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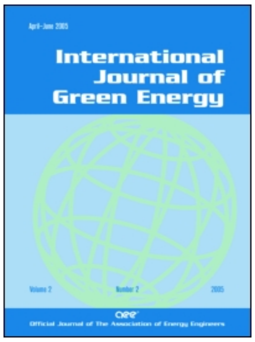

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Evaluating Japanese policy instruments for the promotion of renewable energy sources

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ABSTRACT
In Japan, the Renewable Portfolio Standard (RPS) and the Feed-in-Tariff (FIT) have been used for the exploitation of renewable energy sources (RES). Although these are significant to enhance the use of RES, the RES penetration is not reaching the expected percentage. The identification of their strengths/weaknesses will allow their improvement for achieving the target. This paper concerned the evaluation of RPS and FIT using a multi-criteria evaluation method. First, official data/information were used to assess their performance using the method. Second, national experts were asked about their performance to verify the outcomes. We found FIT was more effective than RPS.

KEYWORDS
Climate policy; feed-in-tariff; multi-criteria evaluation; renewable energy; renewable portfolio standard

Introduction

Japan's Kyoto Protocol target was 6% reduction of the greenhouse gas (GHG) emissions during the period 2008–2012 compared to those of the base year 1990. In 2007, the total GHG emissions were 1,374 MtCO_2eq, increased by 9% compared to the emissions of the base year, while in 2011 the respective amount decreased to 1,240 MtCO_2eq (The Government of Japan 2010). During 2014, Japan remained among the top emitters (share: 4%) following China (29%), United States (15%), EU28 (11%), India (6%), and Russia (5%) (Olivier et al. 2014). The Japanese share in global CO_2 emissions decreased from 5.2% in the 1990s to 4.5% in the following decade and to 3.8% during 2011–2013. The current national target until 2030 is to reduce GHG emissions by 26% below the 2013 levels.

Renewable energy sources (RES) will be one of the most important elements in securing Japan's energy supply and complying with its climate commitments. In 2008, Japan set the target to increase the solar cell production by about 20 times until 2020 and 40 times until 2030 (Ministry of Economy, Trade and Industry (METI) 2009). In 2010, it aimed 10% of the primary energy supply to be from RES in 2020 (METI 2010). In 2011, the RES share (excluding hydropower) was only 1.4% of total power generation (Agency for Natural Resources and Energy (ANRE), 2012a). After the Fukushima Daiichi nuclear disaster in 2011, RES appeared as an energy alternative for the future and could account for approximately one-fifth of Japanese energy mix by the 2020s (Olivier et al. 2013). In 2012, RES accounted for about 10% of the energy supply, most of which was from hydropower.

The most significant policy instruments used for increasing national use of RES are the Renewable Portfolio Standard (RPS) and the Feed-in-Tariff (FIT). The authors focus on these two for two reasons: (i) different rationality (quantity and price oriented, respectively); and (ii) the Net-metering Scheme, aimed to promote photovoltaics (PV) in Japan, was implemented only for a short period and was a simplified version of the FIT targeting only PV.

There are no studies evaluating the performance of these two policy instruments under the Japanese framework, although there are studies comparing them in general and leading to qualitative conclusions (Hibiki and Kurakawa 2013; Tamas, Shrestha, and Zhou 2010). Hibiki and Kurakawa (2013) compare RPS and FIT assuming imperfectly competitive markets for electricity retailing and RES. They find that the RPS is better than the FIT if the marginal external cost (due to thermal power generation) is high, while FIT is better if the marginal external cost is low. Tamas, Shrestha, and Zhou (2010) compare RPS (tradable green certificates) and FIT assuming a Cournot market for electricity retailing and a perfectly competitive market for tradable green certificates. They find that the RPS tends to bring higher social welfare than the FIT. Another group of papers examines these policy instruments as part of energy policy scenarios or policy mixtures (Ayoub and Yuji 2012; Moe 2012). However, no papers examine RPS and FIT actually implemented or considering the climate change aspect.

This paper aims to evaluate the performance of the Japanese FIT and RPS quantitatively using the AMS method under the climate change perspective to understand which is more appropriate in increasing RES. It is important to involve the climate change perspective, since one of the purposes to increase RES is to tackle climate change issues. Quantitative data and qualitative information can be applied simultaneously for the AMS

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evaluation. The authors also implemented a questionnaire survey to experts in this field to verify the evaluation, which has not been implemented in the previous AMS applications. It is indicative that while Japan started the FIT after the RPS, South Korea started the RPS after the FIT. From this point, the evaluation for these schemes is not firmed and depends on the respective national framework; therefore, evaluating both schemes according to the Japanese framework is significant to verify their effect and propose the appropriate policy instrument for the future.

Policy instruments for promoting RES in Japan

The RPS

The Japanese RPS enacted in 2003 aims primarily at supporting further the use of new energy (or RES) to maintain a stable energy supply by requiring specific electricity companies to use annually a certain amount of electricity generated from new energy. It covers PV, wind, biomass, medium- and small-scale hydro, and geothermal power. The annual targets of new-energy electricity use by electric retailers were defined by the METI (ANRE 2013c) were defined by the METI. The target was set to increase from 7.3 TWh in 2003 to 12.2 TWh in 2010 and 16 TWh by 2014. Annual targets of the new-energy-electricity use were set for 8 years. The targets were lower than in Europe and United States, partly because large hydropower and geothermal are ineligible under the RPS and a considerable amount of electricity generated from biomass is for self-use (Haas et al. 2008).

Electric utilities attain the target by generating themselves RES electricity or purchasing it (or certificates) generated by others. The RES facilities are required to be certified by the METI. If an electric utility does not fulfill the obligation without due reasons, the METI makes a recommendation (or orders) to fulfill the obligation. Finally, an electric utility violating the order will be punished (a fine of less than or equal to one million JPY).

In fiscal year (FY) 2010, 53 electric utilities were required to use 11,015 GWh of RES electricity (METI 2011). In FY 2010, the amount of RES electricity supplied to electric utilities by RES-electricity facilities was 10,246 GWh (8,873 GWh in FY 2009). There is a banking system such that if an electric utility supplies RES electricity in excess of the required amount for the current FY, it may carry over the excess amount to the next FY and include it to meet that year's requirement (METI 2011). From FY 2009 to 2010, 6,406 GWh was carried over (METI 2011).

The FIT

The Japanese FIT, started in 2012, obliges electric utilities to purchase RES electricity at a fixed purchase price for a long-term period guaranteed by the government (Table 1). The scheme regulates the governmental procedures in deciding purchase prices and periods, the certification of facilities, the collection and adjustment of surcharges related to purchase costs, and terms by which electric utilities can reject the contracts. It aims to promote the RES use to enhance international competitiveness, industrial development, local revitalization, and economic development. It is expected to reduce uncertainty in investment recovery for RES-electricity facilities and encourage investment to increase RES (Kitamura 2013). It covers PV, wind, small- and medium-scale hydro, geothermal, and biomass power (Table 1). RES-electricity producers need their power-generating facilities to be certified by the METI.

The prices and periods are set according to the classification, installation mode, and scale of RES-electricity facilities. Basically, the full amount of electricity generated by the certified facilities is purchased. For residential PV, however, only surplus electricity is purchased (ANRE 2013b).

The purchase prices, periods, and classifications are discussed and reviewed every FY by the Procurement Price Calculation Committee (PPCC). The METI makes final

Table 1. Classifications of RES electricity, and purchase prices for electricity produced by RES under both schemes[a].

		Policy instruments			
		RPS[b]		FIT	
RES types		FY 2003	between 2003–2010	FY 2012	FY 2013
Wind	≥20 kW	11.8 [0.118]	10–11.8 [0.10–0.118]	23.1 [0.231] (20)	
	<20 kW			57.75 [0.5775] (20)	
Hydropower	1000–30,000 kW	8.1 [0.081]	7.2–9 [0.072–0.09]	25.2 [0.252] (20)	
	200–1000 kW			30.45 [0.3045] (20)	
	<200 kW			35.7 [0.357] (20)	
PV	≥10 kW	11.5 [0.115] (other than residential)	10.3–13.4 [0.103–0.134] (other than residential)	42 [0.42] (20)	37.8 [0.378] (20)
	<10 kW	21 [0.21] (residential)	19–23.4 [0.19–0.234] (residential)	42 [0.42] (20)	38 [0.38] (10)
	<10 kW (with private power facilities)			34 [0.34] (20)	31 [0.31] (10)
Biomass	Biogas	7.2 [0.072]	7.2–9.4 [0.072–0.094]	40.95 [0.4095] (20)	
	Wood-fired power plant (timber from forest thinning)			33.6 [0.336] (20)	
	Wood-fired power plant (other woody materials)			25.2 [0.252] (20)	
	Waste			17.85 [0.1785] (20)	
	Wood-fired power plant (recycled wood)			13.65 [0.1365] (20)	
Geothermal	≥15,000 kW	NA	NA	27.3 [0.273] (15)	
	<15,000 kW			42 [0.42] (15)	

a: The first values in the cells are in JPY/kWh and the values in the brackets are in USD/kWh (exchange rate of USD 1 = JPY 100). The values in the parenthesis show the purchase periods under the FIT. b: The prices include both the prices of RPS certificates and electricity.
Source: ANRE (2011b) for the RPS Scheme and ANRE (2011a, 2012b, 2014) for the FIT Scheme.

Table 2. Introduction of RES facilities in Japan (MW).

Facilities for renewable electricity (type of source)	Cumulative capacity of facilities as of the end of FY 2011	Combined total capacity of facilities that started operation in FY 2012	Facilities certified until the end of FY 2012
PV (for households)	4,400	1,269 (300 MW from April to June)	1,342
PV (other than households)	900	706 (2 MW from April to June)	18,681
Wind	2,600	363 (zero from April to June)	798
Small and medium hydro (1000 kW or more)	9,400	1 (1 MW from April to June)	61
Small and medium hydro (less than 1000 kW)	200	23 (1 MW from April to June)	10
Biomass	2,300	36 (6 MW from April to June)	194
Geothermal	500	1 (zero from April to June)	4
Total	20,000	2,079	21,090

Source: ANRE (2013d)

decisions considering the discussions. The purchase costs of RES electricity are shared by all electricity consumers in proportion to the volume of electricity they have used. The Surcharge Adjustment Organization (SAO) collects, calculates, and distributes the surcharge. The METI determines the amount of surcharge every FY. This process is done, because the amount of RES electricity produced is different among areas. The surcharge was JPY 0.22/kWh in FY 2012 and has increased to JPY 0.35/kWh in FY 2013 and JPY 0.75/kWh in FY 2014.

RES-electricity producers need to have two contracts with electric utilities: a specific contract for selling generated electricity; and a grid connection contract for the connection to grids of electric utilities. Electric utilities are obliged to purchase the full amount of electricity generated, but there are conditions under which they can deny purchase and connection.[1] If an electric utility repudiates a contract without justifiable reasons, the METI makes recommendation (or orders) to sign the contracts. Finally, an electric utility who violates the order will be punished (a fine of less than or equal to one million JPY).[2]

Table 2 lists RES-electricity facilities introduced in FY 2012 (ANRE 2013a). It shows that the RES-electricity was greatly promoted after the FIT was enforced. PV facilities are popular, because environmental assessment is not required and installation is easier than the installation of facilities of other forms of RES electricity (Kitamura 2013).

Methods

Evaluation with AMS

AMS

Each policy instrument is assessed for its performance under the criteria/sub-criteria of the AMS (combination of the Analytical Hierarchy Process (AHP), the Multi-Attribute Utility Theory (MAUT) and the Simple Multi-Attribute Ranking Technique (SMART) (Konidari and Mavrakis 2006, 2007)). AMS is originally developed for evaluating climate change policy instruments and relevant policy mixtures. It has been applied to evaluate RES policy instruments (Kambezidis, Kasselouri, and Konidari 2011; Konidari 2014).

The AHP provides the weight coefficients of criteria/sub-criteria. MAUT and SMART provide normalized grades for the performance of policy instruments under the sub-criteria. The MAUT is applied when credible data under a sub-criterion for all the evaluated policy instruments are available, while the SMART grades are based on user's judgment and/or experts' opinion due to the lack of proper data (Konidari and Mavrakis 2006, 2007). The AMS consists of four basic steps (Konidari and Mavrakis 2006, 2007).

First, the criteria-tree, which is the tree of previously published applications, is created (Figure 1; Konidari and Mavrakis 2006, 2007). The goal of policy instruments for RES (first level) is to be effective in increasing RES in the energy mix and mitigate simultaneously climate change due to RES. Three criteria (second level) and the sub-criteria under each criterion support the goal. Definitions of criteria/sub-criteria are in Appendix A.

Second, the weight coefficients of the criteria/sub-criteria are calculated. Here, the values of previous works with very good results for the performed consistency test are used (Konidari and Mavrakis 2007). This process—based on the study of National Communications submitted to the United Nations Framework Convention on Climate Change and reports from the Intergovernmental Panel on Climate Change—reflected various socioeconomic perceptions and provided a global dimension to these results. Thus, the specific weight coefficients reflect the cumulative global understanding of the importance that these criteria play in the formation of climate policies over a 15-year period of their development. If the international community increases awareness on climate change, these weight coefficients will change accordingly. Based on the latest National Communications, these values have not changed.

The third step, grading the performance of policy instruments, will be presented analytically in the following section. Finally, a grade (commonly measured performance) of the assessed policy instrument for a certain sub-criterion is multiplied with the respective weight coefficient of the sub-criterion (Konidari and Mavrakis 2007). All products (concerning all sub-criteria) are added for each criterion so as to form its grade. This criterion grade is then multiplied with the respective weight coefficient of the criterion. All new products are added and form the final grade, which expresses the effectiveness of the evaluated policy instrument. Calculations are implemented with the software ClimAMS (Konidari and Thomaidis 2007).

[1] The details are in Morita and Matsumoto (2014).
[2] Other penalties are also provided to the SAO and PPCC.

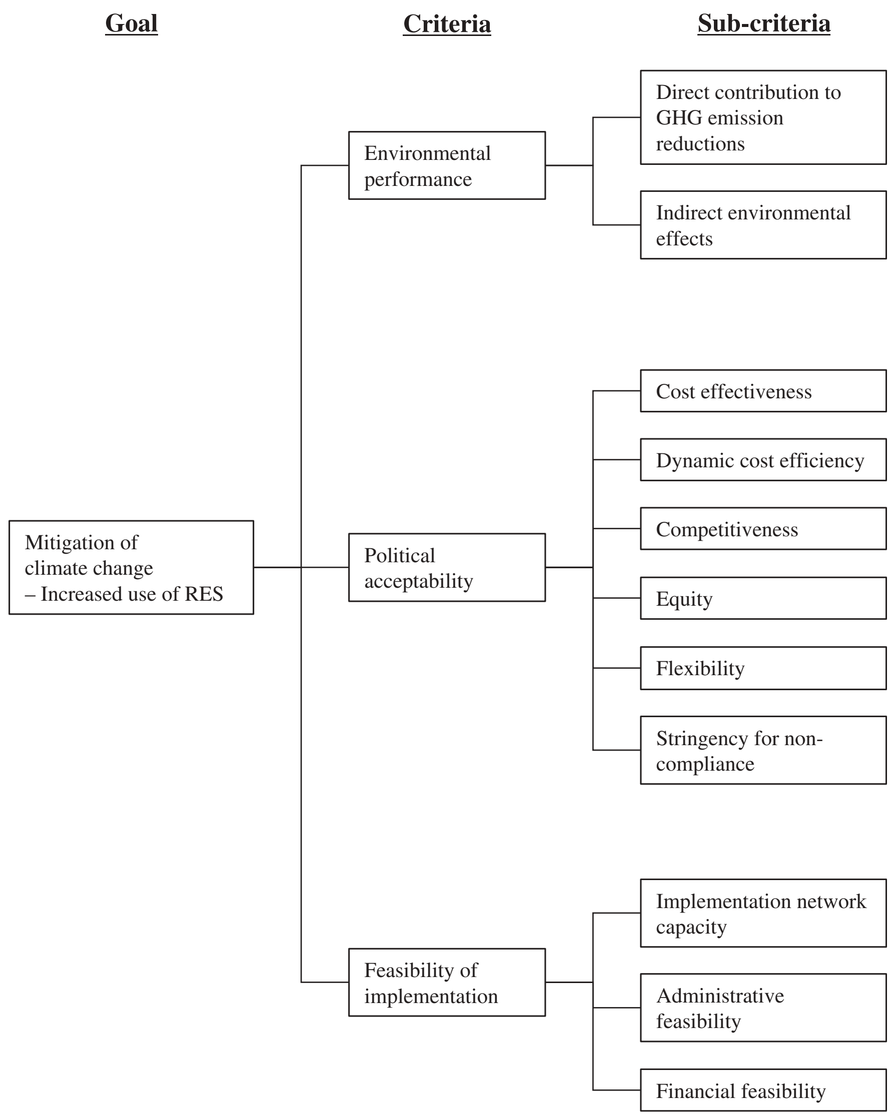

Figure 1. AHP hierarchy in the AMS method (revised version of figures in Konidari and Mavrakis (2006, 2007) and Kambezidis, Kasselouri, and Konidari (2011)).

The AMS evaluation

The two schemes are evaluated against the described criteria/ sub-criteria (Figure 1).

Criterion 1: Environmental performance

Direct contribution to GHG emission reductions: The policy instrument with the highest penetration of RES contributes more to GHG emission reduction. To compare the effect of both schemes, data for the first implementation year were used.

The annual amount of newly installed RES facilities under RPS or FIT is the ideal data for this sub-criterion. For the FIT, the appropriate data are available. For the RPS, it is sometimes difficult to distinguish which RES facility is installed or not under the scheme. Therefore, due to limited data and for consistency with FIT, we used the difference in the capacity between 2002 and 2003 (the year before implementing RPS and the first implementation year). Note that these data are the difference in "total" RES capacity between 2002 and 2003, but not purely counting the effect of RPS and not considering discarded facilities (Table 3).

MAUT is used for assigning the grades through the utility function with the form $y_i = a \times x_i + b$, where x_i is the value of the available data for policy instrument i, y_i is the assigned grade for i, and a and b are coefficients. The respective utility function for this sub-criterion is $y_i = 0.067 \times x_i – 38.877$.[3] The grades show the effectiveness of RPS and FIT under this first sub-criterion. Both contribute to GHG emission reductions, but one has the best performance (grade 100) compared to the other, which has the lowest, i.e., zero.

Indirect environmental effects: The increase in RES is expected to eliminate pollution associated with electricity services (Resch et al. 2005). Therefore, the same amounts

[3] As value x_1 corresponds to the worse performance, the y_1 grade is zero. This forms the first linear equation with coefficients "*a*" and "*b*" unknown. Value x_2 corresponds to the best performance, so y_2 grade is 100. These two equations are used for determining the coefficients of the linear equation. More specifically, x_1 is 582 and its corresponding y_1 is 0 (worse performance), while when x_2 is 2079 then y_2 is 100 (best performance). Based on these pairs of numbers the calculated values of *a* and *b* are those above.

Table 3. RES penetration for the first year of implementation for both schemes.

Policy instruments First year of implementation		RPS 2003	FIT 2012
Difference in RES capacity during the first year of implementation per type (MW)	PV	223	[for households] 1,269 [other than households] 706
	Wind	217	363
	Hydro (small- and medium-scale)	[less than or equal to 1000kW] 22	[1000 kW or more] 1 [less than 1000 kW] 23
	Biomass (including waste)	120	36
	Geothermal	0	1
	Total	582	2,079

with the previous sub-criterion are used considering these effects proportional to their direct contribution in reducing GHG emissions (Kambezidis, Kasselouri, and Konidari 2011; Konidari and Mavrakis 2007).

Criterion 2: Political acceptability

Cost effectiveness: The financial burden of each scheme on the target groups (RES-electricity producers) is expressed for this evaluation through the cost/benefit to generate RES electricity.

For evaluating the RPS, this means to understand what is the actual net cost/benefit for the specific electricity companies to use annually a certain amount of RES electricity. The electricity retailer complies by: self-generation of electricity; purchasing RES electricity from another party; or purchasing RPS certificates (ANRE 2013e). Therefore, the necessary data are about the cost of generating RES electricity, the price at which RES electricity is sold, and the price for RPS certificate.

For evaluating the FIT, only the purchase price of each RES is needed (Table 2). This is justified by the fact that under this scheme electric utilities are obliged to purchase RES electricity produced by the certified producers at a fixed purchase price.

One option for evaluating both schemes would be the comparison of the cost of buying electricity with the price paid for using RES electricity, but target groups that are self-producers for complying with the RPS obligation are not taken into consideration. In addition, generation costs refer to different time periods for both schemes. The more suitable option is to consider all issues and proceed with the qualitative assignment of grades using the SMART approach. Grades are assigned directly based on judgments (justified through the available official information[4]) using a scale from 0 to10 (Konidari and Mavrakis 2006, 2007) and normalized so as to be in equivalence with those from the MAUT approach (that ranges from 0 to 100).

In Japan, PV and wind technologies, compared to other RES technologies, are characterized by very low risks linked with capital cost increases due to rapid advancements (Bhattacharya and Kojima 2012). These are even lower compared to fossil fuel technologies. The capital cost risks for these fuels are high mainly due to increases in the costs of raising capital and continuous technology upgrades. Wind energy is favored option due to comparatively low cost of generation along with very low risk. All RES, except for PV, are less expensive for Japan (Cost Review Committee 2011), but slightly more risky than fossil-fuel-based electricity generation technologies. The waste-to-energy technology option appears as a riskier option of all RES, although Japan is pioneer in this area. Furthermore, its overall generation cost has become highly expensive due to the very high price of the waste collection system. For large hydropower projects, the capital cost risk is the highest in Japan due to high land value and very high costs of rehabilitation, same for nuclear energy. Thus, although PV is the most expensive electricity generation option for Japan, it is still a less risky national option (Bhattacharya and Kojima 2012; Valentine 2011).

Overall risks related to cost of RES technology are very low in Japan because of the availability of highly advanced technology within the country (Bhattacharya and Kojima 2012). However, due to its high labor costs and scarcity of other resources, total generation costs are often very high. Similarly, wind technology is not very expensive in Japan, but because of high costs for land, key materials, and labor, total generation cost is finally expensive (Bhattacharya and Kojima 2012; Valentine 2011).

In 2001, the generation costs were: nuclear power: JPY 5.9/kWh; PV of the mean price (household use): JPY 66/kWh (lowest: JPY 46/kWh); and large-scale wind power: JPY 9–14/kWh (ANRE, 2005). In 2010, METI (2010) provided the following generation costs: PV: JPY 49/kWh; large-scale wind power: JPY 10–14/kWh; hydropower (excluding small scale): JPY 8–13/kWh; thermal power (liquefied natural gas): JPY 7–8/kWh; nuclear power: JPY 5–6/kWh; and geothermal power: JPY 8–22/kWh.

The RPS-equivalent price was around JPY 4.8–5.2/kWh during the implementation period, and was JPY 5.2/kWh in 2003. Note that for PV, electricity is purchased with the price determined based on unit price of electricity that electric utilities are selling according to the voluntary net-metering scheme, which is around JPY 19–23/kWh for residential PV and JPY 10–13/kWh for the others.

By comparing the generation costs for electricity from RES with the purchasing prices, it seems that FIT offers higher financial burden to target groups, but higher financial assistance to RES producers.

[4] The SMART scale is shown in Konidari and Mavrakis (2007).

Grades based on the above information: RPS—7; FIT—6

Dynamic cost efficiency: For this sub-criterion, the variety of RES and information about pilot or national innovations in RES are considered.

The RES types covered by both schemes are similar (see Section 2). However, there is a possibility that FIT covers in the future other RES types.

There was a remarkable increase in PV installations[5] after the FIT introduction (Tables 2 and 3). The market demand for residential PV systems has been continuously increasing due to the double price for electricity generated by PV systems compared to the standard electricity price in November 2009 (Moosavian et al. 2013). Because of this large and rapid introduction of PV, technological improvement is expected to be promoted through learning effect.

Japan holds 55% of the world's RES patent applications followed by United States (22%) and EU (7%) (Kojima and Meisen 2012). Japanese research and development (R&D) in this field is "very advanced" (in academic, public research institutes, and private sector). It has a world leading position for solar cells, wind power, and geothermal generation technologies (Kojima and Meisen 2012). There were proposals when RPS was still in force that the Japanese government should provide more R&D funding about cost effective electricity storage systems, since such technologies would provide intermittent RES technologies an unlimited role in national electricity generation (Valentine 2011).

Grades based on the above information: RPS—6; FIT—7.

Competitiveness: In November 2011—RPS still in effect–, Japan was ranked in the 15th position for all RES (wind power: 23rd; PV: 7th) in the world (Ernst and Young 2011). Compared to other major economies, the country clearly lagged behind in wind power development (Valentine 2011). Japan was unseated in the ranking of 2003 and 2004 (Ernst and Young 2003, 2004), which means it had fallen behind United States and European countries. After the FIT launched, Japan was ranked in the 7th position in all RES (wind power: 14th; PV: 4th) regarding attractiveness of RES investment (February 2013; Ernst and Young 2013a). Later the same year (August), the rankings were improved to 5th in all RES (Ernst and Young 2013b). These ranks are much higher than those before the FIT was enacted. In February 2012 (Ernst and Young 2012), the ranks were 13th in all RES (wind: 22nd; PV: 6th). The FIT improved national competitiveness in RES investments, because the government offered the most generous tariffs in Asia (Webb, Dodd, and Sheehy 2013).

This improvement is justified since the FIT activated the RES markets due to: entry of various industrial sectors irrelevant to energy business; positive stance of banks to finance RES business; and an expectation of energy-related technological innovation (Kitamura 2013). The International Energy Agency and the New Energy and Industrial Technology Development Organization attribute recent improvements in industry to the FIT and to a subsidy reintroduced in January 2009 (Moe 2012). The entry of various sectors concerns industries providing home appliances, information technology, distribution, construction, and agriculture. From the viewpoint of investment, project finances for a period of 20 years and community-based investment involving local financial agencies and civil funds have been created (Morita and Matsumoto 2014).

Japanese PV generation is strategically important, because: Japan demonstrates its strengths as a world leader in technological development and can contribute to the construction of a global low-carbon society enhancing its international competitiveness through further industrial efforts; its massive introduction will reduce the initial investment cost thanks to economies of scale; PV generation is worldwide applicable with ubiquitous solar energy; and batteries of plug-in hybrid and electric vehicles, in which Japan also has technological advantages, can be utilized as storage cells of PV electricity in the future (Committee on Renewable Energy Promotion Policy for Achieving a Low-carbon Society 2009).

In 2010, installed capacity of geothermal power was 535 MW (8th in the world), but geothermal power generation was 3,064 GWh, only 0.2% of all Japanese energy production (Kubota, Hienuki, and Kaieda 2013). The development of geothermal power plants was generally regarded as a high-risk, low-return business, since the RPS did not cover the single and double flash systems used at large geothermal power plants, except for binary cycle power plants (Committee on Renewable Energy Promotion Policy for Achieving a Low-carbon Society 2009). Furthermore, the financial and management risks were high for small- and medium-sized enterprises in particular. Developers of geothermal power plants also face long lead times, with 15 to 20 years between initial planning and starting operation. Legal procedures such as drilling permit applications and environmental impact assessments are time-consuming and entangled in red tape, entailing high labor costs and interest charges (Committee on Renewable Energy Promotion Policy for Achieving a Low-carbon Society 2009).

Under the FIT, the tariffs for PV are very high in international comparison (Table 4; Töpfer and Mans 2012), which is almost three times higher than that of France or Germany, top

Table 4. Comparison of the FIT schemes.

	Feed-in-tariffs for RES types in USD/kWh			
Country	Hydropower	Biomass	Wind	PV
China	0.05–0.07	0.10	0.08–1.00	0.16–0.18
Indonesia	0.07	0.09–0.10	Yet to be introduced	Yet to be introduced
Japan	0.26–0.36	0.14–0.42	0.23–0.59	0.32–0.38
Malaysia	0.00	1.26	Yet to be introduced	0.00–1.08
Mongolia	0.045–0.10	Yet to be introduced	0.08–0.15	0.15–0.30
Philippines	0.13	0.15	0.20	0.22
Thailand	0.03–0.05	0.01–0.02	0.11–0.14	0.21
Vietnam	Yet to be introduced	Yet to be introduced	0.078	Yet to be introduced
Germany	0.04–0.17	0.08–0.33	0.05–0.25	002–0.32
Italy	0.13–0.34	0.16–0.34	0.17–0.38	0.00
UK	0.05–0.33	0.14–0.23	0.06–0.33	0.11–0.24

Source: Webb, Dodd, and Sheehy (2013)

[5] PV systems ranged in scale, from residential rooftop systems with the few kilowatts capacity, up to large "mega-solar" power plants with an output of several megawatts.

RES countries (Kojima and Meisen 2012). Therefore, due to the FIT, Japan will become one of the best business opportunities for RES companies (Töpfer and Mans 2012). The key questions for the sector are how soon (and in what steps) the Japanese government will reduce these tariffs in the coming years so that the required upgrades in grid infrastructure can be done.

The FIT is expected to benefit significantly Japanese solar cell manufacturers, Chinese and other Asian solar cell producers, geothermal technology companies, and foreign wind turbine manufacturers that dominate the local wind energy market in Japan (Burson-Marsteller 2011).

Grades based on the above information: RPS—6; FIT—8.

Equity: It is measured by the cost sharing and the total cost for society. The total cost of introducing RES is smaller under RPS than FIT, since the RES capacity is larger for the latter (Table 3) and the purchase price is set high enough to earn the benefit by introducing RES (Table 1). Concerning the cost-sharing effect, the FIT explicitly introduced the process to adjust the surcharge among electricity consumers, while such process did not exist in RPS. However, similar effect was expected by allowing electric utilities to purchase RES electricity or certificates generated by other facilities in the country, though the unit cost borne by electricity consumers would be different by region. The surcharge under the FIT was JPY 0.22/kWh in FY2012 as described. Nishio and Asano (2003) estimated the additional cost of the RPS as JPY 0.025/kWh in 2003.

The RPS was established with perceived multiple strengths, i.e., less risk in introducing RES electricity, because it sets an obligatory RES amount equitable among electricity utilities; an equitable scheme in cost burden and in market competition; and having cost-effectiveness through market competition among electricity business operators. The RPS legislation has negligible impact on the overall cost of electricity and results in a premium of JPY 0.1/kWh for electricity produced (Valentine 2011).

Grades based on the above information: RPS—8; FIT—6.

Flexibility: The types of RES covered by both schemes are similar with a possibility to add other RES types after coming into effect, although no new types were added under the RPS. For hydropower, the RPS allowed capacity of less than or equal to 1,000 kW, while the FIT also allows that between 1,000 kW and 30,000 kW. For geothermal power, the FIT allows all types/scales, while the RPS allowed the type that did not extremely reduce geothermal resources.

The RPS obligated electric utilities to supply a certain share of their electricity from RES, which was very low (Moe 2012). Furthermore, surplus electricity was banked every year (ANRE 2012c). Thus, utilities had no problem fulfilling this low share. Consequently, RPS put no pressure or provided no incentive for the utilities to undertake the necessary investments to grow the RES amount (Moe 2012; Valentine 2011). The RPS was probably only introduced to pre-empt outside efforts at introducing a FIT (Moe 2012).

Grades based on the above information: RPS—8; FIT—6.

Stringency for non-compliance: It is measured by penalties against violation. RPS and FIT stipulate fines against electric utilities. The amount of fines is similar. Furthermore, the FIT stipulates penalties against the PPCC and SAO.

Grades based on the above information: RPS—6; FIT—7.

Criterion 3: Feasibility of implementation

Implementation network capacity: The implementation network consists of all the relevant public and private institutions (e.g., ministries, agencies, institutes, and NGOs/NPOs) that are responsible for the well implementation of a policy instrument. For both schemes, the institutions are mainly public. The METI is the presiding ministry for both schemes. Other ministries such as the Ministry of the Environment, the Ministry of Agriculture, Forestry and Fisheries, and the Ministry of Land, Infrastructure and Transport have limited roles. Under this point, the ability of personnel, technological infrastructure, and credibility appear to be similar for both schemes.

The difference between the two is that additional entities such as the PPCC and SAO are involved under the FIT, while the RPS Subcommittee was involved for the other. Therefore, the former involves slightly more personnel/organizations. Since important decisions are based on discussions with the related committee and the minutes are open, both schemes are similarly transparent.

The main activities of an implementation network are: dissemination of information to all target groups about the policy instrument; and conduction of controls, audits to ensure compliance of the target groups, and confirmation of progress towards the achievement of the goals. The term "target groups" refers to the entities whose operational activity is planned to be influenced due to the set into force policy instrument (i.e., companies, businesses, factories, industries, and individual consumers). Thus, the larger the implementation network, the more the target groups are facilitated and assisted to compliance. If, however, the personnel of the implementation network are not well trained or do not offer the necessary assistance, it is a disadvantage which lowers its aggregate capacity. In the case of FIT, its implementation was managed to start from 1 July 2012, but proceeded through trial and error due to difficulties, such as certification of facilities, and partly because it was operating for the first time in Japan (Institute for Sustainable Energy Policies 2013). It is implied that the implementation network was not yet ready to proceed with the new scheme. Furthermore, the implementation network does not present a considerable number of reports, studies, and information about either one of the two policy instruments.

The lack of properly skilled workforce for installing and maintaining facilities for large-scale renewables is an obstacle for implementing the FIT (Bret 2014; Katayama, Wakabayashi, and Gladbach 2013). This weakness was revealed in September 2013, when the METI started reviewing major projects that were approved but had experienced long delays. Apart from a delaying factor, this lack is also an opportunity cost: important sub-sectors of promoting RES could have been more developed services and consulting (Bret 2014).

Grades based on the above information: RPS—7; FIT—6.

Administrative feasibility: There are mainly four activities for the implementation of the RPS: the METI determined the

RES targets basically every four years based on discussions by the RPS Subcommittee; electric utilities submitted every year the amount of RES-electricity they were going to use in the coming FY and the amount they used in the previous FY; the RES-electricity facilities were required to be certified so as to supply their electricity; and electronic accounts were operated to register the amount of RES-electricity business operators including electric utilities and RES-electricity producers have.

For the FIT, mainly five activities are necessary: the METI determines the purchase price, periods, and classifications based on the discussions and reviews by the PPCC annually; RES-electricity facilities are required to be certified to supply their electricity; a specific contract and a grid connection contract are necessary between RES-electricity producers and electric utilities to supply electricity; the SAO collects, calculates, and distributes the surcharge to level the burden; and the scheme is reviewed and revised by the legislative branch of the government under the following cases: when the Basic Energy Plan is revised, it is also revised if necessary; it shall be examined at least once every three years; and it shall be revised drastically taking into consideration the enforcement of the scheme by 2020.

Under these perspectives, administrative burden is slightly more for FIT compared to RPS.

Furthermore, the ability of foreign construction firms to obtain appropriate licenses under FIT is tapered given that the approval process is often slow and unwieldy (Katayama, Wakabayashi, and Gladbach 2013). This implies that the administrative procedure creates delays and is time consuming. A Japanese wind power application needs two or more years before a windmill is installed, while for the similar process in the United States, this might last 3–4 months (Moe 2012). Apart from administrative burden, this is also an obstacle for profitability. Similarly, geothermal power application takes around 10 years until it starts operation. Also, small- and medium-scale hydropower application takes 2–3 years to operate the facilities. So far, such procedure is same under both schemes, since both of them treat similar RES.

Grades based on the above information: RPS—7; FIT—6

Financial feasibility: Administrative cost is higher for more complicated policy instrument because of more administrative works (Research Group for Policy Assessment of Regulation 2007). The FIT has the PPCC and SAO, while the procedure to introduce newly established RES-electricity facilities is more complicated (e.g., two contracts are required under the FIT in addition to certifying RES-electricity facilities to supply electricity). On the other hand, the RPS has the RPS Subcommittee and operated electronic accounts to register the amount of RES electricity. Thus, the administrative cost is higher for the FIT, since it has more complicated networks and procedures for contracts and adjusting surcharges.

One more aspect for financial feasibility that can be considered is the funds that a government allocates for RES promotion and that can be linked with the scheme. For Japan, the share of GDP devoted to R&D investment exceeds comparatively that of many other industrialized countries because of the governmental solid commitment to expand R&D, particularly for RES (Aggarwal, Kotin, and Harvey 2012; Greenpeace 2013). In 2008, the government spent USD 3.9 billion (approximately JPY 390 billion) on energy R&D, while 5% of that amount was spent on RES (Aggarwal, Kotin, and Harvey 2012). Now, the government is willing to allocate JPY 6 trillion to cogeneration systems and plans about JPY 38 trillion for RES (30% of the total amount) (Greenpeace 2013).

Grades based on the above information: RPS—7; FIT—6.

Sensitivity analysis

The robustness of the results is tested with sensitivity analysis through two cases (Konidari and Mavrakis 2006, 2007). In the first case, one of the three weight coefficients for the three criteria increases by a certain percentage, a second one decreases by the same percentage, and the third is adjusted properly to these changes. In the second case, one of the three weight coefficients—again for the criteria—remains stable, another one increases gradually, and the third is adjusted again due to these changes. In both cases, the increase continues until there is a change in the order of the ranking. Also, the changes occur as long as each weight coefficient is less than 1 and more than 0.

For the first case, the ranking remains the same for: (i) an increase by 90% to the first weight coefficient (environmental performance) and the same decrease to the second one (political acceptability) (values for weight coefficients: 0.319 (environmental performance)—0.074 (political acceptability)—0.607 (feasibility of implementation)); (ii) an increase by 15% to the second weight coefficient and the same decrease for the first one (values: 0.143–0.849–0.0085); (iii) an increase of the first one by 90% and an equal decrease for the third one (values: 0.319–0.671–0.009); (iv) 6% increase of the second one and same decrease for the third one (values: 0.127–0,785–0.087); (v) 23% increase of the third weight coefficient and the same decrease for the first (values: 0.129–0.755–0.115); and (vi) 90% increase for the value of the third weight coefficient over the same decrease for the second one (values: 0.748–0.074–0.179).

For the second case, the ranking remains the same for: (i) 300% increase for the first weight coefficient with the third one stable (values: 0.672–0.234–0.094); (ii) 50% increase for the first weight coefficient and stable value for the second one (values: 0.252–0.738–0.01); (iii) 12% increase for the second weight coefficient and stable value for the first one (values: 0.168–0.827–0.005); (iv) 500% increase for the third weight coefficient and stable value for the first one (values: 0.168–0.221–0.611); (v) 5.5% increase for the second weight coefficient and stable value for the third one (values: 0.127–0.778–0.094); and (vi) 40% increase for the third one and stable value for the second one (values: 0.130–0.738–0.132).

The second criterion is more sensitive due to the higher value of its weight coefficient, but the ranking is robust for the majority of the changes and for rather high increases. In addition, there are only two policy instruments compared which makes it more sensitive for this criterion compared to the case of a larger number of evaluated policy instruments, while a higher percentage was not acceptable due to the limitation of the acceptable range of values (lower limit: 0, upper limit: 1) (Konidari and Mavrakis 2006).

Evaluation by experts

There are several approaches that address public perception or elicit expert opinion for a certain issue. Surveys are one of them

Table 5. Attributes of the selected experts.

Experts	Attributes
A	The expert A is a professor at a university in Japan. The research area of this expert is environmental economics, particularly on carbon tax and renewable and nuclear energy policy.
B	The expert B is a government officer in an environmental ministry. The expert has experience in working at different divisions in the government. The particular expertise of this expert is climate change and renewable energy policy in global and local levels.
C	The expert C is a government officer in an economic and industry ministry. The expertise of this expert is energy and resource issues.
D	The expert D is an independent consultant on energy and environmental policy. The expert has also experience in working at a private consulting company. The expertise of the expert is particularly climate change and renewable energy policy in the local level.
E	The expert E is a researcher in an NPO on renewable energy. The expert is expertise in environmental economics and renewable energy policy.

Table 6. AMS results for each scheme.

Criteria/sub-criteria (weights)	RPS	FIT
Direct contribution to GHG emission reductions (0.833)	0.000	83.300
Indirect environmental effects (0.167)	0.000	16.700
Environmental performance (0.168)—A	**0.000**	**100.00**
Cost effectiveness (0.474)	28.998	18.302
Dynamic cost efficiency (0.183)	7.042	11.158
Competitiveness (0.085)	3.289	5.211
Equity (0.175)	12.515	4.985
Flexibility (0.051)	3.576	1.424
Stringency for non-compliance (0.032)	1.316	2.084
Political acceptability (0.738)—B	**56.735**	**43.165**
Implementation network capacity (0.309)	18.944	11.956
Administrative feasibility (0.581)	35.619	22.481
Financial feasibility (0.110)	6.744	4.254
Feasibility of implementation (0.094)—C	**61.307**	**38.693**
Total (A + B + C)	*47.634*	*52.293*

that has been adopted for energy or climate policy issues (Carrera and Mack 2010; Geneletti 2010). It is considered useful since: the expert interviews allow the collection of information on the reasoning behind their judgments concerning details on the examined issue (Carrera and Mack 2010); the focused and well-planned questions are directly relevant to the planning and management process (Geneletti 2010); and it cannot be taken as representative of society as a whole, but instead seeks to define or expand on different aspects of national attitudes towards energy issues. The number of experts in similar research work ranges from 1 up to 25 (Krueger et al. 2012).

For this paper, the authors implemented a survey targeting Japanese experts in climate and energy policy so as to compare the outcomes of their analysis based on publicly available data and information, and those opinions. This survey aims to verify the AMS outcomes regarding the strengths/weaknesses of the two schemes. A questionnaire was sent to five persons representing different Japanese stakeholders in the energy sector (ministries, researchers/professors, consultants, and NPOs). The attributes of these five experts are summarized in Table 5. Because they answered to the questionnaire on the condition of anonymity, the specific information of the experts is not shown. We selected these five experts to gather a broad range of answers (opinions) on the RPS and FIT schemes from different position, philosophy, and expertise in energy and environment.

The questionnaire is composed of three open-ended questions. They were asked to: describe three strengths and weaknesses of FIT and RPS, and the reasons; describe the most significant outcome of the two, and the reasons; and evaluate the two schemes from their institutional aspects and outcome, and the reasons. These persons did not know the AMS outcome. Also, they were not informed for the criteria/sub-criteria of the method so as to answer by their own words, without being restricted to the definitions.

Results

AMS results

Based on the aforementioned grades for each sub-criterion, the total grades for evaluating the performance of each of the two schemes were calculated (Table 6; multiplying grades and weight coefficients and summing up outcomes). As the results indicate, the FIT received higher total grade, mainly due to its higher environmental performance.

Experts' evaluation

From the answers to the questionnaire, there is an agreement among them that the FIT is more effective in the RES promotion. There is also an agreement regarding the following strengths for the FIT. This scheme allows the rapid RES penetration (corresponding to environmental performance), which in turn will allow the growth of the RES industry (competitiveness). There will be cost reduction because of advantage of scale by producing a large amount of RES facilities (cost effectiveness), while the electricity price will increase favoring RES (competitiveness). Since RES installers and investors can definitely know the future price under the FIT, they can invest and financial institutions can give a loan to them with favorable conditions; and they can also estimate their return on investment and make their investment plans (dynamic cost efficiency and competitiveness). The transaction costs for electricity selling contracts are reduced and the internal rate of return is ensured for certain period (cost effectiveness).

Regarding its weaknesses, there is difficulty in setting the proper purchase price, since it can be determined in an arbitrary manner (implementation network capacity). Another weakness is its transparency (implementation network capacity). Also, RES are introduced unevenly in the resource-rich regions such as in Hokkaido. Thus, the capacity of the electric system will easily be tight, and controlling the electric systems becomes difficult as a result, which has already appeared (equity and implementation network capacity). Because of the increase in the electricity price due to the surcharge compared to other related schemes, the FIT is not popular to society (political acceptability). Imposing the cost of purchasing RES to electricity consumers as in Germany is a reasonable way, though it tends to be criticized by target groups that are not in favor of it. Ironically, the surcharge increases as the scheme succeeds. Another weakness is that since RES facilities are mainly introduced by well-heeled companies which can afford to invest for RES, profit will not return to the local people (equity). Under the FIT, no public funding is disbursed to promote RES, since there is mutual cooperation among electricity consumers (financial feasibility). Further, so far, the FIT has only contributed in promoting specific RES in Japan, i.e., PV (flexibility).

For the RPS, the strengths pointed out by the respondents were the following. Unlike FIT, it is easier to control the electric system, because the installation of RES electricity could be planned directly by quantity so as to reflect the "best mix" that the government considered (administrative feasibility and flexibility). It means that if the target had been sufficiently high, it could have promoted installation of RES facilities as experienced in United States. Since RES were installed considering the total system, rational installation of RES was possible by this scheme. It was possible for electric utilities to establish a new unit for "RES," but as being a team for RES. Electric utilities had motivation to take initiative for introducing RES.

However, the introduction of RES was slow (criterion: environmental performance and sub-criterion: dynamic cost efficiency), since the target was low due to political reasons allowing flexibility. This resulted in low purchasing prices of RES electricity (or certificates), so that RES-related companies could not earn enough profits, becoming difficult for them to continue business (cost effectiveness and competitiveness), while it did not increase electricity price for consumers. In addition, RPS blocked newcomers' access due to risks and low returns in selling RES electricity (equity and competitiveness). Furthermore, since it is a quantitative scheme and the price of RES was not clear in advance, the price risk was high (and the risk premium becomes high). It results in higher cost for RES investors. Under the RPS in Unites States, only large scale wind energy is promoted compared to other RES types, while small scale projects are also promoted under the FIT introduced not only in Japan but also in other countries (dynamic cost efficiency). A monopoly issue was set for the RPS due to imbalance between sellers and buyers. Buyers tended to be in weaker position (equity).

Discussion

Discussion on AMS outcomes

The performance of the two policy instruments is close. The FIT has a clearly better "environmental performance," since it contributed to the explosive growth of RES. Looking at the other sub-criteria, the strengths of the RPS are equity and flexibility in which it scored more than half compared to the grades of the FIT. The FIT does not show strengths in the same manner. The RPS is more cost efficient, and its feasibility of implementation (specifically administrative and financial) is better than the FIT. Another outcome worth mentioning is that for most of the sub-criteria, the authors used qualitative information and not quantitative data due to their lack. This point is different from previous studies (Kambezidis, Kasselouri, and Konidari 2011; Konidari and Mavrakis 2007). This shows the flexibility of the AMS method.

Discussion on experts' views

Comparing our analysis by the AMS with the experts' answers, we can see similarities. For example, the FIT received a higher evaluation from the point of contributing to extreme increase of RES, since the predetermined purchasing prices allow RES installers and investors to safe investment for expensive RES facilities. The RPS received a higher evaluation from the point that it is possible to install RES considering the total electricity system, since it controls the amount by determining quantitative targets.

One respondent answered that the important point was to introduce more appropriate scheme depending on the stage of electric market. The appropriate order would be first to introduce the RPS to accumulate knowledge of RES by electric utilities, and then to introduce the FIT to further promote RES. The FIT should not last long term, but should be replaced by other supporting policies when the cost of introducing RES is reduced. On the other hand, another person answered that at the initial stage, the FIT is highly effective to reduce the business risk and to promote the investment. After the market becomes mature, it is difficult to say which scheme is appropriate. As this discussion suggests, it is even difficult for the experts to judge which scheme is really effective.

Conclusions and policy implications

In this study, we evaluated two policy instruments for RES in Japan applying AMS. As shown under the evaluation process, both the FIT and the RPS have strengths and weaknesses. In Japan, the FIT has proven to be more effective in delivering the objectives, even for the short period that is in force, mainly due to its high environmental performance. On the other hand, the RPS had significant strengths in cost effectiveness, equity, flexibility, and feasibility of implementation. This study also showed that the AMS captured the preferences of the experts in the various positions within the environmental and energy policy who we implemented the questionnaire survey. It is worth mentioning that both approaches have shown the same outcomes, the one with a quantitative result and the other qualitatively.

Since importance of RES has been increasing globally to combat climate change, it is expected that more policies for enhancing RES will be introduced around the world. Although there are many types of RES policy instruments, RPS and FIT are the two major ones. This study gives a suggestion that FIT is overall superior to RPS when comparing them through their relative strengths and weaknesses. Furthermore, FIT can be more effective by improving its weaknesses as these were proved by the AMS evaluation (e.g., feasibility of implementation), for example by learning from the administrative institutions and networks of RPS. However, the current FIT scheme can be replaced by other schemes such as a net metering scheme and a reverse auction system in the future. Actually, in Japan, the reverse auction system will be introduced for large-scale PV facilities (2,000 kW or larger) within the FIT scheme from FY 2017. The AMS method and the results of this study are applicable for the future. First, any future schemes that will be set in force after the FIT needs to be designed in such a manner so as to overcome the weakness of the current FIT identified by the AMS analysis. Second, the AMS method is applicable to evaluate such a new RES scheme and to compare it with the existing schemes. Finally, we can learn from the experience of other countries introducing a new scheme on ahead. This means that by evaluating such a progressive scheme in other countries by the AMS, countries that follow can decide what scheme to be introduced and also revise the weakness of it.

From the methodology perspective, by using the AMS, the users such as policymakers can realize the strengths and weaknesses quantitatively in a systematic manner and proceed with justified policy recommendations for improving the examined policy instruments. This method is also useful for prior evaluation of multiple policy instruments that are to be introduced.

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Appendix A. Criteria of the AMS

The following definitions of the criteria/sub-criteria reflect environmental, social, financial, institutional and administrative aspects and are based on Konidari and Mavrakis (2006, 2007).

1. *Environmental performance* is defined as the overall environmental contribution of the policy instrument towards the goal. Assessment under this criterion is based on the two sub-criteria:

(a) *Direct contribution to GHG emission reductions*—synthesis and magnitude of GHG emissions reductions directly referred to and attributed only to the policy instrument;

(b) *Indirect environmental effects*—ancillary outcomes attributed only to the policy instrument.

2. *Political acceptability* is defined as the attitude of all involved entities towards the policy instrument. Assessment is facilitated through its six sub-criteria:

(a) *Cost effectiveness*—property of the policy instrument to achieve the goal under the perspective of a financial burden acceptable and affordable by the involved entities in using RES (target groups);

(b) *Dynamic cost efficiency*—property of the policy instrument to create, offer or allow compliance options that support research projects, incremental and radical pioneer technologies and techniques, and institutional or organizational innovations leading to increase in RES;

(c) *Competitiveness*—capacity of the entity to compete, under the particular policy instrument/, via price, products or services with other entities and maintain or even increase the magnitude of specific indicators describing its financial performance;

(d) *Equity*—fairness of the policy instrument in cost sharing, compliance costs and benefits among entities for increasing RES. This equity can be divided into sector and social equity. *Sector equity* is the perceived fairness between different national sectors. *Social equity* is the perceived equity between different groups of society;
(e) *Flexibility*—the property of the policy instrument to offer a range of compliance options and measures that entities are allowed to use in achieving the purposes under a time frame adjusted according to their priorities;
(f) *Stringency for non-compliance*—level of rigidity determined by provisions of the policy instrument towards entities that failed to comply or did not participate to its implementation.

3. *Feasibility of implementation (or enforcement)* is defined as the aggregate applicability of the policy instrument linked with national infrastructural (institutions and human resources) and legal framework. Assessment is based on the following three sub-criteria:

(a) *Implementation network capacity*—ability of all national competent parties to design, support, and ensure the implementation of the policy instrument. The capacity of the network is based on its trained personnel, technological infrastructure, credibility and transparency. The trained personnel concern the national human resources capable in supporting implementation of the policy instrument. Technological infrastructure is the set of available technologies and techniques within the country that can be used for supporting implementation. Credibility is defined as the accuracy and consistency that characterize its activities, mainly measurements and elaboration of data necessary for implementation, promotion, and steering of national compliance efforts. Transparency is defined as the openness of the implementation network towards target groups in providing them with clear information for the implementation of the policy instrument and methods of operation.
(b) *Administrative feasibility*—aggregate work exerted by the regulatory implementation network during the enforcement of the policy instrument;
(c) *Financial feasibility*—property of the policy instrument to be implemented with low overall costs by the pertinent regulatory authorities.