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Technical note

Additionality of wind energy investments in the U.S. voluntary green power market

Michael Gillenwater [a,b,*], Xi Lu [c], Miriam Fischlein [d]

[a] Science, Technology and Environmental Policy Program, Woodrow Wilson School of Public and International Affairs, Robertson Hall, Princeton University, Princeton, NJ 08540, USA
[b] Greenhouse Gas Management Institute, Seattle, WA, USA
[c] School of Engineering and Applied Sciences, Harvard University, Cambridge, MA, USA
[d] Institute of the Environment and Sustainability, University of California Los Angeles, Los Angeles, CA, USA

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ABSTRACT

In the United States, electricity consumers are told that they can "buy" electricity from renewable energy projects, versus fossil fuel-fired facilities, through participation in voluntary green power markets. The marketing messages communicate to consumers that they are causing additional renewable energy generation and reducing emissions through their participation and premium payments for a green label. Using a spatial financial model and a database of registered Green-e wind power facilities, the analysis in this paper shows that the voluntary Renewable Energy Certificate (REC) market has a negligible influence on the economic feasibility of these facilities. Nevertheless, voluntary green power marketers at least implicitly claim that buying their products creates additional renewable energy. This study indicates the contrary. Participants in U.S. voluntary green power markets associated with wind power, therefore, appear to be receiving misleading marketing messages regarding the effect of their participation. In the process of completing this analysis, a potentially relevant factor in explaining investor behavior was identified: the potential for the overlap of voluntary REC markets with compliance REC markets that supply utilities need to meet their obligations of Renewable Energy Portfolio Standard (RPS). The majority of state RPS rules allow for regional or even national sourcing of RECs, meaning that projects are generally eligible to provide compliance RECs to utilities not only in their home states, but in several other states.

1. Introduction

In the United States, electricity consumers are told that they can "buy" electricity from renewable energy projects, versus fossil fuel-fired facilities, through participation in voluntary green power markets.[1] The marketing messages communicate to consumers that they are causing additional renewable energy generation and reducing emissions through their participation and premium payments for a green label. The retailers that operate in this voluntary green power market typically purchase Renewable Energy Certificates (RECs) from renewable energy project developers to resell to their customers. The vast majority of the U.S. voluntary green power market is based upon wind power projects to supply these RECs [1,2].

The marketing promises and claims are debated, but it has not been well-established through quantitative analysis whether this voluntary environmental market leads to additional investment in renewable energy generation [3–6]. Once built, wind energy facilities can be operated with very low variable costs, and so any influence the voluntary green power market has on the amount of electricity produced from wind (as well as solar) must be in the form of additional generation capacity from either new construction or repowering of existing facilities. If voluntary green power markets do not lead to additional investment then consumers who pay a premium to participate in these markets and retailers who promote the purchase of RECs are being mislead and misleading, respectively.

Previously, others addressed the issue of defining RECs, but none provided systematic or quantitative analyses or proposed comprehensive solutions [7–11]. More recently, Holt, Sumner et al. [5] at NREL asked the question "do RECs play a direct role in new

* Corresponding author. Greenhouse Gas Management Institute, Seattle, WA, USA. Tel.: +1 202 997 3335.
E-mail addresses: gillenwater@alum.mit.edu, michael.gillenwater@ghginstitute.org (M. Gillenwater), xilu@fas.harvard.edu (X. Lu), mfischlein@ioes.ucla.edu (M. Fischlein).

[1] For example see the U.S. Environmental Protection Agency's Green Power Partnership at http://www.epa.gov/greenpower/index.htm.

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project development?" Their report addressed both the compliance and voluntary REC markets and was written in response to Gillenwater [3,12,13], Trexler [14], and other critics of the claims made within the green power marketing industry. The authors accepted that "voluntary RECs generally do not by themselves [drive project development]; however, it depends on the nature of the market". Unlike the results presented here, their analysis was qualitative, anecdotal, and at times mixed results for the compliance and voluntary REC markets.

The present study explores the influence of the voluntary REC market on wind energy project finance using a dataset of projects registered with the Green-e[2] program in 2011. In 2010, Green-e certified generation accounted for 65% of the U.S. voluntary green power market, and the vast majority of Green-e registered generation capacity is wind power [15]. Further, the vast majority of the U.S. voluntary green power market is associated with wind power (83%) and some form of REC transaction (56–85%)[3] [2]. Therefore, the focus on wind power projects associated with the Green-e program is assumed to be a reasonable proxy for the broader voluntary green power market.

More specifically, this paper examines the economic feasibility of these Green-e registered wind power projects under scenarios that include and exclude the economic incentive provided by the voluntary green power market. It builds upon the spatial financial model described in Ref. [16], which incorporates geographic factors including wind resource availability and the costs of grid connection at each project site. The wind resources data take advantage of a high-resolution spatial and temporal wind dataset—derived from assimilated meteorological fields compiled by NOAA—to derive project-specific generation capacity factors [17].

In the process of completing this analysis, a potentially relevant factor in explaining investor behavior was identified: the potential for the overlap of voluntary REC markets with compliance REC markets that supply utilities need to meet their obligations of Renewable Energy Portfolio Standard (RPS). It was initially assumed that most wind power projects were limited to either supplying RECs to voluntary or compliance-based REC markets, and so the influence of these two market mechanisms on actual investment patterns could be examined independently. However, upon examination of the projects registered with Green-e, the likelihood of this assumption of independence was found to be low. The majority of state RPS rules allow for regional or even national sourcing of RECs, meaning that projects are generally eligible to provide compliance RECs to utilities not only in their home states, but in several other states [18].

Section 2 describes in more detail the datasets, assumptions and model used in this study. Results are presented and discussed in Section 3, followed by summary conclusions in Section 4.

2. Data and model description

A dataset of 386 renewable electricity generation facilities that have been registered with and approved by Green-e energy—based on the submission of tracking attestations—was used as a representative of the broader voluntary green power market [15]. Of these facilities, 86% are wind on a nameplate capacity-weighted basis. Only wind facilities were included in this study.

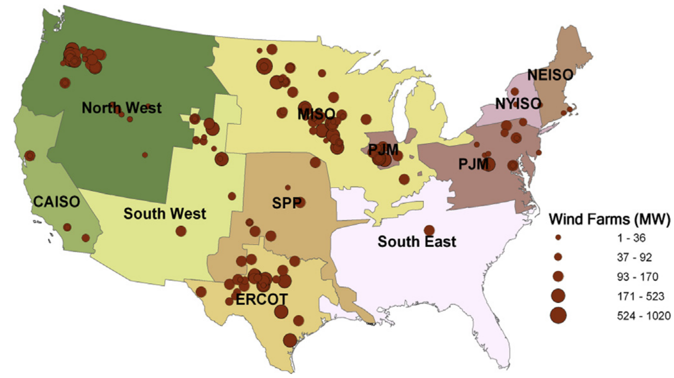

Fig. 1. Map of regional electric grids in the contiguous United States with illustration of locations and capacities of wind facilities considered in this study.

The CRS database includes information on nameplate capacity, state in which the facility is located, and operational date. Importantly, the Green-e program does publish data on how many Green-e certified RECs each facility sells. Latitude and longitude information on each facility was added to the dataset using information from TWR [19] and NREL [20]. Location data were not available from these sources for a subset of facilities (4%). For these facilities, press releases and local utility commission permitting documents were used in combination with satellite imagery from Google and Bing maps to visually locate and geo-code the approximate geographic center of each facility.[4]

Facilities located in Canada, facilities with nameplate capacities less than 10 MW, as well as a small number of facilities (13) for which geo-coded location data could not be found were excluded from the sample. In total, 7% of the U.S. wind generation capacity in the Green-e database was excluded from the present study, resulting in a final sample size of 248 observations. The geographic distribution of facilities and their generation capacities is presented in Fig. 1. Table 1 summarizes the geographic distribution of projects according to the regional certificate tracking system to which they reported. The capacity-weighted age of the final sample is 3.0 years (as of January 1, 2011), with a standard deviation of 2.9 years, so the majority of facilities in the sample went online between 2004 and 2010.

Detailed documentation of the spatial financial model used in this study is provided in Lu, Tchou et al. [16] and therefore only a summary description is provided here. Wind data were derived using NOAA's assimilated meteorological fields, RUC-20, which provides a spatial resolution of 20 km by 20 km [17]. Wind speeds at a 100 m elevation were interpolated and used to calculate turbine electricity generation and capacity factors. The output of each turbine in a given grid cell is calculated hourly using a power curve for a GE 2.5 MW turbine [21] and aggregated over the entire year.

The annual average capacity factors resulting from this approach were then adjusted upwards across the sample based on a statistical comparison with the probability distribution of capacity factors for voluntary market wind projects reported in Gillenwater [22].[5] Fig. 2 shows the distribution of unadjusted capacity factors compared with the distribution developed from an expert elicitation of U.S. wind power industry professionals. Specifically, the

[2] The Green-e energy program certified retail and wholesale green power products and is administered by the Center for Resource Solutions and is the largest such program in the United States. See http://www.green-e.org/.

[3] The lower estimate includes only unbundled REC market while higher estimate also includes green power transactions in competitive electricity markets in which RECs typically remain bundled with power sales.

[4] A single wind facility can include numerous turbines spread over a large area (e.g., multiple acres).

[5] Gillenwater [22]; contains the results of a formal expert elicitation of investment decision makers in the wind power industry and includes a probability distribution of capacity factor values for wind energy projects.

Table 1
Geographic distribution of wind project sample by generation capacity.

Tracking system	Approximate geographic equivalent	Percent of capacity in sample
ERCOT	Texas	30%
MRETS	Northern Midwest states	27%
WREGIS	Western states	27%
PJM-GATS	Eastern mid-Atlantic states	14%
NAR	Southeast and Southern Midwest states	2%
NE-GIS	New England states	1%

capacity factor for each project in the sample was adjusted upwards by 4 percentage points. Projects with capacity factor values that were still less than 26% were then adjusted up to this floor value. The rationale for this adjustment is that project developers choose to site turbines to maximize capacity factors and will not invest in projects with capacity factors below a minimum value. The average wind speed for a grid cell, therefore, is likely to be an under estimate of actual capacity factors achieved. Ultimately, though, the conclusions presented below were unaffected by this adjustment.

The financial component of the model analyzes the net present value (NPV) over a 25 year capital lifetime to estimate the levelized cost for a project to deliver electricity to the grid with an NPV of zero given an assumed internal rate of return (IRR, r_d) (Equation (1)).

$$\mathrm{NPV} = \sum_{n=1}^{25} (\mathrm{revenue} - \mathrm{cost})_n (1 + r_d)^{-n} = 0 \quad (1)$$

Project revenue of a wind facility was estimated as a combination of electricity sales and a 10 year $21/MWh subsidy, in the form of a tax credit, from the U.S. Production Tax Credit (PTC). The financial model was adopted here to estimate the levelized cost of generation of electricity from wind for each facility. Electricity prices in the local power market were based on the annual average wholesale price in the state in which a project is located. Projects in the United States also benefit from accelerated depreciation rules and obtain revenue from the sale of RECs, the latter of which is discussed in the following section.

Wind power projects entail capital, operations & maintenance (O&M), grid interconnect, and tax costs. For this study, all projects were assumed to face costs in keeping with a typical investment. Specific cost assumptions are summarized in Tables 2 and 3. A scenario analysis was conducted on the three major project costs.

The Lu, Tchou et al. spatial financial model has been validated on a dataset of wind projects coming online in the United States during 2006 and 2007 to confirm its ability to predict sites where

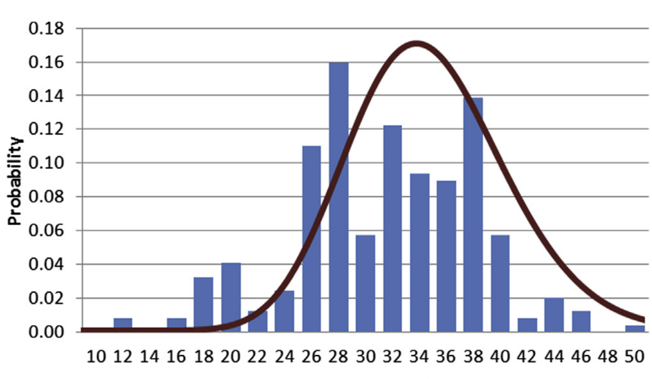

Fig. 2. Unadjusted distribution of capacity factors across sample (bars) and expert elicitation distribution (line).

Table 2
Fixed model cost assumptions.

Parameter	Assumption
Federal income tax	35%
Financing Structure	Single developer corporate equity structure
Accelerated depreciation schedule	MARCS: 20%, 32%, 19%, 12%, 11%, & 6% applied for the first five years of operation
Minimum IRR	7%

Table 3
Model cost assumptions for reference, low and high cost scenarios.

Parameter	Reference cost	Low cost	High cost
Capital cost ($/kW)	1700	1300	2100
Transmission connection cost (million $/mile)[a]	10	6	14
O&M costs ($/MWh)	1.0	0.6	1.4

[a] Calculated based on the shortest distance to existing transmission line.

investments in wind projects are economically feasible [23]. However, the conclusions presented here are nonetheless limited by the representativeness of the assumptions on cost parameters, electricity prices, and REC prices.

Data on RPS eligibility was based on primary textual analysis of all relevant state statutes, regulatory codes and administrative rules for the 30 states that had mandatory renewable portfolio standards as of August 2009. A total of 115 documents were coded for policy design aspects using the NVivo 8 qualitative analysis software. State data was then matched to the individual project based on location and age of the facility.

3. Results and discussion

Wind power project investors in the United States are able to earn revenue from the sale of RECs, which they can add to the revenue sources from electricity sales and other subsidies. There is not one REC market in the United States, but instead multiple overlapping markets with which wind power facility managers may engage.

Until recently, there have also been two voluntary markets for wind power RECs in the United States, with one market price existing in the western portion of the country and a lower price for the broader national market (Table 4). In last couple of years, though, the prices for RECs in the Western United States have converged with prices at the historical low end of the national market range, effectively merging these two markets.

Table 4
U.S. REC markets, spot market price ranges, and portion of sample eligible in each category.

Category	REC price range	Eligible capacity in sample (MW)[c]
Voluntary REC market[b]		
National wind	~$1–2.50	21,448.7 (100%)
West wind (WECC)	~$3–7	14,150.7 (66.0%)
RPS state eligibility[a]		
CT, NH, MA, RI	~$15–25	143.6 (0.7%)
DC, IL, NJ, PA, DE, MD, TX, OH (out of state)	~$1–5	20,377.4 (95.0%)
ME	~$7	2.8 (<0.1%)
OH (in state)	~$10–34	0
Other RPS states	NA	21,448.7 (100%)

[a] Approximate average prices over 2010–2011 (Wiser and Bolinger 2011).
[b] Approximate average prices over 2008–2010 (Bird and Sumner 2010).
[c] Percentages are fraction of total capacity in sample.

States with RPS policies use a variety of rules to determine whether the generation or capacity of a particular wind power facility is eligible to be counted towards compliance of a load serving entity (LSE) [18]. Of the 30 states (including the District of Columbia) with mandatory RPS regulations, less than half allow LSEs to use RECs to track compliance while also having a sufficiently liquid REC market for spot market prices to be available. These states, and their corresponding range of spot market prices, are presented in Table 4, along with the fraction of generation capacity in the sample that is eligible to participate in the REC market for that state.

One of the key findings of this paper is the degree of overlap between RPS compliance markets for RECs and voluntary REC markets. This overlap is illustrated in Table 4 by the large fraction of the sample (95.7%) that is eligible to sell RECs into a liquid RPS compliance REC market as well as a voluntary green power market. On average, a facility in the sample was eligible to be counted towards compliance in 7.2 states, while the minimum number of states for which a facility in the sample met eligibility criteria was four.

The eligibility of RECs produced by an individual wind project for RPS compliance is a function of rules around geographic origin, the facility's in-service date. Rules on the geographic origin of compliance RECs fall in three categories: 1) for RECs to be counted towards RPS, the associated energy either has to be physically delivered to the state, 2) delivered to the region, or 3) there are no restrictions on nationwide trade (Table 5). For a small number of states (CO, DE, KS, MN, MO, NC), RECs from anywhere are eligible, but the more common approach is to restrict RECs to regional origin or to project delivering electricity to the state. Twelve RPS states each have such requirements. Eighteen RPS states also restrict the age of eligible resources by excluding RECs from facilities in service before a certain date. Finally, the liquidity of each state's market for RECs is also influenced by their provisions on how RECs can be used. While all states use RECs in some form for tracking purposes, AZ and WI do not allow RECs to be sold separately from the physical electricity. In addition, states with pure capacity (rather than generation) requirements do not create RECs markets. In practice, wind facilities across the United States are generally eligible to sell into more than one state compliance market.

Table 5
State RPS eligibility rules for the use of RECs from renewable energy facilities.

State	Online after[a]	Unbundled RECs[b]	Location eligibility rules
AZ	NA	Not permitted	Delivered to WECC control area
CA	2005	Capped	Generated in state or first point of interconnection to WECC control area
CO	2004	Permitted	NA
CT	NA	Permitted	Delivered to ISO-NE control area
DC	NA	Permitted	Delivered to PJM control area
DE	1997	Permitted	NA
HI	NA	Permitted	Generated in state (island)
IA	NA	NA	Generated in state or utility's service area
IL	NA	NA	Generated in state (through 2011) and adjoining states thereafter)
KS	NA	Capped	NA
MA	1997	Permitted	Delivered to ISO-NE control area
MD	NA	Permitted	Delivered to PJM control area
ME	2005	Permitted	Delivered to ISO-NE or NMISA control areas
MI	NA	Permitted	Generated in state or service territory of provider
MN	NA	Permitted	NA
MO	NA	Permitted	NA
MT	2005	Permitted	Delivered to state
NC	2007	Capped	Unbundled out of state REC capped at 25%, remainder delivered to state
NH	2006	Permitted	Delivered to ISO-NE control area
NJ	2003	Permitted	Delivered to PJM control area (new resources), generated in PJM area (existing resources)
NM	2004	Permitted	Delivered to state
NV	NA	Not permitted	Delivered to state
NY	2003	NA	Delivered to NYISO control area
OH	1998	Permitted	At least 50% generated in state, remainder delivered to state
OR	1995	Capped	Generated in US and WECC control area, delivered to state
PA	NA	Permitted	Generated in control area (PJM, ISO-NE)
RI	1997	Permitted	Delivered to NEPOOL-GIS area
TX	1999	Permitted	Generated in state
UT	1995	Capped	Generated in WECC control area or delivered to utility
VT	2004	Permitted	Generated at facilities owned by or under contract with VT utilities
WA	1999	Permitted	Generated in Pacific NW, or delivered to state
WI	2004	Not permitted	Delivered to state

[a] Facilities that began operation before this data are ineligible.
[b] RECs can be sold separately from wholesale electricity.

3.1. Spatial financial model

The spatial financial model described in the previous section was used to isolate and investigate the influence of voluntary REC market prices on the economic feasibility of the projects in the sample dataset of Green-e registered facilities. National and Western voluntary market REC prices of \$2.1/MWh and \$6.7/MWh were used based on the approximate average values reported in Wiser and Bolinger [24]. For each facility the spread between the average price for electricity in the power market and the levelized cost of generation of electricity from wind was calculated for each facility in the sample. These levelized costs incorporate factors such as the PTC and accelerated depreciation. The resulting difference can be thought of as approximating the profitability of a project above the investor's minimum rate of return.

Figs. 3–5 present the results from the model for the three cost scenarios. The individual data points in each figure present the cost versus revenue spread excluding any revenue from RECs. The line above the points incorporates revenue from the sale of RECs into a voluntary REC market, assuming ideal market conditions and that all RECs from the facility's generation are sold into the voluntary market. The jagged feature of the "ideal voluntary REC" line is due to the application of the higher REC price for facilities located in the Western Electricity Coordinating Council (WECC) region. The figures show that under ideal conditions, the effect of voluntary REC markets on the economic viability of projects is small but significant. For example, in the reference scenario presented in Fig. 3, a small number of facilities are "pushed up" over the horizontal zero line due the expectation of REC revenue.

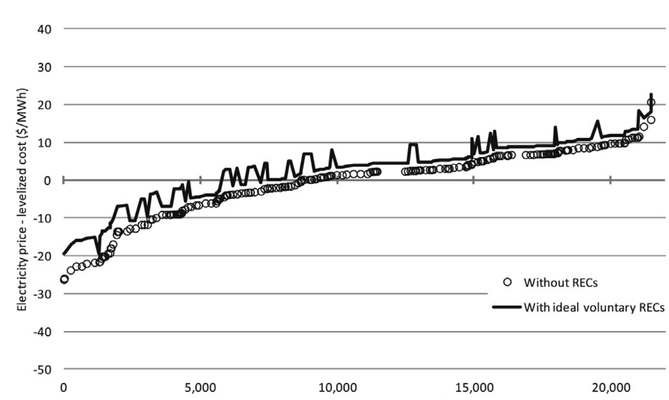

Fig. 3. Electricity price and levelized cost spread for reference cost scenario.

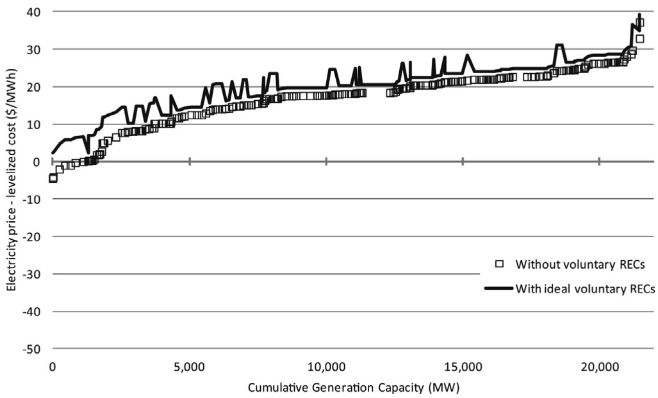

Fig. 4. Electricity price and levelized cost spread for low cost scenario.

The effect depicted in these figures, however, assumes an "ideal voluntary REC" market, meaning that it assumes a market where investors have sufficient confidence in the demand for voluntary market RECs to factor them into their investment decision making. Specifically, it assumes that investors expect the risk-adjusted real price of RECs over the full 25-year lifetime of the project to be the values assumed. Yet, we have evidence that investors do not hold these expectations. Project investors are rarely able to obtain a contract for the sale of voluntary RECs for more than three years, leading to significant risk exposure [5]. Because of this reality, investors have reported that when making investment decisions they typically discount to zero the expected value of any RECs for which they are unable to obtain a firm contract at the time the project investment decision is made [5,22]. Correcting Figs. 3–5 to account the present value of only three years of contractually confirmed REC revenue would depict an imperceptible effect from voluntary REC markets, and therefore is not shown.

For the projects that fall below the horizontal axis (i.e., theoretically should not have been built), if it is not the voluntary REC market that is enabling the projects in the sample to move forward, then what is it? There are a couple potential solutions to this puzzle:

1. Most projects, or at least those with lower capacity factors (e.g., on the left side of Fig. 4) are better represented by the low cost scenario.
2. Projects are not limiting their engagement with REC markets to the voluntary market, but instead are obtaining contracts for their RECs in one or more RPS compliance markets or are otherwise obtaining contracts from LSEs to be counted for RPS compliance.

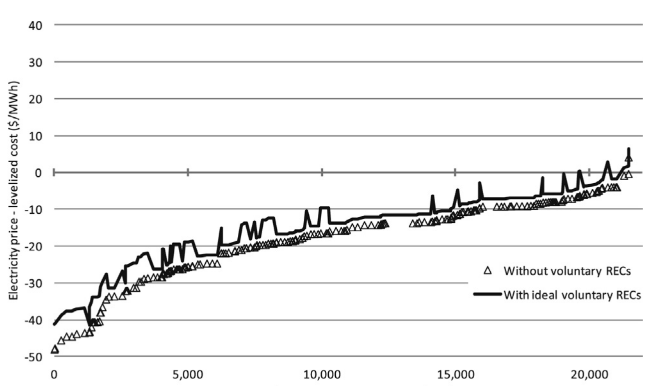

Fig. 5. Electricity price and levelized cost spread for high cost scenario.

Table 6
Wind power capacity in dataset by State compared with total in-State wind capacity.

State	Capacity in dataset (MW)[a]	Fraction of dataset	RPS in state?	State wind capacity[b]	Percent Green-e registered
Texas	7033.4	30.5%	Yes	10,089	69.7%
Iowa	3007.7	13.1%	Yes	3675	81.8%
North Dakota	2207.1	9.6%		2444*	90.3%*
Illinois	2030.5	8.8%	Yes	2045	99.3%
Oregon	1702.2	7.4%	Yes	2104	80.9%
Washington	1653.4	7.2%	Yes	2104	78.6%
Wyoming	1083.1	4.7%		1412	76.7%
Minnesota	745.4	3.2%	Yes	2205	33.8%
California	584.1	2.5%	Yes	3253	18.0%
South Dakota	562.0	2.4%		709	79.3%
Pennsylvania	424.5	1.8%	Yes	748	56.8%
Colorado	400.5	1.7%	Yes	1299	30.8%
West Virginia	330.0	1.4%		431	76.6%
Idaho	325.2	1.4%		353	92.1%
Kansas	185.5	0.8%		1074	17.3%
Missouri	146.0	0.6%		457	31.9%
New York	125.8	0.5%	Yes	1274	9.9%
Indiana	106.0	0.5%		1339	7.9%
New Mexico	102.4	0.4%	Yes	700	14.6%
Oklahoma	100.8	0.4%		1482	6.8%
Michigan	98.9	0.4%	Yes	164	60.3%
Wisconsin	55.0	0.2%	Yes	469	11.7%
Utah	18.9	0.1%		223	8.5%
Total	**23,028**	**100.0%**	–	**40,053**[c]	**57.5%**[c]

[a] Total generation capacity registered with Green-e (CRS 2011).
[b] Wiser and Bolinger (2011), Table 2.
[c] The NREL capacity data does not appear to account for Baldwin project (1020.4 MW) in North Dakota, which went operational in July 2010. The data in this table has been corrected to include this project.

The first potential solution seems plausible. Gillenwater [22] found that investors in the wind power industry will tend to invest in projects at less windy sites (i.e., lower capacity factor) if they are able to offset the loss in revenue through lower investment costs. And Wiser and Bolinger [24] have reported that actual project installation costs, the vast majority of which are related to turbine costs, have historically varied. Upon examination, though, the projects in the sample with negative spread values do not show a correlation between the spread variable and facility age (correlation coefficient of 0.09). Less economically viable projects do not appear to have been built in years when turbine prices were atypically low.

The second potential solution has already been supported above by showing that all of the projects in the sample also meet the eligibility under multiple State RPS regulations. And that nearly all of the projects in the sample are eligible to sell RECs into least four RPS compliance markets, where it is possible to obtain long-term purchase contracts. To further illustrate this finding, Table 6 presents the distribution of wind power nameplate capacity by State and compares this to the total generation capacity in the State reported by the U.S. Department of Energy. Across the States with RPS legislation, 60% of the wind power capacity in those States is also registered with Green-e. Clearly, most of the generation from this capacity is being counted by LSEs for RPS compliance and not supplying the voluntary green power market. Similarly, statistics compiled by the National Renewable Energy Laboratory (NREL) on the total size of the U.S. voluntary green power market indicate that the total generation capacity registered with Green-e is roughly three to four times larger than necessary to supply the entire market (correcting for typical capacity factors) [2].[6]

[6] See Tables 6 and 8 in Heeter and Bird [2]; assuming an average capacity factor of 0.32.

3.2. Discussion

So, what is occurring here? Wind power project investors appear to be using the voluntary REC market as a backstop market for RECs associated with generation in excess of that already under their long-term contracts with LSEs. These RECs are sold into which ever spot market offers the best price and terms. Importantly, as reported in Gillenwater [22], any potential revenue from future REC spot market transactions is not generally considered by investors in their upfront decision making process due to the risk involved. The voluntary REC market is essentially invisible to most investors, and instead is the purview of their REC brokers, who are charged with disposing of excess RECs and RECs associated with any merchant portion of a project's output.

The implications of this finding are that in the United States, the voluntary REC market does not appear to result in additional investments in wind power generation capacity. In other words, there appears to be support for the conclusion that under counterfactual conditions in which the voluntary green power market for RECs did not exist, the amount of electricity generated by wind power in the United States would be little different than what we actually see today.

4. Conclusions

Using a spatial financial model and a database of registered Green-e wind power facilities, the analysis in this paper showed that the voluntary REC market has a negligible influence on their economic feasibility. Nevertheless, voluntary green power marketers at least implicitly claim that buying their products creates additional renewable energy. This study seems to indicate the contrary. Therefore, in the United States consumers appear to be receiving misleading marketing messages regarding the effect of their participation in voluntary green power markets that rely on RECs as a tradable environmental commodity. This study has found that investments in wind power projects registered with Green-e are not additional due to the incentive from the voluntary REC market. Rather, investments in wind projects seem to be more influenced by compliance REC markets. Therefore, causal claims within the voluntary REC market regarding emission reductions are not substantiated by evidence.

The present study focused exclusively on the voluntary REC market, while the broader voluntary green power market also includes utility green pricing programs and competitive electricity markets in some states. Some, but not all of these other types of programs utilize RECs. Many state voluntary green power rules explicitly forbid that credits marketed under such programs can be counted towards compliance with state renewable energy requirements. It is possible that some programs under these two smaller aspects of the green power are more likely to result in additional wind power investment. And although RECs from wind power account for the majority of the voluntary green power market, RECs from solar energy projects are often traded as a distinct commodity with a separate price. Therefore, the conclusions here may not apply to these projects, which accounted for an estimated 0.2% of the U.S. voluntary green power market in 2010 [2].

Another key finding of this study was the overlap between voluntary REC markets and compliance REC markets that supply utilities to meet their RPS obligations. The majority of state RPS rules allow for regional or even national sourcing of RECs. The broad eligibility of wind power projects across several states allows them to sell into multiple compliance markets. As a result, wind power project investors appear to be using the voluntary REC market only as a backstop for RECs in excess of demand associated with RPS compliance. A significant increase in both the confidence in and magnitude of the voluntary REC market price signal would alter these conclusions. Alternatively, an aggressive national RPS would present a public policy (versus voluntary) replacement for investors. Area of future research is the degree to which demand for RECs from the voluntary market improves the efficiency of state compliance RECs markets.

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