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This is the accepted version published as:

Buckman, G. The effectiveness of Renewable Portfolio Standard banding and carve-outs in supporting high-cost types of renewable electricity.

Energy Policy 39.7 (2011): 4105-4114

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A definitive version was subsequently published in *Energy Policy*, vol. 39, issue 7, (July 2011) doi:10.1016/j.enpol.2011.03.075

The Effectiveness of Renewable Portfolio Standard Banding and Carve-outs in Supporting High-cost Types of Renewable Electricity

Article for *Energy Policy*

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23.3.11

7,120 words

ABSTRACT

Renewable Portfolio Standards (RPSs) are renewable electricity (RES-E) subsidy mechanisms in which governments mandate how much RES-E should be generated and markets determine the cost of the subsidy needed to generate the RES-E. Two modifications of the RPS that can help support high-cost types of RES-E are banding, where governments mandate higher multiples of RPS tradable certificates for high-cost types of RES-E, and carve-outs, where governments prescribe a part of an RPS target that can be met only by a particular type, or types, of RES-E.

This paper analyses the design and generation performance of banding, as used in the UK, with some reference to Italy; and carve-outs, as used in the USA. To date, there is insufficient experience of either device to reach firm conclusions about their generation effectiveness. However, there is early, tentative evidence that banding is successful at supporting high-cost types of RES-E in the UK. Carve-outs are not being fully exploited in US states that use an RPS mechanism, and Italy is using banding in a fairly insignificant way. Though both devices have different design strengths and weaknesses, and either could be adapted to specific RPS markets, banding is probably the better device for supporting high-cost RES-E.

Key words: renewable electricity, banding, carve-outs.

Abbreviated title: 'Carve-out and banding effectiveness'

1. Introduction

Renewable electricity (RES-E) is assuming increasing policy importance around the world because it is considered a significant means by which greenhouse gas emissions can be reduced (Mendonca et al., 2010). However, RES-E currently generally costs more to generate than electricity generated by fossil fuels without a carbon price (although this can depend on the technology in question and the site where RES-E is located). Several different support mechanisms have evolved that subsidise RES-E so that it can overcome its generation cost disadvantage with fossil fuel generated electricity. Two of the most popular use subsidies financed by electricity consumers. They are: Feed-in Tariffs (FITs), in which governments mandate a level of subsidy and markets determine how much RES-E is generated; and Renewable Portfolio Standards (RPSs), in which governments mandate how much RES-E is generated and markets determine the price it is to generated for (either through the spot market trade of RES-E generation certificates or through contracted certificate trade) (Finon, 2006). FITs are generally differentiated – and therefore pay a different subsidy per unit of generation of different types of RES-E (ie wind, solar, biomass etc) – whereas RPSs are generally not differentiated and pay the same subsidy regardless of RES-E type.

Because RPSs are generally undifferentiated, they support low-cost types of RES-E and give no incentive for high-cost types of RES-E to be purchased. However, as the reduction of greenhouse gas emissions assumes increasing importance, the RPS mechanism is being called upon to support the full range of RES-E types, including high-cost types. This is because high-cost RES-E types often have significant generating potential which will need to be developed if a large proportion of a country's electricity is to be generated by RES-E. Examples are offshore wind in the United Kingdom and solar in Australia (Secretary for Energy and Climate Change, 2009, p. 44; Garnaut, 2008, p. 486). This article discusses and analyses two RPS design devices that can allow this to happen: banding and carve-outs. *Banding* is a device in which different multiples of tradable certificates are issued for each unit of generation depending on the type of RES-E. *Carve-outs* are parts of an RPS market that are reserved for particular RES-E types: they are, effectively, RPS submarkets.

Several authors have compared the RPS mechanism to the FIT one (Mitchell et al., 2006; Butler and Neuhoﬀ, 2004; Toke, 2005) while others have analysed a country, or group of countries, that use RPS mechanisms (Van der Linden et al, 2005; Kaberger et al., 2007). Others, still, have considered particular aspects of RPS design (Agnolucci, 2007; Kildegaard, 2008). However, none have compared the effectiveness of banding and carve-outs.

Section two of this paper discusses the evolution, and global use, of the RPS mechanism; section three discusses the strengths and weaknesses of an undifferentiated RPS. Section four analyses the use of banding in the United Kingdom and Italy while section five analyses the use of carve-outs in the United States of America. Section six compares the strengths and weaknesses of banding and carve-outs, and section seven concludes.

2. History and use of the RPS

The RPS was originally developed in the USA in the late 1990s: about ten years after the FIT was established. As shown in Table 1, the RPS is less extensively used around the world than the FIT, especially at a national level. The RPS is popular in North America while the FIT is extensively used in Europe. Neither the RPS, nor the FIT, is widely used outside those two continents although there is limited use of both in Asia and some use of the FIT in Africa and Central/South America.

Compulsory RPS mechanisms have been adopted by half of the states in the USA as well as by the District of Columbia. They have also been adopted by three of the 13 provinces and territories of Canada; are deployed in Belgium, Italy, Sweden, the UK, Romania and Poland; are used in Japan, Thailand and Australia; and have been used in six states in India.

Table 1: RPS and FIT jurisdictions around the world, 2008

<i>Region</i>	<i>No. of countries using an RPS</i>	<i>No. of sub-national governments using an RPS</i>	<i>No. of countries using an FIT</i>	<i>No. of sub-national governments using an FIT</i>
Europe	5	0	28	0
North America	0	27	0	3
Central and South America	1	0	5	0
Asia	3	5	6	12
Middle East	0	0	1	0
Pacific	1	0	0	5
Africa	0	0	3	0
Total	10	32	43	20

Source: Renewable Energy Policy Network, 2009; Wiser and Barbose, 2008.

The RPS mechanism generally involves an obligation on electricity retailers to purchase a government pre-determined proportion of their sales as RES-E, either directly from RES-E generators via contracts, or indirectly via RES-E open market tradable certificate sales (which typically represent one megawatt-hour of RES-E generation). The organisation that did the most to develop the RPS was the American Wind Energy Association (AWEA). It wanted a mechanism that was compatible with deregulated electricity markets. It also wanted a mechanism that would be acceptable to the US Congress which, in the late 1990s, was dominated by the Republican Party. The FIT was not considered politically acceptable in the USA at the time. The 1995 commencement of trading of sulphur-dioxide emission licenses under quantity-based rules enshrined in the nation's *Clean Air Act* — the predecessor of greenhouse gas emissions trading widely viewed in the US as a cost-effective way of reducing sulphur-dioxide emissions — also influenced the US renewable energy political landscape of the time (Wood, 2007, p. 2). The AWEA official most credited with developing the mechanism, Nancy Rader, argued that 'the flexible, market-based implementation of the standard would ensure achievement of policy goals at least cost' (Rader and Norgaard, 1996, p. 44).

3. Strengths and weaknesses of an RPS

Particularly when compared to the FIT, the big advantage of an RPS mechanism is its theoretical ability to contain RES-E subsidy costs. This is achieved through its dictation of the quantity of RES-E that is to be provided, as well as through its incentive to source least-cost types of RES-E. Menanteau et al (2003, p. 810)

argue that quantity based systems like an RPS give governments direct control over the amount of installed RES-E capacity and, therefore indirectly, over the marginal cost of RES-E production. Finon (2006, p. 331) similarly argues that one of the strengths of an RPS is the possibility it provides for the control of collective subsidy costs. This theoretical ability to contain subsidy costs means that RPS mechanisms have a high *static efficiency*: the ability to contain short-term costs without regard for longer term cost consequences. It is also argued that the use of non-compliance penalties — fees imposed when electricity retailers do not purchase the required amount of RES-E — further enhance the static efficiency advantage of an RPS (Finon, 2006, p. 331). Other theoretical strengths of an RPS include the fact that through allowing all RES-E generators, and all electricity retailers, to buy and sell into the same market they are better than FITs at allocating marginal generation costs across a market (Menanteau et al, 2003, p. 803). A further theoretical strength is that, because the RPS is a mechanism that assumes a separation between RES-E production and consumption, is better suited to unbundled liberalised electricity markets where generators and distributors are not vertically integrated (Finon, 2006, p. 328; Menanteau et al, 2003, p. 809).

However, the theoretical strengths of an RPS are challenged by many commentators. While the RPS may have a theoretical cost containment/static efficiency advantage over an FIT, many argue this advantage is more than outweighed by the risk premium that RES-E generators demand in an RPS market. The risk premium is a product of RPS tradable certificates trading for uncertain, and potentially volatile, prices which reduces the ability of an RES-E investor to attract loan finance which they compensate for by selling generation certificates at a premium (Menanteau et al, 2003, p. 810; Finon, 2006, p. 332). The existence of this risk premium led Butler and Neuhoff (2004, p. 13) to conclude that, over the lifetime of a wind generator, the resource adjusted cost of the FIT subsidy it attracted in Germany was less than the equivalent RPS subsidy extended to a generator in the UK. Toke (2005, p. 30) also concluded that there was no evidence that the UK RPS supplies RES-E less expensively than an FIT. Similarly, Mitchell et al (2006, p. 304) argued that, although FITs and RPSs had similar volume risks, RPSs had higher price risks.

A second major criticism of the RPS holds that because it only incentivises least-cost RES-E, it lacks *dynamic efficiency*: the reduction of long-run marginal

costs through the development of less mature RES-E types (Finon, 2006, p. 318; Menanteau et al, 2003, p. 805; Jaffe et al., 2005). As shown in Table 2, the generating costs of solar photovoltaic, solar thermal and offshore wind are currently much higher than those of onshore wind and biomass using steam, so any mechanism, like an RPS, that is focused on the subsidisation of least-cost RES-E types will not provide much support to them. This criticism of the RPS is sometimes extended through an argument that says that not only does the RPS only incentivise least-cost RES-E, but because, in undifferentiated form, it provides a homogeneous subsidy to all types of RES-E, it tends to oversubsidise mature, least-cost types of RES-E whilst undersubsidising less mature, high-cost types of RES-E (Toke, 2007, p. 283).

Table 2: 2005 generating costs of RES-E.

<i>RElec technology</i>	<i>Generating cost: US\$/MWh</i>
Onshore wind	\$40 - \$90
Biomass	\$30 - \$120
Geothermal	\$40 - \$100
Ocean	\$80- \$400
Solar thermal	\$120 to \$450
Solar photovoltaic	\$250 to \$1600

Source: Intergovernmental Panel on Climate Change, 2007, p. 293.

As climate change awareness has grown, the inability of the RPS to support a wide range of RES-E types has been increasingly seen as a significant weakness of the mechanism. In 2008, the United Kingdom government (which began using an RPS in 2002, called the ‘Renewables Obligation’ (RO)) said: ‘We acknowledge that in the past the overall effectiveness of the RO has been hampered by the fact that it did not incentivise a sufficiently wide range of technologies’ (Department for Business Enterprise and Regulatory Reform, 2008a, p. 91). Governments that have tried to address the dynamic efficiency weakness of the RPS mechanism have either opted to use another mechanism to support high-cost types of RES-E, like an FIT or budget financed subsidies, or have redesigned their RPSs so that they include banding or carve-outs. Amongst governments that have redesigned their RPS mechanisms, carve-outs tend to be preferred in North America while banding tends to be preferred in Europe.

4. The use of banding in the United Kingdom and Italy

Examination of the experience of banding in particular countries is instructive; two countries that have attempted to make significant use of the device are the United Kingdom and Italy.

4.1 The use of banding in the United Kingdom

The country that has most enthusiastically embraced RPS banding is the United Kingdom. After extensive public consultation, in April 2009 it introduced the banding tradable certificate multipliers shown in Table 3 (although, when originally announced, the offshore wind multiplier was 1.5, not 2). In April 2010 it also introduced an FIT for small scaled RES-E generation of less than 5 MW capacity (which cannot also be subsidised through the RPS). As shown in Table 3, emerging and post-demonstration RES-E types receive more tradable certificates per unit of generation than referenced and established types. However, RPS banding in the UK may end up having a relatively short life: in December 2010 the country's Department of Energy and Climate Change released a consultation document on possible electricity market reforms in which it stated that the government's 'preferred package' of reforms included a premium based FIT which it argued was the type of RES-E support mechanism that would work most effectively with its current greenhouse gas emissions trading system (Department of Energy and Climate Change, 2010c, p. 111).

Table 3: UK RPS banding rates, 2009.

<i>RES-E type</i>	<i>Banding multipliers (tradable certificates per MWh)</i>	<i>UK government classification of RES-E type</i>
Landfill gas	0.25	Established
Sewage and biomass cofiring	0.5	Established
Onshore wind, hydro, other cofiring	1.0	Reference
Regular biomass	1.5	Post-demonstration
Offshore wind, dedicated biomass	2.0	Post-demonstration
Wave, solar PV, geothermal	2.0	Emerging

Source: Enviro, 2009; Department for Business Enterprise and Regulatory Reform, 2008a and 2008b.

The UK banding rates were mainly based on short and medium term RES-E generating costs calculated by Ernst and Young (2007). However, the offshore wind rate was revised after new generating cost projections were made for that type of

RES-E by Ernst and Young in 2009 and a new sewage and co-firing band was introduced after public consultation on the originally proposed banding rates (Department for Business Enterprise and Regulatory Reform, 2008b). When setting the banding rates, the UK government made it clear that it was not its intention ‘to provide all projects with exactly the support level they need’. It argued that doing so would not necessarily incentivise RES-E developers or recognise the future limits of the resources some RES-E types rely on (Department for Business Enterprise and Regulatory Reform, 2008a, p. 8). For most types of RES-E, the new tradable certificate multipliers applied to generators who received accreditation after the banding device was foreshadowed in July 2006. RES-E generators accredited before that time were grandfathered with one tradable certificate per MWh of generation, except for biomass and mixed waste generators which received banded certificate rates regardless of when they were established (Department of Energy and Climate Change, 2008, pp. 17 – 20).

Under an RPS, RES-E generators derive their income from two sources: the wholesale price of electricity, which all electricity generators receive, and the sale of tradable certificates (by contract or on spot market), that only RES-E generators receive. This means RPS tradable certificates cover the part of RES-E generating costs that is not covered by the wholesale price of electricity. Table 4 therefore shows the 2006 (or 2009 in the case of offshore wind) RES-E generating costs determined by Ernst and Young, as well as their projected 2020 generating costs, less the average wholesale price of electricity in the UK in the first quarter of 2009 (£47/MWh). It also shows the relationship of those net generating costs to the net generating cost of the reference large onshore wind and how that relationship compares to that of the different tradable certificate multiplier rates compared to large onshore wind’s.

Table 4: Current and future estimated RES-E generating costs of selected RES-E types and relationship to their United Kingdom 2009 banding rates.

<i>RES-E type</i>	<i>2006 or 2009 medium levelised generating cost less wholesale price of electricity: £/MWh (2007 or 2009 £)(1)</i>	<i>Ratio of 2006 RES-E generating cost to 2006 large onshore wind generating cost (2)</i>	<i>2020 medium levelised generating cost less wholesale price of electricity: £/MWh (2007 £)(3)</i>	<i>Ratio of 2020 RES-E generating cost to 2020 large onshore wind generating cost (4)</i>	<i>2009 tradable certificate multiplier rates (tradable certificates per MWh of generation)(5)</i>
Sewage gas	16.1	0.77	16.1	0.83	0.5
Landfill gas	1	0.05	1	0.05	0.25
Large onshore wind (high and low wind average)	21	1.0	19.5	1.0	1.0
Regular biomass	43	2.05	48	2.46	1.5
Offshore wind	97	4.62	38	1.95	2.0
Tidal	134	6.38	90	4.62	2.0
Wave	152	7.24	104	5.33	2.0
Solar PV	588	28.0	397	20.36	2.0

Source: Ernst and Young, 2007, (cols. 1 and 3); Department for Business Enterprise and Regulatory Reform, 2008a, (cols. 1, 3 and 5); Ernst and Young, 2009, (cols. 1 and 3); author's calculations, (cols. 2 and 4).

The author calculations in Table 4 show that for all non onshore wind types of RES-E, apart from landfill gas, the ratio of its banding rate to that of onshore wind is lower than the ratio of its 2007 (or 2009) net generating cost to onshore wind's. When it comes to net 2020 generating costs, the ratio of banding rates to onshore wind's is still lower than that of net generating costs for all RES-E types apart from landfill gas and offshore wind. Those two RES-E types are therefore the ones that the UK's banding is most generous to. The poor relationship of the banding rates of the other RES-E types, when compared to net generating costs, especially solar PV's, is probably a product of the UK government wanting to create an ongoing incentive to develop decreasing generating costs for those RES-E types, as well as a possible fear that a high banding rate would make the scheme very costly. It may also reflect a prediction that most solar PV generators, and some generators of the other RES-E types, will elect to be subsidised under a new FIT for generators up to 5 MW in capacity that began in April 2010.

It is clear from Table 4 that the projection of RES-E generating costs by governments is pivotal to the effectiveness of banding. It could be argued that this introduces a significant level of risk into the mechanism and that poor cost projections could make banding impotent, or overly generous, to some RES-E types. However, it has to be remembered that undifferentiated RPS markets are

overly generous to some RES-E types whilst not being generous enough to others. Toke (2007, p. 283), for instance, argues that because RPS mechanisms have a homogenised tradable certificate price, they tend to oversubsidise mature, inexpensive RES-E types while undersubsidising more expensive types. This means that, if well constructed, a banded RPS can more closely align tradable certificate creation with RES-E generating cost relativities compared to an undifferentiated RPS, but it could also mean that a poorly constructed banded RPS could make them less well aligned.

The adoption of RPS banding was a major policy change for the UK government; as recently as 2001 it had declared that ‘banding would be too rigid an approach for a long-term policy such as the [Renewables] Obligation, and would require the Government to dictate the contribution of each energy source. This approach would be contrary to the market-led basis of the Obligation’ (Department of Trade and Industry, 2001, p. 26). This was despite the fact that extensive public consultation, held before its RPS was introduced, supported the introduction of banding (Foxon and Pearson, 2007, p. 1543). The government’s change from an unbanded RPS was largely prompted by its desire to support significantly more wind generation, particularly offshore wind. The UK government has an official RES-E target of a 20% share of all electricity generation by 2020, although it has only set interim targets through to 2015-16 (the target for that year is 15.4%) (Mitchell et al, 2011). However, as part of a European Union goal of sourcing 20% of all energy use (electricity, heat and transport) from renewable sources by 2020, it is committed to sourcing 15% of all its energy from renewable sources by 2020. In order to comply with this, there is an unofficial aspiration to source 30% of the country’s electricity from RES-E by 2020 about 70% of which the government hopes will be generated by wind (both onshore and offshore) and about a third of which it hopes will be generated by offshore wind (Secretary for Energy and Climate Change, 2009, pp. 44, 52). In 2007 the UK sourced 5.1% of its electricity from RES-E (European Commission, 2010).

Table 5 shows the change in the RES-E generation covered by the UK RPS between 2006, when banding was announced, and 2009, the year when it commenced. The largest increases in generation were recorded by offshore wind, onshore wind and biomass. Of these, offshore wind and biomass are the standouts because onshore wind did not receive any increase in tradable certificates per unit of

generation under banding. So while there is too little significant data to say definitively say how successful the UK's banding has been at putting the country on a path to achieving its ambitious unofficial 2020 RES-E generation goal, the Table 5 results suggest a credible start has been made. It should be noted that solar PV in the UK during the 2006 to 2009 period was assisted through a government grants program and its RPS was not necessarily the key driver of its increased generation. Also worthy of note is that co-firing is limited to a maximum of 12.5% of the generation accounted for by the UK's RPS (Mitchell et al, 2011).

Table 5: Change in RES-E generation under United Kingdom RPS, 2006-07 and 2009-10

<i>RES-E type</i>	<i>2006-07 generation: GWh/yr</i>	<i>2009-10 generation: GWh/yr</i>	<i>2006-07 to 2009-10 change</i>
Hydro	2,447	2,614	+7%
Landfill gas	4,424	4,952	+12%
Sewage	447	638	+43%
Co-firing	2,528	1,806	-29%
Biomass	797	1,729	+117%
Offshore wind	651	1,740	+167%
Onshore wind	3,574	7,564	+111%
Solar PV	11	20	+82%
Total	14,879	21,063	+42%
RES-E diversity index	4.81	4.51	-7%

Source: Department of Energy and Climate Change, 2010b.

Table 5 includes an RES-E diversity index for 2006-07 and 2009-10. The indexes are computed using an inverted Herfindahl index: the sum of the squares of the shares of RES-E generation of each RES-E type in a jurisdiction in a given year. The higher the diversity index, the less concentrated is the overall mix of RES-E types. The RES-E diversity index fell, slightly, in the UK over the period as its RES-E generation became more concentrated around hydro, landfill gas and onshore wind but the index will rise if offshore wind generation continues to increase. The UK's RES-E generation is more diverse than that of Italy, shown in Table 9, and US carve-out and non carve-out RPS states, shown in Table 14. However, its commencing RES-E diversity in 2006-07 was already significantly more diverse than that of US carve-out and non carve-out RPS states in 2003, and Italy in 2008.

The UK has a complicated non-compliance charge mechanism that, to date, has had a major negative effect on the attainment of its RPS targets that may significantly affect the success of its banding. The country's non-compliance charge was £36.99/MWh in 2009/10. The charge, known as a 'buyout fee', is recycled amongst complying electricity retailers. When combined with the high degree of ownership concentration in the UK electricity industry, it is often argued this recycling gives the industry an incentive to under-invest in new RES-E capacity. This happens through the highly concentrated UK RES-E generators restricting the supply of RES-E, thereby keeping tradable certificate prices high, which increases the incentive for electricity retailers to pay the buyout fee instead of purchasing tradable certificates. Because buyout fee charges are recycled amongst complying electricity retailers that purchase tradable certificates, and because the retailers are also in many cases RES-E generators, it is argued they have a vested interest in restricting RES-E supply to increase the amount of buyout fee income that comes back to them. When combined with the fact that full attainment of each year's RPS target would have caused the UK tradable certificate price to crash before the guaranteed headroom feature was introduced (discussed below), the recycling phenomenon is often credited with being the driving force behind the low attainment of UK annual RES-E targets, shown in Table 6. Whether the UK buyout fee is too low or too high depends on whether an electricity generator in the country is also an RES-E generator and it also depends on what type of RES-E is being considered. The combined value of the buyout fee and the amount recycled from the buyout fund acts can act as an RPS tradable certificate price ceiling if set too low, for 2008-09 it was $£35.76 + £18.61 = £54.37$. If an electricity retailer is also an RES-E generator, then the cost to it of generating wind, as shown in column 1 of Table 4, is less than this amount and it would be worth the retailer generating this type of RES-E instead of paying the buyout fee. This is also the case if a retailer is not a generator and has to buy RES-E tradable certificates on the open market. As shown in Table 7, in summer 2010-11, the cost of a UK tradable certificate was £52.20, again less than the effective £54.37 cost of the buyout fee. Similar calculations apply to biomass and offshore wind, after factoring in their multipliers as shown in Table 4. However, wave and solar PV are more expensive to generate than the effective value of the buyout fee, even after factoring in their multipliers, in

which case the retailer would be better off paying the buyout fee, if it was also an RES-E generator.

Table 6: UK RPS annual targets, attainment rates, buyout fee and recycled buyout fund amount, 2002-03 to 2008-09

<i>Year</i>	<i>RPS target: % of electricity generation</i>	<i>RPS % achieved</i>	<i>% of RPS target achieved</i>	<i>Buyout fee: £/MWh</i>	<i>Recycled buyout fund amount: £/MWh</i>
2002-03	3.0%	1.8%	60%	£30.00	£15.94
2003-04	4.3%	2.2%	51%	£30.51	£22.92
2004-05	4.9%	3.1%	63%	£31.59	£13.66
2005-06	5.5%	4.0%	73%	£32.33	£10.21
2006-07	6.7%	4.4%	66%	£33.24	£16.04
2007-08	7.9%	4.8%	62%	£34.30	£18.65
2008-09	9.1%	5.4%	59%	£35.76	£18.61

Source: Ofgem, (various); Department of Energy and Climate Change, 2010b;
Mitchell et al., 2011.

The introduction of banding into the UK's RPS has not been without its critics. Johnston et al (2008, pp. 2492, 2496) argue that banding will create 'regulatory and market uncertainty' which may justify additional risk premiums for RES-E investors. They argue this is because future tradable certificate prices will depend on the degree to which different types of RES-E penetrate the RPS market. However, a device that the UK government has introduced which should minimise this tradable certificate price uncertainty is 'guaranteed headroom'. This is a set percentage (currently 8%, rising to 10% from 2011) by which the RPS obligation on electricity retailers is increased each year above, and beyond, the number of tradable certificates expected to be created in the year. It ensures that the annual RPS obligation always keeps ahead of the expected level of RES-E generation which should keep an upward pressure on tradable certificate prices (Department of Energy and Climate Change, 2010a). Typically, a large (but variable) proportion of RES-E sold in an RPS is transacted via contracts between RES-E generators and electricity retailers. However, a significant proportion is typically sold via spot tradable certificate markets which influences contract prices. Table 7 shows UK tradable certificate market prices since its RPS began in 2002. It shows that, generally, prices have trended upwards but over the past three years have been more variable than they were in the previous three years, lending limited support to the argument of Johnston et al (2008). Between winter 2004/05 and winter 2007/08

prices traded between a low of 4.03 p/kW-h and a high of 4.92 p/kW-h: a range equal to 22% of the low certificate price. However, between winter 2007/08 and winter 2010/11, prices traded between a low of 4.87 p/kW-h and a high of 6.68 p/kW-h: a range equal to a higher 37% of the low certificate price.

The presence of headroom does not remove all uncertainty in an RPS tradable certificate market because the amount of the headroom might change and there is no guarantee that it will always be used by the UK government. This means there will always be a justification for some risk premium, however it also has to be remembered that FIT subsidy rates can also be altered and therefore also carry a political risk, as argued by Finon (2006, p. 320).

The headroom device provides an implicit tradable certificate price floor but it does not have to be linked to banding, it could just as easily be used in an RPS carve-out market. Some RPS countries have developed explicit RPS tradable certificate price floors; two such countries have been Belgium and Sweden. Belgium's RPS is divided into three separate sub-national markets each of which has a minimum tradable certificate price below which prices are not allowed to fall (Coenraads et al 2008). In the case of Sweden, in order to develop early confidence in its RPS, a minimum tradable certificate price guarantee operated for an introductory period between 2003 and 2007 (Wang, 2006). The use of implicit, or explicit, RPS price floors, along with RPS carve-outs or banding, would give an RPS two of the key features that differentiate an FIT from an RPS: subsidy certainty along with differentiation of subsidy according to RPS type.

Table 7: Tradable RPS certificate auction prices of the UK RPS (excluding the value of non RES-E electricity) since 2002

<i>RPS tradable certificate contract period</i>	<i>Average RES-E tradable certificate price p/kWh</i>
Winter 2002/03	4.57
Summer 2003	4.14
Winter 2003/04	4.10
Summer 2004	4.12
Winter 2004/05	4.13
Summer 2005	4.03
Winter 2005/06	4.15
Summer 2006	4.48
Winter 2006/07	4.92
Summer 2007	4.85
Winter 2007/08	4.87
Summer 2008	5.41
Winter 2008/09	6.68
Summer 2009	5.84
Winter 2009/10	5.40
Summer 2010	5.03
Winter 2010/11	5.22

Source: NFPAS Limited, 2010.

4.2 The use of banding in Italy

Another European country that uses the RPS mechanism, Italy, has also incorporated banding. However, as shown in Table 8, its banding rates are not highly differentiated, apart for wave/tidal and biomass (generators of less than 1 MW capacity have the option of using an FIT for most of the RES-E types listed in Table 8). It seems, therefore, that Italy has not enthusiastically embraced the banding concept. This view is somewhat reinforced by the fact that it uses an FIT, and not an RPS band, to subsidise solar PV electricity irrespective of generator capacity as well as all small scaled RES-E generation from generators with less than 1 MW capacity (Coenraads et al., 2008, p. 81; Rathmann et al, 2009, p. 139). As mentioned in s4.1, the UK also has an FIT for solar generation but it only applies to generators of 5 MW capacity or less. The use of an FIT for solar PV could reflect a belief that RPSs are ill suited for transitioning an RES-E type from a pre-commercialisation stage to a supported commercialisation one, as argued by Foxon et al (2005, p. 2132). However, their argument did not anticipate the use of either banding or carve-outs in an RPS. If banding rates are not particularly generous, or if carve-out targets are not particularly ambitious, these devices may fail to help the

transition to the supported commercialisation stage but if they are generous and ambitious enough, they could and FITs need not have a monopoly on this function.

Table 8: Banding rates of RES-E types in Italy's RPS

<i>RES-E type</i>	<i>Tradeable certificate multiplier rates</i>
Onshore wind	1.0
Offshore wind	1.1
Geothermal	0.9
Wave/tidal	1.8
Hydro	1.0
Biodegradable waste	1.3
Biomass	1.8
Biogas biomass	0.8

Source: Rathmann et al., 2009, p. 139.

Table 9 shows the generation of RES-E in Italy in 2008, when it introduced banding, and in 2009, the latest year for which data is available. As the table shows, solar PV experienced the largest increase in generation over the period but the increase was due to its FIT, not its banded RPS. Biomass, whose main form receives a higher tradable certificate multiplier than onshore and offshore wind, did not increase as much as wind over the period despite its multiplier advantage. Italy's RES-E diversity index barely changed between the two years and its 2009 RES-E diversity was lower than the UK's 2009-10 one (shown in Table 5) and lower than the 2008 diversity of US RPS states that use carve-outs (shown in Table 14). However, its commencing 2008 RES-E diversity was also lower than that of the UK in 2006-07 (shown in Table 5) and US carve-out states in 2003 (shown in Table 14). It is difficult to avoid the conclusion that banding is only used in a token way in Italy.

Table 9: Change in RES-E generation in Italy since introduction of its RPS, 2008 and 2009

<i>Technology</i>	<i>2008 generation: GWh/yr</i>	<i>2009 generation: GWh/yr</i>	<i>2008/2009 change: %</i>
Hydro	41,623	49,137	+18%
Wind	4,861	6,543	+35%
Biomass	5,966	7,631	+28%
Solar photovoltaic	193	676	+250%
Geothermal	5,520	5,342	-3%
Total	58,163	69,329	+19%
RES-E diversity index	1.86	1.89	+2%

Source: Terna, 2010.

Unlike most RPS jurisdictions, Italy does not have an explicit non-compliance penalty charge. If, after auditing, a retailer does not furnish the required number of tradable certificates, it is reported to the Regulatory Authority for Electricity and Gas which confers with its minister about appropriate sanctions. However, the legislation such sanctions are taken under is vague and undefined and there is therefore less of a compliance incentive in Italy than in most other RPS jurisdictions (Coenraads et al., 2008, p. 82; Rathmann et al., 2009, p. 138).

5. The use of carve-outs in the USA

The most significant use of the RPS carve-out device has occurred in the USA. The RPS is used by 25 of the 50 states in the USA, as well as by the District of Columbia. Out of the 26 RPS jurisdictions in the country, 11 use carve-outs within the mechanism. Details of the US RPS state carve-outs, as well as of the RPSs they sit within, are given in Table 10 (including Washington DC).

Table 10: US state RPS commencement, RPS target and carve-out details, 2009

<i>State</i>	<i>RPS commence- ment year</i>	<i>Overall RPS RES-E target (% of all generation)</i>	<i>Carve-out target and details</i>
Colorado	2004	20% by 2020 for private generators	At least 4% of RES-E in all years must be solar (ie at least 0.8% of all generation by 2020)
Connecticut	1998	23% by 2020	At least 3% of all generation by 2020 must be waste, pre 1998 biomass and/or pre 2003 small hydro
Delaware	2005	20% by 2019	At least 2.005% of all generation by 2019 must be solar PV
Maine	2000	40% by 2017	At least 10% of all generation by 2017 must come from new RES-E
Maryland	2004	20% by 2022	At least 2% of all generation by 2022 must be solar
Nevada	1997	20% by 2015	At least 1% of all generation by 2015 must be solar
New Hampshire	2008	20.8% by 2022	At least 0.3% of all generation by 2025 must be solar, at least 6.5% of all generation by 2025 must be methane or small/medium biomass and at least 1% of all generation by 2025 must be small hydro
New Jersey	1999	20.365% by 2019	At least 1.836% of all generation by 2019 must be solar
New Mexico	2002	20% by 2020 for private generators	At least 5% of public generator generation by 2020 must be wind, at least 5% of public generator generation by 2020 must be solar, and at least 0.6% of public generator generation by 2020 must be distributed
North Carolina	2007	12.5% by 2020 for private generators	At least 0.2% of all generation by 2012 must be solar, at least 0.2% by 2021 must be swine waste, and at least 900 TWh/yr by 2021 must be poultry waste
Pennsylvania	2004	18% by 2020	At least 0.5% of all generation by 2020 must be solar, and at least 10% of all generation by 2020 must be waste coal, distributed generation, large hydro, municipal waste or gasified coal
Washington DC	2005	20% by 2020	2.5% by 2015 must be hydro or waste (declining to 0% by 2020) and at least 0.4% by 2020 must be solar.

Source: Union of Concerned Scientists, 2008.

As shown in Table 10, in only four states do any of the carve-outs account for a significant proportion (at least a quarter) of their RPS target: Maine, New Hampshire, New Mexico and Pennsylvania. Even in those states, the carve-outs are not necessarily used to support high-cost RES-E. The largest Maine and Pennsylvania carve-outs are for fairly amorphous groups of RES-E (or even non-RES-E): new RES-E in Maine, and waste/gasified coal, distributed generation, large hydro and municipal waste in Pennsylvania. In New Mexico (whose carve-outs start in 2011), one of its largest carve-outs is dedicated to wind, which is not a high-cost type of RES-E, and in New Hampshire its largest carve-out is devoted to small/medium biomass (including methane), which is also not a high-cost type of RES-E. This does not mean the carve-outs are superfluous, but it does mean they are not being used to support high-cost RES-E, and therefore to broaden the support of the RPS. In the other seven carve-out states, none has a carve-out for more than a

quarter of its RPS target. Most of the Table 10 RPS states have carve-outs for solar, which is a high-cost type of RES-E, but few of them are particularly significant (with the exception of New Mexico's solar carve-out for public generators). Nevada uniquely combines a carve-out with banding by awarding 2.4 tradable certificates for each unit of solar generation (with other RES-E types getting one) while having a solar carve-out that embraces 5% of its RPS target (Union of Concerned Scientists, 2010).

Table 11: US state RPS carve-out commencement, carve-out cost cap and RPS exemption details, 2009

<i>State</i>	<i>Carve-out commencement year</i>	<i>Carve-out cost caps</i>	<i>RPS retailer or customer exemptions</i>
Colorado	2007	Compliance cost capped at 2% of sales	None
Connecticut	2004	General penalty payment of \$55/MWh	None
Delaware	2007	General alternative compliance payment of US\$25/MWh (rising in future to US\$80/MWh); solar alternative compliance payment of US\$250/MWh (rising to US\$350/MWh in future)	Industrial customers with peak demand greater than 1.5 MW and municipal and cooperative retailers
Maine	2008	Alternative compliance payment of US\$57.12/MWh plus inflation	Contracted electricity and municipal or cooperative retailers
Maryland	2006	General alternative compliance payment of US\$15/MWh for Tier 2 through to US\$45/MWh for solar carve-out, lower payments apply to industrial customers	Customers with greater than 300 GWh/yr in sales, municipal and cooperative retailers
Nevada	2005	None but utilities can be exempted if there is insufficient RES-E supply	Municipal and cooperative retailers
New Hampshire	2008	Alternative compliance payments for all carve-outs from US\$28.72/MWh for class 3 and 4 to US\$153.54 for class 2 (adjusted for inflation)	Some imported electricity and pre 2007 contracted supply exempted
New Jersey	2001	Alternative compliance payment of US\$50/MWh for general RES-E (declining in future) and US\$711/MWh for solar carve-out of (declining in future years).	Publicly owned retailers exempted
New Mexico	2011	Compliance cost capped at 1% of sales in 2006 rising to 2% in 2011. Alternative compliance payments by RES-E type from US\$49/MWh for wind and hydro through to US\$150/MWh for solar	Municipal and privately owned retailers
North Carolina	2010	Compliance cost to customers capped at US\$10/yr for residential through to US\$500/yr for industrial	None
Pennsylvania	2006	Non solar alternative compliance payment of US\$45/certificate and for solar of 200% of recent average certificate price	Municipal and cooperative generators and retailers with restructuring costs
Washington DC	2007	Alternative compliance payments of US\$10/MWh for Tier 2 through to US\$80/MWh for solar carve-out	Suppliers within and a building and purchasers of electricity for own use

Source: Union of Concerned Scientists, 2008.

As shown in Table 11, all but two of the US carve-outs commenced in 2005 or later so, like banding in the UK and Italy, it is a relatively recent RPS refinement although it has a slightly longer history than banding in those two countries does. Table 11 also shows that nearly all US carve-out states have some form of alternative compliance payment, or cost capping provision, as well as some retailer or customer exemption. All could significantly erode the effectiveness of each state's RPS in general as well as of its carve-outs in particular. However, it cannot be assumed that the alternative compliance payment provided for by a carve-out state is necessarily comparable to the current cost of its tradable certificates and therefore necessarily acts as a low to moderate ceiling on carve-out tradable certificate prices. If the alternative compliance payments for Connecticut, Maryland, New Jersey and Washington DC detailed in Table 11 are compared to the July 2008 tradable certificate prices shown in Table 15, in all cases they are higher than the Table 15 certificate prices.

Unlike the enabling legislation for early, non carve-out RPS mechanisms, the RPS legislation for carve-out states generally emphasised the importance of electricity generation diversity. The legislation for the RPS mechanism of Delaware, New Hampshire and Washington DC, for instance, speaks of the desirability of increased electricity 'supply' or 'fuel' diversity while New Mexico's talks about promoting 'energy self-sufficiency' (Union of Concerned Scientists, 2010).

Table 12 shows the RES-E generation performance, between 2003 and 2008, of two of the four states with significant carve-outs: New Hampshire and Pennsylvania. As detailed in Table 10, New Hampshire's most significant carve-out is for methane and small/medium biomass which Table 12 shows experienced significant growth between 2003 and 2008. New Hampshire also has a less significant carve-out for small hydro which the table also shows experienced significant growth over the period. Table 12 further indicates that, like New Hampshire, Pennsylvania's greatest RES-E generation growth between 2003 and 2008 occurred in a low-cost RES-E type, in its case wind. The RES-E generation experience of New Hampshire, in particular, demonstrates that carve-outs can be effective in supporting the growth of particular types of RES-E but, as previously stated, they are not being widely used in US RPS states to support high-cost types of RES-E.

Table 12: RES-E generation change in New Hampshire and Pennsylvania, 2003 and 2008

<i>RES-E type</i>	<i>New Hampshire 2003 generation: GWh/yr</i>	<i>New Hampshire 2008 generation: GWh/yr</i>	<i>2003/2008 change in New Hampshire generation</i>	<i>Pennsylvania 2003 generation: GWh/yr</i>	<i>Pennsylvania 2008 generation: GWh/yr</i>	<i>2003/2008 change in Pennsylvania Generation</i>
Geothermal	0	0		0	0	
Hydro	1,331	1,633	+23%	3,346	2,549	-24%
Solar	0	0		0	0	
Wind	0	10		112	729	+551%
Biomass	796	1,165	+46%	1,986	2,074	+4%
Total RES-E	2,127	2,808	+32%	5,444	5,353	-2%

Source: Energy Information Administration, 2009 and 2010.

Table 13 shows the aggregated change in RES-E generation between 2003 and 2008 in US RPS states that do, and do not, use carve-outs. It confirms the contention that carve-outs are not being extensively used in US RPS states to support high-cost RES-E. It shows that the only types of RES-E whose generation grew significantly better over the period in the carve-out RPS states, compared to the non carve-out RPS states, were wind and geothermal. But wind is a low-cost type of RES-E so its growth is no testament to the potential for carve-outs to support high-cost types of RES-E. All the geothermal generation in carve-out RPS states between 2003 and 2008 took place in Nevada which does not have a dedicated carve-out for geothermal generation.

Table 13: Changes in RES-E generation in US RPS states that do, and do not, use carve-outs, 2003 and 2008

	<i>2003 generation: GWh/yr</i>	<i>2008 generation: GWh/yr</i>	<i>2003/2008 change: %</i>
RPS states that use carve-outs:			
Hydro	19,929	16,292	-18%
Wind	295	2,535	+759%
Biomass	10,634	11,498	-8%
Solar	0	161	
Geothermal	1,066	1,383	+30%
Total RES-E	31,924	31,866	-1%
RPS states that do not use carve-outs:			
Hydro	184,894	184,768	-1%
Wind	8,699	39,843	+358%
Biomass	15,185	15,620	+3%
Solar	534	703	+32%
Geothermal	13,975	13,228	+1%
Total RES-E	223,287	254,162	+14%

Source: Energy Information Administration, 2009.

Table 14, which shows the RES-E diversity indexes for US RPS states that do, and do not, use carve-outs for 2003 and 2008, reinforces the contention that carve-

outs have not been effectively used in the USA to support the full range of RES-E types. Table 14 shows that, although US RPS that do not use carve-outs had less diverse mixes of RES-E than RPS states that use carve-outs in both 2003 and 2008, between the two years the diversity in both sets of RPS states increased by similar proportions. There was therefore no obvious greater diversification increase taking place in US RPS carve-out states compared to non carve-out RPS states.

Table 14: RES-E diversity indexes for US RPS states that do, and do not, use carve-outs, 2003 and 2008

<i>Type of RPS state</i>	<i>2003 diversity index</i>	<i>2008 diversity index</i>	<i>2003/2008 change</i>
Carve-out states	2.03	2.5	+23%
Non carve-out states	1.42	1.79	+26%

Source: Energy Information Administration, 2010; author calculations.

RPS tradable certificate prices, as at July 2008, for four US RPS carve-out states — Connecticut, Maryland, New Jersey and Washington DC — are shown in Table 15. The table shows that carve-outs can cause significant variation in tradable certificate prices, even within a state. Carve-out tradable certificate prices are mainly influenced by the range of RES-E types that can be used within a carve-out and the medium term target for each carve-out. The spread in tradable certificate prices that carve-outs can cause is a disadvantage of the device as it introduces more complexity, and less liquidity, into an RPS tradable certificate market, as discussed below.

Table 15: Prices of RPS tradable certificates in Connecticut, Maryland, New Jersey and Washington DC, July 2008

<i>State</i>	<i>Tradable certificate class/tier</i>	<i>RES-E types that qualify for class/tier</i>	<i>Target for class/tier (% of electricity generation)</i>	<i>Price of tradable certificates: US\$/MWh</i>
Connecticut	I	solar, wind, biomass, ocean, post 2003 small hydro	20% by 2020	\$25.00
Connecticut	II	waste, pre 1998 biomass, pre 2003 small hydro	3% by 2020	\$0.65
Connecticut	III	combined heat and power, energy efficiency, heat recovery	18% by 2022	\$26.75
Maryland	1	solar, wind, biomass, geothermal, ocean, fuel cell, pre 2004 small hydro	18% by 2022	\$1.00
Maryland	2	other hydro, poultry biomass, waste energy	2.5% by 2018	\$0.60
New Jersey	I	solar, wind, fuel cell, geothermal, ocean, biomass, waste	16.029% by 2019	\$17.50
New Jersey	II	small hydro, waste	2.5% by 2019 (can include class I)	\$0.60
New Jersey	Solar	solar	1.836% by 2019	\$265.00
Washington DC	1	solar, wind, biomass, geothermal, ocean, fuel cells	20% by 2020	\$1.15
Washington DC	2	hydro, waste	2.5% by 2015	\$0.75

Source: Evolution Markets, 2008; Union of Concerned Scientists, 2008.

6. Strengths and weaknesses of banding and carve-outs

The price-based banding device, and the quantity-based carve-out device, have strengths and weaknesses similar to any pair of price- and quantity-based control mechanisms as originally explored by Weitzman (1974) and recently reviewed for carbon pricing by Hepburn (2006). However, published literature, to date, has given the specific strengths and weaknesses of banding and carve-outs little attention.

The strengths of banding are that its tradable certificate multiplier rates, and generation of particular RES-E types, can be flexible. It is relatively easy to make changes to its certificate multiplier rates (as the UK government did with its offshore wind rate in 2009 before banding commenced) resulting (probably) in different amounts of generation for the RES-E types the changes are applied to. However, such changes can increase risk, and therefore cost, and can also impact on other RES-E multiplier rates. Another strength of banding is that by retaining a single tradable certificate market, it retains a homogenous certificate market and therefore retains liquidity. A further strength is that it can remove over-subsidisation of low-cost RES-E types (although if carve-outs are created for each RES-E type, it too can achieve this). It can also be argued that governments can use banding

multiplier rates to help drive reductions in RES-E generating costs. The weaknesses of banding are that it creates a relatively complex tradable certificate market and it delivers an uncertain amount of generation of particular RES-E types. Arguably, the setting of its certificate multiplier rates by governments, and not by markets, is another weakness (although markets determine the amount of generation that different multiplier rates result in). A further possible weakness can be that if banding sits within an RPS whose target is expressed as a number of tradable certificates, its certificate multipliers can, effectively, reduce the target. The UK government avoids this problem in its RPS target by factoring in the number of extra tradable certificates likely to be created by banding before adding on its 'headroom' adjustment (already noted in section 4.1) (Department of Energy and Climate Change, 2010a). As long as the post-headroom total falls below the RPS ceiling (currently 20% of all UK electricity generation), then banding does not erode its target, although it could do so once the projected level of RPS tradable certificates gets near the ceiling. The potential erosion of RPS targets by banding certificate multipliers can also be overcome by expressing the target as an RES-E market share. Until 2009, the UK RPS obligation was expressed as a percentage of an electricity retailer's sales but was changed, after the introduction of banding, to be a number of tradable certificates per 100 MWh of electricity sales. However, the UK retains an overall official RES-E market share target of 20% by 2020, as discussed in ss4.1. The use of banding makes the connection between this target and RES-E generation less certain although yearly market shares are still computed that show progress towards the target.

The great strength of carve-outs is that they deliver (or should deliver) a fairly predictable amount of generation of particular RES-E types (if the size of each carve-out is realistic). Arguably, another strength is that it allows markets to set the differentials between its tradable certificate prices (although governments still determine the size of each carve-out). Its weaknesses are that, by creating a series of separate tradable certificate markets, it reduces the liquidity of the pre-existing homogenised market and, therefore, can be just as complex as banding. It can also be inflexible in the amount of generation it allows of particular RES-E types. A further weakness can be that once RES-E generation nears a carve-out target, the tradable certificate price for the type of RES-E in question can fall, creating a 'boom-bust' environment.

In theory, both the banding tradable certificate multiplier rates, and the size of individual carve-out markets, can be changed as market circumstances evolve, so those two flexibility weaknesses need not be serious for either device (although there is a limit to the frequency of change either can have before eroding RES-E investor confidence). Both also necessarily involve more complexity than undifferentiated, homogenised RPS tradable certificate markets so neither can claim to be inherently less complex than the other.

When it comes to market or government determination of RES-E subsidies, in both cases, markets and governments together determine the total size of their RES-E subsidies. This is because each controls either the per-unit subsidy rate, or the amount of RES-E generation. This means neither can claim to be more market- or government-driven than the other. However, it is important that the government component of each be linked to market realities. There is no point in creating very large carve-outs for RES-E types at embryonic stages of development and it is unwise to set banding multiplier rates that are conspicuously disconnected from the short and medium term generation costs of the RES-E types they are applied to.

As discussed in section 3, a major theoretical strength of the RPS is its ability to contain static costs (Finon, 2006, p. 337; Menanteau, 2003, p. 807). It could be argued that because carve-outs preserve the one-to-one link between RES-E generation and tradable certificate creation, they retain this quality better than banding does and should, therefore, be able to deliver increased RES-E diversity at less cost than banding. However, if a target for a particular carve-out is set unrealistically high by a government, it will exert an upward force on tradable certificate prices and will not deliver diversity at least cost. This is also the case if a banding rate is made unrealistically generous for a type of RES-E. So both are capable of delivering expensive RES-E diversity if governments design them poorly.

The significance of the reduction in market liquidity caused by carve-outs depends on the size of the pre-existing homogenised certificate market it is applied to (measured as the number of tradable certificates exchanged each year: a product of the RPS target size and the proportion met by open market certificate trading). In some RPS mechanisms, like that of Massachusetts, most generator income is derived from the open market sale of tradable certificates (Wiser et al., 2007). In others, such as Australia's, only a small amount of RES-E is sold via the open

market sale of tradable certificates (about 20% in its case) (McLennan Magasanik Associates, 2007, p. 18)) with the balance sold through contracts. Obviously, the larger the pre-existing open market for certificates, the less its division into separate carve-out markets matters. The potential for carve-out certificate prices to fall as carve-out limits are approached can be overcome only by increasing the size of the carve-out before this happens.

There is, then, no clear design supremacy in either banding or carve-outs. However, on balance, the liquidity and generation flexibility strengths of banding probably make it superior to carve-outs, though either is capable of being incorporated into a specific RPS market.

7. Conclusion

The purpose of the banding and carve-out devices is to introduce different levels of support for different types of RES-E into the RPS mechanism so that high-cost types, in particular, receive adequate support. To date, there is insufficient experience, and reliable data, to be able to reach definite conclusions about the effectiveness of either device in fulfilling this although there is ample information about the design differences between the two devices. Banding needs several more years of use in the UK before clear trends are evident. There also needs to be more significant use of carve-outs, in the USA or anywhere else, before any firm conclusions can be reached about its use. However, there is early, tentative evidence that banding is being effective at supporting high-cost offshore wind generation in the UK. There is also some evidence that carve-outs are being somewhat effective in supporting some low-cost types of RES-E in US RPS states but there is little evidence of high-cost RES-E support. In theory, both banding and carve-outs are capable of supporting high-cost RES-E. On balance, however, banding is probably a superior device to carve-outs although either could be incorporated into specific RPS markets.

Acknowledgements. The author acknowledges the helpful advice of Dr. Jack Pezzey, Senior Fellow at the Australian National University's Fenner School of Environment and Society, in the preparation of this article. This research received

generous support from Dr Nick Eyre, and the Low Carbon Futures group of Oxford University's Environmental Change Institute, as well as from the Australian National University's Vice Chancellor's travel grant program.

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