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Redefining RECs—Part 1: Untangling attributes and offsets

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ABSTRACT

Renewable energy and greenhouse gas emissions markets are currently in a state of confusion regarding the treatment of Renewable Energy Certificates (RECs). Should consumers buy RECs or emission offsets? After examining this question, the author concludes that RECs are not equivalent to emission offset credits, and as currently defined, the retiring of a REC may have no impact on emissions from electric power generation. Consumers who purchase RECs in voluntary green power markets are providing financial assistance to renewable generators in the form of a production subsidy. Generators that sell RECs are not transferring emission reductions, since they are unlikely to have ownership or the ability to quantify reductions using a commonly accepted standard. More importantly, RECs currently sold in voluntary markets do not pass credible additionality tests and can, at best, be expected to have a market demand effect, which will be less than the supply of RECs on the market. REC definitions that use the term "environmental attributes" or "environmental benefits" are almost universally ambiguous, providing the mistaken impression that consumers are purchasing a good instead of subsidizing a public good.

1. Introduction

Tradable environmental commodities are becoming a favored instrument for policy makers. Renewable Energy Certificates (RECs) are one type of environmental commodity intended to provide an economic incentive for electricity generation from renewable energy sources. A REC is created when one (net) megawatt hour of electricity is generated from an eligible renewable energy resource. RECs are unbundled environmental commodity, and therefore may be sold separately, from the underlying electricity generated.

A behind-the-scenes debate has been raging within the environmental markets and renewable energy communities regarding the proper definition of a REC, what a REC represents, and whether RECs should be treated as equivalent to emission offsets.[1] Emission offsets represent the avoided release of a unit mass of a pollutant to the atmosphere. Offsets offer buyers an alternative to reducing their own emissions, which they may be unwilling or unable to reduce at a lower cost.

The root of this debate is the fact that RECs are being used for multiple applications in multiple markets. Each of these applications entails conflicting requirements for an environmental commodity. Carefully addressing these conflicts is essential given the interactions between renewable and emission markets. This paper (Part 1) will focus on the relationship between RECs and emission offset credits. A more general discussion on the relationship between RECs and emission markets, along with recommendations for how to resolve conflicts between REC and emissions trading markets, is provided in a second paper (Part 2) (Gillenwater, 2008).

Both compliance and voluntary environmental markets use RECs. In the United States, compliance markets have been established by state Renewable Portfolio Standards (RPSs). Several states allow or require load-serving entities (LSEs)[2] to use tradable RECs to meet a quota for the amount of their delivered electrical load that must be met by electricity from renewable generation. Both voluntary "green power" markets—which provide retail customers the choice to pay a premium to electricity generators using renewable resources—and voluntary greenhouse gas (GHG) offset markets trade in RECs.[3] No single commodity is an appropriate tradable instrument for all of these applications.

Two fundamental problems exist within many REC markets. First, most REC products are ambiguously defined and are purported to represent attributes indirectly associated with renewable energy generation, resulting in their inability to

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[1] An emission 'offset' is an intangible economic commodity that represents the avoidance or sequestration of emissions.

[2] A load-serving entity provides the electrical demand and energy requirements of its customers (e.g., an electrical distribution utility).

[3] RECs may also be used by LSEs to track their generation mix for public disclosure purposes on retail electricity bills (Holt and Bird, 2005).

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function as a homogeneous commodity. A typical definition of a REC includes language such as "RECs represent all environmental attributes or benefits from electricity generated by renewable sources," although there is wide variation in the language and specificity of definitions used in both the compliance and voluntary markets (Holt and Wiser, 2007).

Second, RECs are used for multiple applications, each of which requires an environmental commodity with different characteristics. Many REC definitions imply questionable claims regarding their impact on electricity markets and pollutant emissions from the electric power industry. Specifically, RECs have become popular with marketers, corporations and individuals to offset their GHG emissions (Bird et al., 2007). Their argument is that the generation of electricity by a renewable facility, such as a wind turbine, avoids or displaces generation, and therefore emissions, from a fossil fuel-fired power plant.

This paper examines the following questions regarding renewable energy markets and emissions markets:

- Are RECs equivalent to or fungible with emission offsets?
- What are consumers of RECs buying?

Others have addressed the issue of defining RECs, but few systematic analyses or comprehensive solutions have been proposed (Bird et al., 2007; Holt and Bird, 2005; Jansen, 2003; Leahy and Hathaway, 2004). This paper attempts to answer the above questions by first looking at the history of RECs and existing definitions. It will then analyze RECs and associated emission reduction claims according to three characteristics: additionality, ownership, and quantification.

The concept of additionality—that a project activity is beyond business as usual—is fundamental to emission offset accounting. Both RECs themselves and any associated emission reduction claims can be evaluated against various additionality tests. Ownership issues relate to the ability of REC owners to claim property rights or make marketing claims regarding the impacts of renewable energy generation that occur off-site from the renewable generation facility. And quantification issues relate to the complexity of credibly quantifying the impact of renewable generation on a networked electrical transmission grid. Before further discussing these characteristics, however, it is instructive to examine the historical origins of RECs and current REC definitions used in compliance and voluntary markets.

2. A brief history of RECs

RECs were originally proposed during the US electricity restructuring debates of the mid-1990s as a tradable environmental commodity and accounting device for renewable energy policies. The concern at the time was that newly competitive electricity markets would drive renewable energy generation out of the market (Rader and Norgaard, 1996; UER, 1996b; Wingate and Holt, 2004; Wood, 2007).

Some of the earliest discussion of RECs was in 1995 during the California Public Utilities Commission's debates regarding the adoption of a RPS (Holt and Bird, 2005). News articles at the time described RECs as "credits [that] would be tradable like emission allowances under the federal Clean Air Act" (UER, 1996a, c).

An RPS was not mandated in California at that time, but the concept of tradable RECs entered the debates in Congress over the repeal of the Public Utility Holding Company Act (PUHCA) and amendments to the Public Utility Regulatory Policies Act (PURPA). In order to promote renewable energy in a competitive generation market, several bills called for a national RPS that included the use of tradable RECs for determining compliance.[4] Here too, the model for a REC was an emission allowance under the recently implemented sulfur dioxide (SO_2) trading program under Title IV of the 1990 amendments to the Clean Air Act.

Despite the failure of these federal bills to become law, several states and localities proposed RPS legislation that included tradable RECs.[5] In 2001, Texas was the first state to implement an RPS after passing the enabling legislation in 1999 (Holt and Bird, 2005; Sloan, 2001).[6] The Texas RPS required LSEs to use tradable RECs purchased from generators to track compliance.

Around the same time, RECs were adopted by non-governmental organizations (NGOs) in the United States and Europe as an instrument to promote voluntary markets in green power (Martinot et al., 2005; Morthorst, 2000; Voogt et al., 2000).[7]

The history of an idea matters, and it is clear that RECs were originally conceived as an instrument to be used to meet a regulatory quota, analogous to an emission allowance.[8] This distinction is important when we consider today's environmental markets in which RECs are traded. Despite this history, the definition of RECs, like other environmental policy instruments, can be modified as needs change. So what types of environmental commodity instrument could a REC be defined as?

3. Environmental markets and market instruments

For the past several years, renewable energy markets and emissions markets have developed in parallel. Both regulated compliance and voluntary versions of these markets exist. Two fundamental types of tradable commodity instruments operate in these markets: quota instruments and offset credit instruments. The difference between these two types of instruments can most simply be explained in terms of the boundaries of a trading scheme and the accounting basis used.[9]

3.1. Quota instruments

The demand for quota instruments by entities within a defined boundary is predetermined. The quota instrument serves as a tradable commodity and the regulatory quota creates a market scarcity. Entities within the boundaries of a scheme with a quota (e.g., cap) are required to submit a certain number of quota instruments to comply with the scheme. Allowances under an

[4] For example, see H.R. 3790 "Electric Consumer's Power to Choose Act of 1996" (Schaefer, CO) in July 1996; as well as S.237 "Electric Consumers' Protection Act of 1997" (Bumpers, AR) and H.R. 1960 "To modernize the Public Utility Holding Company Act of 1935, the Federal Power Act, the Fair Packaging and Labeling Act, and the Public Utility Regulatory Policies Act of 1978 to promote competition in the electric power industry, and for other purposes" (Markey, MA) during the 105th Congress.

[5] For example, see (UER, 1997).

[6] Texas was the 6th state to pass RPS legislation, but it was the first state to promulgate and implement rules.

[7] In January 1998 a voluntary renewable energy certificate system called "Green Label" was introduced in the Netherlands. In 2002, the Center for Resource Solutions in San Francisco launched the Green-e certification label for renewable energy retail renewable energy sales, including RECs.

[8] Unfortunately, the original terminology for a REC in Congressional legislation was "renewable energy credit," which probably fostered confusion with emission offset credits.

[9] Environmental commodities are intangible instruments. In most cases, they are only a record in a registry database. Therefore, transacting an allowance, REC, or offset credit is simply an act of information management. Anyone can potentially buy an environmental commodity from anywhere. Trading in environmental commodities makes most sense where the geographical and temporal extent of environmental good or harm represented by the environmental commodity is not localized. For example, greenhouse gases have long atmospheric lifetimes and mix well in the atmosphere.

emissions cap-and-trade scheme and RECs under an RPS are examples of quota instruments. An allowance is a transferable commodity that legally confers the legal authorization to an entity to take some action (e.g., to emit a unit amount of a pollutant) without facing a penalty. Similarly, a REC is proof that an entity has taken a required action (i.e., purchased a unit of electricity from a renewable generator) or has the right to sell a commodity representing that action.[10]

As of the end of 2006, 21 states and the District of Columbia had mandated RPSs in the United States.[11] However, only 18 of these states allowed the use of tradable RECs[12] and neither REC definitions nor nomenclature is consistent across states (see Electronic Annex 1 and 2 in the online version of this article). REC definitions vary in the restrictions placed upon trading and what a REC fundamentally represents. In practice, these inconsistent definitions and restrictions create separate local compliance markets for RECs.

3.2. *Offset credit instruments*

Voluntary GHG markets are examples of markets that trade in offset credit instruments. The accounting for offset credit instruments is based on some type of activity baseline. Typically, this baseline is assumed to represent some "business-as-usual" (BAU) level of activity, such as forecasted emissions. Credit is then awarded for the amount that a project causes an activity level to deviate from this baseline (e.g, baseline emissions minus actual emissions). In contrast, the accounting basis for quota instruments is typically an absolute level of activity (e.g., total emissions) instead of a change in the activity.

The demand for offset credits can come from two sources: (1) entities under a quota that purchase credits from project activities implemented by entities not subject to the quota; and (2) entities and individuals that voluntarily purchase and retire offset credits for the purpose of making environmental claims regarding their support of some public good. If sold into a compliance market with a quota (i.e., #1 above), offset credits have the effect of reducing the scarcity of tradable commodities in the market. An example of an offset credit instrument sold into a compliance market is a Certified Emission Reduction (CER) under the Kyoto Protocol's Clean Development Mechanism (CDM). RPS schemes typically have not allowed the use of offset credits for compliance, although such provisions are feasible.

3.3. *Voluntary markets*

Consumers can directly participate in renewable energy markets by purchasing generating equipment and installing it on-site, enrolling in green power pricing programs, purchasing renewable power directly from generators in competitive electricity markets, or purchasing RECs (Bird and Swezey, 2006; Pino, 2006).[13]

Table 1
Estimated consumer green power sales by market sector in the United States (thousand MW h)[a]

Market sector	2003	2004	2005	Average annual change (%)
Utility green pricing programs	1280	1840	2450	39
Competitive generation sales	1900	2650	2150	10
REC markets	660	1720	3890	144
Total	3840	6210	8490	50

[a] In 2005, total voluntary market green power sales were about 0.2 percent of total US electricity sales. Wind energy provided 61 percent, followed by biomass energy sources, including landfill gas (27 percent), hydropower (6 percent), geothermal (5 percent), and solar (1 percent). Data taken from (Bird and Swezey, 2006).

Although much smaller than RPS compliance markets, voluntary REC markets are growing rapidly in the United States (Table 1) and in Europe.[14] The voluntary purchase of RECs accounted for 46 percent of US consumer green power sales in 2005, and REC markets are growing faster than other segments of green power markets. The voluntary market for RECs is dominated by commercial and industrial customers, versus residential customers who are more likely to utilize local green pricing programs (Bird and Swezey, 2006). The advantage of RECs in voluntary markets is that they can be sold unbundled from electricity, and so their market is national, while green power markets tend to be tied to local providers.

Because they lack a regulatory mechanism to define compliance boundaries and enforce quotas on market participants, voluntary environmental commodity markets are typically viewed as trading in offset credit instruments.[15] Voluntary emission offset markets are focused almost exclusively on GHG emissions.[16] These voluntary GHG offset markets are generally unregulated and lack standard protocols and nomenclature; some refer to GHG offset credit instruments as voluntary emission reductions (VERs).[17] Consumers in these markets include both organizations and individuals who voluntarily commit to offset some portion of their GHG emissions from their operations,

[10] It would be feasible to design an RPS scheme in a way that is more analogous to a cap and trade system. Under such an approach, a cap would be set on the amount of non-renewable electricity that LSEs are permitted to utilize to meet their load instead of the amount of renewable electricity they must utilize. The effect on the generation mix should be equivalent to a traditional RPS design. However, an absolute cap on non-renewable generation could provide incentives for LSEs to invest in electricity demand reduction, unlike an RPS.

[11] Several utilities have also adopted RPS policies. See the Database of State Incentives for Renewables & Efficiency (DSIRE) at Several utilities have also adopted RPS policies. See the Database of State Incentives for Renewables & Efficiency (DSIRE) at http://www.dsireusa.org/.

[12] If tradable RECs are not allowed under a state's RPS, then LSEs must either own and operate their own renewable generation or contract for electricity wholesale from renewable generators, which is then tracked for compliance with the RPS.

[13] RECs are often re-bundled by utilities and marketers with wholesale electricity and sold to retail customers as a green power product. When retail consumers purchase RECs directly and then retire them, these customers are effectively re-bundling RECs with their electricity. For a list of green power marketers see RECs are often re-bundled by utilities and marketers with wholesale electricity and sold to retail customers as a green power product. When retail consumers purchase RECs directly and then retire them, these customers are effectively re-bundling RECs with their electricity. For a list of green power marketers see http://www.eere.energy.gov/greenpower/markets/marketing.shtml?page=2.

[14] In September 2001, the European Commission passed Directive 2001/77/EC, which calls for member states to set quantitative targets for electricity consumed in the country produced from renewable energy sources. A European Energy Certificate System (EECS) is being developed to register and track an environmental commodity called Guarantees of Origin (GoOs), which are replacing RECs in the voluntary green power market in Europe. The voluntary market for green electricity in Europe varies greatly among countries. It is significant in the Netherlands, Germany, and Sweden. http://europa.eu.int/eur-lex/pri/en/oj/dat/2001/l_283/l_28320011027en00330040.pdf/.

[15] The Chicago Climate Exchange (CCX) is an example of a voluntary emissions market where participants voluntarily accept a quota (i.e., cap). Such markets will tend to attract more sellers than buyers. Therefore, the market will tend to be oversupplied and fail to create an economic incentive to reduce emissions.

[16] Voluntary markets exist for purchasing and retiring SO_2 or NO_x allowances from compliance markets in the United States. The volumes purchased by voluntary participants and retired in these markets are extremely small.

[17] Also referred to as verified emission reductions. For an example see the Gold Standard Foundation's Gold Standard VER at: /www.cdmgoldstandard.org/.

events, travel, products, concerts, or other activities. Although small, GHG offset markets are growing rapidly in several regions, including North America and Europe. A recent estimate showed that voluntary GHG offset markets, in aggregate, traded an estimated 23.7 million metric tons of CO_2 reductions worth $91 million USD in 2006 (Hamilton et al., 2007). A study by ICF International estimated that the voluntary GHG offset market will grow to 200 million tons by 2010.[18]

4. Existing definitions and standards

There is little agreement regarding the question of what a REC is or represents. Electronic Annex 1 in the online version of this article presents a selection of REC definitions used in both RPS compliance and voluntary REC markets. Holt and Wiser (2007) also discuss the variation and inconsistency in REC definitions among state RPS mandates.

There is little consistency across REC definitions. REC definitions often rely on the use of the term "attribute" or "benefit". RECs are often purported to "include all" attributes or benefits, but there is rarely any attempt to address what these attributes or benefits are, how they should be quantified, or how ownership can be assigned unambiguously. Do these attributes or benefits include both pollutants directly released by the renewable energy generator and impacts of renewable generation on the broader electricity grid? Is there a distinction between an "attribute" and a "benefit?" If a REC includes emission attributes or benefits, then why denote it in MW h instead of tons of specific pollutants?

The language used by participants in the voluntary REC market is quite diverse. Some REC marketers make specific claims that RECs include rights to emission reductions from displacing fossil generation (Holt and Bird, 2005). Pino (2006) states that RECS "may include" air pollution and GHG benefits, but she does not specify under what conditions they would or would not.

Similar language is used in RPS legislation to define RECs for compliance markets (Holt and Bird, 2005). A point of particular confusion is the treatment allowances under existing cap-and-trade programs, such as for SO_2 and NO_x in the United States. Despite claims implied in many of these definitions, RECs have failed to prove that they convey any legal rights to emission allowances allocated to fossil fuel-fired generators (Gillenwater, 2008).[19]

Groups such as Green-e have attempted to address this issue by including language in their definition saying that attributes exclude any pollutant under a regulatory cap. They concede that REC marketers who use their certification standard must retire an allowance of any capped pollutant as a prerequisite for an emission reduction claim of a capped pollutant.

RECs have been described as being a "green jewel box" of all good things resulting from renewable energy (Jansen, 2003). A minority have argued that RECs simply represent the "unique proof that (i) the underlying specific quantity of renewables-based electricity has been produced under conditions specified by the standard information on the certificate, and (ii) that the certificate has not yet been used for another application" (Jansen, 2003; Leahy and Hathaway, 2004).

The Renewable Energy Resources Committee of the american bar association (ABA), the american council on renewable energy (ACORE), and the environmental markets association (EMA) have recently drafted a Master Renewable Energy Certificate Purchase and Sale Agreement in an attempt to address the confusion with REC and environmental attribute definitions.[20] The agreement is intended to be applicable to both voluntary and compliance REC markets, with the objective of promoting "the fungibility of RECs across programs."

However, the draft agreement fails to achieve this objective. It provides a detailed framework for sellers and buyers of RECs to define RECs specifically for each transaction and defines three categories of REC types: "standard", "basic" and "specified". Their "standard" REC definition suffers from the same faults as earlier ambiguous definitions. The agreement's "basic" and "specified" REC types do improve transparency, but the agreement not does create homogeneous commodities for the marketplace that would be fungible across programs. Deciphering what collection of public goods that any given REC might represent requires a careful reading of more than 40 pages of legal contract language plus attestation statements and verification reports specific to each transaction.[21] The agreement does not address the issue of additionality, yet its promoters advertise RECs as a way to reduce GHG emissions.

Given the claims made regarding emission reductions within the voluntary REC market, RECs should be defined as an offset credit instrument. While RECs used for RPS compliance should be regarded to be quota instruments. Yet, both voluntary markets and RPS compliance markets fail to make this distinction. In sum, RECs are currently defined vaguely or inconsistently and so cannot function as a single homogeneous environmental commodity.

5. Are RECs additional?

5.1. Additionality

Additionality is a judgment about cause and effect. The principal cause (i.e., dependent variable) is the revenue from the selling of an offset credit. The effect (i.e., independent variable) is some environmental benefit (e.g., increased generation from renewable energy sources and/or reduced GHG emissions). This effect is quantified as a change relative to a BAU baseline. Additionality is a key determinant of whether a project is eligible to be awarded credits for producing some public good.

Additionality is a concept most commonly associated with emission markets, but it is relevant to other public good markets. Trexler et al. (2006) frames the issue of additionality using a statistical analogy. Additionality tests control the number of false positives (i.e., crediting BAU activities) and false negatives (i.e., rejecting non-BAU activities with environmental benefits).[22] The underlying concern is the overall stringency of the additionality tests, which regulate the supply of credits on the market. Overly stringent tests may unnecessarily increase offset credit prices by rejecting many truly additional projects. While overly lenient tests may submerge the market with BAU credits and depress prices, thereby driving out activities with real public good benefits. The overall goal of additionality determinations is to screen out free-riders from receiving credits; thereby ensuring that the commodity sold in the market actually represents a change in behavior.

[18] ICF International, "Voluntary Carbon Offsets Market: Outlook 2007." http://www.icfi.com/Newsroom/carbon-offsets-2006.asp/.

[19] The California REC definition is the most detailed, yet it also fails to address the practical issue of ownership of emission allowances.

[20] See Electronic Annex 1 in the online version of this article and See Electronic Annex 1 in the online version of this article and http://www.acore.org/programs/rectrading.php/.

[21] See flowchart on Exhibit A/Part B, page 31 of the ABA/ACORE/EMA draft master agreement.

[22] A false positive is a positive test result in a subject that does not possess the attribute for which the test is being conducted. A false negative is a negative test result when the attribute for which the subject is being tested actually exists in that subject.

The key question, as noted by Trexler et al. (2006) is whether the incremental revenue from the sale of offset credits is a "decisive reason (although not necessarily the only reason)" for the project activity. They go on to explain that additionality is determined by asking "holding everything else constant, would an [activity have occurred] in the absence of the offset crediting mechanism."[23]

One of the difficulties with the concept of additionality is that it is judged against a counterfactual. It is not known what would have been done in the absence of the offset credit revenue.[24]

5.2. Testing RECs for additionality

It is unnecessary for quota instruments to demonstrate additionality relative to a BAU scenario if they are used to meet a quota requirement.[25] Quota instruments are typically denoted in terms of an absolute level of an activity because the scarcity created by the overall quota ensures that the policy creates behavior change. However, voluntary markets that trade instruments claiming to produce quantified behavior changes, are implicitly claiming to be trading in offset credit instruments. In these markets it is necessary to have some procedure to determine the additionality of projects that are awarded offset credits. If the argument made by REC marketers is that the revenue from the sale of RECs "caused" a public good to be produced, then additionality tests determine the credibility of this causation claim. So, do RECs sales in US voluntary green power markets lead to additional electricity generation from renewable sources relative to BAU? It should not be taken as a given that voluntarily buying green power or RECs will increase the amount of renewable electricity generated or, more importantly, decrease the amount of non-renewable energy generated.

Why should we care about the additionality of RECs? The concern is that in a system that ignores additionality, BAU projects will dominate the market. Truly additional projects that result in environmental improvements beyond BAU will not be able to compete in the marketplace because they face additional costs or barriers. In such a market, there are two losers: the public good and well-intentioned project developers. Eventually, these environmental markets will collapse due to lack of credibility with the public.

There is no single test to objectively determine the additionality of all types of project activities. Therefore, it is typical to rely on a combination of tests.[26] A variety of different types of additionality tests have been applied to offset crediting schemes (Table 2). Trexler and Kosloff (2006) state that RECs are not subject to any additionality tests. However, voluntary market RECs certified under the major NGO standards do pass some additionality tests (Table 2). However, these tests, compared to those typically applied to GHG offset crediting projects, are the weakest of those available and do little more than screen out the most patently non-additional projects.

The two major REC certification schemes cover a large portion of the market, and both apply nearly identical additional tests.[27] The *regulatory additionality test* applied to certified voluntary market RECs requires that the same MW h of renewable generation must not be counted toward RPS compliance. The *technology test* is simply that electricity is generated from an eligible renewable energy technology (e.g., wind, solar, or geothermal). The *initiation date test* is formulated such that all generation capacity installed since the early days of the voluntary green power market is eligible.

In combination, these tests assume that all renewable energy generation capacity not counted towards an RPS and built after 1996 would not have been constructed without revenue from REC sales into the voluntary market. To determine whether this assumption is adequate for screening out most free-riders, we must consider the economics of renewable energy generation, investments, and REC markets.

5.3. Economics of renewable investment and additionality

Electricity generation technologies that use wind, solar, and geothermal operate with near zero variable operating costs, as well as being zero emitting.[28]. Once constructed, renewable generation units always run, assuming availability (e.g., wind is blowing and unit is operational) because revenue can be earned from generating electricity without incurring variable costs. The additional revenue supplied to a renewable generator from REC sales is unlikely to affect the dispatch or quantity of electricity produced by an existing renewable generation facility. Therefore, the additionality of RECs must be determined when a decision whether to invest in renewable generation capacity is made. Projects shown to have been started with the expectation and need for REC revenues are likely to be additional.[29]

Renewable energy investment decisions are affected by a variety of financial considerations. Overall, investors need a minimum amount of revenue per MW h to recover their initial capital investment. In the United States wind generators need a fairly predictable revenue stream of about $70–80/MW h, while solar photovoltaic requires roughly $210/MW h (EIA, 2006a). Wholesale electricity prices paid to generators, including renewable generators, in the United States ranged of from $37 to $64/MW h, with a national average of $51/MW h in 2005 (EIA, 2006b).

In addition to revenue from wholesale electricity sales, renewable generators may also receive government-mandated support. Many countries, as well as some states and localities, provide incentives for renewable energy investments such as guaranteed feed-in-tariffs, exemption from property taxes, an

[23] The concept of additionality has an ethical dimension, especially in voluntary markets. Implicitly, it assumes that the entity selling offsets has no ethical obligation to reduce emissions, and instead should be paid to do so.

[24] There are some relatively unambiguous examples of additional activities. These activities would provide public good benefits, have no source of revenue besides offset credits, and be unaddressed by regulations or other obligations or standards.

[25] The eligibility requirements for RECs under a few state RPS requirements do include weak additionality tests. However, there is no need to burden a quota-based trading system with the transaction costs associated with additionality tests. It is only under an open, or uncapped, system that a determination of additionality is necessary.

[26] It is important to note that despite the calls for consumers to educate themselves about the quality and additionality of the RECs and GHG offset credits they purchase, it is both impractical and inefficient for individual consumers to make these evaluations. Consumers have limited access to information and limited capacity to interpret this information. Evaluations are better made through the application of common commodity standards, ideally including some government oversight.

[27] Not all RECs sold into voluntary green power markets are certified under these standards. It is likely that these uncertified RECs are not subject to any additionality tests. For a list of REC products and marketers see Not all RECs sold into voluntary green power markets are certified under these standards. It is likely that these uncertified RECs are not subject to any additionality tests. For a list of REC products and marketers see http://www.eere.energy.gov/greenpower/markets/certificates.shtml.

[28] Biomass may have fuel costs, although these should be low, especially if the biomass is a waste product. Wind typically accounts for the largest portion of renewable generation supplying REC markets.

[29] Although common in voluntary REC markets, insisting on the purchase of current vintage year RECs does nothing to address the issue of additionality. Additionality is independent of when electricity is generated. Prohibiting banking of RECs or offset credits from renewable energy projects will also do nothing to address additionality.

Table 2
Types of additionality tests and their application to GHG offset credits and US voluntary REC markets[a]

Type[b]	Description[b]	Stringency	Applied to ghg offsets[c]	Applied to RECs[d]
Regulatory	The project activity is not required by government regulations or commonly accepted industry standards. Behavior change from the project activity must exceed that required or implied by regulations or standards	Typically weak. Also depends on level of regulatory enforcement	✓	✓ Cannot be counted toward RPS compliance (weak)
Technology	Specific technologies are predetermined to be additional or eligible	Can be weak or strong depending on technology and support mechanisms	(Varies)	✓ Eligible renewable technologies (weak)
Financial	The project activity would have a lower than acceptable financial return without the revenue from the sale of offset credits	Typically strong	✓	
Barriers	A project activity must face significant implementation barriers (e.g., lack of local infrastructure) that the revenue or other assistance provided through the sale of offset credits allows the project to overcome	Can be weak or strong. Difficult to objectively assess	✓	
Common practice	The project activity must utilize technologies or practices that are not in common use within a particular jurisdiction or industry	Can be weak or strong. Easier to analyze where data on industry practices available	✓	
Initiation date	The project activity must be initiated by a certain date. Projects started earlier than this date are deemed non-additional	Weak	✓	✓ Began operation after 1996
Performance benchmark	The project activity must perform at a rate (e.g., per MW h of electricity generated) that is lower than some industry or technology benchmark	Can be weak or strong. Requires extensive methodological development	(Varies)[e]	

[a] Whether a project is determined additional is also a function of time. For example, an activity that is not common practice today may be next year. Additionality standards are typically updated in conjunction with a crediting period. Project developers need warning about updates to additionality standards to avoid stranded investments.
[b] Types and descriptions modified from (Trexler et al., 2006).
[c] Primarily based on Clean Development Mechanism (CDM) (UNFCCC, 2006).
[d] Based on US NGO certification standards (CRS, 2006; ERT, 2006). Not all voluntary market RECs are certified.
[e] The Australian National Emissions Trading Scheme is developing performance benchmarks and model projects to determine additionality for sub-sectors (Fowler, 2007).

accelerated depreciation option, and tax credits. In the United States, the Production Tax Credit for new wind generation capacity currently provides \$19/MW h for 10 years (Wiser et al., 2007).[30] In some cases, subsidies and other incentives make renewable generation investments economical.

Renewable generators may also sell RECs into RPS compliance or voluntary green power market as an additional source of income. REC prices in RPS compliance markets vary widely and are primarily a function of the stringency of the quota mandated by the RPS.

REC prices in voluntary markets vary by resource type (e.g., biomass, wind, and solar) (Holt and Bird, 2005) and region (Hathaway, 2007). In 2006, wholesale REC prices in the US voluntary market range from \$0.5 to \$10/MW h, with a typical price around \$2/MW h (Bird and Swezey, 2006; Hathaway, 2007). Solar RECs may sell for significantly more, as customers exhibit a higher willingness to pay for solar (Borchers et al., 2007).

The wholesale price of RECs represents the gross income from certificate sales. There may be certification and/or broker fees involved in a voluntary market REC transaction. Typically, certification and brokerage costs separately range from 3 to 5 percent (e.g., \$0.05–0.15/MW h) (Hathaway, 2007). At current prices, the net income from REC sales for wind generator accounts for roughly 1–10 percent of total project revenue (Fig. 1). For solar, income from RECs can more than double revenues.

The retail prices for voluntary market RECs are often significantly higher than wholesale prices, reflecting marketing costs and profit margins. Retail REC prices for residential and

[30] The Production Tax Credit covers the entire output of a wind generator and is adjusted for inflation. However, it regularly expires and must be renewed by Congress.

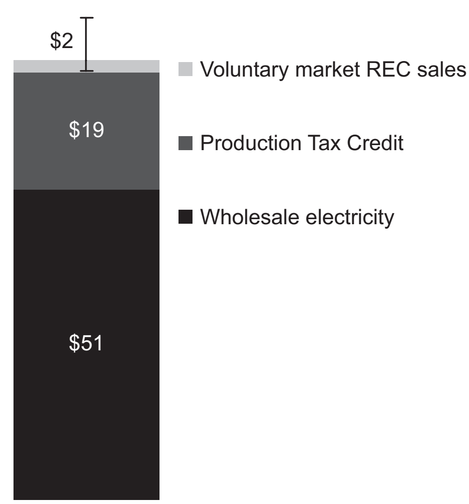

Fig. 1. Typical revenue streams for a US wind power generator (\$/MW h). Average US whole sale electricity price data from (EIA, 2006b). Typical wholesale REC prices from (Bird and Swezey, 2006; Hathaway, 2007). Error bars for voluntary market REC sales indicate typical range of prices. The value indicated for the Production Tax Credit (PTC) has a pre-tax value significantly greater than illustrated in this figure. The amount of pre-tax income necessary to yield a an after-tax income of \$19/MW h is \$19/(1-marginal tax rate). Assuming a marginal tax rate of 35 percent, this is equivalent to \$29.30/MW h (Wiser et al., 2007).

small commercial customers range from \$15 to \$30/MW h, although for solar they may be as high as \$100–\$200 MW h (Bird and Swezey, 2006; Hathaway, 2007). Large commercial and industrial customers are often able to negotiate lower prices.

It is widely recognized that it is essential for project developers to procure long-term purchase contracts to make the financing of renewable generation capacity economical (Agnolucci, 2007;

Baratoff et al., 2007; Holt and Bird, 2005). The additionality of renewable energy projects is therefore affected by the ability of investors to secure long-term contracts for REC sales. Holt and Bird (2005) note that a problem with the voluntary REC markets is that they often do not provide sufficient income certainty to alter investment decisions.

Most renewable energy projects in the United States are implemented without financial consideration of any revenue from REC sales into the voluntary market, and therefore are not additional.[31] What revenue is obtained from RECs is severely discounted by investors, unless a long-term contract for REC sales can be obtained (Baratoff et al., 2007). Such long-term contracts can be obtained in some RPS compliance markets, but are much less common in voluntary REC markets. For a voluntary REC market to influence the decisions of renewable energy investors in the United States, it is necessary for customers or retail marketers to be willing to make a long-term commitment to purchase RECs.

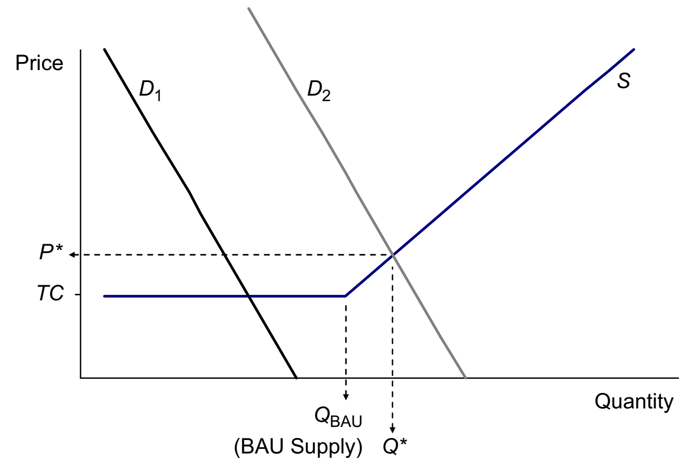

Fig. 2. Idealized supply–demand curves for a voluntary REC market.

5.4. *The importance of scarcity*

In determining the additionality of RECs it is also helpful to consider the market as a whole. The supply of non-additional RECs, referred to here as the BAU supply, is likely to account for a large fraction of the market where the process for determining the additionality of renewable energy projects for the REC market is grossly insufficient at screening out free-riding projects. The BAU supply is how many RECs are awarded to non-additional renewable energy projects (i.e., false positives). A large BAU supply is likely to cause the overall market to be long, and thereby depress prices. A market is long when the supply of RECs is greater than the demand.

Both RPS compliance and voluntary REC markets can be long. However, it is more likely that a RPS compliance market, with its defined participation boundaries, will exhibit a market scarcity due to the ability of government to set a mandatory quota for RECs.

How do you determine whether a REC market is long? One approach is to look at prices. If wholesale REC prices are not significantly above the level of transaction costs in the market, then it implies that the market is long and BAU projects have not been adequately screened out.[32]

Fig. 2 presents an idealized supply–demand curve for a voluntary REC market. The supply line (S) is discontinuous because RECs are not the only source of revenue for renewable energy generators. There is a supply of RECs on the market that result from projects that are implemented with consideration of the revenue from REC sales.

Two demand scenarios are presented in Fig. 2. Demand scenario 1 (D_1) illustrates a case where the voluntary market demand for RECs is less than the amount supplied by BAU projects and the REC market is long. The wholesale price of these RECs is equivalent to transaction costs (TC). Renewable generators face transaction costs, including certification and brokerage fees (Table 3). A wholesale REC price of at least \$0.5/MW h is likely necessary to cover these transaction costs. Therefore, a long REC market will not present a price of zero for RECs. Under demand scenario 1, the voluntary REC market has no effect on the supply of renewable energy generation or capacity and no additional environmental benefits are created. The second demand scenario (D_2) does create a scarcity and the market does have a marginal effect on renewable energy investments. Under this second scenario, wholesale REC prices trade at a price of P^*, which is above the level of transaction costs.

It is important to recognize that even if a voluntary REC market exhibits a scarcity for RECs, not all of the RECs sold in that market are necessarily from additional renewable energy projects. There can still be an excessive number of free-riders that have not been screened out of the market. It may simply be that consumer demand exceeds the BAU supply of RECs in the market. In this case, the incremental effect on renewable energy investments caused by the voluntary REC market is not equivalent to the total number of RECs sold in the market. The incremental effect is instead equal to the total demand for RECs minus the BAU supply (Q^*-Q_{BAU}). If RECs sold in voluntary markets do not pass credible additionality tests, then they can at best be expected to have a marginal effect that is less than the total number of RECs sold.

It is, therefore, inaccurate to assume that RECs represent additional megawatt-hours of renewable energy generation because they have a market demand effect. Even if there was such an effect—because the voluntary market demand was greater than the BAU supply—many RECs would still be sold to customers from non-additional projects because of inadequate additionality tests.

Although we are concerned with the effect of the voluntary REC market on renewable energy investments, additionality tests are best applied at an individual project level, instead of for the market as a whole. Projects have clearly defined boundaries (e.g., a power plant facility or collection of proximate wind turbines). As the boundaries of an activity enlarge, monitoring becomes increasingly difficult, determining additionality becomes more complex, and assigning ownership of the marginal impact of the credit market to multiple project investors becomes difficult.

So, is the demand for RECs in voluntary markets greater than the BAU supply? Additional research is needed to answer this question more definitively, but an examination of actual prices in the US voluntary REC market gives us a hint of what the answer is likely to be. REC prices in the US voluntary market are quite low, as shown above, and do not appear to be significantly above the level of transaction costs. More importantly, the evidence available indicates that voluntary market REC sales, at least for most renewable energy sources (e.g., non-solar) do not factor into investor calculations. The revenue stream is too small, and it is too uncertain (Baratoff et al., 2007).

[31] RECs sold into RPS compliance market, in contrast, may represent a reliable long-term revenue stream and are therefore a significant consideration when project investment decisions are made.

[32] Another approach would be to investigate whether there is a significant number of renewable energy generators that are eligible, but do not sell RECs into the market. Some small renewable energy generators in the United States do not sell RECs into the voluntary market (Hathaway, 2007).

Table 3
Generic supply and demand characteristics of REC markets

Demand scenario	Marginal cost of REC supply	Generator response	REC price determinant
D_1 (long market)	0	The demand for RECs is less than the BAU supply that would be produced anyway	Prices are roughly equal to transaction costs. Prices are mostly unaffected by changes in demand below the BAU supply
D_2 (market scarcity)	Positive	Additional generation capacity with lowest marginal cost will be brought online to meet demand above BAU	Marginal cost of generating additional MW h of renewable electricity above BAU demand plus transaction costs

5.5. Voluntary and RPS compliance market interactions

Consumers may have the option of purchasing and retiring RECs that are eligible for use in RPS compliance markets. Doing so reduces the supply of RECs available to LSEs to meet their quotas. If an RPS target does not produce a real scarcity (i.e., the compliance REC market is long) then voluntarily removing a REC from the market will have no effect on renewable energy investments or generation. Voluntarily removing RECs from a RPS compliance market with a stringent quota, however, is an effective tactic to ensure the additionality of RECs. The act of retiring and removing RECs from the compliance market, in this case, determines additionality. When an RPS creates a REC market scarcity and a REC is retired so that it cannot be used for compliance by LSEs, then a renewable generator will have to produce an additional REC to supply the fixed market demand. Retiring RECs and other environmental commodities from a compliance market, that exhibits a market scarcity, avoids the need to conduct project-by-project additionality determinations.

Like voluntary REC markets, whether a RPS compliance market is long can be evaluated based on REC wholesale prices. REC prices in these markets vary with the stringency of the RPS target and by technology type. Wholesale REC prices in RPS compliance markets range from \$2/MW h to over \$200/MW h for solar RECs in New Jersey. A relatively clear indication that an RPS market is not long is when REC prices are at or near the penalty fee for non-compliance (Agnolucci, 2007).

5.6. Summary

Because of the weak additionality tests applied, RECs sold in voluntary markets are more accurately regarded as a production subsidy for renewable electricity generation. A determination of additionality distinguishes between projects that would have occurred without the subsidy from those that would not. But the voluntary REC market does not make this distinction.

In contrast to the typical definition of a subsidy,[33] in the voluntary REC market it is the consumer, not the government, which fills the role of subsidy provider. Financial contributions provided by the public in support of a public good, are typically referred to as charity. The use of RECs as an accounting instrument, though, allows consumers to collectively offer renewable generators a production subsidy for each MW h they generate.

The impact of a production subsidy is on the margin of the market (Fig. 2). The subsidy makes a certain amount of production economical that was not in the absence of the subsidy, assuming the subsidy exceeds the transaction costs of receiving it. In the language of environmental markets, we would say that it is this marginal increase in production resulting from the subsidy that is additional to BAU. However, voluntary markets cannot guarantee the subsidy to all eligible recipients. When available supply of a production subsidy (i.e., consumer demand) is less than the BAU supply of the subsidized product or service by producers and the subsidy price is determined by the market, then the subsidy will have a negligible effect on production or investments.

It is not clear how significant an impact the voluntary REC market has had on renewable investment decisions. Overall, though, there appears to be little evidence that the voluntary REC market in the United States is a deciding factor in renewable energy generators' decision to invest in new capacity. Because of the weak additionality tests applied and low wholesale REC prices, it is safe to assume that most RECs sold in voluntary markets are not additional (i.e., false positives are prevalent). The exception, in some cases, is solar, which typically benefits from higher REC prices.

The primary drivers for new capacity investments in the United States and Europe are government mandates and subsidies (Baratoff et al., 2007; Bird et al., 2003; Heiman, 2006; RECS, 2005). However, in other jurisdictions where renewable technologies do not receive financial support from the government, renewable energy projects are more likely to be additional and the revenue from RECs sales may be a deciding factor for investors.

6. If additional, are RECs equivalent to emission offset credits?

There has been much confusion regarding the effect of RECs on emissions since the emergence of REC markets (Sloan, 2001). Again, the central problem is that RECs are assumed to be an emission offset credit instrument.[34] Can an entity credibly claim to have offset GHG emissions by purchasing and retiring RECs? More specifically, can an entity purchase and retire RECs and then claim rights over emission reduction offset credits or claim to have offset its emissions from electricity consumption? The real question in both formulations is whether less is emitted from grid-connected electricity generation due to the purchase and retirement of RECs.

Electricity is a major source of energy for most consumers. Voluntary green power and GHG offset markets both lack standardized commodities or regulation, which results in a great deal of confusion on the part of consumers wishing to offset emission associated with their electricity consumption. Because RECs are typically less expensive than credible GHG offset credits, they are often favored for purchase by those unable to distinguish between the two types of environmental commodities. The difference in price, however, is partly due to the difference in the additionality of RECs and GHG offset credits. For example,

[33] A subsidy is typically defined as financial assistance from the government that encourages the production or purchase of a good or service.

[34] In their Staples case study, the World Resources Institute states that Staples' REC purchases "resulted in an additional 35,000 metric tons of avoided GHG emissions." Clearly the author is equating RECs with offset credits (Pino, 2006). This type of claim is commonplace in voluntary REC markets in the United States. See also TerraPass (www.terrapass.com) and Green-e (www.green-e.org).

CDM offset credits (i.e., CERs) trade on the market for around \$20/metric ton CO_2. In contrast, RECs in the US voluntary market can be purchased wholesale for around \$2/MW h. Conservatively assuming that a MW h of renewable electricity did displace electricity from a coal-fired power plant, which emits 1 metric ton/MW h, then the retirement of one REC would offset about one metric ton of CO_2 for a price of \$2/metric ton CO_2. Many consumers wish to contribute to the fight against global warming, but they also want to do it as cheaply as possible, especially if they cannot evaluate the claims made by marketers and brokers.

Treating RECs as being equivalent to offset credits is analogous to assuming that none of the electricity associated with RECs would have been generated without the additional income from the sale of RECs. Given that many or most RECs sold in voluntary markets are *not additional,* then this assumption is clearly false. A non-additional REC cannot result in additional emission reductions.

If a consumer was able to procure RECs from a renewable energy project that was determined to be additional (i.e., strong additionality tests were applied), then treating RECs as emission offsets still presents two more problems. The first is resolving ownership issues. The ownership of RECs themselves has at times been contested (Holt and Bird, 2005; Holt et al., 2006). The more important issue, though, relates to ownership claims over emission reductions that occur off-site from the renewable energy facility. The second problem relates to the difficulty in quantifying the effect that renewable energy generation has on the dispatch of grid-connected fossil fuel-fired generation as well as the effect that REC markets have on renewable generation.

6.1. *Ownership*

Before discussing ownership issues related to emission reduction claims made in REC markets, it is necessary to introduce the concept of direct and indirect emissions (WRI/WBCSD, 2004, 2005). Direct emissions are those that occur on the site of the renewable energy facility, while indirect emissions are those that occur off-site.

Although most renewable energy projects will not be associated with significant direct emissions, some may. For example, landfill gas methane may be used as a biofuel to generate electricity. Such projects may produce direct emissions reductions by combusting previously vented methane that are additional to BAU. The ownership of these emission reductions are relatively unambiguous (i.e., belong to parties invested in the project).

The more central issue for RECs relates to ownership claims over indirect emissions from the consumption of electricity (i.e., GHG Protocol Scope 2) and indirect emission reductions assumed to occur at a fossil fuel-fired power plant because electricity was instead generated by a renewable technology.[35] Due to the complex operations of the electric power grid, it is difficult to establish unambiguous causal linkages between renewable energy generation and changes in generation at other power plants on the grid. Since most of the benefits associated with renewable generation result from changes in behavior at off-site facilities that are under the control of other entities (e.g., at fossil fuel-fired power plants), ownership of benefits can be ambiguous without regulatory guidance.

It is also ambiguous whether entities wishing to offset their emissions should claim responsibility for the indirect emissions associated with their electricity consumption in the first place, since these emissions occur at fossil fuel-fired power plants. Although regulatory liability to mitigate GHG emissions is more likely to be placed on power plants that emit rather than on end-users of electricity, it is clear that electricity demand is a proximate cause of GHG emissions. Many entity-level emission accounting protocols have accepted the use of RECs and green power purchases to offset indirect emissions from an entity's electricity consumption. Their argument is seductive because it seems logical that the purchase of green power should offset indirect emissions resulting from electricity consumption. We can all agree that renewable energy does not emit pollution. However, this fact does not allow us to conclude that the sale of RECs caused additional renewable energy to be generated.

The argument that RECs can be used as emission offsets for Scope 2 emissions implicitly claims that the offsetting of indirect emissions should be held to a lower standard of credibility than claims regarding the offsetting of direct emissions. It is reasonable to debate whether emissions from electricity generation are the responsibility of electricity consumers or generators. However, if consumers decide to claim responsibility for indirect emissions associated with their electricity consumption, then they should apply credible emission offsets to them. Ambiguity regarding the ownership of the emissions from electricity generation does not justify ignoring the additionality, ownership, and quantification characteristics of credits used to offset them. To claim that RECs or green power purchases offset indirect emissions from electricity consumption is equivalent to claiming that the generation of renewable energy is inherently additional and equivalent to an offset credit. As shown above, such a claim is not justified.[36]

With ownership issues it is also important to distinguish between legal property rights and customary rights to make marketing claims. It is common to find advocates of voluntary REC markets making statements such as "If a company can claim ownership of a REC it can also claim the environmental benefits of the associated green power" (Pino, 2006). However, in the United States and Europe a legal basis for holders of RECs to make property rights claims over indirect GHG emissions or emission reductions (i.e., government-sanctioned emission allowances or offset credits) has not been demonstrated.[37,38]

By equating RECs with emission offsets, consumers are attempting to claim ownership of a public good (e.g., reduced pollution) or set of public goods (e.g., all environmental benefits). In doing so, they are attempting to make a non-excludable public good (e.g., emissions reduced through generating electricity from renewable sources) excludable (i.e., a private good). Typically, only governments are thought of as being capable of assigning property rights over public goods. In voluntary markets without government oversight, entities can only attempt to exclude others from making marketing claims regarding a given public good. Ownership claims by participants in voluntary REC and GHG offset markets are (or should be) restricted to marketing claims until governments assign ownership.

[35] Indirect emissions from electricity consumption are referred to as Scope 2 emissions under the World Resource Institute/World Business Council for Sustainable Development GHG Protocol (WRI/WBCSD, 2004).

[36] An instructive mental exercise is to imagine a world in which BAU is that 50 MWh of electricity is generated from renewable energy and 50 MWh from non-renewables. Then a green power market develops and some consumers purchase 50 RECs. These consumers then claim to have offset their indirect emissions from electricity. From the perspective of the atmosphere, however, the amount of pollution emitted has not changed. The renewable/non-renewable mix of generation is the same. And it is unlikely that the customers not purchasing RECs are now claiming that their electricity is now more polluting.

[37] In countries eligible for CDM projects, renewable energy projects may be able to claim property rights over offset credits because fossil fuel power plants in most developing countries are not currently under the threat of emission caps.

[38] For a case describing the allocation of NO_x allowances to entities for their purchase of RECs, see (Jacobson, 2007).

REC and certificate registries are being established in many states, regions, and countries to facilitate REC markets and deal with ownership and double counting issues (Wingate and Holt, 2004). Although these tracking systems will address double counting issues with certificates, they do not address ownership issues with emission reductions or other environmental benefits.[39]

6.2. Quantification

Quantifying the number of MW h produced by a renewable energy project is not problematic, as meter quality data is typically available. However, the quantification of environmental benefits (e.g., emission reductions) that may be produced off-site from the renewable generation facility is problematic.

It is not feasible to track electrons through the electric transmission and distribution grid. Therefore, the effect of an input of electricity from a renewable generator on other grid-connected generators is difficult to quantify. Emissions trading is typically prefaced with the assumption that it does not matter where or when emissions occur. In the case of renewable energy generation's displacement of fossil generation, where and when the generation occurs matters a great deal. GHG offset crediting methodologies under the CDM recognize this issue and utilize quantification methods that approximate the relevant marginal emissions from generators supplying the local electrical grid.[40] In contrast, marketers that claim RECs are equivalent to GHG emission offset credits typically apply a simple grid average emission rate.[41]

If REC additionality claims are based on incremental renewable investments caused by purchasing RECs in a market exhibiting some scarcity (i.e., the claim is based on the marginal increase in renewable electricity generation produced by the voluntary REC market's production subsidy effect) then the magnitude of this incremental investment must be quantified. The difficulty of performing this type of market analysis and then allocating emission reductions to individual renewable generators is one reason that additionality is best determined, and offset credits are best awarded, to individual projects.

7. Discussion and conclusion

Environmental markets for renewable energy and emission offset commodities are currently in a state of confusion. Consumers are not clear what they are getting when they purchase RECs. The promotion of renewable energy markets is a reasonable approach to increase the supply of a variety of public goods. However, because of the economics of most renewable generation technologies, policies and voluntary markets should focus on the promotion of additional investment in renewable generation capacity above BAU levels. Financial contributions to existing renewable capacity are unlikely to result in the supply of additional public goods.[42]

Are consumers that voluntarily purchase and retire RECs buying green power? Because RECs are an intangible market instrument, unbundled from the actual commodity being sold (i.e., electricity), this is the wrong question to ask. RECs provide only a small portion of most renewable generator's revenue. The sale of RECs only has an impact on the production of electricity from renewable generators if RECs can be sold at sufficiently high prices under long-term contracts. A more appropriate question is: Did purchasing a REC cause renewable electricity to be generated and delivered to the grid instead of electricity from some non-renewable energy source? Because renewables have minimal operating costs, the revenue from REC sales will not affect decisions to operate or dispatch renewable generation. For RECs to be considered to come from an additional project, the revenue from certificate sales needed to have caused investments in additional renewable generation capacity. Without credible additionality tests, the sale of RECs in voluntary markets can at best be expected to have a market demand effect that will be less than the supply of RECs on the market.

It was found that voluntary market RECs are not equivalent to emission offsets and the retiring of a REC may have no impact on emissions from electric power generation. Instead, consumers that purchase RECs in voluntary markets are providing financial assistance to renewable generators in the form of a production subsidy. Generators that sell RECs are, also, not transferring property rights to emission reductions, since they are unlikely to have ownership. Consumers that wish to make more credible claims that they are displacing non-renewable generation can purchase RECs from a RPS compliance scheme that has created a market scarcity.

The error in the belief that RECs are equivalent to emission offset credits partly lies with the use of the term "environmental attribute" or "environmental benefit." Definitions using this type of language are almost universally ambiguous, give consumers the mistaken impression that they are purchasing a good instead of subsidizing a public good, and prevent RECs from functioning as a homogeneous environmental commodity.

There is much confusion regarding the issue of RECs and GHG emission reductions, in part because of the ownership and quantification issues regarding an entity's emissions from electricity consumption (i.e., Scope 2 emissions) that it wishes to offset. An entity's decision regarding its responsibility for emissions from its electricity consumption, however, should be separated from requirements for the credibility of emission offset credits applied to them. If the goal is to reduce GHG emissions, then first best measures (i.e., GHG emission offsets) are the appropriate instrument. Evaluating the quality of voluntary market GHG offset credits, especially the additionality of projects, is an issue, however, that requires its own careful attention (Akerlof, 1970; Kollmuss, 2006; Trexler, 2006; Trexler and Kosloff, 2006).[43]

These conclusions should not be taken to mean that renewable energy projects cannot be awarded emission offset credits. But they do mean that offset credits from renewable energy projects

[39] None of the certificate tracking systems in the United States or Europe track off-site attributes of renewable generation. Massachusetts has attempted to do so by assigning a monthly average emission rate for the grid to certificates with the assumption that it is equivalent to avoided emissions.

[40] For an example of marginal dispatch substantiation of emission reductions see (RSG, 2006). It is important to note, however, that this type of analysis can become overly complex and indeterminate when the marginal effect of multiple renewable energy generators is analyzed simultaneously.

[41] The difference between an approximation of a marginal emissions rate a grid average emission will depend on the mix of generation on and planned for the grid as well as its dispatch order.

[42] Unless the original investment was made with the need and assumption of revenue from certificate sales.

[43] The United Kingdom has recently drafted a code of best practices for the voluntary GHG offset credit market. The code limits the market to obtaining reductions from CDM CERs, Joint Implementation ERUs, and EU-ETS allowances. The code excludes voluntary emission reductions (VERs) because of their lack of standardization and verification. They do not acknowledge problems resulting from the over-allocation of allowances in the first phase of the EU-ETS, which makes the additionality of retiring these allowances questionable.

should be based on project-level accounting process that fully addresses additionality, ownership, and quantification issues.

Having addressed the relationship between RECs and emission offset credits in this paper (Part 1), the relationship between RECs and emission markets more generally is provided in Gillenwater (2008). Specifically, this Part 2 paper explores the relationship between RECs and emission allowances used in GHG emissions cap-and-trade schemes.

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Appendix A. Supporting Information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.enpol.2008.02.036.

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