A Data-Driven Approach to Rooftop Solar Adoption in Rural Regions*

A. Gupta, K. Lockwood, A. Marathe, S. Swarup, A. Vullikanti

1 Objective

The goal of this research is to work with the rural electric cooperatives to facilitate the diffusion of solar energy adoption in households located in the rural and semi-urban areas of Virginia by identifying social and behavioral factors that are unique to rural regions. This research will develop a solar adoption propensity score for each household in rural Virginia based on its demographics, and social and behavioral characteristics.

2 Methods

We begin by building a synthetic representation of Virginia by combining data from multiple sources into a synthetic information platform that provides a geographic and individual-centered coordinate system for integrating the data. In this approach, demographics and activity/behavior patterns are associated with individuals, who are grouped into households. Each synthetic person is endowed with social and demographic attributes who works, moves, and behaves like a real individual. Further a co-location-based social contact network is generated which is used to study peer effects, norms and other social-behavioral factors. The population is categorized as rural-urban based on the rural-urban regions, as classified by the US Census.

Further an agent based diffusion model of solar adoption is applied on this dataset to study problems such as (1) what is the minimum number of seeds (initial adopters) required for the diffusion to take place in rural regions? (2) if there a fixed budget available to incentivize initial solar adopters, which households should be incentivized in order to maximize the total adoption in the entire region?

3 Experiments & Results

Our simulation-based results show that a diffusion model that uses peer effects to cause diffusion, requires a greater proportion of initial adopters in remote rural regions, to result in diffusion. The areas with relatively high population density required fewer initial adopters to start diffusion through peer influence, whereas low density zip codes required at least 10% households to have solar panels in order for the diffusion to take place.

The second set of results address which households should be incentivized initially so that they lead to maximum total adoption in the region. This is a more challenging non-linear stochastic maximization problem. The results show that if the influence function follows a diminishing return property, a greedy algorithm can provide an almost optimal solution. We can also ensure that the initial adopters are “well separated” so that grid level instabilities that might arise due to lopsided solar penetration, can be minimized.

4 Conclusions

We demonstrate that a data-driven, high resolution simulation platform can be combined with a diffusion model and an optimizer such as our greedy optimizer to address questions of optimality, which is a new frontier in the use of big simulations. This holds the promise of moving the conversation from hypothetical and counter-factual simulations to notions of optimal behavior and optimal action in large scale settings.