option of repaying the grant (BERR (UK) 2008). There appear to be four plants accredited prior to this date, that therefore have not repaid the grant. However, as these firms also receive a subsidy under the Renewables Obligation, abatement and an implicit abatement subsidy are not estimated for this scheme.

Estimating the subsidy equivalent

Each of the four plants subsidised received £10 million upfront — a total of £40 million in nominal terms. The four wind farms were commissioned in 2003, 2004, 2005 and 2006. While it was unclear when the grants were paid out, it was assumed that they were paid out in the year the plant was commissioned. Therefore, converting into 2010 currency, the subsidy provided by the scheme was £46.1 million.

Assuming an interest rate of 7 per cent, and an economic lifetime of 20 years, the annualised subsidy equivalent of the scheme was estimated to equal £4.3 million (A$8.1 million)

Sensitivity analysis

The subsidy equivalent was estimated using two alternate discount rates for annualising the capital subsidy:

- 11 per cent, which implies a subsidy equivalent of £5.8 million (A$10.8 million)
- 3 per cent, which implies a subsidy equivalent of £3.1 million (A$5.8 million).

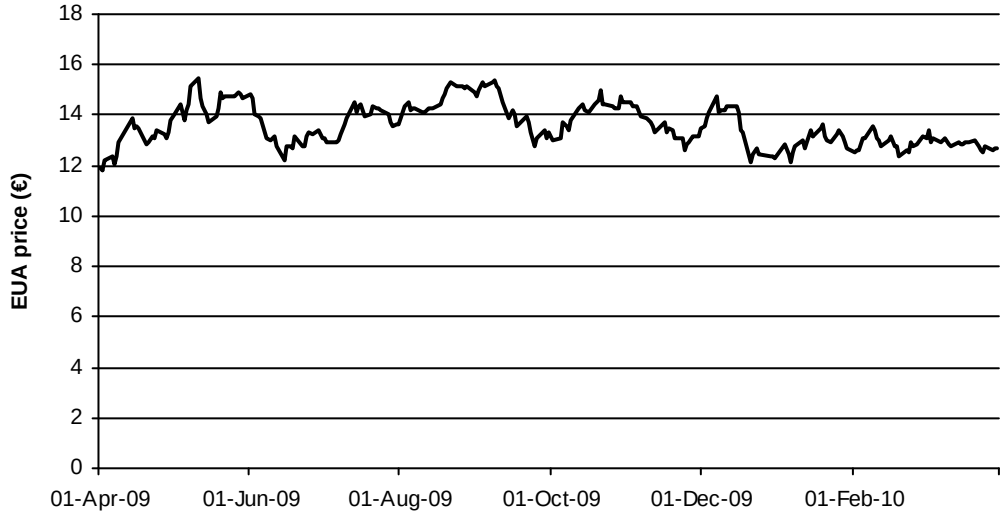
J.7 European Union Emissions Trading Scheme

Under the European Union ETS, electricity generators are obliged to surrender one European Union Allowance (EUA) for each tonne of CO_2 they emit. The total number of EUAs issued is capped at a level consistent with the EU target for EU-wide emissions reductions, and permits are traded in a market. Over the year 1 April 2009 to 31 March 2010, the average spot price of EUAs was €13.60

(£15.38), with a maximum daily settlement price of €15.50 (£13.70) and a minimum of €11.79 (£10.42) (figure J.4).[5]

Figure J.4 **EUA prices April 2009 to March 2010**

Weighted average daily settlement price (€) of the ECX EUA daily futures contract



Source: Frontier Economics (unpublished data).

The obligation to surrender EUAs increases the marginal costs of fossil-fuel generators. The increase in costs is proportional to the emissions intensity of electricity generation — coal-fired generators experience a larger increase in their marginal costs than gas generators because they are more emissions intensive. Through this effect on marginal costs, the European Union ETS effectively operates as a differential tax on electricity generators. Because gas-fired generators are taxed at a lower rate, they effectively receive a production subsidy equal to the difference between the effective 'tax rates' faced by coal and gas generators per MWh.

Using data on EUA prices and the average emissions intensity of coal- and gas-fired generators, the Commission has estimated that on average, the European Union ETS increased the marginal costs of coal-fired generators by £14.07/MWh, and gas-fired generators by £6.23/MWh (table J.14). This implies that the production subsidy equivalent to gas under the European Union ETS was £7.84/MWh.

5 Conversion based on the average exchange rate for April 2009 to March 2010 — €1 = £0.89.

Table J.14 **Parameter values — European Union ETS**

United Kingdom, April 2009 – March 2010

Parameter	*Notation*	*Value*	*Source*
Emissions intensity (t CO_2/MWh)			
Coal	a_c	0.915	DECC (UK) 2010a
Gas	a_g	0.405	
Average EUA price (2009-10)	p_{EUA}	€13.60 (£15.38)	Frontier Economics (unpublished data)
Average wholesale price of electricity (2009) (£/MWh)	p_1	34.70	Frontier Economics (unpublished data)
Total generation (2009) (GWh)			
Coal	q_c	104 608	DECC (UK) 2010a
Gas	q_g	165 482	DECC (UK) 2010a
Marginal cost increase (£/MWh)			
Coal	c_c	14.07	$c_c = a_c \cdot p_{EUA}$ = £14.07
Gas	c_g	6.23	$c_g = a_g \cdot p_{EUA}$ = £6.23

Sources: DECC (UK) 2010a; Frontier Economics (unpublished data); McGuinness and Ellerman (2008); Productivity Commission estimates.

Switching from coal to gas

Through the differential marginal cost increases, the European Union ETS gives electricity generators an incentive to switch from coal to gas. The existing literature provides some guidance on the extent of fuel switching. McGuinness and Ellerman (2008) analysed the effects of the European Union ETS on the UK electricity sector in 2005 and 2006, concluding that:

> … the CO_2 price did impact dispatch decisions, resulting in natural gas utilization that was from 19% to 24% higher and coal utilization that was 16% to 18% lower than would have otherwise occurred in 2005 and 2006. (McGuinness and Ellerman 2008, p. 1)

Between April 2005 and April 2006 (when the EUA price collapsed), the average price of EUAs was around €23. It is likely that this EUA price induced more fuel switching in 2005 and 2006 than in 2009-10, when the average was around €13.60. Hence, the Commission has assumed that the European Union ETS led to an increase in the use of gas of less than 20 per cent. The Commission's 'central' estimate is based on an assumption that the European Union ETS increased the use of gas by 10 per cent, compared to how much gas would have been used in the absence of the ETS. Other assumptions are tested in the sensitivity analysis.

Switching from coal to gas leads to abatement (because gas-fired electricity generation is less emissions intensive). For each MWh that was produced using gas rather than coal, the net reduction in emissions was given by the difference between the emissions intensity of coal and gas:

$a_c - a_g = 0.915 - 0.405 = 0.510$ t CO_2/MWh

Using data on the actual production of gas-fired electricity in 2009, it was possible to estimate the total amount of gas-fired generation that was induced by the European Union ETS (15 TWh) and the abatement attributable to the fuel switch (7.7 Mt CO_2) (table J.15).

The subsidy equivalent was equal to the implicit production subsidy to gas-fired generation (£7.84/MWh) multiplied by the total increase in gas-fired generation, and was estimated to be £118 million (A$220 million).

The implicit abatement subsidy is the subsidy equivalent divided by abatement attributable to the ETS, and is equal to the EUA price (A$28.64/t CO_2 in the year of analysis).

Table J.15 **European Union ETS-induced gas-fired generation, abatement and subsidy equivalent**[a]

United Kingdom, April 2009 – March 2010

	Calculation	*Value*
Total gas generation 2009	*g*	165 TWh
Total gas generation induced by the EU ETS	*qg = g – (g / 1.10)*	15 TWh
Abatement	*A = qg · (ac – ag)*	7.7 Mt CO_2
Subsidy equivalent[b]	*TSE = qg · 106 · £7.84*	£118m (A$220m)

a Assuming that the European Union ETS led to an increase of 10 per cent in the use of gas in 2009-10. **b** The quantity of gas induced by the ETS was multiplied by 10 million because generation is in TWh and the production subsidy equivalent is in £/MWh.

Sources: DECC (UK) 2010a, Productivity Commission estimates.

Sensitivity analysis

The Commission's estimate of the subsidy equivalent to gas-fired generators was based on the assumption that the European Union ETS increased the use of gas-fired generation by 10 per cent in 2009-10. This assumption was based on the limited academic literature on the subject (McGuinness and Ellerman 2008). Estimates of abatement and subsidy equivalent are sensitive to changes in this parameter (table J.16).

Table J.16 **Sensitivity analysis — European Union ETS-induced gas-fired generation**

United Kingdom, April 2009 – March 2010

Increase in gas-fired generation attributable to European Union ETS	*Induced generation*	*Subsidy equivalent (UK pounds)*	*Subsidy equivalent (Australian dollars)*	*Abatement*
%	TWh	£m	A$m	Mt CO_2
0	0	0	0	0
5	7.8	62	115	4
10	15.0	118	220	7.7
15	21.5	169	315	11
20	27.6	216	403	14

Source: Productivity Commission estimates.

The interaction of the European Union ETS with other policies

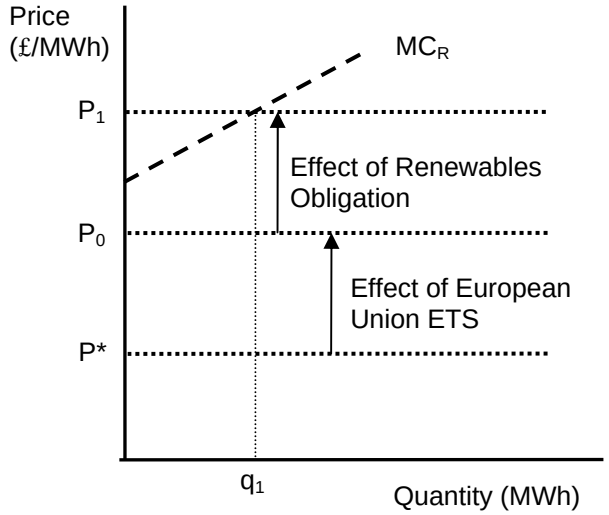
The Commission's analysis of the European Union ETS has focused on the effect of the ETS on the mix of coal- and gas-fired generation. The estimates of the subsidy equivalent and abatement arising from the European Union ETS in the United Kingdom relate exclusively to this effect. However, the European Union ETS also has other effects, and interacts with other policies that the Commission has assessed. In particular:

- the European Union ETS provides a subsidy to renewables that was in addition to the subsidies delivered through other analysed policies
- the existence of the European Union ETS is relevant when considering the net abatement brought about by the other policies.

Subsidy equivalent effects

As well as the implicit subsidy to gas-fired generators during some periods, the ETS also delivers an effective subsidy to other low-emissions generators, by increasing the average wholesale price of electricity more than it increases their costs. This is illustrated in figure J.5, using the example of the Renewables Obligation. In the absence of any policy intervention, the wholesale price of electricity would be P*. At this level, renewables would not be used, because the marginal cost of renewables (MC_R) exceeds the wholesale price of electricity. The introduction of the European Union ETS increases the wholesale price of electricity to P_0, and Renewables Obligation certificates provide an additional incentive, and increase the effective price received by renewables to P_1. At this price, output from renewables will equal q_1.

Figure J.5 **Interaction of the European Union ETS and the Renewables Obligation**



The Commission's analysis of the Renewables Obligation, CCL, and the Offshore Wind Capital Grants Scheme was based on the assumption that the counterfactual price of electricity that would have been received in the absence of the policies was equal to the 2009-10 average wholesale electricity price (in figure J.5 this is P_0). However, renewables also receive an additional effective subsidy arising from the wholesale electricity price uplift that results from the European Union ETS (raising the price from p* to p_0).

Estimating what the wholesale electricity price would be in the absence of the European Union ETS is complicated because the effects of the ETS on electricity markets vary during the year. Specifically, if the marginal generator was gas-fired, the wholesale price uplift would be equal to the marginal cost uplift faced by gas-fired generators. If the marginal generator was coal-fired the wholesale price uplift would be equal to the marginal cost uplift fact by coal-fired generators.

The average wholesale electricity price uplift over the course of the year can be estimated using the average emissions intensity of the marginal generator over the year. Frontier Economics stated that the average emissions intensity of the marginal generator in the United Kingdom in 2009-10 was 0.565 t CO_2/MWh. This is consistent with the marginal generator being gas approximately two-thirds of the time, and coal approximately one-third of the time.

Given an average EUA price of £15.38, the average wholesale price uplift attributable to the European Union ETS was £8.69/MWh. This suggests that for every MWh of electricity induced by the Renewables Obligation, CCL and the

Offshore Wind Capital Grants Scheme, the operators of these facilities received an additional subsidy with an average value of £8.69.

In estimating the value of the subsidy equivalent arising from the European Union ETS, it is important to note that each unit of electricity can receive this subsidy only once. There are significant overlaps in the Renewables Obligation, CCL and the Offshore Wind Grants Scheme:

- Electricity that was produced by offshore wind farms also received ROCs. To avoid double counting, the electricity generated by offshore wind farms has only been credited against the Renewables Obligation. Hence, the interaction of the European Union ETS and the Offshore Wind Capital Grants program was estimated to be zero.
- Most generators that receive a CCL exemption also received ROCs (section J.5 estimates the total additional generation arising from the CCL exemption).

The Commission has estimated that the additional subsidy equivalent that should be attributed to these policies was around £150 million (A$278 million) (table J.17).

Table J.17 **European Union ETS, interaction with other policies**
United Kingdom, April 2009 – March 2010

		Subsidy equivalent from European Union ETS	
Policy name	*Generation induced*	*UK pounds*	*Australian dollars*
	TWh	£m	A$m
Renewables Obligation	15.5	135	251
Climate Change Levy	1.7	15	27
Offshore Wind Capital Grants Scheme	0	0	0
Total	17.2	150	278

Source: Productivity Commission estimates.

Abatement effects

The European Union ETS places a cap on the total greenhouse gas emissions from electricity generation and a range of industrial sectors in 30 countries. The advantage of using an ETS to achieve a given emissions-reduction target is that it creates incentives for firms to seek out the least-cost options for abatement. Alternative policies generally operate by mandating or giving preference to particular technologies (such as renewable energy). While such policies may be

successful in meeting the target for emissions reductions, generally the cost of achieving a given level of abatement is higher.

The three other policies analysed for the United Kingdom (the Renewables Obligation, CCL and the Offshore Wind Capital Grants Scheme) all have the effect of providing effective subsidies to renewable energy. The renewables offset some fossil-fuel generation, leading to emissions reductions. However, given that the United Kingdom is a member of the European Union ETS, the net effect of these policies is to induce no additional emissions reductions across the EU as a whole. The policies might lead to abatement in the UK electricity sector, but this will be offset by higher emissions in other sectors and other countries (because the emissions cap is binding at the EU-wide level).

Effectively, these policies 'carve out' a portion of the emissions-reduction target and reserve it for particular technologies. Inevitably, this results in an over-supply of higher-cost abatement options (chapter 3). As well as not providing any additional net abatement, these policies increase the costs of meeting a given emissions-reduction target. As the Commission has stated previously:

> Reserving a proportion of electricity generation for renewable energy sources changes the generation mix in a way that increases abatement costs for no additional emissions reduction benefit. (PC 2008, p. xvii)

The Commission's estimates of the abatement attributable to the policies and the implicit abatement subsidies give an indication of the relative efficiency of each policy in achieving a given emissions -reduction target. The European Union ETS leads to a significant amount of relatively low-cost abatement (around 7.7 Mt at an implicit abatement subsidy of around A$29/t CO_2). The Renewables Obligation leads to a similar amount of abatement at around six times the cost (8.9 Mt at an implicit abatement subsidy of around A$176/t CO_2).

J.8 Feed-in Tariffs

The United Kingdom introduced a FIT scheme for Great Britain in April 2010 (the scheme does not apply in Northern Ireland). The first year of the scheme concluded on 31 March 2011. Feed-in tariffs apply to small -scale renewable generation that is less than five MW capacity.

The Commission has not included the FIT scheme in its estimates of the subsidy equivalent for emissions-reduction policies in the United Kingdom for two reasons. The first is that the Commission chose to analyse UK policies for the 2009-10 financial year. This decision was made because data for the 2010-11 year were

unlikely to be available in time to carry out a thorough analysis. Given the start date of the FIT scheme, it was not possible to include the FITs in the detailed analysis. Second, many of the installations that are eligible to receive FITs had been eligible to receive certificates under the Renewables Obligation in 2009-10. The Commission has estimated the subsidy equivalent and abatement attributable to the Renewables Obligation in 2009-10. When the FIT scheme commenced, installations were transferred out of the Renewables Obligation and into the FIT scheme. While it might have been possible to estimate the subsidy equivalent of the FITs (using a number of assumptions), aggregating the effects of the FITs in 2010-11 with the effects of the Renewables Obligation in 2009-10 would lead to double-counting of the abatement attributable to these installations. Instead of estimating the subsidy equivalent and abatement attributable to the FITs, the Commission provides some background information on the scheme.

Estimating the subsidy equivalent

Under the FIT scheme, electricity generated from hydroelectricity power, wind, solar PV, anaerobic digestion and micro CHP pilot plants receive FITs. Rates vary by technology and by the size of installations (smaller plants receive higher tariffs) (Ofgem (UK) 2010d). Based on the average 'system sell price' of electricity, it was possible to estimate the production subsidy equivalent ($\square_i$) arising from the FITs (table J.18).

There are currently no data available on the quantity of electricity that received the FITs. However, the Commission has accessed data on the total payments made under the FIT scheme. For the first nine months of the scheme (to 31 December 2010), total payments were £6.2 million (approximately A$10.4 million) (Ofgem (UK) 2010d; 2010e; 2011a). Data on the number of installations registered to receive FITs suggest that this number would be expected to increase in 2011-12.

Implicit abatement subsidy

The Commission has estimated the implicit abatement subsidy for each technology that was eligible to receive FITs based on the estimated emissions counterfactuals supplied by Frontier Economics. The Commission's estimates (table J.18) suggest that the implicit abatement subsidy through the FITs will be significantly larger for some technologies than others. In particular, small wind and solar PV installations will receive very large implicit abatement subsidies. This is consistent with the estimates of implicit abatement subsidies provided by FITs for these technologies in other countries.

Table J.18 **Implicit abatement subsidy, Feed-in Tariffs**
United Kingdom, April 2010 – March 2011

Technology	*FIT*	*Production subsidy equivalent*	*Counterfactual emissions*	*Implicit abatement subsidy*[a]	
				UK pounds	*Australian dollars*
	pence/kWh	pence/kWh	t CO_2/MWh	£/t CO_2	A$/t CO_2
Hydroelectricity	4.5–19.9	0.8–16.2	0.565	14–287	24–481
Wind	4.5–34.5	0.8–30.8	0.587	14–545	24–914
PV	29.3–41.3	25.6–37.6	0.61	453–665	760–1 116
MicroCHP pilot	10	6.3	0.565	112	187
Anaerobic digestion	9–11.5	5.3–7.8	0.565	94–138	157–232
Existing microgenerators transferred from the RO	9	5.3	0.565	94	157

a Based on a conversion factor of £0.60 per $A (2010).

Sources: Ofgem (UK) (2010c); Frontier Economics (unpublished data); Productivity Commission estimates.

The UK FIT system operates as a gross FIT scheme, with additional subsidies for electricity exported. For electricity generated and consumed on the premises, generators receive the FIT. For electricity exported to the grid, generators receive the relevant FIT, and an additional tariff of £0.03/kWh. In the initial period of the FIT scheme, the percentage of electricity that was exported to the grid was 'deemed' by the regulator to be 50 per cent for wind, solar and CHP, and 75 per cent for hydroelectricity and anaerobic digestion.

The effect of the deemed export tariff was to increase the production subsidy equivalent by an average of £0.015/kWh for wind, solar and CHP, and £0.0225/kWh for hydroelectricity and anaerobic digestion. This would raise the implicit abatement subsidy for each source.

J.9 Summary

Based on the subsidy equivalent and abatement estimates for each policy outlined in the sections above, the UK electricity generation sector total subsidy equivalent, total abatement and average implicit abatement subsidy can be estimated. This section outlines the approach taken to calculate these estimates.

The total subsidy equivalent

The total subsidy equivalents estimated represent the total value of the subsidy granted to low-emissions generation that was 'induced' by each policy. These can be added together, to give an estimate of the total subsidy equivalent for the UK electricity sector. The estimates implied a range for the total subsidy equivalent of between £1.1 billion and £1.3 billion (A$2 billion and A$2.4 billion) (table J.19). This represented between 0.08 and 0.10 per cent of UK GDP.

Table J.19 **Total subsidy equivalent[a]**

United Kingdom, April 2009 – March 2010

	Total subsidy equivalent (UK pounds)			*Total subsidy equivalent (Australian dollars)*		
Policy	*'Central'*	*High*	*Low*	*'Central'*	*High*	*Low*
	£m	£m	£m	A$m	A$m	A$m
European Union ETS — coal/gas switch	118	216	62	220	403	115
Renewables Obligation						
Certificates	845	845	810	1 573	1 573	1 508
Effects of the European Union ETS	135	135	135	251	251	251
Climate Change Levy						
LEC exemptions	90	90	72	168	168	135
Effects of the EU ETS	15	15	15	27	27	27
Offshore Wind Capital Grant Scheme	4	6	3	8	11	6
Total	1 207	1 307	1 096	2 247	2 433	2 042

a High — the highest subsidy equivalent estimated under sensitivity analysis. Low — the lowest subsidy equivalent estimated under sensitivity analysis. No sensitivity analysis has been carried out for the estimates of the effects of the European Union ETS on the policies to encourage the use of renewables.

Source: Productivity Commission estimates.

Total abatement

Added together, the estimate of the total abatement in the UK electricity sector due to the policies analysed was between 12.3 Mt and 27.4 Mt of CO_2 (table J.20). This represented between 8 and 15 per cent of UK counterfactual electricity sector emissions in 2009.

Table J.20 **Total abatement in the UK electricity sector**[a]

United Kingdom, April 2009 – March 2010

	Total abatement		
Policy	*'Central'*	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
EU ETS	8	14	4
Climate Change Levy (renewables)	1	1	1
Climate Change Levy (CHP)	2	2	2
Renewables Obligation	9	11	6
Total	19	27	12

a High — the highest abatement estimated under sensitivity analysis. Low — the lowest abatement estimated under sensitivity analysis.

Source: Productivity Commission estimates.

Average implicit abatement subsidies

Using the above estimates, a range of sector-wide average implicit abatement subsidy estimates can be calculated for the United Kingdom (table J.21). Depending on the assumptions used, these ranged from £40–£107/t CO_2 (A$75–A$198).

Table J.21 **Average implicit abatement subsidy**

United Kingdom, April 2009 – March 2010

	Implicit abatement subsidy (UK pounds)			*Implicit abatement subsidy (Australian dollars)*		
Total subsidy equivalent scenario	*'Central' abatement*	*High abatement*	*Low abatement*	*'Central' abatement*	*High abatement*	*Low abatement*
	£/t CO_2	£/t CO_2	£/t CO_2	A$/t CO_2	A$/t CO_2	A$/t CO_2
'Central'	63	44	98	118	82	183
High	69	48	107	128	89	198
Low	58	40	89	107	75	167

Source: Productivity Commission estimates.

In addition, given the overlaps discussed in section J.4, it was possible to estimate an implicit abatement subsidy for the renewable generation induced by all UK policies separately. The subsidy equivalent is the sum of the renewable component of the CCL and the European Union ETS, plus the subsidy equivalent of the Offshore Wind Capital Grants scheme and the Renewables Obligation. This was estimated to be between £1 billion and £1.1 billion (A$1.9 billion and A$2 billion), with a 'central' estimate of £1.07 billion (A$1.99 billion).

Abatement was the sum of the Renewables Obligation abatement, plus the additional abatement attributed to the renewables component of the CCL. This was estimated to be between 7 Mt CO_2 and 12 Mt CO_2, with a 'central' estimate of 10 Mt.

Therefore, the implicit abatement subsidy of renewables generation in the United Kingdom was estimated to be between £86–£158/t CO_2 (A$160–A$294), with a 'central' estimate of £108/t CO_2 (A$201).

J.10 Other UK electricity generation policies

The Commission's analysis is based on a subset of the emissions reduction measures that apply in the UK electricity generation sector. While these measures are considered to represent a large proportion of the total subsidy equivalent (and associated abatement) applicable in the United Kingdom, they do not reflect the entire suite of measures that are in place. Moreover, some recently committed measures will have implications for future analyses of implicit abatement subsidies.

Excluded policies

The Commission identified a number of electricity sector measures in the United Kingdom that were not included in the preceding analysis as they did not meet the Commission's criteria for policy inclusion. These policies include:

- the Energy Crops Scheme (UK) — subsidies to farmers for the establishment of crops for use in CHP
- Carbon Capture and Storage readiness (UK) — requirement for all new coal-fired power stations over 300 MW in capacity to be carbon capture and storage ready
- reduced VAT for energy saving materials and micro-generation (UK) — reduced VAT rate of 5 per cent (compared to 20 per cent) for micro-generation
- various community-based programs, including:
  - Ynni'r Fro (Wales) — capital subsidies for community-based renewable projects
  - Arbed (Wales) — direct government investment in low-income communities focusing on renewable energy programs (among other things)
  - Community and Renewable Energy Scheme (Scotland) — subsidies to community organisations (such as schools) for renewable technologies.

Individually, these policies were not considered likely to have provided a material subsidy equivalent for lower -emissions technologies, relative to the policies for which subsidy equivalents were estimated. Nor where they considered to have contributed significant amounts of abatement relative to the policies for which abatement was estimated — either as a result of limited coverage or budget. However, combined, it is possible that these measures could have a small influence on the Commission's estimate of the total subsidy equivalent and total abatement for the United Kingdom.

Committed policies

The Commission's analysis for the United Kingdom was undertaken for the financial year 2009-10. As such, it excluded a number of policies that have been committed for future implementation by the UK Government. In particular, the 2011 UK Budget announced the introduction of a carbon price floor for electricity generation.

Carbon price floor

From 1 April 2013, a carbon price floor for electricity generation will be introduced. The carbon price floor will start at around £16/t CO_2 and follow a linear path to £30/t CO_2 in 2020 (HM Treasury (UK) 2011a). The UK Government has indicated that it will adopt the following measures to achieve the carbon price floor:

- A carbon price support rate — the difference between the Government's carbon price (the floor) and the futures market price for carbon under the European Union ETS in 2013. The tax rate will be equivalent to £4.94/t CO_2 in 2013-14.
- The carbon price floor will be given affect through changes to the CCL and fuel duty. From April 2013, suppliers of fossil fuels used in electricity generation will become liable either for the CCL or fuel duty — suppliers will be charged the relevant carbon price support rate based on the average carbon content of each fossil fuel. Currently, these supplies are exempt from the CCL.
- Fossil fuels used to generate electricity in a CHP plant will be liable for reduced carbon price support rates of CCL and fuel duty.
- The existing rates of CCL will be retained.

Further details on the carbon price floor are expected to be available in consultation legislation in the second half of 2011 (HM Treasury (UK) 2011b).

Where the price floor is binding, the effect would be to increase the subsidy equivalent for renewable sources exempt under the CCL. The removal of the exemption for fossil fuels used to generate electricity (including in a CHP plant) has the effect of imposing a new fossil fuel tax. This would be considered as a new and additional policy to the suite of measures estimated by the Commission.