SEEDS II: Modeling Residential Rooftop Solar Adoption

Key Findings

- The SEEDS II project is a Department of Energy (DOE)-funded collaborative project with the University of Virginia (UVA) and electric cooperatives to develop a model for estimating the probability of an individual household to adopt rooftop solar, based on demographics, social characteristics, and behavioral characteristics.
- The project created two separate prototype models. The "static model" identifies households that are likely to be adopters or non-adopters of rooftop solar at a specific point in time. The "dynamic diffusion" model estimates the likelihood of adoption at a future point in time.
- The data informing these models were partially provided by focus groups and survey results from electric cooperative staff and consumer members.

What has changed?

Many stakeholders in the electric industry are interested in learning more about trends in consumer adoption of technology. In the case of solar, interest is sufficient to drive government sponsored research in the topic, especially by the Department of Energy (DOE) Solar Energy Technology Office (SETO). Input from America's Electric Cooperatives to these projects can add value and perspective that is potentially otherwise unavailable to the research community. NRECA continues to facilitate electric cooperative involvement with leading research projects funded by the DOE.

What is the impact on cooperatives?

The Solar Energy Evolution and Diffusion Studies (SEEDS II) Project, a DOE-funded collaborative effort between the University of Virginia and electric cooperatives, focused on ways to identify the interest of consumers in rooftop solar. The final project deliverable was to create two models for cooperatives to use to better understand their consumer-members' perspectives on residential solar generation. Through these models, cooperatives can gain insights about who in their service area has a higher likelihood of adopting residential rooftop solar technology.

The models are currently in a prototype phase of their development and are not ready for commercial use, and need to be tested further for prediction accuracy. A challenge of these current prototype models is that they are not user-friendly to those who are not familiar with using the software R and Java, making the models not available for widespread use among cooperatives. Another potential barrier for use will be access

to individual household data within cooperative service territories, for cooperatives who do not already have the data in their own portals or GIS systems.

What do cooperatives need to know or do about it?

Cooperatives have the opportunity to learn the results of the SEEDS II project and to understand how the final models were created. It is helpful for cooperatives to be aware of these types of projects which can help them to understand their own needs and opportunities for research, especially as they relate to renewable energy opportunities. Cooperative involvement in research projects can help to developing new findings that are specific to electric cooperatives, rather than the entire utility industry, which can benefit all cooperatives.

NRECA aims to inform electric cooperatives on the results of various research projects that directly involve cooperatives, such as the SEEDS II project. The following further explains the background and insights gained from the project to date. For cooperatives that are interested in potentially using the models, please contact Maria Kanevsky, whose contact details are provided at the end of this advisory.

Project Background

The SEEDS II project is a three-year project funded by the Department of Energy (DOE) Solar Energy Technology Office (SETO). In collaboration with Virginia electric cooperatives, NRECA worked with researchers from the University of Virginia (UVA), previously at the Virginia Polytechnic Institute and State University (Virginia Tech), who led the project. This project is a continuation of a DOE SEEDS I project, where Sandia National Laboratories developed a model to predict solar proliferation based on the city of San Diego. Building off this previous project, SEEDS II aimed to refine the initial model using rural demographics and energy data gathered through partnerships with rural electric cooperatives and through national databases. One of the goals of SEEDS II was to create a solar adoption model that allows rural electric cooperatives to predict the probabilities of residential rooftop solar adoption and the growth of adoption within their service territories.

Using demographic, social, and behavioral data from cooperatives, and synthetic population modeling, UVA created two prototype models to predict the adoption of residential rooftop solar. Focus groups and survey results from electric cooperative staff and consumer members in Virginia also provided information that helped to develop the two models. The first model estimates the probability of adoption at a single point in time (static model), and the second model estimates the probability of adoption over time in a region using a diffusion model (dynamic diffusion model). The static model is applied to individual households, while the dynamic diffusion model used data from two cooperative regions to find how solar adoption is diffused in those regions.

Project Models

The Static Model

The static model calculates a specific household's probability of adopting solar PV panels. If the probability is above the certain threshold, then the household is labeled as an "adopter" – or if below the certain threshold, labeled as a "non-adopter." The model uses a logistic regression, including 20 variables, and is built in the programming software R. Depending on the input data of all the variables, the probability of

adoption will change, and the household will be identified as an adopter or non-adopter of solar panels. Once the model is developed beyond a prototype, cooperatives can potentially use it to help identify households in their service territory that are likely to be adopters of rooftop solar.

The variables included:

- housing unit type (mobile home, single-family detached house, single-family attached house),
- year the house was built,
- estimated value of the house,
- rural or urban area,
- climate region,
- acreage of the house,
- number of bathrooms,
- number of bedrooms,
- primary fuel type the house uses,
- daily electricity consumed by the house,
- number of car parking spaces at the house,
- square footage of the house,
- presence of a swimming pool,
- number of people in the household,
- education level of the household,
- annual income of the household, and
- number of solar adopters within 1 mile, 2 miles, 3 miles, and 4 miles of the household.

The Dynamic Diffusion Model

The dynamic diffusion model predicts the number of solar rooftop adopters over time, using data from cooperatives in rural Virginia in this case. To understand the diffusion of solar adopters in two regions, the model uses household demographics and neighborhood information that is also used in the static model. The two test regions that were examined in the model are the service territories of Rappahannock Electric Cooperative and Shenandoah Valley Electric Cooperative. This model was created using a contagion model, with the idea that cooperative consumer-members are, in theory, more inclined to adopt rooftop residential solar if their neighbors have already done so.

The model uses a synthetic population that provides a representation of the population of a region, including demographics, daily activity sequences and locations, and social contact networks. The synthetic population was built by combining multiple sources of data from the U.S. Census Bureau, the American Time Use Survey, the National Household Travel Survey, and Dun & Bradstreet. The combination of data represents contingent realities of the area including socio-economic characteristics and the built environment. A detailed demand model is also used to generate hourly energy demand profiles for each household in the population. Shenandoah Valley EC provided the core training data for the model, from year 2017, on 23,000 households.

The seeding strategy used in this model is "random," meaning the seed households are chosen uniformly randomly among all the households in the region. Each seed node represents a household that adopts rooftop solar, which then affects other household nodes in adopting rooftop solar through the peer effects in the social contact network. A regression model is then used to determine the household level probability of adoption, and neighborhood features are dynamically updated at every time step to reflect the changes. The diffusion modeling used here combined models of urban/rural areas and the embedded social network comprising end users, their interactions, and movements (using synthetic data), with sophisticated diffusion models, publicly available solar adoption data, and survey data collected from NRECA members. Taken all together, this modeling creates realistic response behaviors of households with respect to rooftop solar adoption.

The results of the dynamic diffusion model show that, relative to urban areas, a greater proportion of initial adopters is required in rural regions in order to achieve diffusion. Even within rural regions, areas with relatively high population density required fewer initial adopters, whereas low-density zip codes required at least 10% of households to have solar panels for the diffusion to take place.

Focus Group Results

To provide input into the development of the SEEDS II models, the Market Research Team at NRECA conducted a focus group of co-op staff in Delaware, Maryland and Virginia, and a telephone survey of consumer-members in those states. In addition to the work done on this project, NRECA's Market Research Team offers a service in market segmentation for all cooperatives. For more information on market segmentation services, please see the side bar on page 6 of this advisory.

In order to develop a successful electric cooperative program on renewable energy, it will be crucial to understand how the entire member base views renewable energy. In this SEEDS II project, the consumer survey found that solar adopters within cooperatives can be placed into the following categories:

- Group one: Older, higher income, empty nesters, doing solar because they can afford to,
- Group two: Lower income, look at leasing solar as a way to save money, and
- Group three: Those approached by third parties looking to lease large amounts of land for purposes of solar farms (prevalent in other states and now moving into the Virginia area).

For all three groups, it has also been observed that an overwhelming majority of solar installs take place on new residential construction.

High level findings from the focus group and survey include:

- There is higher interest in solar than other types of renewable generation; to some renewables and solar are the same. Some of the reasons co-ops identified for the focus on solar are that it is:
    - More accessible to members
    - More prevalent than other types of renewables, particularly for home installations
    - More scalable; can be adjusted to fit needs
    - More heavily marketed

- Consumers are looking at solar to save money, however, they are facing the following challenges:
    - Getting a lot of misinformation from 3rd party vendors
    - Having a perception of no bill or "getting a check" for excess solar generation
    - Not clear on the actual Return on Investment (ROI), since many are getting pulled in by misinformation, and not educated on the real ROI

- Solar strategies are in place at a number of co-ops, and key success elements are:
    - Focus on educating members
    - Need to provide accurate information (realistic ROI, billing expectations, etc.)
    - Need to cover fixed costs
    - No one group should subsidize another (cross-subsidies, do not have one group pay for another, i.e. non-solar members pay for higher fixed costs due to solar)

- Ideal solar program:
    - Get the rates right and let members do what they want (i.e. NO SUBSIDIES)
    - Be a trusted advisor on solar
    - Really comes down to what co-ops have always done, serving the needs and desires of the membership

- Does self-generation change the member's relationship with the co-op?
    - Can lead to greater engagement as the member needs to interact with the co-op for implementation and ongoing support
    - Members with positive experiences can become advocates for the co-op
    - Risk for conflict with the co-op based on false expectations created by 3rd parties (i.e. members want to know why they still have a bill; 3rd party never discussed fixed rates, promised "check back" for excess generation)

- Influencers:
    - Co-op is and should be a trusted energy advisor. To some consumers, the co-op can be doing a very good job of supplying electricity and still not be a trusted resource on solar.
    - Peer-to-peer and word-of-mouth have an influence
    - Heavy marketing of rooftop and "positive" ROIs
    - Some sway from community groups

Creating a Successful Solar Program

Benefits of Market Segmentation

Finding the right message to communicate your products and services is one of the big challenges that marketers and communicators face. Communicating your co-op's solar project is no exception. One of the keys to creating a message that will resonate with your members is to understand their views on renewable energy. A tool commonly used in traditional marketing is customer segmentation. Consumer packaged goods companies invest heavily in understanding who their customers are and how they think about their products, using this information to build messages that "speak" to the way those customers think and behave. How do your members think about energy efficiency and renewable energy? Are they actively working to live a green lifestyle? Are they skeptical about environmental change? If you don't know, how can you effectively communicate?

NRECA Market Research offers an Energy Efficiency and Renewable Energy Segmentation service that will help co-ops understand their membership. The model segments residential members based on their likelihood of embracing various energy efficiency and/or renewable energy programs offered by their co-op. It is based on statistical techniques to surface natural groupings, identifying segments based upon survey responses to a wide range of attitudinal questions related to energy, economics, and the environment. The analysis identified five distinct segments of consumers and provided profiles of each.

The segmentation is derived using attitudinal questions and identified a battery of eight questions that are predictive of the segment a consumer would fall in. To find the composition of the five member segments in their own residential membership, cooperatives can include the eight questions in a survey being conducted with a random sample of members (e.g., a Member Satisfaction Survey) or conduct a survey based on the eight segmentation questions. This will provide the co-op with an overview of the proportion of their members that fall into each of the five segments. Combining the survey results with a demographic data append for their full membership will allow additional analysis to be conducted resulting in a mapping of the co-op's full membership to the highest probability segment. This will enable the co-op to further refine the marketing for their programs and services.

Additional Resources

- Where Does Solar Stand? Focus Group Results

Contact for Questions

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