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# I South Korea's electricity generation sector

## I.1 Introduction

The Commission has estimated the subsidy equivalent, abatement and implicit abatement subsidy for six policies in South Korea: Feed-in Tariffs (FITs) for renewable energy; preferential loans for renewable energy; the Korea Certified Emission Reduction (KCER) scheme; and three capital subsidy programs — the Regional Deployment Subsidy program, the General Deployment Capital Subsidy program, and the 'One Million Green Homes' program.

In addition to these programs, the South Korean Government has committed to the introduction of Renewable Portfolio Standards and mandatory emissions-reduction targets for large emitters (including power generators). An emissions trading scheme has also been proposed for introduction (section I.12).

2009 was the most recent year for which data were available for most measures. Hence, subsidy equivalents and abatement were estimated for the 2009 calendar year and then converted to 2010 dollars using International Monetary Fund GDP deflators for South Korea (IMF 2011). Subsidy equivalents and implicit abatement subsidies are reported in both South Korean Won (KRW) and Australian dollars (A\$), with currency conversion rates based on the average exchange rate for 2010 of A\$0.000939/KRW (RBA 2011).

References in this appendix to Vivid Economics refer to unpublished data supplied to the Productivity Commission by that contractor. The relevant data are provided on the Productivity Commission's website where there are no commercial-in-confidence restrictions.

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## I.2 Electricity generation in South Korea

### The South Korean electricity market

The South Korean electricity market is largely state owned and regulated, though efforts have been made to liberalise the generation market.

Traditionally, the largely government-owned Korea Electric Power Corporation (KEPCO) has owned the generation, transmission and retail assets. In 2001, KEPCO's generation assets were split across six subsidiaries. Efforts were made to privatise some of these entities, but this did not go ahead. As of August 2010, the government has taken direct control of five of the subsidiaries, with only the nuclear assets remaining 'independent' as a subsidiary of KEPCO (EIA (US) 2010b).

There are also a number of independent power producers. As of 2009, these were responsible for 13 per cent of generation capacity in South Korea (KPX 2010a).

The majority of power produced in South Korea must be dispatched through a mandatory pool, which is operated by the Korea Power Exchange. This pool is a 'cost-based pool' system — unlike standard electricity pools, generators do not submit bids. Rather, they submit their availability for a time period, with the merit order (and thus the system marginal price) based on an assessment of each generator's marginal cost (KPX 2010a).

In general, aside from renewable generation, generators do not receive the system marginal price. Rather, the price they receive is based on estimates of their marginal cost, plus an adjustment that takes into account the difference between their marginal cost and the marginal price (KEPCO 2008).

The South Korean market also features capacity payments — generators are paid for capacity they make available during a period, regardless of whether the capacity is required in that period or not. In 2009, the capacity payment averaged KRW 7.71/kWh, and approximately 14.8 per cent of payments to generators was in the form of the capacity payment (KPX 2010a).

KEPCO is the sole retailer in South Korea. Therefore, aside from large wholesale purchasers, KEPCO is the sole purchaser of electricity from the pool.

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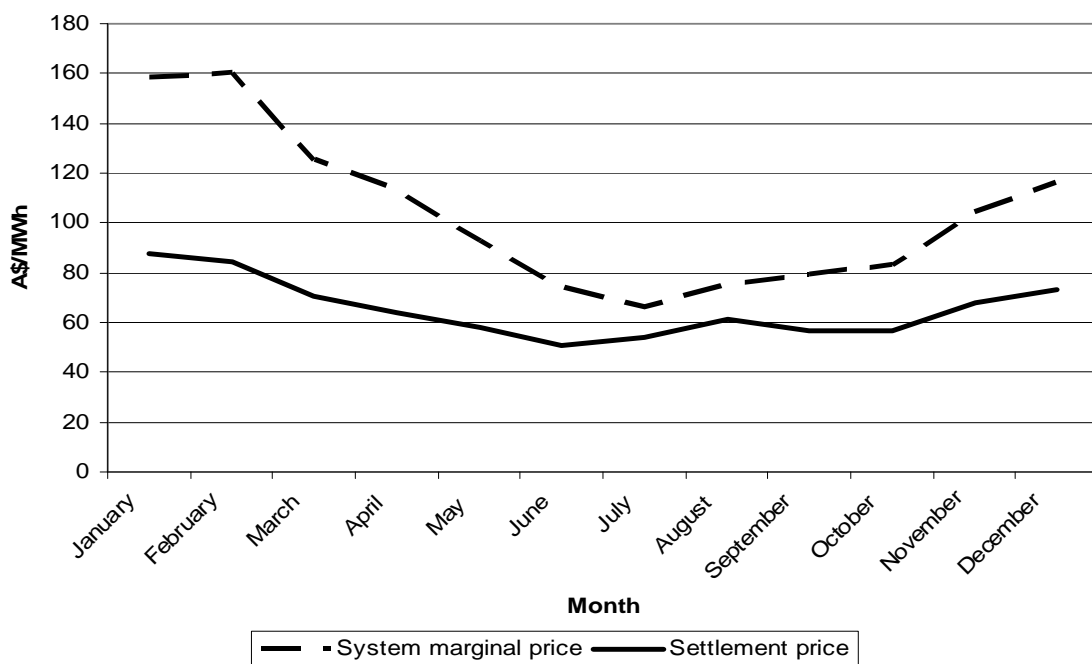
## Key statistics

### *Electricity prices*

The average system marginal price fluctuated over 2009, with electricity prices high during winter (with a peak of KRW 161/kWh (A\$0.16) in February) and declining during summer (with a low of KRW 66/kWh (A\$0.07) in July (figure I.1)). The average system marginal price in 2009 was approximately KRW 105/kWh (A\$0.10).

The average settlement price was more stable, reflecting the fact that this is based largely around the marginal costs of generators. The average settlement price in 2009 was KRW 66/kWh (A\$0.07). Note that the settlement price is the average price generators receive, as opposed to the system marginal price which is the price of the marginal generator.

Figure I.1 **Electricity prices<sup>a</sup>**  
South Korea, 2009



<sup>a</sup> System marginal price is the average price of the marginal generator. Settlement price is the average price received for dispatched generation. Converted to Australian dollars using the average 2009 exchange rate A\$0.000993/KRW.

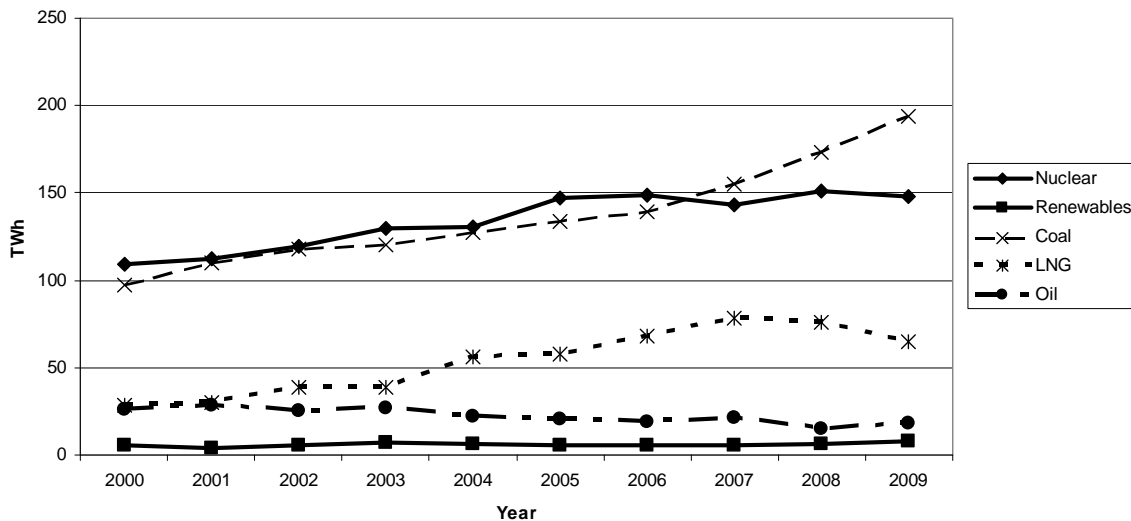
Source: KEEI pers. comm., 9 April 2011.

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## Generation mix

South Korea's electricity generation is dominated by a mix of coal and nuclear baseload power (figure I.2). Liquefied Natural Gas (LNG) and oil make up a smaller proportion of the generation mix, and are largely peak-load generators. The share of renewable generation is small, but increasing. In 2009, renewables generated approximately 8 TWh (up from 5.6 TWh in 2005), of which over half was hydroelectricity.

**Figure I.2 Electricity generation**  
South Korea, 2000–2009



Source: KPX (2010b).

## Emissions

The Commission was unable to locate data on emissions from the electricity sector. Emissions in the electricity and heat sectors combined in 2008 were 191 Mt CO<sub>2</sub>, of which almost 80 per cent was from coal (IEA 2010a).

Note that in 2008 there was approximately 446 TWh of electricity generation (89 per cent) and 56 TWh of heat (11 per cent) (IEA 2010h). This implies an average emissions intensity of 0.43 t CO<sub>2</sub>/MWh for electricity and heat generation.

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### **I.3 Estimating abatement in South Korea**

In order to estimate the abatement attributable to each policy, the Commission has used data provided by Vivid Economics (2011).

The Commission's analysis of abatement is based on identifying the marginal generator in a country's electricity market as this is the generator that is expected to be displaced from the merit order when renewable energy is installed. The marginal generator will always receive the highest price, while other generators will often receive a price that is lower than the system marginal price, based on a percentage of their variable costs (new and renewable energy sources are exempt from this, and simply receive the system marginal price). As such, generators that receive a higher price can be assumed to have higher variable costs, and therefore are more likely to be marginal generators.

According to the Korean Power Exchange (KPX 2010b), the three generators that received the highest average price over 2009 were pumped storage, oil and gas based generators. The emissions intensity of pumped storage generation is equal to the emissions intensity of the generator used to pump the water, plus some efficiency loss. The Commission does not have information on the emissions intensity of the pumped storage and for this reason has not included it in its estimates of the emissions intensity of the marginal generator. Instead, the Commission has assumed that oil and gas were the marginal generators.

According to Vivid Economics (2011), the average emissions intensity of oil generation in South Korea is 0.653 t CO<sub>2</sub>/MWh and LNG's emissions intensity is 0.39 t CO<sub>2</sub>/MWh.

The Commission has considered three scenarios in its estimates (table I.1).

- In the 'central' scenario, both LNG and oil are the marginal generation source 50 per cent of the time. This results in an average counterfactual emissions intensity of 0.522 t CO<sub>2</sub>/MWh.
- The other two scenarios assume that either LNG or oil is the marginal generator 100 per cent of the time. This results in average counterfactual intensities of 0.39 t CO<sub>2</sub>/MWh and 0.653 t CO<sub>2</sub>/MWh respectively.

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**Table I.1 Counterfactual scenarios**

South Korea, 2009

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<i>Scenario</i>	<i>Counterfactual emissions intensity</i>
	t CO <sub>2</sub> /MWh
'Central'	0.522
LNG counterfactual	0.390
Oil counterfactual	0.653

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*Sources:* Vivid Economics (2011); Productivity Commission estimates.

## I.4 Policy overlaps

The Commission has estimated subsidy equivalents and abatement attributable to six policies: Feed-in Tariffs for renewable energy, preferential loans for renewable energy; the KCER scheme; and three capital subsidy programs — the Regional Deployment Subsidy program; the General Deployment Capital Subsidy program; and the 'One Million Green Homes' program. The Commission considers that the overlap between each of these policies is limited:

- Generators are only eligible for the feed-in tariffs if the subsidy they receive is less than 30 per cent of the costs (KEMCO 2010). Therefore, it is unlikely that firms receiving a capital subsidy could be eligible for the FITs, given that these schemes typically subsidised over 50 per cent of costs, and as such, abatement is not being 'double counted'.
- It is likely that generators receiving a preferential loan could be part of other subsidy schemes, such as the FITs and the General Deployment Subsidies. Therefore, it is likely that the loans program fully overlaps with the other policies analysed.
- KCERs appear to be created for the installation of more efficient fossil fuel generation. As such, this scheme will not overlap with the renewable energy schemes.

The Commission was unable to obtain data on the extent of the overlaps between the Loans Incentive Program and the other policies analysed. As such, the subsidy equivalent for the Loan Incentive Program has been estimated separately, and no abatement or implicit abatement subsidy has been estimated for this policy. As generation receiving the FITs (or other subsidies) could also receive the loans, this means that the policy implicit abatement subsidy estimates are likely to be a slight under-estimate of the true implicit abatement subsidy to the generation supported by each policy.

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## **I.5 Feed-in Tariffs**

The Korean Feed-in Tariffs (FITs) offer fixed or variable tariffs for a range of new and renewable energy sources, including solar photovoltaic (PV), wind, fuel cells, waste and biomass, hydroelectricity and wave and tidal energy. Many of these installations have the option of:

1. a fixed tariff — for most of the sources apart from PV and fuel cells this appears to be below the average system marginal price
2. a variable tariff — often set at KRW 5–20/kWh (approximately A\$0.005–A\$0.02/kWh) above the system marginal price.

The most generous tariffs are set for solar PV, which has received 86 per cent of the total subsidy since the scheme was introduced in 2002, despite only contributing 15 per cent of FIT-eligible generation. Tariffs of up to KRW 700/kWh are available for solar PV installations (approximately A\$0.70/kWh) — well above the average system marginal price of KRW 105/kWh in 2009 (KPX 2010b).

The FITs are expected to run until 2012, when they are expected to be replaced by the South Korean Renewable Portfolio Standard (KEMCO 2010).

### **Estimating the subsidy equivalent**

The Korean Energy Economics Institute (KEEI) (pers. comm., 9 April 2011) stated that, in 2009, KRW 263 billion of FITs were paid out by the South Korean Government to new and renewable energy sources. Converted to 2010 KRW, the total subsidy equivalent was estimated to be KRW 271 billion (A\$255 million).

As the Government pays the difference between the wholesale price and the FIT rate, this is the subsidy equivalent paid out.

### **Estimating abatement**

According to the KEEI (pers. comm., 9 April 2011), 1.5 TWh of generation was supported by the FITs in 2009. Although data on the generation capacity that already existed prior to the FITs were not available, the Commission considers it likely that most generation that existed prior to the introduction of FITs would have received a subsidy from either the Regional Deployment Subsidy or the General Deployment Subsidy (which both existed prior to the introduction of the FITs). Generators receiving these subsidies are not eligible for FITs.

This generation is multiplied by the emissions intensity of replaced generation — estimated to be 0.522 t CO<sub>2</sub>/MWh (section I.3) — to estimate abatement of 785 kt CO<sub>2</sub>.

## Estimating the implicit abatement subsidy

Based on the above estimates, the implicit abatement subsidy was estimated to be KRW 345 990/t CO<sub>2</sub> (A\$325).

## Sensitivity analysis

There is some uncertainty about the emissions intensity of the marginal generator. To address this, the Commission analysed the effects of varying the emissions intensity of the counterfactual generator:

- Using a counterfactual emissions intensity of 0.39 t CO<sub>2</sub>/MWh, the implicit abatement subsidy was estimated to be KRW 463 095/t CO<sub>2</sub> (A\$435/t CO<sub>2</sub>).
- Using a counterfactual emissions intensity of 0.65 t CO<sub>2</sub>/MWh, the implicit abatement subsidy was estimated to be KRW 277 857/t CO<sub>2</sub> (A\$261/t CO<sub>2</sub>).

## Summary

Table I.2 outlines the results of the estimation for the South Korean FITs. The implicit abatement subsidy estimates range from KRW 277 857/t CO<sub>2</sub> to KRW 463 095/t CO<sub>2</sub> (A\$261 to A\$435), due to variations in the assumptions about the counterfactual emissions intensity.

**Table I.2 Summary, South Korean FITs**  
South Korea, 2009 (in 2010 values)

<i>Scenario</i>	<i>Subsidy equivalent</i>		<i>Abatement</i>	<i>Implicit abatement subsidy</i>	
	A\$m	KRW b		A\$/t CO <sub>2</sub>	KRW/t CO <sub>2</sub>
Central' counterfactual	255	271	0.8	325	345 990
Oil counterfactual	255	271	1	261	277 857
Gas counterfactual	255	271	0.6	435	463 095

*Source:* Productivity Commission estimates.

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## I.6 Korea Certified Emission Reductions

Since 2005, a voluntary market for KCERs has operated in South Korea. Companies that abate more than 500 tonnes of emissions a year are eligible to receive KCERs — where one KCER is created per tonne of CO<sub>2</sub> abated. Based on advice from the KEEI (pers. comm., 15 April 2011) it appears that KCERs created in the electricity sector are for efficiency improvements in fossil fuel generation. KCERs can be purchased in the market for around KRW 4800/t (Vivid Economics). However, in practice the Government tends to purchase the KCERs as there is no domestic obligation for emission reductions or KCER purchase.

### Estimating the subsidy equivalent

The Commission has estimated the subsidy equivalent of the KCERs using an approach similar to the one used for renewable energy certificates — where the total subsidy equivalent is equal to the certificate price (price of KCERs) multiplied by the number of certificates created. However, because the KCER market is a voluntary one, companies creating KCERs only receive a subsidy equivalent upon the sale of the KCER. Moreover, as the Commission's focus is on the electricity sector, only KCERs created by electricity generators are relevant to the analysis.

The Commission used the following approach to determine how many electricity generation-related KCERs were created and subsequently purchased by government:

- In 2009, 2.7 million KCERs were generated, of which 2.2 million were purchased by the Government (Vivid Economics). Information from the KEEI (pers. comm. 14 April 2011) suggests that there is no market for the purchase of KCERs outside those that are purchased by government.
- Of all KCERs created between 2007 and 2010, approximately 1.1 million were created by electricity generators (KEEI, pers. comm., 13 April 2011)<sup>1</sup>. This is equivalent to 12 per cent of all KCERs over the period 2007–2010 (8.8 million).
- Applying this proportion to the number of KCERs purchased by government in 2009 suggests that 272 772 of the 2.2 million KCERs purchased by government were from electricity generators.

The price paid by government per KCER was KRW 4837 in 2009. Multiplying this price by the Commission's estimate of the number of electricity KCERs purchased

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<sup>1</sup> The Commission was unable to obtain data on the number of electricity sector KCERs created per year. Therefore the total over the period 2007–2010 was used.

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by government in 2009 gives a subsidy equivalent of KRW 1.4 billion (A\$1.3 million) in real 2010 values (table I.3).

**Table I.3 Subsidy equivalent, KCERs**  
South Korea, 2009

<i>Variable</i>	<i>Value</i>
Subsidy equivalent (KRW 2009)	1.3b
Subsidy equivalent (real 2010 KRW)	1.4b
Subsidy equivalent (real 2010 A\$)	1.3m

*Source:* Productivity Commission estimates.

## Estimating abatement

As noted above, it appears that KCERs were mainly created for more efficient fossil fuel electricity generation (for example, the introduction of high-efficiency gas turbines and ultra-supercritical generation). This suggests that abatement from the program does not appear to overlap with that from other measures analysed by the Commission (section I.4). Nonetheless, as each KCER represents one tonne of CO<sub>2</sub> abated, the Commission has assumed that abatement from the KCER program is equivalent to the total number of electricity sector KCERs created and purchased in 2009, which was estimated to be 273 kt CO<sub>2</sub>.

## Implicit abatement subsidy

The implicit abatement subsidy of the KCER scheme is simply the permit price (in 2010 KRW) — KRW 4992/t CO<sub>2</sub> (A\$4.75).

## I.7 Regional Deployment Subsidy scheme

The Regional Deployment Subsidy scheme provides an upfront capital subsidy for renewable energy systems in regional areas. The subsidy is available for:

- building infrastructure to support renewable energy — up to 100 per cent of costs
- building renewable energy systems (both electricity and heat) — up to 60 per cent of costs.

The Commission's estimates only consider subsidies for building renewable electricity — infrastructure and heat have not been included.

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## Estimating the subsidy equivalent

Since 2000, a total of KRW 477 billion of subsidies have been granted under the regional deployment subsidy. According to the KEEI (pers. comm., 9 April 2011), KRW 290 billion of this amount was paid for the installation of solar PV, biomass, wind and small hydroelectricity systems (which are assumed to be renewable electricity).

As this subsidy is provided over a number of years, the annual value of the subsidy has been deflated to 2010 KRW. This results in a subsidy of KRW 324 billion to renewable electricity in real terms.

Using the standard approach to estimating capital subsidies — with a discount rate of 7 per cent and an expected economic life of 20 years — the annualised subsidy equivalent has been estimated to be KRW 31 billion (A\$29 million) (table I.4).

**Table I.4 Subsidy equivalent, Korean Regional Deployment Subsidy**  
South Korea, 2009

<i>Variable</i>	<i>Value</i>
Total subsidy (2010 KRW)	KRW 324b
Discount rate	7 per cent
Expected economic lifetime of assets	20 years
Subsidy equivalent (2010 KRW)	KRW 31b
Subsidy equivalent (2010 A\$)	A\$29m

*Source:* Productivity Commission estimates.

## Estimating abatement

The Commission obtained data on total generation from subsidised sources since the commencement of the scheme. In order to estimate abatement, this needed to be converted into generation in 2009.

In order to do this, it was assumed that generation was installed each year in proportion to the amount of the subsidy given. Each unit of generation was assumed to generate an equal amount per year.

Using this approach, annual generation from the subsidised sources was estimated at:

- 82 GWh from solar PV
- 9.3 GWh from hydroelectricity

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- 21 GWh from wind
  - 18.3 GWh from waste and biomass.

Therefore, the total annual generation subsidised by the scheme is estimated at 130 GWh.

As noted in section I.3, the average counterfactual emissions intensity is estimated to be approximately 0.522 t CO<sub>2</sub>/MWh. Therefore, the estimated abatement of the Regional Deployment Subsidy is 68 kt CO<sub>2</sub>.

### **Estimating the implicit abatement subsidy**

Using the Commission's estimates of the subsidy equivalent and abatement outlined above, the implicit abatement subsidy of the Regional Deployment Subsidy is estimated at KRW 449 612/t CO<sub>2</sub> (A\$422).

### **Sensitivity analysis**

The Commission has performed two sets of sensitivity analysis for the regional deployment subsidy — varying the discount rate, and varying the counterfactual.

#### *Varying the discount rate*

The Commission has used two alternative discount rates for sensitivity analysis — 3 and 11 per cent:

- Using a discount rate of 11 per cent results in an implicit abatement subsidy of KRW 598 141/t CO<sub>2</sub> (A\$562).
- Using a discount rate of 3 per cent results in an implicit abatement subsidy of KRW 320 162/t CO<sub>2</sub> (A\$301).

#### *Varying the counterfactual emissions intensity*

As noted in section I.3, the Commission has used two alternative emissions intensity scenarios.

- If an emissions intensity of 0.39 t CO<sub>2</sub>/MWh is used, the implicit abatement subsidy estimate is KRW 600 403/t CO<sub>2</sub> (A\$564).
- If an emissions intensity of 0.65 t CO<sub>2</sub>/MWh is used, the implicit abatement subsidy estimate is KRW 359 690/t CO<sub>2</sub> (A\$338).

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## Summary

Table I.5 displays a summary of the estimates for the Regional Deployment Subsidy. The estimates range from KRW 320 161 to KRW 600 403/t CO<sub>2</sub> (A\$301 to A\$564).

**Table I.5 Summary, Regional Deployment Subsidy**  
South Korea, 2009 (2010 values)

Scenario	Subsidy equivalent		Abatement	Implicit abatement subsidy	
	KRW b	A\$m	Mt CO <sub>2</sub>	KRW	A\$/t
'Central'	31	29	0.07	449 612	422
High discount rate	41	38	0.07	598 141	562
Low discount rate	22	20	0.07	320 161	301
Counterfactual emissions intensity of 0.65	31	29	0.09	359 690	338
Counterfactual emissions intensity of 0.39	31	29	0.05	600 403	564

Source: Productivity Commission estimates.

## I.8 General Deployment Subsidy scheme

The General Deployment Subsidy scheme offers upfront capital subsidies to established renewable technologies, including solar and wind. The subsidy supports up to 50 per cent of the costs of installing a renewable energy system (KEMCO 2010).

This subsidy scheme also provides a subsidy to renewable heat technologies, such as geothermal and solar thermal. These subsidies are not included in the estimates, as they do not apply to electricity generation.

### Estimating the subsidy equivalent

As of the end of 2009, the General Deployment Subsidy scheme had provided KRW 76 billion to renewable electricity generators (KEEI pers. comm., 9 April 2011). Data were available on the subsidy paid out per year, and this was converted to 2010 values using the South Korean GDP deflator. The total value of the deployment subsidy to renewable electricity generators in 2010 values was KRW 86 billion.

The cost of the capital subsidy has been annualised using a discount rate of 7 per cent and an expected lifetime of 20 years. This provides an estimate of the subsidy equivalent of KRW 8 billion (A\$8 million) (table I.6).

**Table I.6 Subsidy equivalent, General Deployment Subsidy**  
South Korea, 2009 (in 2010 values)

<i>Variable</i>	<i>Value</i>
Real value of electricity subsidies	KRW 86b
Discount rate	7 per cent
Economic lifetime of subsidised sources	20 years
Subsidy equivalent (KRW)	KRW 8b
Subsidy equivalent (A\$)	A\$8m

*Source:* Productivity Commission estimates.

## Estimating abatement

Since the commencement of the subsidy program, these subsidies have supported:

- 11.32 MW of solar PV
- 390 kW of wind
- 5.9 MW of biomass
- 1 kW of fuel cells.

These capacity values have been converted into annual generation using capacity factor estimates. Solar is assumed to have a capacity factor of 12.6 per cent (IEA 2010b). However, data on the capacity factors for other generation sources were not available, and these were estimated.

Using data from the IEA (2010e; 2010h), average capacity factors in South Korea were estimated to equal 25 per cent for wind, 47 per cent for biomass, and 35 per cent for fuel cells (table I.7).

Based on this, the Commission estimated annual generation from each source. Using a counterfactual emissions intensity of 0.522 t CO<sub>2</sub>/MWh, the abatement from the General Deployment Subsidy was estimated to be 20 kt CO<sub>2</sub> (table I.8).

## Estimating the implicit abatement subsidy

From the above estimates, the implicit abatement subsidy was estimated to equal KRW 411 967/t CO<sub>2</sub> (A\$387).

**Table I.7 Estimating capacity factors**

South Korea, 2008

<i>Generation source</i>	<i>Capacity in South Korea</i>	<i>Generation in South Korea</i>	<i>Estimated capacity factor</i>
	MW	GWh	%
Wind	190	414	25
Biomass	170	700	47
Fuel cells <sup>a</sup>	20	62	35

<sup>a</sup> Fuel cell data are from KEEI (pers. comm., 9 April 2011), and represent the fuel cells receiving FITs in 2009.

Sources: IEA (2010e; 2010h).

**Table I.8 Estimating abatement — General Deployment Subsidy**

South Korea, 2009

<i>Generation source</i>	<i>Capacity</i>	<i>Capacity factor</i>	<i>Estimated annual generation</i>	<i>Counterfactual emissions intensity</i>	<i>Abatement</i>
	MW	%	MWh	t CO <sub>2</sub> /MWh	Mt CO <sub>2</sub>
Wind	0.4	25	843	..	..
Solar	11.3	10	12 492	..	..
Biomass	5.9	47	24 257	..	..
Fuel cells	0.001	35	3	..	..
Total	17.6		37 596	0.522	0.02

.. Not applicable.

Sources: KEEI (pers. comm., 9 April 2011); Productivity Commission estimates.

## Sensitivity analysis

### *Varying the discount rate*

Two scenarios were estimated, one with a discount rate of 3 per cent, and the other with a discount rate of 11 per cent. With a low discount rate, the implicit abatement subsidy was KRW 293 356/t CO<sub>2</sub> (A\$275) and with a high discount rate the estimate was KRW 548 061/t CO<sub>2</sub> (A\$515).

### *Varying the counterfactual*

Two alternate counterfactual scenarios were considered:

- If the counterfactual emissions intensity was 0.65 t CO<sub>2</sub>/MWh (section I.3), the implicit abatement subsidy was estimated to be KRW 330 842/t CO<sub>2</sub> (A\$311).

- If the counterfactual emissions intensity was 0.39 t CO<sub>2</sub>/MWh, the implicit abatement subsidy was estimated to be KRW 551 403/t CO<sub>2</sub> (A\$518).

## Summary

Table I.9 displays the results of the estimation, including the sensitivity analysis. The estimates of the implicit abatement subsidy range from approximately KRW 293 356/t CO<sub>2</sub> to KRW 551 403/t CO<sub>2</sub> (A\$275 to A\$518).

**Table I.9 Summary, General Deployment Subsidy**  
South Korea, 2009 (in 2010 values)

Scenario	Subsidy equivalent		Abatement	Implicit abatement subsidy	
	KRW b	A\$m	Mt CO <sub>2</sub>	KRW/t CO <sub>2</sub>	A\$/t CO <sub>2</sub>
Baseline	8	8	0.02	411 967	387
Discount rate of 11 per cent	11	10	0.02	548 061	515
Discount rate of 3 per cent	6	5	0.02	293 356	275
Counterfactual intensity of 0.65	8	8	0.02	330 842	311
Counterfactual intensity of 0.4	8	8	0.01	551 403	518

Source: Productivity Commission estimates.

## I.9 One Million Green Homes

The ‘One Million Green Homes’ program provides subsidies for the installation of a range of renewable energy systems in residential homes. Subsidies are provided to cover up to 50 per cent of the installation costs for roof-top solar PV, small-scale solar thermal and geothermal, and small-scale hydroelectricity and wind. The objective of the program is for one million South Korean homes to be using one of these renewable energy sources by 2020.

In 2009, the One Million Green Homes program subsumed the ‘100,000 solar-roof installations program’ and expanded the coverage of subsidies to other renewable systems. As a result, the large majority of renewable generation supported by the program up until the end of 2009 relates to roof-top solar — around 90 per cent of the total subsidies paid out under the program.

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## Estimating the subsidy equivalent

The Commission has estimated the total subsidy equivalent for solar PV and small-scale hydroelectricity subsidies paid out over the period 2004 to 2009.<sup>2</sup> The total value of the subsidies was KRW 247 billion (in 2010 real KRW). Using a discount rate of 7 per cent, and an expected useful economic life of generation assets of 20 years, the annualised subsidy equivalent of the One Million Green Homes program is KRW 23 billion (A\$22 million) (table I.10).

**Table I.10 Subsidy equivalent, One Million Green Homes**

South Korea, 2004 to 2009 (in 2010 values)

<i>Variable</i>	<i>Value</i>
Real value of PV subsidies (2010 KRW)	247b
Discount rate	7 per cent
Useful economic life of generation assets	20 years
Subsidy equivalent (KRW (2010))	23b
Subsidy equivalent (A\$ (2010))	22m

*Source:* Productivity Commission estimates.

## Estimating abatement

The total installed capacity of renewable electricity supported by the program until the end of 2009 was 43.7MW, with an annual generation of 48 GWh. Annual generation for solar roof-top systems is estimated using a capacity factor of 12.6 per cent (IEA 2010b) and for small-scale hydroelectricity using a capacity factor of 2.5 per cent (IEA 2010e; IEA 2010h).

The Commission has used the ‘central’ counterfactual emissions intensity of 0.52t CO<sub>2</sub>/MWh (section I.3). Based on this, abatement was estimated to be 25 kt CO<sub>2</sub> (table I.11)

## Implicit abatement subsidy

Based on the Commission’s estimate of the subsidy equivalent and abatement, the implicit abatement subsidy of the One Million Green Homes program was estimated to be KRW 922 661/t CO<sub>2</sub> (A\$866).

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<sup>2</sup> The subsidy was also provided to solar-thermal and geothermal. However, this has been excluded from the analysis as it is assumed to relate to heat rather than electricity. As of the end of 2009, no subsidies were paid out to small-scale wind.

**Table I.11 Abatement, One Million Green Homes**  
South Korea, 2009

<i>Variable</i>	<i>Value</i>
Total installed capacity (MW)	44
Capacity factor (%)	12.6
Annual generation (GWh)	48
Counterfactual emissions intensity (t CO <sub>2</sub> /MWh)	0.522
Abatement (Mt CO <sub>2</sub> )	0.03

*Sources:* KEEI (pers. comm., 9 April 2011); IEA (2010b; 2011e; 2010h); Productivity Commission estimates.

### Sensitivity analysis

The Commission has undertaken sensitivity analysis on two parameters, the discount rate and the counterfactual emissions intensity.

#### *Discount rate*

Using discount rates of 3 and 11 per cent, the implicit abatement subsidy of the One Million Green Homes program is estimated to be KRW 657 012/t CO<sub>2</sub> (A\$617) and KRW 1.2 million/t CO<sub>2</sub> (A\$1152) respectively.

#### *Counterfactual emissions intensity*

Using a counterfactual emissions intensity of 0.39 t CO<sub>2</sub>/MWh, the implicit abatement subsidy is estimated to be KRW 1.2 million/t CO<sub>2</sub>. (A\$1156).

Using a counterfactual emissions intensity of 0.65 t CO<sub>2</sub>/MWh, the implicit abatement subsidy is estimated to be KRW 737 704/t CO<sub>2</sub> (A\$693).

### Summary of estimates

The Commission's estimates of the subsidy equivalent, abatement, and implicit abatement subsidy for the One Million Green Homes program are summarised in table I.12. These estimates imply an implicit abatement subsidy in the range KRW 657 012/t CO<sub>2</sub> (A\$617) to KRW 1.2 million/t CO<sub>2</sub> (A\$1156).

**Table I.12 Summary, One Million Green Homes**

South Korea, 2009

Scenario	Subsidy equivalent		Abatement	Implicit abatement subsidy	
	KRW b (2010)	A\$m (2010)	Mt CO <sub>2</sub>	KRW/t CO <sub>2</sub>	A\$/t CO <sub>2</sub>
'Central'	23	22	0.03	922 661	866
Discount rate of 11 per cent	31	29	0.03	1.2m	1 152
Discount rate of 3 per cent	17	16	0.03	657 012	617
Counterfactual intensity of 0.65	23	22	0.03	737 704	693
Counterfactual intensity of 0.39	23	22	0.02	1.2m	1 156

Source: Productivity Commission estimates.

## I.10 Loan Incentive Program

The South Korean Government offers long-term low-interest rate loans for both the installation and operation of new and renewable energy generators. Operation loans are provided either for the construction of renewable energy facilities or for the operation and management of renewable energy facilities. Preferential loans are provided for up to 90 per cent of the total cost (50 per cent for large corporations) (KEMCO 2010) and are repayable in 10 years (KEEI pers. comm., 21 April 2011).

The Commission considers the Loan Incentive Program to fully overlap with other policies in South Korea, such as the FITs and the General Deployment Subsidy. As a result, only the subsidy equivalent for the Loan Incentive Program has been estimated — abatement and the implicit abatement subsidy has not been estimated as abatement is assumed to have been counted under the other schemes.

### Estimating the subsidy equivalent

The Commission's approach to estimating the subsidy equivalent of preferential loans is to estimate the total value of loans outstanding in 2009, and then estimate the difference in the annual repayments of these loans using the preferential interest rate offered under the program and that which would have applied had the preferential rate not been offered. The difference in the annual repayments is the subsidy equivalent of the program.

### Value of loans outstanding in 2009

The Commission obtained data on the total value (and renewable energy source) of loans supported by the loan incentive program over the period 1983 to 2009 (table I.13).

**Table I.13 Total value of loans by renewable energy source<sup>a</sup>**

South Korea, 1983–2009

	1983–2004	2005	2006	2007	2008	2009	Total
<i>KRW b</i>							
Solar thermal	155.1	1.0	0.0	0.4	0.0	0.3	156.9
Photovoltaic	9.7	24.3	48.2	98.8	163.6	90.6	435.3
Bioenergy	80.9	27.6	8.4	2.8	4.3	0.0	124.0
Waste	86.4	4.2	11.9	5.2	0.0	0.0	107.7
Hydroelectricity	37.0	6.3	7.6	3.5	2.6	1.8	58.8
Geothermal	5.1	2.5	2.7	3.1	0.4	0.0	13.9
Wind	14.0	28.9	36.2	4.9	3.5	20.6	108.3
Fuel cell	7.8	5.0	4.6	1.9	4.4	11.1	34.7
Total (electricity) <sup>b</sup>	236	96	117	117	178	124	869
Total (electricity) (2010 KRW)	334	108	131	129	190	128	1 020
Total (electricity) (2010 A\$m)	314	101	123	121	179	120	958

<sup>a</sup> The Commission was unable to obtain the necessary information to disaggregate the data in table I.13 by 'operation loans' and 'installation loans'. Operation loans are provided either for the manufacture of renewable energy facilities or for the operation and management of renewable energy facilities. Ideally, the manufacture of renewable energy facilities would be excluded from the Commission's analysis as it does not strictly apply to the electricity generation sector. However, based on data provided by KEEI (pers. comm., 9 April 2011), only 1.5 per cent of total loans supported were operation loans (of which a lesser amount would be for manufacture of renewable energy facilities). Therefore they have not been subtracted from the total value of loans. <sup>b</sup> The total for electricity generation is estimated by summing the value of loans for photovoltaic, bioenergy, waste, hydroelectricity, wind and fuel cells. Solar thermal and geothermal are assumed to be used for the generation of heat and therefore have been excluded from the estimate.

Sources: KEEI (pers. comm., 9 April 2011); Productivity Commission estimates.

These data suggest that over the period 1983–2009 the total value of loans (in real 2010 values) provided to renewable electricity generators was approximately KRW 1020 billion (A\$958 million).

As the preferential loans are payable in ten years (KEEI, pers. comm., 15 April 2011) the Commission has estimated the subsidy equivalent of the preferential loan program using loans provided over the period 2000–2009.

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However, as indicated in table I.13, data on the value of loans to renewable electricity generators are only available on an annual basis from 2005 onwards. Therefore, the Commission used the following approach to estimate the proportion of loans that were provided to renewable electricity generators in the period 2000–2004:

- Based on data from the KEEI (pers. comm., 9 April 2011) the value of loans supported over the period 1983–2004 was KRW 397 billion (A\$373 million) and the value of loans supported between 2000–2004 was KRW 135 billion (A\$130 million). Therefore the proportion of loans supported in the period 2000–2004 was 34 per cent.
- Applying this proportion to the total value of electricity sector supported loans in the period 2000–2004 (table I.14) provides an estimate of KRW 114 billion (A\$107 million) (in 2010 values).
- Adding this value to the annual value of electricity sector supported loans over the period 2005 to 2009 gives an estimate of total supported electricity sector loans (in 2010 values) of KRW 799 billion (A\$751 million).

#### *Annual loan repayments*

To estimate the annual repayments on these loans, the Commission used the following formula (which is consistent with the approach applied to estimating the subsidy equivalent of explicit capital subsidies):

$$R_i = [ P_i * r ] / [ (1 - (1 + r)^{-n_i}) ]$$

where:

$R_i$  = annual loan repayment

$P_i$  = the principle value of loans outstanding in 2010

$r$  = interest rate

$n_i$  = the economic life of the asset

The subsidy equivalent of the Loan Incentives Program was estimated to be the difference between:

- the annual loan repayment using the preferential interest rate
- the annual loan repayment using the rate that would have applied if the investor was not offered a preferential rate.

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According to the KEEI (pers. comm., 21 April 2011) the preferential rate was 2.75 per cent. For the alternative rate — which would have applied had the investor been required to privately finance the loan — the Commission has used the standard commercial rate that applied in South Korea in February 2011. This was 5.81 per cent (KEEI pers. comm., 21 April 2011).

Based on a 2.75 per cent interest rate, the annual repayment was estimated to be KRW 53 billion (A\$49 million) in 2010.

Based on a 5.81 per cent commercial interest rate, the annual repayment was estimated to be KRW 67 billion (A\$64 million) in 2010.

This implies a difference of KRW 16 billion (A\$15 million), which was the subsidy equivalent of the program.

## **Sensitivity analysis**

If it is assumed that a higher commercial interest rate would have applied in the absence of the preferential loan program — assumed to be 11 per cent in line with the Commission's highest sensitivity value used in other parts of this study — then the subsidy equivalent of the loan incentives program was estimated to be KRW 48 billion (A\$45 million).

## **I.11 Summary**

This section combines the individual policy estimates to provide an estimate of the total subsidy equivalent, total abatement and the average implicit abatement subsidy for South Korea's electricity generation sector.

### **The total subsidy equivalent**

The individual policy subsidy equivalents represent an estimate of the subsidy granted to low-emissions generation by each policy. These can be added together to provide an estimate of the total subsidy equivalent to low-emissions generation in South Korea.

The total subsidy equivalent for South Korea was estimated at between KRW 333 billion and KRW 403 billion (A\$313 million and A\$379 million) (table I.14). This represents around 0.03 per cent of South Korea's GDP.

**Table I.14 Total subsidy equivalent**

South Korea, 2009 (In 2010 values)

<i>Schemes</i>	<i>Central</i>	<i>High</i>	<i>Low</i>	<i>'Central'</i>	<i>High</i>	<i>Low</i>
	KRW b	KRW b	KRW b	A\$m	A\$m	A\$m
Regional Deployment Subsidy	31	41	22	29	38	20
1 Million Green Homes	23	31	17	22	29	16
General Deployment Subsidy	8	11	6	8	10	5
Feed-in tariffs	271	271	271	255	255	255
Loans	16	48	16	15	45	15
KCERs	1	1	1	1	1	1
<b>Total</b>	<b>351</b>	<b>403</b>	<b>333</b>	<b>329</b>	<b>379</b>	<b>313</b>

Source: Productivity Commission estimates.

### Total abatement

The Commission considers that overlaps between South Korea's policies is limited (section I.4). In the one example where overlap was deemed to be an issue (in the case of the Loan Incentive Program) abatement was not estimated for this policy. Thus the policy abatement estimates can be added together, to provide an estimate of total abatement in South Korea's electricity sector. The total abatement is estimated to be between 0.9 Mt CO<sub>2</sub> and 1.4 Mt CO<sub>2</sub> (table I.15), which represents less than one per cent of South Korea's 2008 counterfactual electricity sector emissions.

**Table I.15 Total abatement**

South Korea, 2009

	<i>Central</i>	<i>High</i>	<i>Low</i>
	Mt CO <sub>2</sub>	Mt CO <sub>2</sub>	Mt CO <sub>2</sub>
Regional Deployment Subsidy	0.07	0.09	0.05
One Million Green Homes	0.03	0.03	0.02
General Deployment Subsidy	0.02	0.02	0.01
Feed-in tariffs	0.8	1	0.6
KCERs	0.3	0.3	0.3
<b>Total</b>	<b>1</b>	<b>1</b>	<b>0.9</b>

Source: Productivity Commission estimates.

## The average implicit abatement subsidy

Using the estimations above, the Commission has estimated an implicit abatement subsidy for the South Korean electricity generation sector. This was estimated to be between KRW 239 476 and 427 286/t CO<sub>2</sub> (A\$225 and A\$401) (table I.16).

**Table I.16 Average implicit abatement subsidy**

South Korea, 2009 (in 2010 values)

Total subsidy equivalent scenario	Implicit abatement subsidy					
	High abatement	'Central' abatement	Low abatement	High abatement	'Central' abatement	Low abatement
	KRW/t CO <sub>2</sub>	KRW/t CO <sub>2</sub>	KRW/t CO <sub>2</sub>	A\$/t CO <sub>2</sub>	A\$/t CO <sub>2</sub>	A\$/t CO <sub>2</sub>
High	289 859	344 484	427 286	272	323	401
'Central'	252 303	299 850	371 923	237	282	349
Low	239 476	284 606	353 015	225	267	331

Source: Productivity Commission estimates.

## I.12 Other South Korean electricity generation policies

The Commission's analysis for South Korea is considered to reflect the large majority of electricity generation measures that exist in South Korea. However, two policies were excluded from the analysis that may have had a material effect on the total subsidy equivalent estimates for South Korea. Moreover, the South Korean Government has committed to the introduction of a number of measures that could also materially affect future analyses.

### Excluded policies

The following electricity sector measures were identified but not estimated due to data constraints:

- The 'Green New Deal' — an economic stimulus package announced in 2009. The package includes a plan to spend US\$1.8 billion between 2009–2012 on 'Low-Carbon Power Renewable' measures (HSBC 2010). The Commission was unable to obtain specific information on the nature of electricity generation measures funded by the Green New Deal in 2009 and 2010.
- Tax deductions — approximately 20 per cent of the investment cost of new and renewable energy systems can be deducted from income tax or corporate income tax (KEMCO 2010).

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The exclusion of these two measures may have resulted in the Commission underestimating the total subsidy equivalent for the South Korean electricity sector. However, they are not expected to bias the Commission's estimates of abatement. To the extent that they are focused on renewable electricity — and therefore overlap with other measures, in particular Feed-in Tariffs — they are unlikely to have contributed additional abatement.

### **Committed policies**

The Commission identified a number of emission reduction measures that the South Korean Government has committed to in the electricity generation sector:

- The Greenhouse Gas and Energy Target Management Scheme — a system of mandatory emission reduction agreements covering 374 companies (including 36 electricity generators) that emit more than 25 000 t CO<sub>2</sub> per year. The scheme is expected to include an offset system.
- Renewable energy portfolio standards (RPS) — a requirement for large fossil fuel electricity generators (plants over 500 MW) to source a proportion of their total electricity production from renewable sources — starting at 2 per cent in 2012 (KEMCO 2010). The RPS will include a renewable energy certificate trading scheme, which is expected to replace the current Feed-in Tariff program. Based on information provided by KEEI (pers. comm., 9 April 2011), the RPS certificate price was estimated to be KRW 200–300/kWh (A\$0.19–0.28/kWh) for solar PV and KRW 40/kWh (approximately A\$0.04/kWh) for other new and renewable electricity sources.
- Emissions trading scheme — proposed for implementation in 2015. The Commission understands that the South Korean Government is considering the use of KCERs in the emissions trading scheme although details of the policy are unclear at this stage.

The combined effect of these policies may be to increase the total abatement and total subsidy equivalent for the South Korean electricity generation sector — to the extent that they provide a larger subsidy equivalent to renewable generators. However, they will be offset to some extent by changes to existing measures. For example, the Feed-in Tariff is expected to be replaced by the RPS and the KCER scheme is expected to be rolled into the proposed emissions trading scheme.