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# The *New* Economics of Solar Energy: A Case Study in Demand for Renewable Energy Certificates (RECs)

*By: Joe Kastner, Cynthia Ryals, Scott Shibata, & Ian Stone[1]*

## Problem Statement

Although the demand for renewable energy is growing, the cost of its production can be prohibitive. In particular, electricity generated using solar photovoltaic systems has significant environmental advantages over conventionally produced electricity, but its high production cost renders it unviable in standard electricity markets.

The recent creation of a voluntary secondary market based on Renewable Energy Certificates (RECs), which are the environmental attributes associated with renewable electricity generation, has shown some promise in improving the economic viability of renewable energy. Information is available pertaining to REC purchases in government and commercial markets; however, little is known about the general public demand for RECs.

This research focused on estimating the household demand for RECs, primarily for application in the solar photovoltaic electricity market. The following questions were posed:

**Questions Posed:**
- How can the public demand and value of Renewable Energy Certificates (RECs) be determined?
- What is the public demand for RECs, **unbundled** from and **bundled** with commodity electricity?
- What are the characteristics of likely purchasers of RECs?

[1] Advisor: Christopher Costello, PhD

## Renewable Energy Certificates

In order to help recover the costs of photovoltaic electricity generation, a market has been created for RECs. The REC concept breaks renewable energy into two products: 1) the commodity electricity itself, or "brown power", and 2) the environmental attributes associated with producing that electricity from a renewable source (i.e. the REC). RECs encompass the relative benefits associated with renewable energy production, such as cleaner air and water. Figure 1 illustrates the concept of RECs.
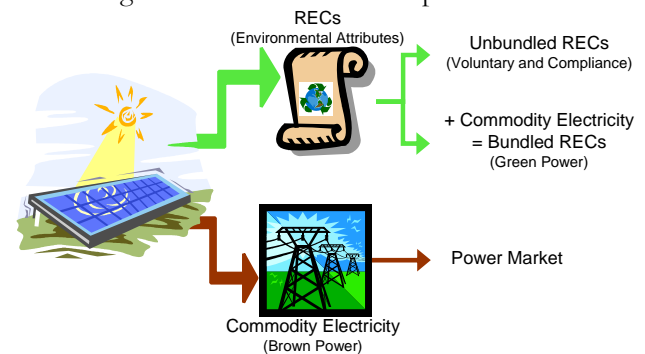


**Figure 1. The creation of RECs and electricity in renewable electricity generation.**

Currently, there are two vehicles by which RECs can be delivered. One vehicle involves a purchase through the local utility or rival energy service provider in competitive markets, as part of a green pricing program. This is referred to as a "bundled" purchase because the RECs are combined with commodity electricity. The second vehicle involves a purchase through any number of companies and organizations selling REC-only products. This is referred to as an "unbundled" purchase because the RECs are offered by themselves. Under this new market framework, renewable generators can sell RECs and commodity electricity separately.

## Significance and Background

The benefits and potential for photovoltaic energy to become a significant source of power in some regions has been broadly recognized. The economics of the solar energy market are changing with the separation of the REC product from commodity electricity to

make solar energy more viable. For example, a private market for RECs sold to households could reduce the need for public subsidy programs and liberate state funds for other social programs. This budding expansion of the REC consumer base from primarily government and commercial buyers to include households has created a need for different marketing strategies and understanding of public demand. It is clear that public demand does exist and is largely untapped, as national surveys show that a majority of Americans rank solar as the number one energy source with regards to the environment, safety, expense, and security[2]. Recognizing and quantifying the public demand for RECs, both bundled and unbundled, is a key aspect of the new economics of solar energy.

Bundled RECs began infiltrating the market in the early 1990s through "green power" pricing programs. As of 2002, there were 90 utilities nationwide that offered such programs. This represents about 10 percent of all U.S. utilities. While the number of programs has exploded, 10 programs (11 %) are responsible for 75% of the customers. People are willing to pay a $0.50 to $50 per month premium for renewable energy in these utility green pricing programs. A comparison of current green power utility pricing programs shows that even the best programs have only 10% participation. This is well below the stated participation rates of 50 to 80 percent[3], illustrating that challenges exist in accurately capturing public REC demand.

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Like bundled RECs, there is also evidence that the unbundled REC market is growing. According to Green-e's 2003 audit of unbundled REC markets, the total number of megawatts hours sold in the U.S. increased twelve-fold from the previous year. The number of residential customers grew 34% during this period, but still remains less than 0.5% of the total market.

Because the two vehicles for REC sales have different logistical and marketing needs, it is important to recognize the difference in demand between the two. We estimated separate demand curves for bundled and unbundled RECs.

## Approach

Our approach involved designing a model and survey to estimate the public demand for RECs. The city of Davis, California was chosen as the case study because of an existing photovoltaic electricity-generating facility located within the community, called PVUSA (Photovoltaics for Utility Scale Applications). PVUSA is operated by the group project client, Renewable Ventures, LLC.

The first step of the project was the creation of a predictive model. A logistic regression model (logit model) was developed to estimate an individual's willingness to pay for a 750 kWh REC, as a function of the following variables: product description (price, bundled or unbundled REC), demographics (gender, age, income, educational attainment), an indicator of general knowledge regarding renewable energy, an individual's dollar amount of charitable donations, and political affiliation[4].

Next, a corresponding contingent valuation survey was developed based on the logit model variables and NOAA panel recommendations described in contingent valuation literature. The overall survey structure was modeled after a similar survey conducted by Wiser. The NOAA recommendations provided survey development guidelines for data collection, value scenario, question type, scenario description, budget constraint, substitutes, and a follow-up question. These guidelines were followed and modified as they applied to the case study. In order to separately capture the demand for bundled and unbundled RECs, two versions of the survey were created: one offered green power from the existing utility and the other offered unbundled RECs from a private company.

Once the model and survey were completed, an iterative pretesting process ensued. A preliminary survey was administered, results entered into the model, and a demand curve derived. After each pretest, the survey was revised based on the model output to more accurately capture individual valuation of RECs.

[2] Farhar, Barbara C. 1996. *Energy and the Environment: The Public View*. REPP Issue Brief, No. 3. http://www.repp.org.

[3] Wiser, R. and Holt, E., 1999. *Consumer Interest in Green Power*. National Wind Coordinating Committee.

[4] Wiser, R. 2003. *Using Contingent Valuation to Explore Willingness to Pay for Renewable Energy: A Comparison of Collective and Voluntary Payment Vehicles*. LBNL-53239.

After four pretests, the refined survey was administered to case study participants in Davis. The survey respondents were voluntary participants exiting voter polling stations throughout the city during the November 2, 2004 elections.

A thorough analysis of the survey responses was then performed, including deriving a demand curve and calculating the REC price that would maximize revenue in Davis. These demand curves were used to develop a marketing plan targeting the characteristics of individuals most likely to buy a REC. From this information, a pilot sale of RECs via the World Wide Web was implemented. Finally, the model results were extrapolated to other populations within California to assess their likelihood to purchase RECs based on their similarities to the Davis profile. California counties with populations having high probability for REC consumption were consequently identified.

**Results and Discussion**
Approximately 400 surveys were completed during the case study. The demographics of the sample set closely resembled those of the Davis population, as shown in Figure 2.

| Demographic | Case Study Sample | City of Davis |
|---|---|---|
| Male | 50% | 48% |
| Female | 50% | 52% |
| Median Income | $40,000-69,000 | $42,454 |
| Age (years) | 25-34 | 25.2 |

*Figure 2. Demographic comparison of survey sample population to entire Davis population.*

The statistically significant variables in the regression analysis (p-value < 0.1) were: the price offering of the REC, whether the REC was sold bundled or unbundled, the location of the polling station at which the survey was administered (for only two of the stations), and annual household income (see Figure 3). The signs of the coefficients for each significant variable were consistent with marketing and REC literature research findings: lower price, higher income and a bundled REC corresponded with higher demand.

| Significant Coefficients: | Estimate | Pr(>|z|) | ME |
|---|---|---|---|
| REC price | -0.07 | 1.4E-03 | -0.02 |
| bundled | 0.71 | 0.01 | 0.17 |
| income | 7.6E-06 | 0.10 | 1.8E-06 |
| location (#1) | -0.91 | 0.08 | -0.22 |
| location (#2) | -1.00 | 0.08 | -0.24 |

*Figure 3. Logistic regression results for significant variables of Davis case study.*
*ME = marginal elasticity*

The model was run with all variables to derive separate demand curves for bundled and unbundled RECs (see Figure 4). For each case, the price of a REC had a negative coefficient, meaning the demand curves were strictly downward sloping.
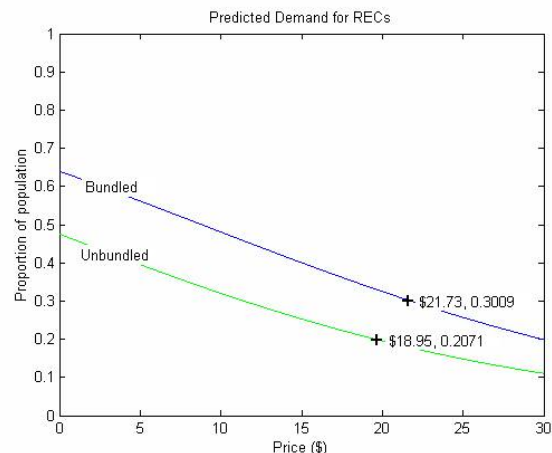


*Figure 4. Estimated demand curves for bundled and unbundled RECs in Davis.*

The price for a bundled REC that maximizes revenue was found to be $21.73, with 30.09% of the Davis population expected to buy at that price. The optimal price of an unbundled REC was $18.95, with 20.17% of the population expected to buy. These prices are consistent with actual REC offerings in green power and unbundled REC markets[5].

**Marketing and potential markets**
The unbundled REC price derived from the case study was used to develop and implement a pilot sale via the World Wide Web. Unbundled RECs were marketed despite a higher demand for bundled RECs because bundled RECs were not available for the purposes of the case study. The RECs marketed for sale were

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[5] Department of Energy, 2003. www.eere.doe..gov.

generated at the PVUSA facility and offered in cooperation with Renewable Ventures. Approximately 400 door hangers were distributed and resulted in one sale on the website within four weeks. This suggests that although a potential market exists, more time and resources are needed to implement a marketing campaign and diffuse product knowledge before market expectations are reached.
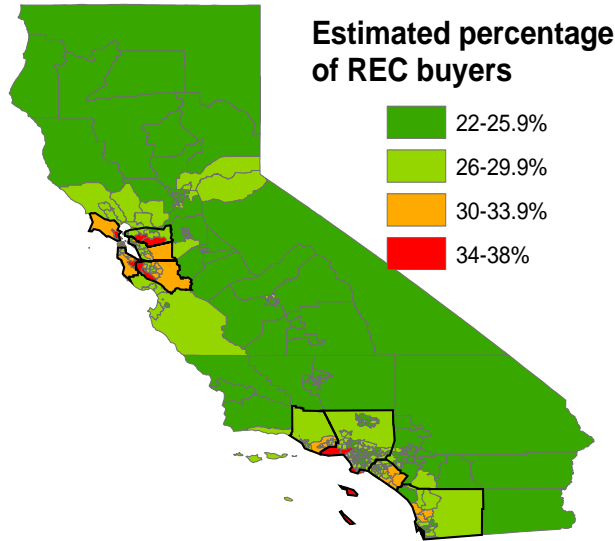


**Estimated percentage of REC buyers**

- 22-25.9%
- 26-29.9%
- 30-33.9%
- 34-38%

*Figure 5. Estimated percentage of REC buyers by county in California.*

Using the variables of the model that were also available in public census information, an additional analysis identified populations in California with the highest REC demand. These variables included REC price, bundled or unbundled, gender, age, education level, and income. The counties with the highest predicted percentage of buyers are identified in Figures 5 and 6.

| County | Percent of Population Predicted to Buy a REC |
|---|---|
| Contra Costa | 38 |
| Santa Clara | 38 |
| San Mateo | 35 |
| Los Angeles | 34 |
| Marin | 34 |
| Orange | 32 |
| Alameda | 31 |
| San Diego | 31 |
| Ventura | 30 |

*Figure 6. California counties most likely to buy RECs based on case study findings.*

**Conclusions**

RECs are seen as a crucial market mechanism for increasing the economic viability of renewable energy, particular solar photovoltaic energy. Knowing the demand for RECs can help determine whether or not specific renewable energy projects are feasible.

This study addressed the issue of public demand for RECs through the formation of an economic model and contingent valuation survey that were applied as a case study in Davis, California. A unique aspect of this study involved the use of two vehicles for delivering RECs to the public: bundled and unbundled.

The findings of this study agree with the published literature on RECs, which states that persons with higher income are more likely to purchase RECs. In addition, the optimal REC prices from the estimated demand curves for this study fall within the range of actual market prices for both bundled and unbundled RECs. Contrary to our initial assessment of potentially significant variables, this study found education level, political affiliation, age, gender, amount of charitable donations, and renewable energy knowledge to be statistically insignificant indicators of public demand for RECs.

Based on results from applying the case study model to census data, we recommend REC sellers target the counties of Marin, Contra Costa, San Mateo, Alameda, Santa Clara, Los Angeles, Ventura, Orange and San Diego. Although renewable energy knowledge was found to be insignificant, based on green power marketing literature, we further recommend that educating the public about RECs, renewable energy, and their benefits be a key strategy for any REC provider.