G Japan's electricity generation sector

The Commission estimated the impact of seven Japanese policies — the Japanese Renewable Portfolio Standard (RPS), the Project for Promoting the Local Introduction of New Energy, the Project for Supporting New Energy Operators, the New Buyback Program for Solar Photovoltaic (PV), the National PV Capital Subsidies, the Tokyo PV Capital Subsidies and the Petroleum and Coal Tax.

A number of other policies were considered, but were not included in the analysis as they were deemed unlikely to affect the aggregate results in a material way, or because data limitations prevented their estimation. In addition, the Commission was unable to locate data on the full subsidies provided by the Project for Promoting the Local Introduction of New Energy and the Project for Supporting New Energy Operators. As such, only the wind components of these schemes have been estimated, and therefore the total subsidy equivalent and total abatement estimates for Japan may be an underestimate.

The policies have been estimated for the Japanese 2009 fiscal year (1 April 2009 to 31 March 2010, hereafter referred to as FY 2009). The estimates have been converted to Australian currency using the average exchange rate over this period (A$0.0126/¥).

G.1 Electricity generation in Japan

The Japanese electricity sector

The electricity sector in Japan is largely operated by ten privately-owned vertically-integrated utilities (VIUs), each operating in a distinct region (table G.1). These utilities operate the transmission networks, are responsible for balancing supply and demand in their region, and operate much of the generation capacity. Historically, interconnections between the VIU regions have been limited (IEA 2008). In particular, there is limited connection between the Western side of the grid and the Eastern side of the grid.

Table G.1 **VIU regions**
Japan, 2008

VIU region	*Capacity as of 2008*	*VIU region*	*Capacity as of 2008*
	GW		GW
Tokyo	78	Shikoku	14
Kansai	44	Hokkaido	9
Kyushu	30	Hokuriku	9
Tohuku	27	Chubu	40
Chugoku	22	Okinawa	2

Source: IEA (2008).

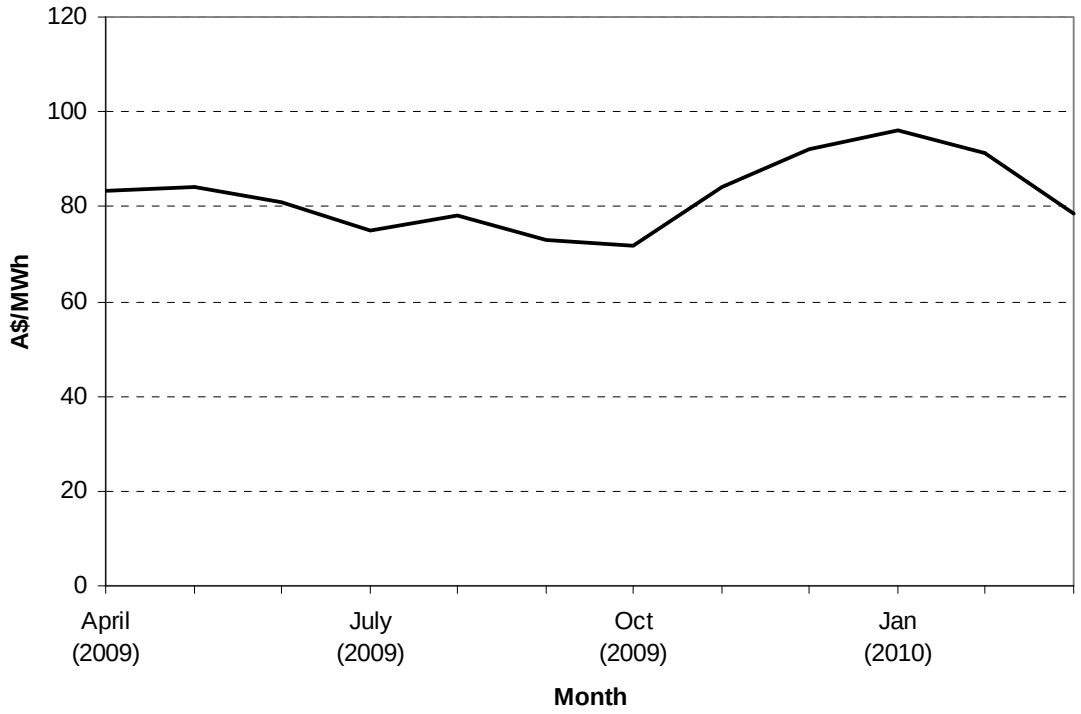
A limited portion of the market has been deregulated. High voltage customers with demand above 50 kW are able to choose their own supplier. Others must use the VIUs as suppliers. According to the International Energy Agency (IEA 2008), in FY2006, customers representing 1.3 per cent of load chose a non-VIU supplier, and 11 per cent of the load was via autoproducers (those supplying their own generation). A small power exchange (the Japanese Electric Power Exchange) also operates, however, trading on this market is limited (in FY 2009, a total of 3.5 TWh of generation was traded on the exchange — about 0.3 per cent of total generation (JEPX 2010)).

Key statistics

Wholesale electricity price

The only available data on wholesale prices were from the Japanese Electric Power Exchange (which, as noted above, forms a very small part of the market). In FY 2009, the unweighted monthly average price on this exchange ranged from around ¥5982/MWh (A$70/MWh) to ¥7687/MWh (A$96/MWh), with an average price of ¥6528/MWh (A$82/MWh). The Commission did not require estimates of the wholesale electricity price for the analysis of Japan's electricity sector measures but has included the data here for illustrative purposes (figure G.1).

Figure G.1 **Japanese Electric Power Exchange wholesale prices**
Japan, April 2009 – March 2010

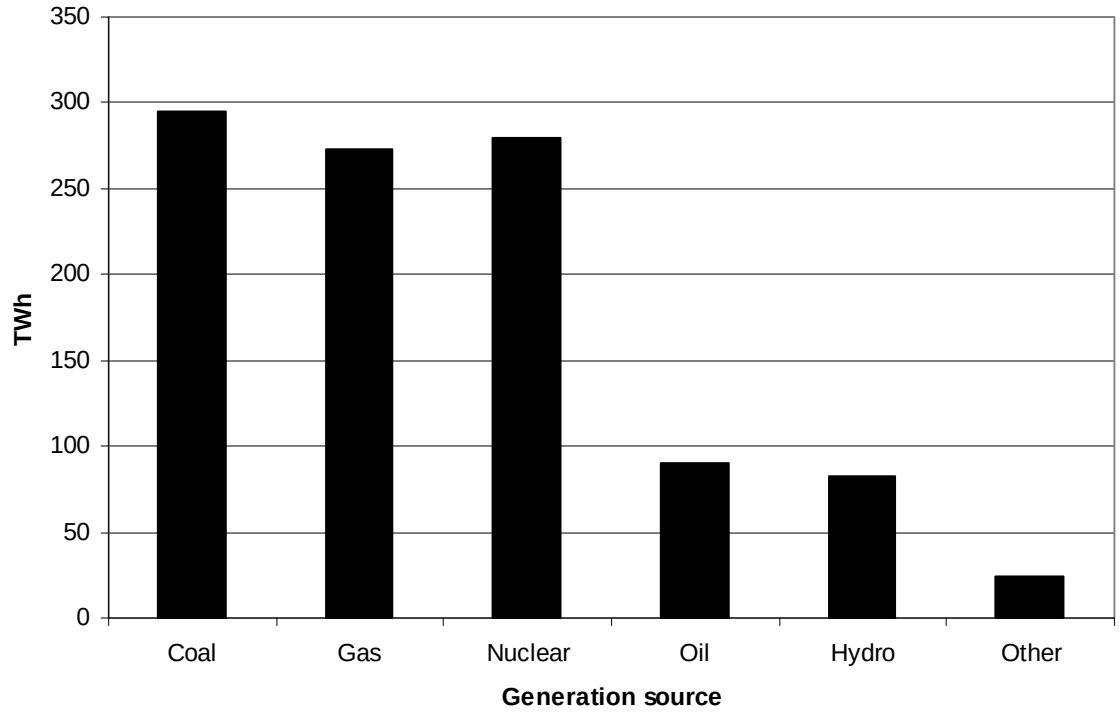


Source: JEPX (2010).

Fuel used in electricity generation

In 2009, total electricity generation was 1046 TWh. Japan's electricity generation sector consists of relatively equal proportions of coal, gas and nuclear based generation (each generated approximately 26–28 per cent of Japan's electricity in 2009) (figure G.2). Oil and hydro also generate a significant proportion of Japan's electricity (approximately 8–9 per cent each in 2009).

Figure G.2 **Generation sources used in Japan's electricity sector**[a]
Japan, 2009



a 'Other' includes mostly renewable sources.

Source: IEA (2010e).

Aside from hydro, biomass and waste are the largest sources of renewable energy generation in Japan (table G.2). Japan also has smaller amounts of wind, geothermal and solar electricity.

Table G.2 **Renewable generation**
Japan, 2009

Source	*Generation*	*Proportion of total generation*
	TWh	%
Hydro	82.6	7.9
Biomass and Waste	16.3	1.6
Wind	3.4	0.3
Geothermal	2.9	0.3
Solar	2.3	0.2

Source: IEA (2010e).

Emissions

In 2008, total emissions from the Japanese electricity and heat sectors was 396 Mt CO_2 (UNFCCC 2011) (of which electricity is likely to make up a large proportion). The average emissions intensity of the Japanese electricity and heat sector was 0.436 t CO_2/MWh in 2008 (table G.3).

Table G.3 **Emissions intensity of electricity and heat generation[a]**
Japan, 2008

Source	*Emissions intensity*
	t CO_2/MWh
Coal	0.911
Gas	0.439
Oil	0.574
Grid average	0.436

a Note that heat makes up a small proportion of these figures, and as such they are largely reflective of the emissions intensity of electricity generation.

Source: IEA (2010a).

G.2 Abatement

In order to calculate the abatement 'induced' by each policy, an estimate of the generation source that was replaced by the low-emissions generation was required. This was based on an assessment of the marginal generator — the highest cost generation in the merit order — which is the most likely generator to be replaced by renewable electricity. Note that this would be a reasonable assumption if the VIUs were profit maximising.

According to the Federation of Electric Power Companies of Japan (FEPC 2010), oil and pumped-storage generation were used to meet peak load fluctuations in demand in Japan. 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 was not able to obtain information on the emissions intensity of pumped-storage generation and for this reason did not included it in its estimates of the emissions intensity of the marginal generator. Instead, the Commission assumed that oil was the marginal generator. This is supported by IEA analysis of the costs of oil-fired generation. The IEA stated that 'oil-fired capacity [in Japan] is relatively old and depreciated — as well as expensive to operate' (IEA 2008, p. 121).

The average emissions intensity of oil-fired generation in Japan in 2008 was 0.574 t CO_2/MWh (table G.3). This was the counterfactual emissions intensity used to estimate abatement in the Commission's 'central' analysis.

The Commission has also considered an alternative counterfactual — gas-fired generation. The Federation of Electric Power Companies of Japan (FEPC 2010) suggested that in the Japanese merit order, gas-fired generation was dispatched before oil. In periods of low demand, it is possible that there would be no oil-fired generation, and thus the marginal generator would be gas. This counterfactual could thus be considered a lower bound on the marginal emissions intensity. The alternative emissions intensity used was 0.439 t CO_2/MWh.

G.3 Policy overlaps

The Commission has estimated the subsidy equivalent and abatement attributable to seven policies: the Japanese RPS, the Project for Promoting the Local Introduction of New Energy, the Project for Supporting New Energy Operators, National Solar PV Feed-in Tariffs, National PV Capital Subsidies, Tokyo PV Capital Subsidies and the Petroleum and Coal Tax. There are considerable overlaps between the policies that have led the Commission to presume that:

- the abatement covered under the RPS was not considered to overlap with the PV subsidies at all. The PV subsidies apply only to residential solar, whereas solar within the RPS does not contain generation which is used for 'self-use'. In addition, generation receiving the feed-in tariffs cannot receive credit under the RPS
- wind subsidies received through the Project for Promoting the Local Introduction of New Energy and the Project for Supporting New Energy Operators are assumed to fully overlap with the RPS, where the subsidies were granted after the RPS commenced
- PV systems subsidised through the Tokyo PV Capital Subsidies are also subsidised through the National PV Capital Subsidies (100 per cent overlap)
- the New Buyback Program for Solar PV (national FITs) was estimated to overlap by 90 per cent with the National PV Capital Subsidies. (Both policies apply to residential solar PV, but the national FITs also subsidise some non-residential installations. The Commission has estimated that non-residential installations account for 10 per cent of total subsidies under the FITs.)
- the Petroleum and Coal Tax was considered to provide an effective production subsidy to all renewables, but not lead to any additional abatement that was not captured by the other policies.

Taking into account these overlaps, the total abatement attributable to these policies was estimated to arise from:

- electricity generation that was induced by the RPS
- electricity generation subsidised under the Project for Promoting the Local Introduction of New Energy and the Project for Supporting New Energy Operators prior to the commencement of the RPS
- electricity generation that was subsidised under the National PV Capital Subsidies
- 10 per cent of the electricity generation that was subsidised through the National FITs.

Other policies provide additional support to electricity generation from renewables, but these subsidies are to a large extent estimated to overlap with other subsidies.

Due to the overlap between the policies, the Commission estimated the abatement, and thus the implicit abatement subsidy, for two groups of policies:

- the RPS, the Project for Supporting the Local Introduction of New Energy, and the Project for Supporting New Energy Operators (section G.4)
- the National PV Capital Subsidies, the Tokyo PV Capital Subsidies and the Buyback Program (section G.5).

Thus the estimates take into account these policy interaction effects.

G.4 Renewable Portfolio Standard and wind subsidies

Due to overlaps between the policies, the Commission estimated the abatement, and hence the implicit abatement subsidy, for three programs combined — the RPS, the Project for Promoting the Local Introduction of New Energy, and the Project for Supporting New Energy Operators. The subsidy equivalent for each policy was estimated separately.

Renewable Portfolio Standard

The Japanese RPS was introduced in 2003, and requires VIUs to source a specified percentage of their electricity sales from eligible renewable sources. (Note that large hydro and most geothermal are not eligible. In addition, electricity generated for 'self-use' is not covered.) The 2010 target was for 10 TWh of renewable electricity.

Retailers can meet their obligations in several ways:

- by generating the electricity themselves
- by purchasing the electricity from another retailer
- by purchasing renewable electricity certificates.

Unlike many similar schemes, such as Australia's Renewable Energy Target, the bulk of the obligation appears to be met by self-generation — only a small proportion of certificates are traded. According to the Institute of Energy Economics, Japan (IEEJ) (pers. comm., 8 April 2011), only 233 GWh of renewable certificates were issued in FY 2009, out of 8.61 TWh of eligible renewable generation.

The scheme includes a banking mechanism, which has led to an oversupply of permits. This was due to low targets and a large amount of eligible pre-existing generation in the early years of the scheme, which resulted in a substantial amount of banking. This meant that renewable generation in FY 2009 was less than required by the target in FY 2009 — the difference was made up by banked permits.

However, due to this banking mechanism, the renewable energy permits have a non-zero price. Thus, despite the target being exceeded in previous years, there will still be a subsidy equivalent and abatement occurring due to the scheme.

Estimating the subsidy equivalent

The subsidy equivalent for the RPS was estimated by multiplying the 'induced' RPS eligible generation by the renewable certificate price.

In FY 2009, there was 8.61 TWh of eligible renewable generation in Japan. This consisted of:

- 3.7 TWh of wind
- 3.2 TWh of biomass
- 1 TWh of small hydro
- 0.7 TWh of solar (note that solar electricity was 'double counted' for the purposes of the RPS (IEA 2010i). This implies that 0.35 TWh of eligible solar was generated in FY 2009)
- minimal amounts of 'mixed power' and geothermal (METI and ANRE (Japan) 2010).

However, much of this generation may have already existed prior to the commencement of the scheme. While pre-existing generation receives credit under the scheme, in FY2003, when the scheme commenced, the target was adjusted down to represent the amount of renewable generation in FY2002 (this adjustment has since been removed). The adjustment factor was 4 TWh (METI (Japan) 2011a), and this was taken to be the amount of eligible renewable generation that occurred in FY2002. Therefore, 4.6 TWh of renewable generation was assumed to have been 'induced' by the scheme.

While, as noted above, most generation does not create certificates, the certificate price represents the effective subsidy given to renewable generation. Profit maximising VIUs will generate electricity up until the point where the cost of generation is equal to the electricity price plus the certificate price. Where the costs of generation exceed this value, retailers purchase renewable certificates rather than generate the electricity themselves.

According to IEEJ (pers. comm., 8 April 2011), the average certificate price in FY 2009 was ¥5.2/kWh (A$0.07/kWh). This resulted in a subsidy equivalent estimate of ¥23.8 billion (A$300 million).

Project for Promoting the Local Introduction of New Energy

The Project for Promoting the Local Introduction of New Energy subsidised up to half the installation costs for local governments and non-profit organisations installing renewable energy. The scheme subsidised a variety of technologies, including PV, wind, small hydro, some geothermal, solar thermal heat and biomass (heat, electricity and fuel).

This scheme has since ceased operating. However as it was in operation during FY 2009, it was relevant to the Commission's analysis. The Commission was only able to obtain data on the subsidies offered to wind generators under this scheme.

Estimating the subsidy equivalent

From FY1997 (when the scheme commenced) through to FY 2009, the Project for Promoting the Local Introduction of New Energy offered ¥21.9 billion in subsidies to wind generators (in ¥2009) (A$277 million) (METI (Japan), pers. comm., 20 May 2011). Converted into an annualised subsidy equivalent using a discount rate of 7 per cent and an economic lifetime of 20 years, this was estimated to be ¥2.1 billion (A$26 million).

Alternatively, discount rates of 3 and 11 per cent can be used. These discount rates resulted in subsidy equivalent estimates of ¥1.5 billion (A$19 million) and ¥2.8 billion (A$35 million) respectively.

Estimating annual generation

Since FY1997, 236 MW of wind capacity has been subsidised under this scheme. However, generation built since FY2003 will overlap fully with the RPS. As such, only the 106 MW of capacity subsidised before FY2003 was included in the estimates of generation (METI (Japan), pers. comm., 20 May 2011).

The EIA (US) (2011i) states that, in 2008 Japan had 1.8 GW of wind capacity, and 2.5 TWh of wind generation. This led to an estimate of the capacity factor of wind in Japan of around 16 per cent. Therefore, the annual generation of the subsidised capacity was estimated to be 150 GWh.

Project for Supporting New Energy Operators

The Project for Supporting New Energy Operators provided either a subsidy or a debt guarantee for installation of new energy, including biomass heat and electricity, biofuels, small hydro, geothermal, wind and solar PV. Like the Project for Promoting the Local Introduction of New Energy, this scheme has ceased operating, but was in operation during FY 2009. Again, only data on the subsidies provided to wind generation were available.

Estimating the subsidy equivalent

Between FY1997 and FY 2009, this scheme provided ¥130 billion (A$16 million) of subsidies to wind generators (METI (Japan), pers. comm., 20 May 2011). Using a 7 per cent discount rate, and a 20 year economic lifetime of the assets, the subsidy equivalent was estimated to be ¥12 billion (A$155 million).

Alternatively, discount rates of 3 and 11 per cent can be used These resulted in subsidy equivalent estimates of ¥8.8 billion (A$110 million) and ¥16 billion (A$206 million) respectively.

Estimating annual generation

Since FY1997, this scheme has provided subsidies to 2.3 GW of wind generation. However, as generation subsidised after FY2003 will overlap fully with the RPS,

only generation subsidised prior to FY2003 was included in the estimates of generation and abatement. This was equal to 542 MW (METI (Japan), pers. comm., 20 May 2011).

Using a capacity factor of 16 per cent, annual generation from this capacity was estimated to be 770 GWh.

Estimating the combined abatement and implicit abatement subsidy

Combined values for the subsidy equivalent, abatement and the implicit abatement subsidy can be estimated based on the above estimates.

The subsidy equivalent was estimated by simply adding together the three policy subsidy equivalent estimates. This was estimated to be between ¥34 billion and ¥43 billion (A$429 million and A$541 million), with a 'central' estimate of ¥38 billion (A$481 million).

Abatement was estimated by adding together the individual policy generation estimates, and multiplying by a counterfactual emissions intensity. Annual generation induced by the three schemes combined was estimated to be 5.1 TWh.

Using a counterfactual emissions intensity of 0.574 t CO_2/MWh, annual abatement from the schemes was estimated to be 3 Mt CO_2. Alternatively, using a counterfactual emissions intensity of 0.439 t CO_2/MWh, abatement was estimated to be 2 Mt CO_2.

Based on this, the implicit abatement subsidy for the three schemes combined could be estimated. This was estimated to be between ¥11 500/t CO_2 and ¥18 964/t CO_2 (A$145 and A$239), with a 'central' estimate of ¥12 899/t CO_2 (A$163) (table G.4).

Table G.4 **Summary, Renewable Portfolio Standard and Wind subsidies**

Japan, April 2009 – March 2010 (in 2009 values)

Scenario	*Subsidy equivalent*		*Abatement*	*Implicit abatement subsidy*	
	¥b	A$m	Mt CO_2	¥/t CO_2	A$/t CO_2
Oil counterfactual					
7 per cent discount rate	38	481	3	12 899	163
11 per cent discount rate	43	541	3	14 504	183
3 per cent discount rate	34	429	3	11 500	145
Gas counterfactual					
7 per cent discount rate	38	481	2	16 866	213
11 per cent discount rate	43	541	2	18 964	239
3 per cent discount rate	34	429	2	15 037	190

Source: Productivity Commission estimates.

G.5 Japan's solar PV programs

The Commission estimated the subsidy equivalents for three measures relating to solar PV in Japan — one federal level FIT (the Buyback program) and two capital subsidy programs. For abatement, the Commission estimated the combined effect of these policies as there was significant overlap in the generation eligible for each of these subsidies.

The New Buyback Program for Solar PV

In November 2009, the Japanese Government introduced FITs for small-scale solar PV systems — the '*New Buyback Program for Solar Photovoltaic Generation*' (the Buyback Program). The Buyback Program requires electricity utilities to buy excess electricity generated from PV systems from residential and non-residential sources at a fixed tariff rate for 10 years, the cost of which will be passed on to consumers through a 'solar surcharge'. The current rates of the tariff are:

- ¥48/kWh for residential solar PV less than 10 kW (or ¥39/kWh if generators are coequipped with other forms of generation, such as fuel cells)
- ¥24/kWh for non-residential solar PV (or ¥20/kWh if generators are coequipped) (METI (Japan) 2011b).

The Commission was unable to obtain data on the proportion of eligible generators that were coequipped with other forms of generation. Therefore, the Commission's estimate of the subsidy equivalent for this policy is likely to be an upper bound (as

generators that are coequipped receive a lower FIT rate). However, the Commission considers it unlikely that coequipping (at the residential level) was widespread.

As the Buyback Program has only been in place since November 2009, the Commission estimated the subsidy equivalent and abatement of the program for the period 1 November 2009 to 31 March 2010.

Estimating the subsidy equivalent

The subsidy equivalent of the solar FITs was estimated by multiplying the production subsidy equivalent by total electricity generation from eligible solar PV.

To estimate the production subsidy equivalent, the counterfactual electricity price was subtracted from the FIT rate. The counterfactual electricity price is the price that would have been received for excess electricity generated from solar PV in the absence of the FIT. In Japan, electricity utilities appear to voluntarily pay higher rates for excess electricity generated from residential and non-residential solar PV than for electricity from conventional sources (Ito 2010, IEA 2010a). Ito (2010. p. 2), suggested that the buyback tariff was 'double the "autonomous" purchase price conventionally paid by electric power companies (¥24/kWh for residential and ¥11–¥15/kWh for non residential buildings), when applied to solar PV excess power'.

Therefore, the production subsidy equivalent for residential and non-residential solar PV was estimated to be ¥24/kWh and ¥12/kWh respectively — half of the rates applied under the Buyback Program.

Estimating generation

Generation from solar PV that was eligible for the FIT was 265 GWh over the period 1 November 2009 to 31 March 2010 (METI and ANRE (Japan) 2010).

Data on the proportion of this generation that were from residential and non-residential solar PV were not available. However, according to Ito (2010), the Buyback Program was mainly designed to apply to small-scale solar PV installed in residential buildings. As such, it was anticipated that most solar PV installed under the program would be in residential buildings. Moreover, in 2009 residential PV systems accounted for 89.5 per cent of grid-connected PV in Japan (IEA 2010i).

Therefore, the Commission assumed that 89.5 per cent of the total generation eligible for the solar FIT was from residential sources and 10.5 per cent was from non-residential sources.

Subsidy equivalent

Based on the above assumptions, the subsidy equivalent of the Buyback Program was estimated to be ¥6 billion (A$76 million) (table G.5). The Commission understands that the total value of the Buyback program in 2009 was much higher than this estimate (METI (Japan), pers. comm., 20 May 2011). The Commission was unable to reconcile this difference and has retained the above estimate to maintain consistency in the approach used to estimate the subsidy equivalent of FIT programs in other countries.

Table G.5 **Subsidy equivalent, National Buyback Program**
Japan, April 2009 – March 2010

	Units	*Residential*	*Non-residential*	*Total*
Feed-in tariff rate	¥/kWh	48	24	..
Counterfactual electricity price	¥/kWh	24	12	..
Production subsidy equivalent	¥/kWh	24	12	..
Solar PV generation[a]	GWh	237	28	265
Subsidy equivalent	**¥m (2009)**	**5 688**	**334**	**6 022**
Subsidy equivalent	**A$m (2009)**	**72**	**4**	**76**

[a] Residential and non-residential solar PV generation were assumed to be 89.5 per cent and 10.5 per cent of total generation respectively. **..** Not applicable

Sources: METI and ANRE (Japan) (2010); METI (Japan) (2011a); Productivity Commission estimates.

National Solar Photovoltaic Capital Subsidies

Since 1994 the Japanese Government has provided capital subsidies for the installation of solar PV systems in residential buildings.[1] The rate of the subsidy was ¥70 000/kW (A$880/kW) for solar PV systems with a generation capacity of 10 kW or less in 2009. The federal subsidy was provided in addition to other metropolitan and municipal level subsidies (including the Tokyo Metropolitan Solar PV Subsidy).

Estimating the subsidy equivalent

The Commission obtained data on the total value of subsidies paid out under the program from the IEEJ (IEEJ, pers. comm., 8 April 2011). These data suggest that the total value of the subsidy for the period 1 April 1994 to 31 March 2010 was ¥173 billion (in 2009 ¥) (A$2.2 billion). Assuming a 7 per cent discount rate and an

1 The subsidy program ceased in 2005 but was reinstated in 2007.

asset life of 20 years, the annualised value (subsidy equivalent) of the subsidy was estimated to be ¥16.4 billion (A$206 million).

Estimating generation

The cumulative capacity of solar PV supported by the subsidy program over the period 1 April 1994 to 31 March 2010 was 2.17 GW (IEEJ, pers. comm., 8 April 2011). The annual generation of subsidised solar PV was estimated using a capacity factor of 12 per cent (IEEJ, pers. comm., 8 April 2011). This provided an estimate of annual generation of 2.28 TWh in 2009-10.

Sensitivity analysis

As sensitivity analysis, the Commission varied the discount rate to 3 and 11 per cent:

- Assuming a discount rate of 3 per cent, the subsidy equivalent was estimated to be ¥11.6 billion (A$147 million).
- Assuming an 11 per cent discount rate, the subsidy equivalent was estimated to be ¥21.8 billion (A$274 million).

Based on the above parameter values, the subsidy equivalent of the National Solar PV Subsidy program was estimated to be in the range of ¥11.6 billion (A$147 million) to ¥21.8 billion (A$274 million) in FY 2009 (table G.6).

Table G.6 **Summary, National Solar Photovoltaic Capital Subsidies**
Japan, April 2009 – March 2010

	Units	*Discount rate*		
		3%	7%	11%
Subsidy equivalent[a]	¥b (2009)	11.6	16.4	21.8
Subsidy equivalent	A$m (2009)	147	206	274

[a] The subsidy equivalent was based on an estimate of the total value of the subsidy for the period 1 April 1994 to 31 March 2010 of ¥173 billion (where values have been converted to 2009 ¥ using IMF GDP deflators).

Source: Productivity Commission estimates.

Tokyo Solar Photovoltaic Capital Subsidies

From 1 April 2009 to 31 March 2010 (FY 2009) the Tokyo Metropolitan Government provided capital subsidies for the installation of solar PV systems in residential buildings. The rate of the subsidy was ¥100 000/kW of solar PV installed

(Tokyo Metropolitan Environmental Improvement Corporation 2011). Subsidies were also available for solar water heaters but have been excluded from the Commission's analysis as they apply to heat rather than electricity generation.

Estimating the subsidy equivalent

The total capacity of solar PV supported by the subsidy program for FY 2009 was 25 MW (Tokyo Metropolitan Foundation for Environmental Development 2011). Multiplying this capacity by the value of the subsidy in this period (¥100 000/kW) gives an estimate of ¥2.5 billion (A$32 million) for the total value of the subsidy.

Assuming a 7 per cent discount rate and an asset life of 20 years for solar PV panels, the annualised value (subsidy equivalent) of the subsidy was estimated to be ¥236 million (A$3 million).

Estimating annual generation

Annual generation of subsidised solar PV was estimated using a capacity factor of 12 per cent (IEEJ, pers. comm., 8 April 2011). This provided an estimate of annual generation of 26.3 GWh in FY 2009.

Sensitivity analysis

As sensitivity analysis, the Commission varied the discount rate to 3 and 11 per cent:

- Assuming a discount rate of 3 per cent, the subsidy equivalent was estimated to be ¥168 million (A$2.1 million).
- Assuming an 11 per cent discount rate, the subsidy equivalent was estimated to be ¥314 million (A$4 million).

Based on the above parameter values, the subsidy equivalent of the Tokyo Solar PV Capital Subsidies was estimated to be in the range of ¥168 million (A$2.1 million) to ¥314 million (A$4.0 million) (table G.7).

Estimating abatement from the solar programs

In order to estimate the abatement induced by the solar programs, an estimate of the generation supported by the three schemes was required.

The National and Tokyo capital subsidies and a large part of the Buyback Program all target residential solar panels. The Commission assumed that all owners of residential solar panels that are eligible under these schemes receive all of the subsidies they are eligible for. As such, the residential generation covered by the three schemes was equal to the generation covered by the National PV Subsidies (2.28 TWh).

Table G.7 **Summary, Tokyo Solar Photovoltaic Capital Subsidies**
Japan, April 2009 – March 2010

	Units	*Discount rate*		
		3%	7%	11%
Subsidy equivalent	¥m (2009)	168	236	314
Subsidy equivalent	A$m (2009)	2.1	3.0	4.0

Source: Productivity Commission estimates.

In addition, a component of the Buyback Program was targeted at non-residential solar. As noted above, the Commission assumed that 90 per cent of the Buyback Program tariffs were provided to residential solar. Therefore, the Commission estimated that 28 GWh of non-residential solar generation was covered under the Buyback Program (10 per cent of the generation).

Therefore, the total generation covered by these three schemes was estimated at 2.31 TWh. Using a counterfactual emissions intensity of 0.574 t CO_2/MWh, the estimated abatement from the three schemes was 1.3 Mt CO_2.

Sensitivity analysis

The Commission used an alternate counterfactual emissions intensity of 0.439 t CO_2/MWh. This results in an abatement estimate of 1 Mt of CO_2.

Estimating the implicit abatement subsidy of solar programs

The implicit abatement subsidy of all three solar programs combined was calculated by adding together the three subsidy equivalent estimates, and dividing by the combined estimate of abatement. Based on these estimates, the implicit abatement subsidy of the solar programs was estimated to be between ¥13 450/t CO_2 and ¥27 699/t CO_2 (A$170 and A$349) (table G.8).

Table G.8 **Implicit abatement subsidy, solar programs**

Japan, April 2009 – March 2010 (in 2009 values)

	Subsidy equivalent		*Abatement*	*Implicit abatement subsidy*	
	¥b	A$m	Mt CO_2	¥/t CO_2	A$/t CO_2
Oil counterfactual					
7 per cent discount rate	22.6	285	1	17 052	215
11 per cent discount rate	28.1	354	1	21 184	267
3 per cent discount rate	17.8	225	1	13 450	170
Gas counterfactual					
7 per cent discount rate	22.6	285	1	22 295	281
11 per cent discount rate	28.1	354	1	27 699	349
3 per cent discount rate	17.8	225	1	17 586	222

Source: Productivity Commission estimates.

G.6 Petroleum and Coal Tax

A petroleum tax was introduced in Japan in 1978, and initially only applied to oil. The tax was expanded in 1984 to cover liquefied natural gas and liquefied petroleum gas, and in 2003 it was expanded to cover coal. The tax rates currently stand at ¥2040/kL for oil, ¥1080/t of gas and ¥700/t of coal.

Japan is proposing to progressively lift these tax rates between 2011 and 2016 as part of its environmental tax reform. The rates are expected to rise by 37 per cent for oil, 72 per cent for gas and 96 per cent for coal (Nikkei 2010).

Estimating the subsidy equivalent

Tax rates for FY 2009 were converted into a price per tonne of carbon dioxide emitted from electricity generation from each of these sources. For each fuel, the Commission estimated the amount of fuel used and/or GWh of electricity generated based on the generation from the top ten producers in 2008. This figure, and the emissions intensity of generation of each fuel were used to convert the tax per litre or tonne of fuel into a tax per tonne of CO_2 (table G.9). Tax rates were estimated to be:

- For liquefied natural gas (LNG), the tax per tonne of CO_2 was estimated at ¥366 (A$4.61)
- for coal, the tax per tonne of CO_2 was estimated at ¥266 (A$3.36)
- for oil, the tax per tonne of CO_2 was estimated at ¥822 (A$10.37).

Table G.9 **Estimating the tax per tonne of CO_2**
Japan, FY 2009

	Units	*LNG*	*Coal*	*Oil*
Tax rate (¥)		1080/t	700/t	2040/kL
Generation from the top 10 power producers (2008)[a]	TWh	278	147	79
Fuel used by the top 10 power producers (2008)[a]		41 321 kt	50 774 kt	18 258 ML
Amount of fuel used per GWh		149t	347t	231L
Tax per kWh	¥/kWh	0.16	0.24	0.47
Average emissions intensity of generation	t CO_2/MWh	0.439	0.911	0.574
Tax per tonne of CO_2 (¥)	¥/t	366	266	822
Tax per tonne of CO_2 (A$)	A$/t	4.61	3.36	10.37

[a] The generation from top ten power producers and fuel used from top ten power producers were used to derive the average amount of fuel used per GWh. This was taken as a proxy for all power producers.

Sources: IEEJ (pers. comm., 8 April 2011); IEA (2010a); Productivity Commission estimates.

The Commission considers it unlikely that the fuel tax resulted in any fuel switching between the fossil fuel sources. This is because:

- while oil had the highest tax rate, it is generally already the highest-cost fossil fuel source. As such this will not result in any change in the merit order
- the difference in the tax rate between coal and gas was very small when converted into per unit of electricity (¥0.08/kWh — A$1/MWh). This was unlikely to result in a switch in the merit order between the two sources.

In addition, given the relatively high cost of renewable energy, it was unlikely that the fuel tax was inducing any additional renewable generation on its own. As such, the Commission considers that (in the context of electricity generation) the impact of the fuel tax was to add to the effective subsidy equivalent received by renewable sources 'induced' by other Japanese policies.

The effective subsidy received by renewable generation under this policy was estimated as the electricity price uplift induced by the policy (or alternatively, given the structure of the Japanese market (with VIUs and regulated prices) this can be thought of as the increase in the marginal cost of fossil-fuel-based generation, relative to renewable generation).

Under the Commission's analysis oil was considered to be the marginal generator. Therefore, oil was assumed to be driving the marginal cost of fossil-fuel-based generation, and the effective subsidy received by renewable generators was estimated to be ¥0.47/kWh (A$0.006), or ¥822/t CO_2 abated (A$10.37) (assuming full pass through of costs).

The Commission estimated that 6.5 TWh of renewable electricity was policy-induced in Japan (estimated by dividing the abatement estimate in section G.7 (3.9 Mt CO_2) by the counterfactual emissions intensity (0.574 t CO_2/MWh)). Therefore, the subsidy equivalent of the fuel tax was ¥3.1 billion (A$39 million).

Sensitivity analysis

For sensitivity analysis, the Commission assumed that natural gas was the marginal generator. This implies a subsidy of ¥0.16/kWh (A$0.002/kWh), and therefore, given an induced renewable generation estimate of 6.5 TWh, the subsidy equivalent was estimated at ¥1.1 billion (A$13 million).

G.7 Summary

This section combines the individual policy subsidy equivalent and abatement estimates into country-wide estimates for the total subsidy equivalent, total abatement and the average implicit abatement subsidy for the Japanese electricity sector.

The total subsidy equivalent

The total subsidy equivalent represents an estimate of the total subsidy provided to renewable generation as a result of the policies analysed. This is simply the sum of the individual policy subsidy equivalent estimates. This was estimated to be between ¥53 billion and ¥75 billion (A$669 million and A$940 million) (table G.10) and represents around 0.01 per cent of Japan's GDP.

Total abatement

As the estimates provided above take into account policy overlaps, the abatement estimates can be added together to provide an estimate of total abatement in Japan's electricity sector. This was estimated at between 2.9 Mt CO_2 and 3.8 Mt CO_2 (table G.11).

Given the emissions estimate for 2008 reported in section G.1 (396 Mt CO_2), this abatement estimate represents less than one per cent of Japan's counterfactual electricity sector emissions in 2008.

Table G.10 **Total subsidy equivalent**

Japan, April 2009 – March 2010 (in 2009 values)

Policy	*'Central'*	*High*	*Low*	*'Central'*	*High*	*Low*
	¥b	¥b	¥b	A$m	A$m	A$m
Renewable Portfolio Standard	23.8	23.8	23.8	300	300	300
Project for Promoting the Local Introduction of New Energy	2.1	2.8	1.5	26	35	19
Project for Supporting New Energy Operators	12.3	16.3	8.8	155	206	110
National PV Subsidies	16.4	21.8	11.6	206	274	147
Tokyo PV Subsidies	0.2	0.3	0.1	3	4	2
Feed-In Tariffs	6.0	6.0	6.0	76	76	76
Petroleum and Coal Tax	3.1	3.1	1.1	39	39	13
Total	64	75	53	811	940	669

Source: Productivity Commission estimates.

Table G.11 **Total abatement**

Japan, April 2009 – March 2010

Policy	*'Central'*	*High*	*Low*
	Mt CO_2	Mt CO_2	Mt CO_2
Renewable Portfolio Standard plus wind subsidies	3	3	2
National PV Subsidies, Tokyo PV Subsidies and the Buyback program	1	1	1
Total	4	4	3

Source: Productivity Commission estimates.

The average implicit abatement subsidy

Based on the estimates above, the average implicit abatement subsidy for the Japanese electricity sector was estimated at between ¥12 384/t CO_2 and ¥22 744/t CO_2 (A$156 and A$287) (table G.12).

Table G.12 **Average implicit abatement subsidy**

Japan, April 2009 – March 2010 (In 2009 values)

		Abatement					
		'Central'	*High*	*Low*	*'Central'*	*High*	*Low*
		¥/t CO_2	¥/t CO_2	¥/t CO_2	A$/t CO_2	A$/t CO_2	A$/t CO_2
Total subsidy equivalent	High	17 395	17 395	22 744	219	219	287
	'Central'	15 007	15 007	19 622	189	189	248
	Low	12 384	12 384	16 192	156	156	204

Source: Productivity Commission estimates.

G.8 Excluded and committed policies

Excluded policies

The Commission endeavoured to include all material policies operating at the federal level in Japan. However, there may be policies operating below the federal level, such as capital subsidies for renewable energy provided by metropolitan governments (similar to the Tokyo PV Capital Subsidies) that could have an effect on the estimates. Including these policies would increase the total subsidy equivalent estimate, but is expected to have minimal impact on total abatement (as the abatement is likely to be covered by the federal schemes). Thus, this may mean that the average implicit abatement subsidy estimates are underestimates.

Committed policies

While the Commission did not identify any material Japanese policies which could be classed as 'committed' (aside from increasing the level of the Petroleum and Coal Tax — section G.6), in March 2010 the *Bill of the Basic Act on Global Warming Countermeasures* was introduced into parliament. This Bill proposed the introduction of:

- an emissions trading scheme
- a system of FITs, which would replace the RPS.

The Bill aimed to reduce Japanese emissions to 25 per cent below 1990 levels by 2020. Clearly these would be substantial emissions-reduction measures that, when introduced, the Commission would expect to have a large effect on the implicit abatement subsidy estimation. However, the Bill has not yet been passed into law, and it is unclear when this will occur.