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Excerpt from NREL report "Diffusion Into New Markets: economic returns required to adopt rooftop photovoltaics"

Diffusion into New Markets: Economic Returns Required by Households to Adopt Rooftop Photovoltaics

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Abstract

While the U.S. residential solar market is growing quickly, costs for acquiring customers are high--and this indicates the value of efforts to identify new market segments and predict areas ripe for adoption. To better understand how the next wave of solar diffusion could occur, we explore the range of economic thresholds that households without PV would require to consider solar adoption, finding that these households require more attractive payback times by 1-3 years to achieve comparable market share as current adopters. In contrast, non-adopters indicate they would be satisfied with equal or lower returns when the benefits of solar are expressed in terms of their monthly bill savings—as is the case for third-party owned systems. If true, this suggests that the leasing model fundamentally inverts the assumption that later adopters require higher economic benefits. Adopters, both buyers and leasers, are compared to their non-adopting peers across a range of demographic and attitudinal factors. We find that leasers appear to be more highly influenced by installer advertising (radio, TV) and marketing, while buyers were more influenced by personal contacts. Environmental concern, once a preeminent reason for adopting is decreasing in relative importance, whereas lowering total electricity costs and protecting one's household from future increases in prices are now the two more important reasons. Understanding these dynamics, and how they are changing, offers installers low-cost opportunities to attract new customers and expand their market base.

Introduction

The U.S. residential solar market is expanding quickly, with installed capacity more than doubling between 2012 and 2014 (SEIA 2014). Several trends point to a maturing market—consolidation of market share among solar installers, increasing access to low-cost capital--particularly from institutional funding sources, and increased competition between market players. California, the largest market for solar in the U.S. stopped issuing state-issued rebates for residential systems in the second half of 2013 in the SCE and PG&E service territories, yet installations have continued. The U.S. Federal Installation Tax Credit, once an irreplaceable incentive for profitable installations, is expected to decrease from 30% to 10% in 2016—and the industry will live on.

Yet installers and their industry are not completely in the clear. Customers still need to be recruited, and costs for acquiring customer are high, estimated at $0.49/W per customer, or roughly 10 - 20% of a system's costs (GTM 2013). In part this is because rooftop solar is an unproven commodity for many households. Trusted contacts from social networks (friends, family, coworkers, and neighbors) combined with observations of existing systems does much of the heavy lifting in convincing unsure customers. In response, the industry has experimented with a number of innovative advertising and marketing methods to either recruit new leads or improve their conversation rate for existing ones. These methods range from door-to-door canvasing, to partnerships with established retailers, to purchasing customers leads wholesale from third party aggregators (GTM 2013). All of these point to a continued need for research that can help identify new market segments, predict areas ripe for adoption, and test effectiveness of marketing tactics (Davidson et al 2014).

Customer behavior has been a focus of recent research. In this, the main framework is of the consumer as a decision-maker, drawing on the behavioral economics, Diffusion of Innovations, and Value-Based Norms frameworks (Faiers and Neame 2006; Rogers 2003; Stern et al 1999; Wilson & Dowlatabadi 2007) to understand the economic, informational, social, and behavioral factors that predict adoption trends. Some early insights from this field are that social networks can help reduce customer uncertainty (Bollinger and Gillingham 2012; Rai and Robinson 2013) and that customers are motivated to adopt for a variety of reasons—not economics or environmental concerns alone (Schelly 2014; Zhai & Williams 2011). Finally, that a number of barriers may exist which inhibit adoption including high upfront costs, inadequate access to financing options, lack of awareness of available products,

adopters, having already researched solar, judge the risk to their home to be manageable. Conversely, this suggests that the general populace considers PV installation to pose a potential risk to their home value (founded or otherwise). Efforts to provide additional information therefore could provide a low-cost opportunity to expand potential market size.

Economic returns required for adoption

To understand how adopters and non-adopters evaluate the economics of a residential PV system, both surveys solicited a number of questions relating to the economic thresholds that individuals would require to seriously consider adopting solar for their home. Since adopters have actually already adopted PV for their home, the question is posed in two ways—the historic return they expected to receive at the time of adoption, and the return they would require to readopt. Non-adopters were asked a similar question regarding the level of returns they would require to seriously consider adopting solar.

First, respondents were asked to select the economic metric they would/did use to evaluate whether solar panels made economic sense for their household. Again, for adopters this is a question about their previous evaluation, but for non-adopters it is a hypothetical question—"*If you were seriously considering solar, how would you evaluate whether solar panels made sense*". A majority of all populations reported they would primarily use monthly bill saving ($/month) (MBS) to evaluate solar economics (Table 3), followed by payback period (years to investment payoff). Other metrics were reported to be used, such as net present value (NPV) and rate of return (RoR), though they are used by a minority of households. Given the variation in preference for different metrics—and that these metric show different price thresholds for when a PV investment becomes profitable (Drury et al 2011), this has strong implications for the price at which a solar PV system becomes appealing to different types of customers.

Previously, the consumer behavior literature has suggested that residential customers primarily use a simple payback time to evaluate a new technology (Rai and Sigrin 2013; Camerer et al. 2004; Kempton & Montgomery 1982; Kirchler et al. 2008). However, with the strong growth of third-party owned systems, we expected that leasing customers are frequently being pitched PV systems based on the monthly bill savings rather than a payback time. Surprisingly, customers who bought PV systems are *also* increasingly using monthly bill savings. Use of the MBS metric is consistent with the importance respondents place on reducing their current and future bills.

Table 3: Economic metrics used to evaluate solar investment

	Buyers	Leasers	Non-Adopters
Monthly bill savings	40.3%	60.5%	43.4%
Payback time	29.5%	16.1%	41.8%
Rate of return	17.1%	9.8%	6.3%
Net present value	2.2%	1.6%	3.5%
I would not estimate economics	3.0%	4.6%	3.7%
Other	7.8%	7.2%	1.4%

Based on the metric respondents indicated they would use, they are then asked a series of questions to evaluate the minimum economic return they would require to seriously consider adopting solar. As we assume most non-adopters have not substantially examined the potential solar returns, their question requires more finesse. Specifically, non-adopters are asked a series of questions implying an increasing or decreasing attractiveness e.g "*I would seriously consider solar if the payback time was one year or less*", *"…two years or less*", etc. Permissible responses are "*Yes*", "*Maybe*", "*No*", or "*I don't know*". One expects the respondent to indicate in the affirmative for highly attractive returns, with a transition to "maybe" and then "no" as returns become less attractive. The respondent's willingness-to-pay is taken as the average value for which they indicate "*maybe*". For quality control, we discard all responses that imply a preference for lower returns over higher ones as well non-ordinal responses; for responses with no "maybe" response, the value is taken as the transition from "yes" to "no". In addition, respondents were randomly assigned questions with either incrementally increasing or decreasing returns; willingness to pay was found invariant to the ordering of these questions.

Economic thresholds are given in terms of the percent of the sample that indicated they would be willing to seriously consider solar at a given return or better (Figures 3- 4). Since the sample is small for the metrics other than payback period or MBS, the analysis will focus on these two metrics.

Among respondents that used payback time to evaluate returns, non-adopters required more attractive paybacks by 1-3 years. That is, 50% of non-adopters would require a payback of 6 years or less to seriously consider adopting, whereas adopters would only require a 7.5 year payback. Expectations converge for paybacks greater than 10 years for both groups, where approximately 20% of all respondents indicated they would consider adopting at a 10-year payback.

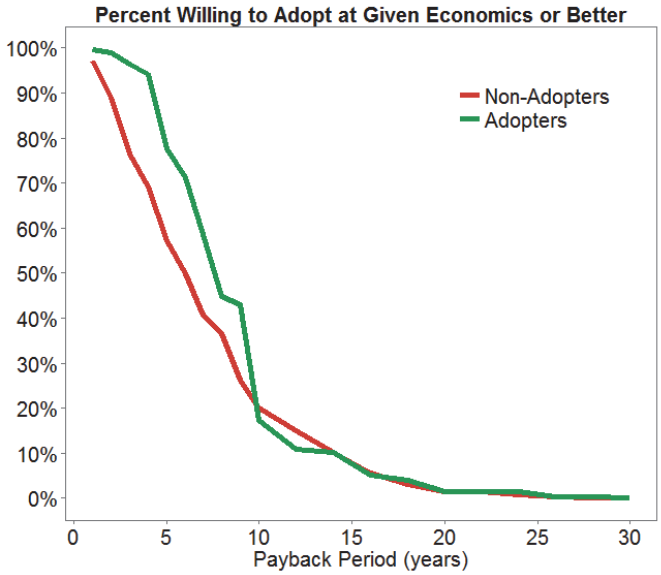

Fig 3: Customer willingness-to-adopt for given payback period or better

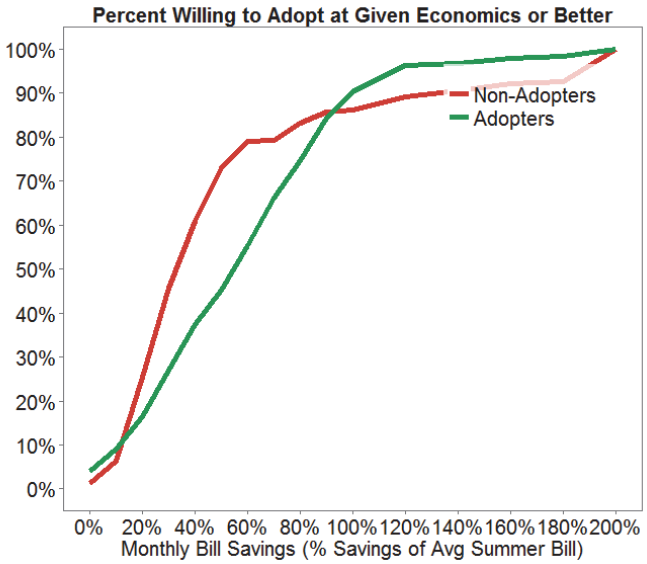

Fig 4: Customer willingness-to-adopt for normalized monthly bill savings

Differences in responses for the monthly bill savings metric are opposite those of payback time, with non-adopters indicating they would be satisfied with lower savings when using the MBS metric. For example, only 24.7% of adopters indicate they would consider adopting with savings of $50/month, whereas 71.9% of non-adopters indicate that would at the same level of returns. Because monthly bill savings scales with both system size (larger systems offset more consumption) and the customer's consumption prior to adoption (larger bills allow more potential for avoided cost), we normalized the MBS values by each customer's reported summer bill; for adopters we use summer bills prior to adoption. Thus, the transformed metric is now the MBS as a percentage of a summer bill, or the fraction of avoided bill. Note that with this normalization, savings can exceed 100% if the respondent indicates they would only adopt if monthly savings exceed their monthly bill.

Savings of roughly 15% of the average summer bill are required to entice 10% of both populations. Thereafter, between 20% and 90% of the summer bill, an *additional* 10% - 35% of the non-adopter population indicates they would seriously consider adopting. For savings above 90%, the pattern reverses, with adopters more likely to indicate they would adopt—though 85% of the potential market has been saturated at this level of returns.

Differences in the adopter and non-adopter populations' willingness to consider adoption for different metrics offers an intriguing insight into how each group perceives the relative benefits of adoption. If true, this suggests that the leasing model fundamentally inverts the traditional *Diffusion of Innovations* assumption that later adopters require higher economic benefits. By framing the proposition for adopting solar as a series of monthly savings—as opposed to a large upfront payment, greater portions of the general population could be enticed than if projects' returns were expressed in terms of the payback time. Conversely, the results suggest that there are portions of the general population that are either unaware of the potential MBS returns available, or are prevented from adopting for other reasons e.g. insufficient roof space, HOA restrictions, or low electricity bills. If activated, these groups could provide additional momentum to the growing solar market as they indicate they would be willing to adopt under current market conditions.

Conclusion

The U.S. residential solar market is growing quickly, and to continue growing, it must expand into new populations. In the San Diego market motivations for adopting are evolving, with environmental concerns decreasing in priority, replaced with greater interest in saving money and, particularly, reducing exposure to higher future bills. Customers leasing their systems now constitute a majority of new installations in many national markets—and these customers are more representative of the general population than early adopters.

Looking to future market growth, there are substantial demographic gaps between adopters and the general populace. A key insight is that non-adopting households are more concerned with the risk of solar negatively impacting their home's value—reducing this concern could unlock additional market potential. Consistent with prior

research, we find that the general populace would require more attractive payback periods by 1 – 3 years than current adopters to consider adopting. Surprisingly, the general populace would be satisfied with lower savings when adoption benefits are framed in terms of the monthly bill savings. For installers seeking to lower customer acquisition costs, framing the benefits of solar in this way could be a successful tactic.

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