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Solar Community Organizations and active peer effects in the adoption of residential PV

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HIGHLIGHTS

- New dataset on Solar Community Organizations (SCOs) in the U.S. during 1970–2012.
- Shock events catalyze formation of SCOs.
- SCOs-driven peer effects found to positively impact PV adoption.
- Leveraging trust networks is crucial for the success of SCOs.
- In addition to information provision, financing options also key for SCOs′ success.

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ABSTRACT

Solar Community Organizations (SCOs) are formal or informal organizations and citizen groups that help to reduce the barriers to the adoption of residential solar photovoltaic (PV) by (1) providing access to credible and transparent information about the localized benefits of residential PV and (2) actively campaigning to encourage adoption within their operational boundaries. We study the peer effect, or social interaction, process catalyzed by SCOs to understand the impact of these organizations on the residential PV market. Using a standardized search methodology across spatial scales (state; city; neighborhoods), we identify and characterize the operations of 228 SCOs formed in the U.S. between 1970 and 2012. We also present case studies of four successful SCOs and find that a common thread of why these SCOs are successful involves effectively leveraging trusted community networks combined with putting together a complete information and financial-tools package for use by interested communities. Finally, our findings suggest that empirical studies that attempt statistical identification and estimation of peer effects should pay close attention to the role of SCOs, as the social interactions engendered by SCOs may be correlated both with the level of social learning and the socio-demographic characteristics of the communities of interest.

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1. Introduction

Information flow through peer effects and social networks are known to impact the diffusion of innovations (Banerjee et al., 2012; Cox et al., 2007; Rogers, 2003; Stern, 1992; Wilson and Dowlatabadi, 2007). Role of these information channels is even more profound for *experience goods*[1] in general (Nelson, 1970; Rogers, 2003; Stern, 2000; Wilson and Dowlatabadi, 2007), and particularly critical for technologies that require high upfront capital (Bollinger and Gillingham, 2012; Narayanan and Nair, 2011; Nelson, 1970; Rai and Robinson, 2013). Because some of the key innovations in alternative energy such as plug-in electric vehicles (PEVs) and solar photovoltaics (PV) are capital-intensive technologies, a better understanding of the underlying channels of information flow could provide insights for overcoming some inherent barriers to the broader diffusion of these technologies. In this paper we focus on the role of community or non-profit organizations in catalyzing peer effects and other forms of information dissemination in the residential PV sector in the United States.

The residential PV market in particular is of interest for a number of reasons. First, the residential sector accounted for 36.9% of total electricity end-use in the U.S. in 2011 (EIA, 2012), thus making it one of the key targets for reducing both electricity

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[1] Experience goods are goods for which key information on quality and performance can generally be obtained only through a (typically) costly search process often involving actually purchasing and using the good. Nelson (1970) showed how the difficult and costly nature of the process of obtaining information for experience goods impacts monopoly power in consumer industries.

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demand and greenhouse gas (GHG) emissions (U.S. DOE, 2012). Second, despite significant growth in recent years, in the first 9 months of 2013 solar energy (including solar thermal and PV) accounted for 0.2% of net electricity generation in the U.S. electric power sector (EIA, 2013). That previous residential solar installations represent only a fraction of the total market potential suggests that the residential market remains a key area for growth for the U.S. solar industry. Third, rates of residential PV adoption remain highly uneven between different states. California and Arizona rank 1st and 3rd in cumulative solar electric capacity, a fact consistent with the high solar resource potential of the southwestern United States (GTM Research, 2012a). However, New Jersey, a state with low comparative resource potential, ranks 2nd in cumulative installations while Texas, with high solar resource potential, ranks 13th and Oklahoma does not rank even in the top 25. These discrepancies reflect both (a) the importance of state and local policies to provide information and incentives that reduce barriers to adoption and (b) the complexity of solar project financing in different electricity markets, which in turn is largely a reflection of the differences in these jurisdictions on regulatory/policy aspects of solar, including interconnection and permitting rules, local rebate programs, and whether solar leasing is allowed. On the positive side, the price of residential PV has been declining rapidly in recent years, leading to escalating rates of installation: Q1 2013 saw a 53% increase over Q1 2012 installations, while average residential installation price fell below \$5/W as compared to approximately \$10/W in 2007 (Barbose et al., 2012; GTM Research, 2013). In more mature solar markets such as Germany, where generous feed-in tariffs and standardized permitting and interconnections processes have brought higher adoption rates and more retail competition, the total cost of installation is approximately half of that in the U.S. (Renewables International, 2012; Seel et al., 2013). As such, there is significant potential for PV prices to fall even further in the U.S. as balance of systems (BOS)[2] costs begin to decline (Feldman et al., 2012; Goodrich et al., 2012; GTM, 2012b; Rai et al., 2014).

Moreover, there is evidence of broad public support for solar power across all states and political parties (Gallup, 2013; SEIA, 2012). A poll conducted by Hart Research in September 2012 assessed public opinion regarding solar as an energy resource (SEIA, 2012). Based on a national survey of 1206 registered voters across both political parties, the study found that solar energy enjoys a high level of support relative to other generating resources. Ninety-two percent of respondents indicated that it was very important (58%) or somewhat important (34%) for the U.S. to develop and use solar power—higher than for any other resource. Respondents also put solar at the top of the list of resources the government should support through financial incentives with 64% of respondents agreeing, compared to 57% for wind, 38% for hydropower, 32% for geothermal and lower rankings for all fossil-based energy sources. A majority of respondents, however, also indicated that they viewed solar energy as too expensive for most consumers (66%) and not practical in many areas of the country (54%).

The results from this poll provide a useful heuristic for gauging the current state of the residential PV market. While a large number of citizens view solar energy with strongly positive opinions, a variety of factors continue to prevent citizens from becoming adopters of PV. A number of studies mirror this conclusion and suggest that the rate of PV diffusion is a function of both high upfront costs (and lack of adequate financing) and non-monetary costs such as a lack of easily-accessible, credible information (Margolis and Zuboy, 2006; Rai and Robinson, 2013; Shih and Chou, 2011). Consequently, the adoption-decision process for a consumer itself involves considerable investment in both capital and time. As such, insights into the process by which consumers make the decision to adopt (or not to adopt) solar and the mechanisms that effectively address existing barriers to adoption can be useful for policy-makers, industry marketers, and non-profit groups who wish to grow the residential PV market by reducing barriers to adoption.

In this paper, we focus on the activities of community-based organizations that are engaged in the residential solar PV market. We define these Solar Community Organizations (SCOs) as *formal or informal organizations or citizen groups engaged in activities explicitly designed to encourage the adoption of residential rooftop solar PV*. These organizations, due to the heterogeneous nature of their structure and formality, may act as either a change agent or an opinion leader (or both) by providing information and advice about overcoming localized barriers to purchasing and installing solar PV.[3] This includes the dissemination of expert knowledge (often from previous adopters) about project financing and incentives, product and installer reliability, system performance and maintenance, and other uncertainties that may lengthen the period of time needed for a potential adopter to reach a decision. This is distinct from other types of organizations and campaigns that also operate in the residential solar market, such as community solar farms or gardens that attempt to pool capital among residents for group purchasing of a solar array at a separate location. It also excludes marketing programs of private entities (e.g. retail installers), incentive programs or other resources provided by public entities (e.g. municipal or state rebate programs), organizations engaged in programs that do not specifically target residential solar PV consumers (e.g. an advocacy organization lobbying Congress), and organizations that do not include the promotion of residential solar PV adoption as an explicit component of its mission (e.g. a regional economic development council). With this limited scope of definition for SCOs, in this paper we analyze the activities and characteristics of SCOs most associated with the successful facilitation of residential PV adoption. Our analysis is based on a new dataset of SCOs we have built based on a standardized search methodology and four case studies, including semi-structured expert interviews and additional supporting data from reports, news items, white papers, and case-specific data.

Strong public support for solar energy reflects the perception that diversity in fuel sources is required for enhancing energy security or that an energy transition from fossil fuels to lower emission generating sources is required to mitigate the environmental consequences of GHG emissions (Gallup, 2013). Further, for early adopters that have installed solar energy at least in part for its environmental benefits, additional value can be gained by convincing other individuals to also reduce their consumption of fossil fuels by adopting solar (VoteSolar, 2013). Accordingly, we expect to find that the elevation of public concern over climate change in the past decade has led to a proliferation of community organizations formed in support of solar energy.

On the aggregate, we expect SCOs to form where the underlying conditions enable them to meaningfully impact the rate and scale of residential PV adoption. In other words, like any other organization, SCOs have a set of objectives and limited resources to meet them. So SCOs, on the average, would try to locate in places

[2] "Balance of system" (BOS) is defined as "all components other than the mechanism used to harvest the resource (such as photovoltaic panels)," including "design, land, site preparation, system installation, support structures, power conditioning, operation and maintenance, and storage" (*Glossary of Energy-Related Terms*. Retrieved October 12, 2012, from Office of Energy Efficiency and Renewable Energy, US Department of Energy: http://www1.eere.energy.gov/site_administration/glossary.html).

[3] In *Diffusions of Innovations* (Rogers, 2003), Everett Rogers defines an opinion leader as a member of a social system in which they exert influence, and a change agent as an individual who influences innovation-decisions in a direction deemed desirable by a change agency in a more professional capacity.

that maximize the leverage of their limited resources towards meeting the objectives (Brass, 2012; Fruttero and Gauri, 2005). Two factors may be expected to particularly impact the geographical distribution and activities of SCOs: the population density and the local context for solar. Areas with higher population density not only allow a larger set of potential adopters (i.e., targets for SCOs), but they also provide more opportunities and channels for SCOs to conduct their outreach activities such as informational workshops, home visits, community events, and other information campaigns. The local context for solar includes factors that directly impact the economics of PV such as solar insolation, electricity rates, availability of local/state solar rebates or renewable portfolio standards, and interconnection and net metering rules. If the context is too strong (that is very favorable for PV economics), then the scope for adoption is very high and economics will drive adoption. On the other hand, if the context is very weak, then the scope for adoption is fundamentally narrow. In either of these extreme situations we expect the impact of SCOs on residential PV adoption would be marginal. It is in middling context situations where SCOs may have the most opportunity to influence the rate and scale of PV adoption. Accordingly, we expect that the underlying context for residential PV will be a key driver for SCO formation. Additionally, in nascent markets with relatively little solar PV deployment, a greater role for SCOs exists as the trusted source of information for potential consumers. Therefore, we expect to find clusters of SCOs in early stages of adoption.

2. Related literature

Although there appears to be some divergence in the literature over the definition of a “peer” or “peer effect”, which depending on the subject of study may include neighbors, friends, roommates, or even firms, numerous studies in the broader social science literature have demonstrated the importance of peer effects, or social network interactions, on socioeconomic outcomes. Researchers have shown that peer effects impact the diffusion of a broad range of innovations (Arndt, 1967; Bass, 1969; Coleman et al., 1957; Rogers, 2003). More recent research specifically on technology adoption behavior confirms the important role played by peer effects (Axsen et al., 2009; Bollinger and Gillingham, 2012; Newell and Kerr, 2003; Oster and Thornton, 2009; Rai and Robinson, 2013; Rogers, 2003). Below we provide a brief summary of the literature on peer effects, especially as relevant to this work. More comprehensive reviews of the literature on peer effects are provided by Brock and Durlauf (2001), Hartmann et al. (2008), Manski (2000, 2010), and Scott and Carrington (2011).[4]

In general, estimating the impact of social interactions in consumer decision-making or technology adoption is complicated by correlated unobservables between peers (Manski, 1993). Stated differently, when two peers are seen to adopt a new technology, it is difficult to distinguish if social learning occurred (*induction*) or if the peers adopted the technology because of similar socio-demographic and behavioral characteristics (*homophily*). To overcome this challenge, methodological approaches to studying peer effects range from mathematical modeling of the dynamics and stability of network formation (for example, see Jackson and Watts, 2002; Skyrms and Pemantle, 2009) to statistical identification and estimation of peer effects (Bollinger and Gillingham, 2012; Christakis and Fowler, 2008; Moffitt, 2001; Narayanan and Nair, 2011; Rai and Robinson, 2013).

Peer effects operate in conjunction with other factors that impact individual decision-making, and hence the diffusion of technologies. In particular, the diffusion of innovations framework

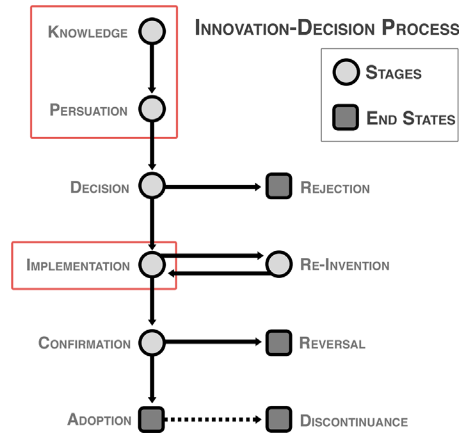

Fig. 1. Diagram of Rogers' innovation-decision process of technology adoption. The boxes around "Knowledge" and "Persuasion" and around "Implementation" indicate the stages at which peer effects can influence consumer decision-making.

has received considerable attention in the academic literature across various disciplines concerning the factors that influence the innovation-decision process. Many of these studies link back to the body of work published in Everett Rogers' 1962 book *Diffusion of Innovations* (1st ed.). Rogers provided a framework for understanding the innovation-decision process of technology adoption that describes the stages and potential end states of the decision-making process of consumers (Fig. 1).

In Fig. 1 we have highlighted in red the stages of the innovation-decision framework of Rogers when external information can be absorbed, and as a result, a peer effect can be experienced. Especially during the *knowledge* and *persuasion* stages, an individual often seeks to gather a large amount of information about the technology in question. The more uncertain an individual is about the performance (technical or financial) of an innovation and the higher the upfront capital requirements, the more likely the individual is to turn to trusted sources/networks for information on the technology (Nelson, 1970; Rogers, 2003). The collection of external information, in combination with characteristics unique to the individual (e.g. social and personality characteristics), informs the individual's perception of the technology's characteristics. Using this framework, positive peer effects in the context of PV can be understood to influence a consumer decision by providing information that (a) demonstrates the relative advantages of solar, (b) proves the compatibility of solar with a consumer's existing beliefs and habits, (c) reduces perceptions of solar technology's complexity, and (d) shows the results of the trials of other installations.

Positive peer effects for PV can also increase the likelihood of adoption and decrease the length of decision time. Two recent studies provide the strongest evidence of peer effects in the diffusion of PV. Bollinger and Gillingham (2012) evaluated the role of peer effects in residential PV by calculating the impact of previous installations on the likelihood of a new adoption in California neighborhoods. They found that an extra adoption in a zip code increased the probability of a new adoption in the same zip code by 0.87 percentage points. A second study by Rai and Robinson (2013) quantified the effect of different information channels on PV adopter decision-making. Using information collected in an online survey of 365 respondents, the study found that residential PV adopters took on average 8.9 months to decide to install solar.[5] The study also found that a high density of

[4] In particular, the SAGE Handbook of Social Network Analysis (Scott and Carrington, 2011) provides a comprehensive overview of previous treatments of peer effects across a variety of disciplines. See Appendix A.1 for more details.

[5] Length of decision period was defined as the amount of time between serious consideration of PV and the final decision to install resulting in a signed contract.

installed systems in a neighborhood resulted in shorter decision periods for adopters and that *passive* observation of solar installations in the area around a potential consumer's house affects the consumer's perception of the costs and barriers to adoption, thereby increasing the consumer's confidence and motivation to adopt. It also evaluated *active* peer effects—direct, in-person interactions between the potential adopters and existing PV adopters in his or her neighborhood—to find that these interactions reduced the decision period by an average of 4.6 months. When combined, the total effect of both active and passive peer interaction resulted in an average reduction of 6.67 months to the decision period. These findings were statistically significant at the $p<0.01$ level (Rai and Robinson, 2013). Given that SCOs facilitate interactions similar to active peer effects, we believe that SCOs may be particularly effective in reducing decision times.

Finally, social norms in local niches (clusters) might emerge, leading to group behavior-change in concert. For example, in their analysis of smoking cessation behavior in the U.S. from 1971 to 2003, Christakis and Fowler (2008) find that, "groups of inter-connected people quit [smoking] in concert." Similarly, using data from the national-scale 1996 General Social Survey in the U.S., DiMaagio and Louch (1998) show that trust networks are not only critical in gathering *information* on what or who to transact with, they are also critical in actually choosing *transaction partners* from within existing social networks. These findings suggest that collective interventions that leverage trust networks and social ties may be more effective in catalyzing and spreading behavior change than individual interventions (Christakis and Fowler, 2008).

3. Data and methodology

Based on our focus on the residential PV market, we define a peer effect for the purpose of this study as a *measured influence of an individual's neighbors, colleagues, or friends on his or her attitude, behavior or other outcomes related to his or her decision to adopt PV*. Notably, this excludes family members as well as certain groups—governments, companies, organizations, etc.—that do not operate in conjunction with the aforementioned types of individuals. The purpose of limiting the scope of what we consider a peer effect is to differentiate SCOs from other organizations that seek to influence potential PV adopters for commercial reasons or as a part of a broader public mission.

Our analysis uses a new dataset of formal and informal community organizations actively engaged in programs to encourage residential PV adoption. The dataset and subsequent analysis is the first of its type as an effort to quantify and describe the activity of these groups. Our data collection relied primarily upon two methods: Internet search queries and interviews with solar organization members. First, an initial round of interviews were conducted with four chapters of the American Solar Energy Society (ASES) to establish a common understanding of activities, organizational structures, and known histories of each organization. Based on these interviews, we created a typology of key organizational characteristics based on the types of information we expected to be able systematically collect and compare across organizations (Table 1).

Second, an extensive series of Internet search queries were performed to identify web pages associated with SCOs. Internet search queries were conducted through the Google Search Engine using a mixture of keyword search terms most common in the names and descriptions of solar organizations identified at the beginning of our study (see Appendix A.2 for more details on the search methodology). Two sets of queries were performed—one on each of the 50 U.S. states and the other on select cities. Cities included in the search were identified by evaluating data from the University of Illinois Carbon Capture Report (www.carboncapturereport.org), which aggregates, geocodes, and ranks information about solar from news, social media, and other online communication. Our study includes searches performed on the top 100 U.S. cities ranked by the total number of content items between November 2009 and February 2013 as a proxy indicator for the level of interest and activity regarding solar in each city. In addition, we also performed city-level searches on the 25 cities designated as Solar America Cities by the U.S. Department of Energy in 2008. Complete details of the search methodology are provided in Appendix A.2.

Table 1
Typology of key SCO characteristics.

Boundary	Neighborhood, City, State, Region, National
Installations	Number of signed contracts the organization credits as a result of its activities
Membership	Community Members, Volunteers, Non-Profit Groups, Retail Installers, Government Officials, University Officials, etc.
Scope	Solar, Renewables, Economic Development, etc.
Funding	None, Government, Private, Individual Donations, Multiple
Year founded	1970—present
Services	Workshops/Events, Information, Discounts, Networking, Tracking Installations, Solar Tours, etc.

Third, a second round of interviews was performed with five organizations identified during our Internet search queries. Based on these interviews and an initial evaluation of the descriptive statistics of our dataset, the typology was modified to reflect data commonly available on most organization websites. This type of iterative, mixed-method approach is appropriate for studying a complex subject such as social interactions, especially when the associated, happenstance data is dispersed across various sources and sets of actors. Mixed-methods sampling techniques are useful in social science research when it is difficult to obtain a representative sample using only a quantitative or qualitative method (Sharp et al., 2012). Finally, four organizations were selected for extended semi-structured expert interviews presented as a multi-site case study. These organizations included the Mueller Megawatt Project, Solar San Antonio, Solar Oregon, and SmartPower. The case study subjects were selected to provide variation in geographic boundary and scope of operation. The Mueller Megawatt Project ($\sim$1 MW) represents a neighborhood-level initiative that was chosen due to its unique, entirely bottom-up community organization efforts. Detailed data were also available with us to quantitatively assess the impact of this project. Solar San Antonio ($\sim$1–2 MW), Solar Oregon (scale varies), and SmartPower ($\sim$2–5 MW; varies) are city-, state-, and nation-level organizations, respectively, that were identified during initial interviews as active organizations with successful track records of encouraging solar adoption. The purpose of the case studies is to identify the characteristics that appear to be common across successful SCOs. While our selection of relatively successful SCOs only represents a selection bias, in our analysis we discuss within-case variations, which enable us to identify potentially causal factors that drive performance of the SCOs.

3.1. Limitations

Designing a research study to collect and quantify this information faced a number of obstacles. Our primary method of collecting data on such a large number of programs necessitated that we collect data using search queries of Internet sites and pages created for these organizations or holding information about these organizations. As such, organizations that were established prior to the "Internet age" are less likely to be captured by our search queries. Similarly, queries are unlikely to identify programs that failed or ceased operations, or programs at such a localized level (e.g. neighborhood) that web-based dissemination was impractical for their purposes. As such, our data is susceptible to a “survivor bias” wherein organizations that were not successful and ceased operations are less likely to be identified in Internet search queries. In view of these limitations, we believe that our results provide a conservative estimate of SCO activity in the U.S. between 1970 and 2012.

4. Results

4.1. Descriptive statistics

Using the approach described in Section 3 we identified 228 organizations that qualify as a SCO. Of these, 95 operate within a statewide boundary, while 75 are citywide, 23 are neighborhood-specific, and 8 are national (Fig. 2). Geographically, only a small number of states contained a high density of SCOs: Massachusetts (31), Oregon (23), District of Columbia (21), and California (18) are the only states with more than 10 SCOs (Fig. 3). On the average these states/regions have some of the highest retail electricity prices in the U.S. and also some of the most favorable solar policies (DSIRE, 2013)—aspects that make the context for solar positive. Six other states—Minnesota (9), Washington (9), Texas (8), Arizona (7), New York (7), and Colorado (6)—contain between 6 and 10 SCOs. On the average, these states have medium retail electricity prices, generally very good solar resource (except New York), and supportive solar policies. All other states contain five or less. Finally, at least one SCO was identified in all states *except* Montana, New Jersey, North Dakota, Oklahoma, South Dakota, and Wyoming (Fig. 4). New Jersey registered zero SCOs despite possessing a well-developed solar industry. This is because of the fact that many entities in the state of New Jersey that support residential solar customers were excluded in the state count because they either (a) did not meet our definition of an SCO (see Section 1) or (b) were regional or national entities not headquartered in the State of New Jersey. For instance, New Jersey belongs to two regional groups that qualify as SCOs: the Mid-Atlantic Solar Industries Association (MSEIA), which covers Pennsylvania, Delaware and New Jersey; and the Northeast Sustainable Energy Association (NESEA), which covers the six New England states plus New York, New Jersey, Delaware, and Pennsylvania.

Of the 228 SCOs, 43 are independent chapters of the American Solar Energy Society (ASES)—a national organization that leads efforts to increase the use of solar energy and other sustainable technologies. ASES supports local chapters and a national membership of 13,000 individuals through organizing informational webinars and training sessions; writing technical reports, policy statements, white papers, and a quarterly magazine; facilitating the exchange of information and best practices; and by coordinating events such as an annual solar conference and the National Solar Tour. ASES

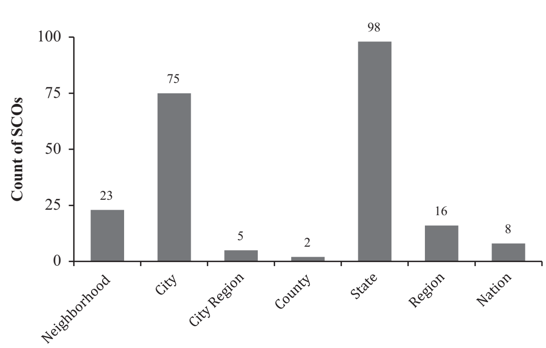

Fig. 2. Proportion of SCOs by geographic boundary.

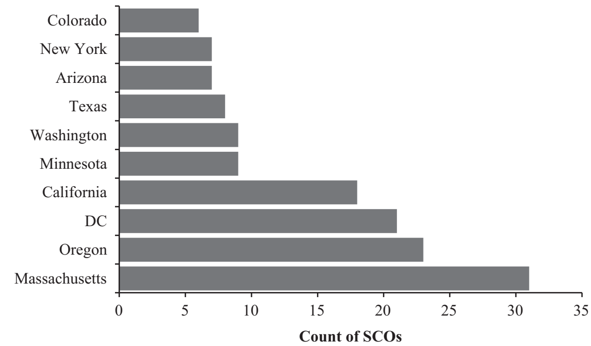

Fig. 3. Top 10 states by number of SCOs.

chapters are predominately statewide organizations, although a few regional and citywide chapters exist. Some chapters, such as the Texas Solar Energy Society (TXSES), are themselves divided into smaller chapters that serve specific cities or geographic regions (e.g. San Antonio and North Texas). ASES chapters vary nationally in terms of the scope of each organization's mission as some focus exclusively on solar PV while others promote solar thermal or other forms of renewable energy as well. A set of core services common to most ASES chapters, however, includes acting as a clearinghouse of information for statewide or regional solar community news and events, facilitating communication between energy professionals in the solar industry and grassroots community supporters of solar, and coordinating participation in the National Solar Tour.

A second grouping of 48 SCOs can be categorized as organizations and programs operating under the Solarize model. Solarize campaigns began with grassroots activity in southeast Portland, OR, in 2009, with the idea of harnessing local support for solar energy to conduct a coordinated outreach and education effort combined with volume discount pricing from a participating contractor. Since its formation, the Solarize model has been documented through a Solarize Guidebook and replicated across Oregon and in 11 other states. Massachusetts has recorded the largest number of Solarize campaigns (21) after 2 years of operation in 2011 and 2012. While individual details vary, Solarize campaigns typically have three common components. First, a participating contractor is selected through a competitive process that articulates the key values and options that the participating city or community hope to achieve during the campaign (e.g. lower prices, local job growth, etc.). Second, a network of grassroots support is deployed to advertise and promote the program within each community. Typically, these networks include supporting individuals from state and local government, economic development organizations, as well as other local organizations with a history of engagement in the community. Third, each campaign is run as a limited time discount opportunity (typically 1 year, but more recently as short as 15–20 weeks). In states such as Massachusetts, cities and other local areas themselves may apply to the statewide Solarize program that selects new areas of operation each year. Between 2011 and 2012 Solarize Mass has led to 21 different city campaigns and almost 6 MW of installed PV capacity (MassCEC, 2012).

The District of Columbia (DC) ranked 3rd due to a number of national organizations with headquarter addresses in Washington and a strong network of “solar coops” active in 12 neighborhoods. The first DC solar coop emerged in the Mt. Pleasant neighborhood in 2008 with a cumulative recorded success of 50 installations. Since then, 11 additional coops have been established and organized under an umbrella organization—DC Solar United Neighborhoods (DC SUN, 2013) that provides information resources, networking opportunities, and representation of solar community

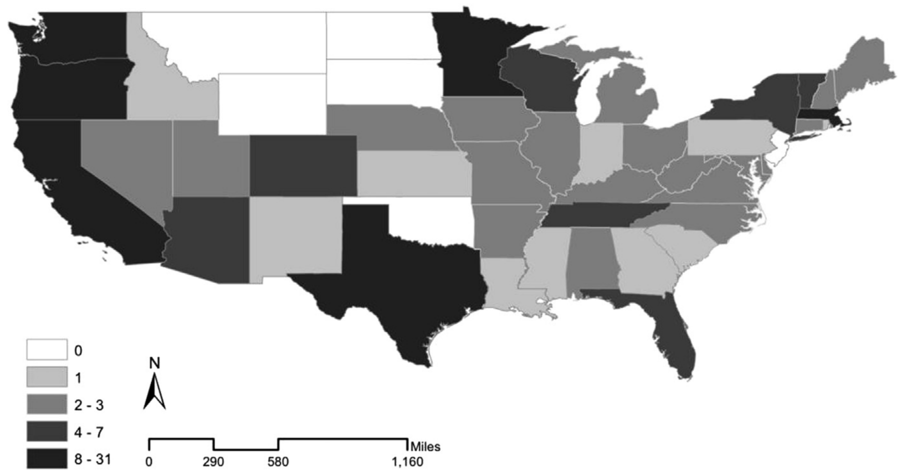

Fig. 4. Cumulative SCOs by state (1970–2012).

interests to the local electric utility and city council. Nationally, 25 organizations included in our SCO dataset carry the title of energy cooperative. Many require formal membership and collect dues from individual members. In exchange, members are eligible for supplier discounts on energy project equipment and other contract services.

A high percentage of SCOs listed a common theme as a primary rationale for its formation—a shared concern among individuals within each organization's membership about the impacts of fossil-based electricity generation. During the mid-to-late 1970s, this concern focuses primarily on the effects of the oil crisis and U.S. dependence on foreign sources of fossil fuels. For example, the mission statement of the Solar Energy Association of Connecticut (founded in 1976) states:

> "*The impact of fuel shortages on a technological society was highlighted by the crisis following the oil embargo in 1973; it spurred interest in the development of solar energy and other renewable energy sources. It was recognized by many that the deeper causes of the crisis must be addressed in order to provide a long-term solution.*"

Similarly, a majority of organizations founded in the 2000s cite concerns over the environmental impacts of fossil fuels and anthropogenic climate change in their mission statements. The broader concern among citizens about the sources and impacts of electricity generation during these two time periods is also reflected in the number of new SCOs (Fig. 5). The sharp rise in new organizations formed after 2005 also corresponds with a growth in both government incentive programs to encourage residential adoption and accelerated growth in the residential PV market itself. While numerous interviewees cited examples of initiatives supported by public funds, it is unclear if greater government emphasis on renewable energy contributed to the rationale for new SCO formation. The majority of SCOs, including those formed after 2005, do not rely primarily (or at all) on public financing to support the organization's activities. In total, 40 SCOs list financial support from public sources (city, state, or federal governments) on their websites while only 21 list financial support from private companies. The majority of SCOs are either supported by individual donations, in-kind contributions from companies or other non-profits, or receive no financial support.

The most common activity for SCOs is to provide information to the public—a service provided by 87% of SCOs (Fig. 6). This information is often delivered through digital resources concerning the financial and non-financial benefits of solar and other resources intended to help to answer frequently asked questions by potential adopters within a particular location during the individual's decision period to install PV. This includes localized information about the combined impact of municipal, state, and federal incentives; testimonials from previous PV adopters in the community; research, fact sheets, news articles about the environmental benefits of purchasing residential solar; and information about local contractors with a prior history among organization members. A strong majority (74%) of SCOs also coordinated workshops or events ranging in purpose from educating members about the benefits of solar to community-service oriented activities to assist other members install PV systems through voluntary support. A minority of SCOs provided formal discount programs for PV system installations (31%) or facilitated networking opportunities between energy industry professionals, members, and PV system contractors (28%).

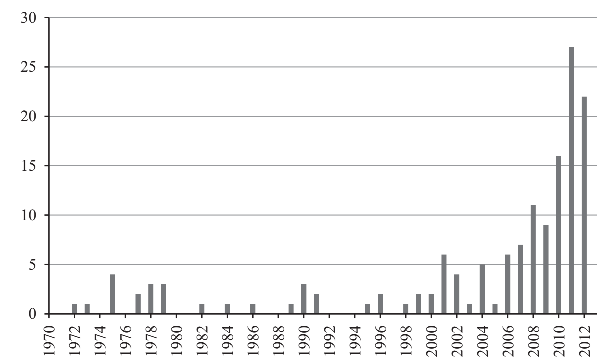

Fig. 5. City and state SCOs by start-up year.

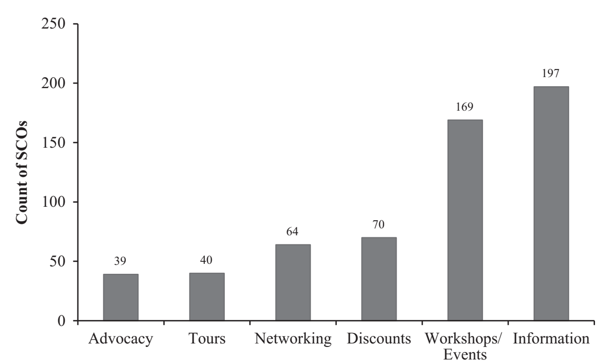

Fig. 6. SCO activity by type.

The least common SCO activities are participation in Solar Tours and advocacy, each listed by only 17% of SCOs. Solar Tours were listed predominantly by local chapters of the American Solar Energy Society (ASES), which coordinates participation in the annual National Solar Tour, whereby member organizations coordinate opportunities for interested members of the public to visit the homes of previous adopters of PV systems. In 2012, the ASES National Solar Tour registered 578 affiliated programs that drew over 90,000 people across 38 states (ASES, 2013). Advocacy and lobbying government for solar-friendly policies, on the other hand, was engaged in predominantly by informal organizations without recognized tax-exempt status as a non-profit organization. Many SCOs not engaged in advocacy activities listed a relationship to affiliated but separate organizations that conduct advocacy on behalf of a state or city solar community.

4.2. Case studies

4.2.1. Solar San Antonio—San Antonio, TX

Motivated to promote solar energy and energy efficiency in Texas, in 1999, William Sinkin established Solar San Antonio (SSA), a non-profit organization dedicated to consumer education. SSA carried out its mission of education by hosting informational workshops, breakfasts and lectures on PV power. A decade later on March 28, 2008, the U.S. Department of Energy designated San Antonio as a Solar America City. As a part of that effort, the National Renewable Energy Lab assessed the local potential market by surveying a sample of San Antonio residents on their familiarity with solar, likelihood to pay, and perceived challenges associated with residential PV. The survey revealed that many residents were familiar with solar and willing to pay more for a solar home—40% of those surveyed were ready to install solar electric and solar water heater systems. However, the major upfront costs and informational barriers associated with residential PV installations had kept adoption rates low.

In 2010, SSA began targeting efforts to increase residential solar adoption through consumer education and a simplified process for “going solar.” This took the form of SSA's “Bring Solar Home” campaign that tried to bridge the gap between consumers and industry and accelerate solar adoption and installations (U.S. DOE, 2011).

In part because of this campaign, the city of San Antonio saw an increase in applications and installations from about 36 per year in 2008 to about 500 per year by 2012. “In the past year [mid 2010–mid 2011], more than 150 homes have been outfitted with solar panels, and over 1000 people have applied to a local non-profit program [SSA] that connects homeowners with companies that perform solar installations” (Eichler., 2011). Many applications do not end up as contracts for several reasons which include lack of financing and trees causing shading constraints. Still, the closure rate on lead generated by the Bring Solar Home campaign is around 18%. When potential solar adopters apply online, SSA assigns three solar installers (from their rotating list of installers) to assess the potential adopter's home and competitively bid for the project. This was a part of the effort to make the pursuit of solar easy for consumers.

SSA expanded its outreach program by hosting school events, fairs, home shows, and most especially their annual solar tour. For the tour, installers mark their projects on a map and interested residents use the map for a self-guided tour of solar installations in their region. The installers and homeowners who adopted PV are at the different sites, available to answer questions.

To tackle the financial barrier, SSA invited lending institutions to explain the CPS rebate (2007) and Federal Tax Credit and figure out a way to make solar financing easy. SSA partnered with San Antonio Credit Union to develop a creative financing program, which covered all upfront costs and reduced financing to reasonable monthly payments of around $40–50. This loan model attracted a total of approximately 1300 applicants.

Table 2
Residential solar installations rebated by CPS Energy FY 2008–FY 2012.

Time	# Installations[a]
8/24/07–1/31/08	4
2/1/08–1/31/09	14
2/1/09–1/31/10	33
2/1/10–2/15/11	137
2/16/11–2/15/12	259
2/16/12–1/18/13	251

[a] Data from Lanny Sinkin, executive director of SSA.

The two biggest advocates for SSA were CPS Energy and Steve Brown, the local weatherman. CPS Energy is San Antonio's municipally owned utility that encouraged residents to “go solar” and inserted information about SSA into their customer newsletter that reaches their entire service area. Steve Brown, the weatherman, had installed a 10 kW system and became a strong ambassador for solar. During TV weather forecasts, he would explain the benefits of solar and encourage viewers to contact SSA to apply. Brown and other local political figures and community leaders provided a key support for SSA by publicly encouraging residents to apply for solar installations through SSA.

According to SSA, residential solar installations in San Antonio have increased dramatically since the start of the Bring Solar Home campaign (Table 2). And while SSA only takes credit for 20% of those installations, they believe that a great portion of subsequent installations are due to passive and active peer effects of the installations through SSA: “Today—more or less as a result of Sinkin's enthusiasm for solar—homeowners are finding their way to Solar San Antonio through word of mouth” (Eichler, 2011). According to SSA's account and media reports, once SSA helped kick-start PV installations in San Antonio, other residents became potential adopters because they were influenced by their neighbors PV activity or by seeing the panels installed on other rooftops. Installation data (Table 2) provide support for these observations. During 2010, the year when SSA started its focused grassroots activities, the number of installations in San Antonio increased by over 300% compared to the previous year (2009). By comparison, in Austin, TX, which is also served by a municipally owned electric utility (Austin Energy), the year-on-year growth rates in the number of installations have varied between 50 and 100% during 2008–2011 (in 2010 the growth rate in Austin actually slowed down due to a programmatic change).

4.2.2. Mueller megawatt project—Austin, TX

The Mueller community in Austin, TX, is a new mixed-use urban village with a sustainable, transit-oriented design. The Mueller Megawatt Project (MMP), which started in 2009, is a community-run grassroots effort to encourage solar adoption and promote Mueller as a sustainable community.

The project started in the summer of 2009 when a dozen people decided to pool their money to get better rates on solar installations. The group invited two solar installation companies to present about solar PV and give them their best bids. A few of the residents worked together to develop a financial toolkit complete with energy bill comparisons and return on investment calculators. After a few months, the group had grown to around 30–40 residents who together applied for Austin Energy's solar rebate and signed up for solar installations. The Federal Investment Tax

Credit (ITC) combined with Austin Energy's solar rebate and the lower rates for group installations made solar attractive for the community group.

In this first wave of installations for MMP, this small group of residents interested in solar had to take on the informational and financial barriers. Drawing from their different backgrounds, they worked to understand solar financing options, develop the financial toolkit and bring in solar installers to explain solar and how it specifically applied to Mueller. It was originally a loosely organized group of neighbors that met after work at happy hours or at each other's houses, working together when it was convenient.

The second phase of MMP involved a pre-planning phase and had much wider participation. Their approach was much more organized with a streamlined application and bidding process. The pre-planning phase involved a one-day presentation with about 60 community members. All eight main solar installation companies within the Austin area were invited to give bid presentations, on which they were judged for professionalism, experience, and process simplicity. After the presentation, the group narrowed down their choices and each resident indicated their preference for installers. This information was aggregated into a running list of contact information of interested homeowners for installers' use. Most homeowners opted to receive multiple bids.

Meanwhile, MMP continued informal outreach by hosting meetings at houses with staggered times in the evening to accommodate every resident and family. They continued with their popular happy hours and put a few flyers at their central mailboxes. According to MMP team members, the most effective approach was what they called "porch talks" where advocates who were community members would sit on their porch after dinner and ask any passerby if they knew about solar and were interested in putting PV on their roof. The door-to-door method and "porch talks" approach were organic approaches since they fit naturally with the very social, very active neighborhood. MMP staff also believe that their community organization efforts were successful because the information could be trusted since the solar advocates were simply their neighbors, who would not make any money off of their participation.

The tools from the first phase were available in the second phase, but this time involved online resources and centralized information, which streamlined the process. Because there was high trust in the information provided by this community project, signing up for solar became easy. Once 100 people signed up, everyone after seemingly did not need a high level of information. They simply believed that if so many of their neighbors were signing up, it must be a good thing and they should do it, too (Fig. 7). This second phase of MMP resulted in a total of 210 homes installing solar. The MMP met its megawatt goal in November 2011 and currently have 1.224 MW of installed capacity in the Mueller neighborhood.

4.2.3. SmartPower

A decade ago, surveys found that as much as 84% of Americans expressed an interest in buying solar power. Yet, the market lacked of any significant installation activity. To many, this was a marketing failure: a clear demand was not being met. Several entities including The Pew Charitable Trusts, the Rockefeller Brothers Fund and The John Merck Fund formed SmartPower—a non-profit designed to use current day marketing strategies to encourage adoption of clean energy and efficiency measures. Since then, SmartPower has partnered with numerous states, communities and associations to set up local solar programs including the Arizona Solar Challenge, The New England Solar Challenge, Solarize Boston, and Solarize Connecticut.

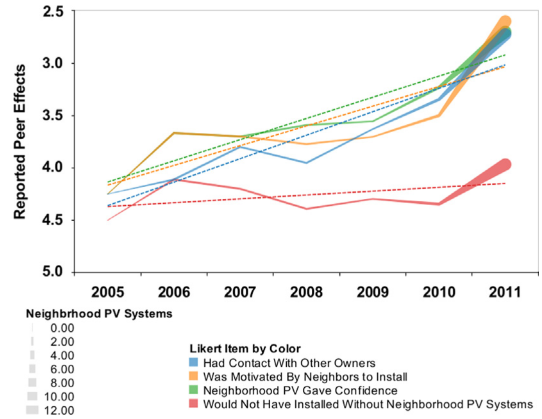

Fig. 7. This chart shows the average survey responses and trends for four 5-point Likert items regarding peer effects from 2005 to 2011 among ~200 residential PV owners in the Austin (TX, USA) area. Lower values on the y-axis correspond to stronger peer effects. Width of the lines represents the average number of systems in the "neighborhood", which was defined a "5 to 10 block radius" from the respondents homes. The increasing thickness (more systems in the neighborhood) since 2010 and the corresponding rise in reported peer influence are largely because of the MMP. This clearly demonstrates the effect of peer effects in driving further PV adoption and the success of the MMP. Adapted from Rai and Robinson (2013).

Among the key barriers SmartPower recognized were the complex buying process and the issue of who to trust. One of their major strategic initiatives was creating the role of solar coaches and solar ambassadors. During their operations, SmartPower noticed the high volume of people willing to help others "go solar." Being a solar ambassador or solar coach allowed local "champions" of solar to have a stage. These were neighbors who were not trying to benefit financially from others "going solar," so they became sources of transparent, trustworthy information and experience.

SmartPower's approach to encouraging residential PV adoption is a self-proclaimed grassroots, community approach where they empower the local community members to lead the tours, workshops and events themselves. SmartPower realized when a known community member led and promoted these events, more people showed up and became engaged than if SmartPower staff had been leading these efforts. Their mission therefore evolved with a new approach as a major supporter (instead of leader) of established community members and networks, providing toolkits for each new solar campaign that included templates for newsletter, yard signs, e-mail blasts and general media. Generally, SmartPower does not provide much financial assistance beyond bulk-purchase discounts, which have reduced costs for solar by 20–25%. However, SmartPower customizes their approach to each new client depending on their respective needs for education and marketing support.

SmartPower has experienced encouraging success with their Arizona Solar Challenge which set the goal of 5% of residential rooftops installing solar power. Although political constraints in Arizona ended the program before its final completion, at least half a dozen communities had already surpassed the 5% goal—reaching over 10%. The first phase of the Solarize Connecticut also experienced a substantial increase in PV adoption in the four communities that took part—during the 20 week program over 2 MW of PV was installed across these four communities, nearly triple the installations in these communities over the previous seven years (SmartPower, 2013). Much of this success is attributed to the broader client base that the Solarize model is able to leverage: about 20% of those who installed solar under this model were considering solar for the first time during each of SmartPower's programs. Thus, SmartPower's marketing and education efforts engendered solar adoption by not only those who are already oriented to pro-environmental choices but also those who are generally interested in stabilizing their energy bills (SmartPower, 2013). SmartPower estimates that the average Solarize customer in their program saved about $7500 on their system compared to market averages at the same time. Perhaps most promising is the fact that the “all in” customer acquisition costs through SmartPower′s Solarize Connecticut Phase 1 programs were approximately $135/kW, which is considerably less than the market averages between $250 and $500/kW (SmartPower, 2013). Overall, these data provide strong evidence of the success of the Solarize model, which effectively leverages grassroots community organization to reduce costs and increase the scale of PV installations.

4.2.4. Solar Oregon

Solar Oregon, formerly known as the Solar Energy Association of Oregon, was incorporated in 1979 when a handful of community associations across the state all believed solar was a solution to the oil crisis and joined as one. Together, this group of volunteers promoted everything from passive solar design to solar water heating and solar PV. Their original mission circulated around consumer education. Income mostly came from hosting the national American Solar Education Society (ASES) conference in Oregon as well as their annual statewide solar tours.

When Oregon Solar Energy Industries Association (OSEIA) was formed in the 1980s, many industry representatives branched out, focusing on best practices and advancing the industry while Solar Oregon remained focused on consumers. Still, installers, business owners and industry professionals remained involved in Solar Oregon′s efforts, supporting their mission of encouraging solar adoption among residents.

In addition to education and outreach, Solar Oregon participated in consumer advocacy and solar policy. For a brief period, policy groups like the Renewable Northwest Energy Project and the Energy Trust helped fill that role, doing most of the policy work. However, Solar Oregon has been pulled back into a policy and advocacy role, undertaking legislative barriers to residential solar adoption. Solar Oregon became a connector for all solar players in Oregon from municipalities, utilities, consumers, installers and manufacturers in different jurisdictions and communities.

Solar Oregon has continued their education efforts with school-based education programs. Curriculum specialists from Solar Oregon design lessons that fit the engineering design and science benchmarks for the state and help to support the teachers in implementing these programs. They are currently in 50 classrooms across the state; demand for this educational program is continually high. Funding for the classes comes from several grants and sponsors.

In 2007, four organizations—Energy Trust of Oregon, Portland′s Bureau of Planning and Sustainability, Solar Oregon, and Oregon′s Department of Energy—came together to form *Solar Now*. With Solar now these organizations merged their efforts to work together on a single campaign for statewide education and outreach. In the last 3–4 years, Solar Oregon has helped organize 19 solarize programs all over Oregon, 12 of which have been completed and 7 are still ongoing at this point (Solar Oregon, 2013). Much of Solar Oregon′s impact has been attributed to the *Solar Now! University*: a three-day conference that began in Pendleton, OR, in 2010. Communities who wish to start a solarize program or a solar campaign in their respective regions are referred to the Solar Now! University where they can send their solar champions for technical education and training. The goal of the conference is to provide all training necessary for individual community members to coordinate and lead solar programs in their own communities. They are taught about the basics of solar technology, community outreach strategies, tax credits, incentives and grants, solar energy policy, financing options, permitting, and codes. The process of going solar could be complex. This conference makes that process easier by providing all the necessary information at one time, while giving participants access to a network of fellow communities, experts and beginners alike, who have or are currently attending the conference. Simultaneously training those interested in starting solar programs saves Solar Oregon a lot of time and money that would otherwise be spent explaining everything to each interested party individually.

Solar Oregon also attributes the success of the many solarize programs in Oregon to their solarize database and registration system, which they have been able to customize for each new program′s needs. The first step in developing a solarize program from Solar Oregon′s perspective is encouraging those interested to go to Solar Now! University. Next, community buy-in is essential; Solar Oregon requires about a 20% match from the community for funding solar programs, achieved through sponsors and grants or through volunteer time and paying for printed materials. Next, the community either appoints a project coordinator from within their community or they hire someone for part time. The crucial role of Solarize project coordinators is to identify and engage with existing networks for effective marketing purposes. Solar Oregon provides one to two staff members to support each campaign. They typically help with the database and other administrative roadblocks. The workshops for each campaign required a lot of effort early on when they were being done by Solar Oregon staff, but now they train the project coordinator to do the workshops in conjunction with the contractor(s) hired for each project. Previously, each Solarize program would select a single installer, but now they choose multiple installers to promote equity.

Finally, Solar Ambassadors have been key players in encouraging residential PV adoption by sharing their stories and offering fellow community members help in “going solar.” A prominently displayed link on the Solar Oregon website called ‘Meet Solar Ambassadors′ attracts significant attention online. Here, Oregon homeowners who have solar electric or hot water system on their residence share their story and their contact information, inviting others to visit them or call with questions. Profiles are listed by city and zip code and are maintained by each ambassador.

The case of the City of Beaverton, OR (USA), demonstrates some of the ground-level impact within the larger Solar Oregon efforts. Solar Beaverton, a community-organized solarize program, was launched in May 2011 after a year-long pilot. Within the first few months of the program′s run, the initial goal of 250 installed systems in 1 year was surpassed (ICLEI, 2012). The program also catalyzed innovative partnering with solar companies such as SolarCity and SolarWorld, engendered a new contracting process in the city, and also motivated another neighboring city (Hillsboro) to launch a similar program (Solar Beaverton, 2013).

5. Conclusion

Understanding the characteristics of SCOs provides useful insights about the distribution of support for solar energy and the activities of organizations that have been successful in encouraging solar adoption, especially via catalyzing positive peer effects. These organizations are an important part of the support infrastructure seeking to harness grassroots support for solar energy and catalyze the adoption of residential rooftop PV.

5.1. "Shock" Events catalyze grassroots environmental action

Our analysis suggests that periods of heightened scrutiny and public concern about the sources and environmental consequences of energy production translate into grassroots activity

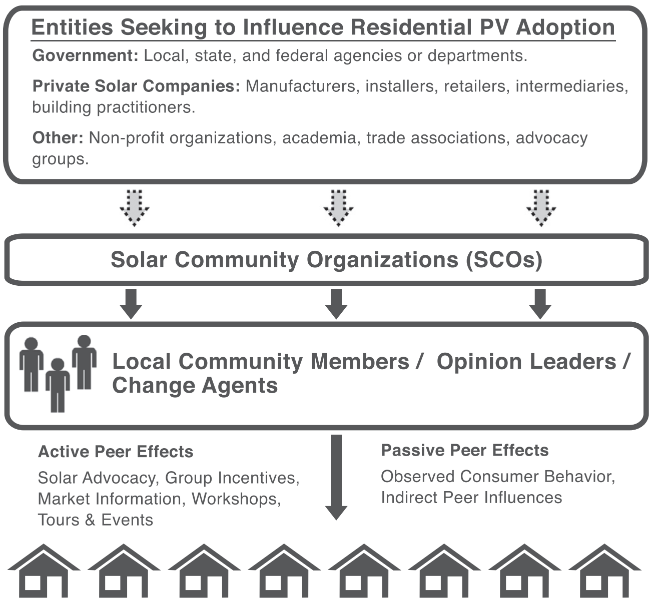

Fig. 8. Schematic diagram demonstrating the SCO-driven active peer-effect process. The dotted arrows from the top layer represent the observation that SCOs can form organically, even without the input of resources from other entities.

and mobilization to encourage the adoption of renewable energy. As expected, the majority of SCO clusters are located in high population states, especially those with high electricity rates and favorable solar policies (for example, California and Massachusetts). Moreover, some outliers such as Washington, DC can be explained by the number of organizations with headquarter addresses in the city for the purpose of pursuing an advocacy or policy agenda. Concern for the environment is among the top reasons cited in SCO mission statements as a rationale for founding the organizations and promoting renewable energy. For example, many organizations founded in the 1970s specifically reference the oil crisis and its economic consequences as a motivating factor and a reason for promoting non-fossil domestic energy production. Similarly, many SCOs formed from 2001 to present cite global warming as a primary rationale.

5.2. *Trust networks are the focal point in the success of SCOs*

Our analysis identified a number of characteristics that lead to the operational success of SCOs. These organizations are unique in their ability to inform and influence consumer decision-making because of the trust networks they hold through longstanding linkages with key individuals in local communities. Working in partnership with governments, private entities, and other non-profits, they support a variety of programs that actively seek to engage consumers to consider installing solar PV. This process of active engagement is described in the peer effects framework in Fig. 8. Governments provide support in the form of rebate programs, solar-friendly building regulations, and workshops. Similarly, other non-profit organizations (including universities) provide technical assistance, research, facilities, and informational resources, while solar companies may contribute by providing discount pricing for PV systems. SCOs, however, are often the key organizational linkage that brings these resources together, communicates their availability and value to citizens, and pioneers coordinated programs to encourage adoption of PV. The success of these programs relies heavily on the status of SCO members as trusted opinion leaders with a history of commitment to the local community. Without this trust relationship, other programs are unlikely to achieve high penetration or success.

Moreover, based on the case studies, three elements are critical to the success of any solar campaign. First, a campaign should involve a local champion(s)—a person(s) who is well connected, active and well known in the community—who is motivated to have his or her community go solar. Second, the community must have existing networks. A well-connected community is more likely to succeed than a relatively disconnected or inactive community. Peer effects play a large role in the success of a Solarize program because neighbors communicated with and motivate neighbors in the complex process. Lastly, there needs to be a financial piece. More consumers have been influenced to adopt solar when a local financial institution provides low (or no) interest loans for their solar system. Financing options that are attractive and nearby in the community are preferred because they are the more accessible and trustworthy options. These three measures, when combined, are likely to lead to a successful PV adoption program run by a SCO.

6. Future work

Additional research is needed to study the momentum of peer effects after limited-time campaigns, such as Solarize programs. With the number of programs increasing rapidly in recent years, it is now possible to investigate the effect of these programs on adoption rates after programs are completed. There is also a need to better evaluate the impact of major potential shifts in the residential market vis-à-vis solar gardens (or community solar) and the option to lease PV systems and how these business models might impact the role of SCOs. Both solar gardens and solar leasing seek to make solar more affordable and accessible and thereby increase residential solar adoption. A significant amount of resources and new organizations have been developed to support both these new types of programs and additional research into the extent and likely trajectory of these programs and the role of SCOs therein is needed.

Acknowledgments

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Appendix A

A.1 Typology of peer effects

The SAGE Handbook of Social Network Analysis (Scott and Carrington, 2011) provides a comprehensive overview of previous treatments of peer effects across a variety of disciplines. It categorizes peer effects across eight dimensions:

1. *Exogenous vs. endogenous*—A peer effect as a result of an unintended spillover of an intervention/action or as intended, targeted action.
2. *Positive vs. negative*—By desirability, the peer effect's normative impact on a subject.
3. *Active vs. passive*—A distinction between whether the subject has explicit recognition of the tie/connection to his or her peer.
4. *Contemporaneous vs. lagged*—A temporal distinction between the action and its effect.

5. *Group vs. individual*—Whether the agent of the peer effect represents a single peer or a group of peers.
6. *Unidirectional vs. bidirectional*—Peer effects can be one-directional or reciprocal in nature.
7. *Symmetric vs. asymmetric*—With reciprocal (bidirectional) peer effects, the effect can be the same or different in magnitude of effect on both agents.
8. *Effect on preference, behavior or outcome*—Peer effects can be distinguished by whether they have an effect on an individual's preferences, behaviors, a specific outcome, or a combination of any of the three.

A.2 Search methodology

State SCO search:

Keywords: State, Solar, Solarize, Residential, Organization, Society, Association, Non-Profit, Education, Workshop, Information, Consumer.

State search combinations:

1. State + Solar.
2. State + Solar + Organization OR Association OR Non-profit OR Society.
3. State + Solar + Residential.
4. State + Solar + Residential + Consumer + Information OR Workshop OR Education.
5. State + Solar + Residential + Community + Workshop OR Organization.
6. State + Solarize.

City SCO search:

Keywords: City, Solar, Solarize, Residential, Organization, Society, Association, Non-Profit, Education, Workshop, Information, Consumer

City search combinations:

1. City + Solar.
2. City + Solar + Organization OR Association OR Non-profit OR Society.
3. City + Solar + Residential.
4. City + Solar + Residential + Consumer + Information OR Workshop OR Education.
5. City + Solar + Residential + Community + Workshop OR Organization.
6. City + Solarize.
7. City + Solar + Neighborhood + Organization.

Cities:

Arlington, VA	Honolulu, HI	Rochester, NY
Atlanta, GA	Houston, TX	Romney, TX
Austin, TX	Imperial Valley, CA	Sacramento, CA
Baltimore, MD		Salt Lake City, UT
Berkeley, CA	Ivanpah, CA	San Bernardino, CA
Blythe, CA	Johannesburg, Gauteng, South Africa	
Boise, ID		San Diego, CA
Boston, MA	Kansas City, MO	San Francisco, CA
Brooklyn, NY	Kern County, CA	San Jose, CA
Camarillo, CA	Las Vegas, NV	San Mateo, CA
Cambridge, MA	Long Beach, CA	San Antonio, TX
	Longmont, CO	Santa Barbara, CA
Cape Canaveral, FL	Los-Angeles, CA	Santa Clara, CA
Capitol Hill, WA	Madison, WI	Santa Cruz, CA
Ceres, CA	Marcellus, NY	Santa Monica, CA
Chicago, IL	Mauna Kea, HI	Seattle, WA
Cincinnati, OH	Miami, FL	Sierra, CA
Cisco, CA	Milpitas, CA	Sonoma, CA
Cleveland, OH	Mojave Desert, CA	Stanford, CA
Clinton, WA		Syracuse, NY
Columbia, CA	Mountain View, CA	Tehachapi, CA
Columbia, FL		Tempe, AZ
Columbia, WA	New Orleans, LA	Thomson, NY
Columbus, OH	Newark, NJ	Trenton, NJ
Dallas, TX	Oakland, CA	Tucson, AZ
Denver, CO	Orange County, CA	Washington, DC
Detroit, MI		
Edison, ca	Palo Alto, CA	Yucca Mountain, NV
Fort Collins, CO	Pasadena, CA	Charlotte, NC
Fremont, CA	Penn, PA	El Paso, TX
Glenview, IL	Phoenix, AZ	Lansing, MI
Goddard, MD	Portland, OR	Philadelphia, PA
Goodyear, AZ	Raleigh, NC	
Hartford, CT	Reno, NV	Rockville, MD
Hillsboro, OR	Richmond, VA	Roseville, CA
Honda, CA	California	

Solar America Cities Recipients:

Ann Arbor, MI	Austin, TX	Berkeley, CA
Boston, MA	New Orleans, LA	San Antonio, TX
Denver, CO	New York City, NY	San Diego, CA
Houston, TX	Orlando, FL	San Francisco, CA
Knoxville, TN	Philadelphia, PA	San Jose, CA
Madison, WI	Pittsburgh, PA	Santa Rosa, CA
Milwaukee, WI	Portland, OR	Seattle, WA
Minneapolis—St. Paul, MN	Sacramento, CA	Tucson, AZ
	Salt Lake City, UT	

State	**Name of program**
Alabama	Alabama Solar Association
Alabama	Alabama Solar Coalition
Alabama	Alabama Solar Energy Association
Alaska	START initiative: Alaska
Alaska	REAP: Renewable Energy Alaska Project
Alaska	Alaska Sun
Arizona	Arizona SmartPower
Arizona	Arizona Solar Energy Association
Arizona	Arizona Solar Center
Arizona	Environment Arizona
Arizona	Sustainable Arizona
Arizona	Greater Tucson Coalition for Solar Energy
Arizona	Renewable Communities Alliance
Arkansas	Arkansas Renewable Energy Association

Arkansas	Arkansas Energy Office: division of Arkansas Economic Development Commission
California	San Diego Renewable Energy Society
California	Solar Living Association
California	California Solar Center
California	Community Energy Services Corporation
California	NorCal Solar
California	California Solar Power Society
California	Sustainable Silicon Valley
California	Solar Sonoma County
California	Self-Sustaining Communities LLC
California	Solarize Ojai
California	Ojai Valley Green Coalition
California	Solarize Santa Barbara
California	Orange County Renewable Energy Society
California	Energy Solidarity Co-op
California	Everybody Solar
California	GRID Alternatives
California	Local Clean Energy Alliance
California	SunWork Renewable Energy Projects
Colorado	COSEIA
Colorado	Solar-Friendly Communities
Colorado	Neighborhood Solar
Colorado	Colorado Renewable Energy Society
Colorado	San Luis Valley Renewable Communities Alliance
Colorado	Colorado Harvesting Energy Network
Connecticut	Connecticut Neighbor to Neighbor Energy Challenge
Connecticut	Solarize Connecticut
Connecticut	Solar Energy Association of Connecticut, Inc.
Delaware	Delaware Nature Society
Delaware	Delaware Million Solar Roofs Coalition
District of Columbia	MDV-SEIA
District of Columbia	DC Solar Flare Renewable Energy Tech Show
District of Columbia	Tour of Solar & Green Homes: 22nd Annual Metropolitan Washington, DC
District of Columbia	DC SUN: Solar United Neighborhoods
District of Columbia	Ward 8 Renewable Energy Co-Op
District of Columbia	DC Sun
District of Columbia	Brookland Solar Co-op
District of Columbia	Capitol Hill Energy Co-op
District of Columbia	Cleveland Park Energy Co-op
District of Columbia	Mt. Pleasant Solar Co-op
District of Columbia	Ward 7 Solar Cooperative
District of Columbia	Shaw Solar Co-op
District of Columbia	Georgetown Solar Co-op
District of Columbia	Palisades Solar Co-op
District of Columbia	Connecticut Avenue Neighbors Energy Performance Initiative
District of Columbia	Rigs Park Solar Co-op
District of Columbia	Petworth Solar Co-op
District of Columbia	Shepherd Park Solar Co-op
District of Columbia	Brightwood Solar Co-Op
District of Columbia	Bloomingdale Solar Co-op
District of Columbia	Deanwood Solar Co-op
Florida	SolarizeNow!
Florida	Florida Renewable Energy Association
Florida	Alachua Clean Energy
Georgia	Georgia Solar Energy Association
Hawaii	Hawaii Solar Energy Association
Hawaii	Solar-Hawaii.org (Solar America)
Idaho	Idaho Renewable Energy Association
Illinois	Illinois Solar Tour
Illinois	Illinois Solar Energy Association
Indiana	Indiana Renewable Energy Association
Iowa	Iowa Renewable Energy Association
Iowa	iSETA: Iowa Solar/Small Wind Energy Trade Association
Kansas	Heartland Renewable Energy Society
Kentucky	KY Solar
Kentucky	Solar Power Rocks
Louisiana	Louisiana Solar Energy Society
Maine	Maine Solar Energy Association
Maine	Maine Solar House
Maine	Natural Resources Council of Maine
Maryland	Mid-Atlantic Solar Energy Society
Maryland	MD Sun
Maryland	Solarize Frederick County
Massachusetts	Solarize Mass
Massachusetts	Boston Area Solar Energy Association
Massachusetts	Massachusetts Clean Energy Center: MassCEC
Massachusetts	Mass Climate Action Network (MCAN)
Massachusetts	Solarize Acton
Massachusetts	Solarize Arlington
Massachusetts	Solarize Boston
Massachusetts	Solarize Hopkinton
Massachusetts	Solarize Melrose
Massachusetts	Solarize Mendon
Massachusetts	Solarize Montague
Massachusetts	Solarize Newburyport
Massachusetts	Solarize Palmer
Massachusetts	Solarize Shirley
Massachusetts	Solarize Lenox
Massachusetts	Solarize Pittsfield
Massachusetts	Solarize Millbury
Massachusetts	Solarize Sutton
Massachusetts	Solarize Lincoln
Massachusetts	Solarize Wayland
Massachusetts	Solarize Sudbury
Massachusetts	Solarize Harvard
Massachusetts	Solarize Hartfield
Massachusetts	Solarize Scituate
Massachusetts	Solarize Winchester
Massachusetts	Co-op Power Franklin County
Massachusetts	Co-op Power Hampshire County
Massachusetts	Co-op Power Boston Metro East

Massachusetts	Co-op Power Hampden County
Massachusetts	Green Decade
Michigan	Great Lakes Renewable Energy Association
Michigan	Sustainable Detroit
Michigan	Midwest Renewable Energy Association
Minnesota	Solar MN Coalition
Minnesota	Minnesota Renewable Energy Society
Minnesota	Minnesota Solar Energy Industries Association (MnSEIA)
Minnesota	Clean Energy Resource Teams
Minnesota	Minnesota Solar Power
Minnesota	Solarize Kingfield
Minnesota	Clean Energy Resource Teams
Minnesota	Cooperative Energy Futures
Minnesota	Our Power
Mississippi	Mississippi Solar Energy Society
Missouri	Missouri Solar Energy Industries Association
Missouri	Show Me Solar
Missouri	Show Me Solar
National	The Solar Foundation
National	Local Initiatives Support Coalition
National	Vote Solar Initiative
National	Clean Coalition
National	Arezza Network of Sustainable Communities
National	New Generation Energy
Nebraska	Nebraska Solar Energy Society
Nevada	Nevada Solar Society
Nevada	Solar NV
Nevada	Sunrise Sustainable Resources Group
New Hampshire	New Hampshire Sustainable Energy Association
New Hampshire	Plymouth Area Renewable Energy Initiative
New Jersey	New Jersey Solar Association
New Jersey	New Jersey Green Association
New Mexico	New Mexico Solar Energy Association
New York	Renewable Energy Long Island
New York	Solarize Madison (NY)
New York	Sustainable Hudson Valley
New York	New York Solar Energy Society, Inc.
New York	Solar One
New York	Sustainable Flatbush
New York	Sustainable Tompkins
North Carolina	North Carolina Solar Center
North Carolina	North Carolina Sustainable Energy Association
North Carolina	Appalachian Institute for Renewable Energy
Ohio	Sustainable Delaware
Ohio	Green Energy Ohio
Ohio	Cleveland Solar Cooperative
Oregon	Solarize Oregon
Oregon	Solarize Eugene
Oregon	Solarize Corbett
Oregon	Solarize Pendleton
Oregon	Solarize Portland
Oregon	Solarize Salem
Oregon	Solarize Southern Oregon
Oregon	Solarize Union County
Oregon	Solar Gresham
Oregon	Rogue Solar
Oregon	Go Solar! Central Oregon
Oregon	Solarize Northeast
Oregon	Solarize Northwest
Oregon	Solarize Southwest
Oregon	Solarize Southeast
Oregon	Solarize North Portland
Oregon	Nike Solar Initiative
Oregon	Solar Beaverton
Oregon	Hillsboro Solar Advantage
Oregon	Solar Oregon (ASES Chapter)
Oregon	Growing Solar Clackamas County
Oregon	Solarize West Linn-Lake Oswego
Oregon	Million Monarchs
Pennsylvania	Northeast Sustainable Energy Association
Rhode Island	Co-op Power Blackstone Valley
South Carolina	South Carolina Solar Council
Tennessee	Tennessee Solar Energy Association (ASES charter member)
Tennessee	Tennessee Solar Institute
Tennessee	TenneSEIA
Tennessee	Solar Knoxville
Texas	Texas Solar Energy Society
Texas	Houston Solar Energy Society
Texas	North Texas Solar Energy Society
Texas	San Antonio Solar Energy Society
Texas	El Paso Solar Energy Society
Texas	Mueller Megawatt Project
Texas	Solar Austin
Texas	Plano Solar Advocates
Utah	Utah Solar Energy Association
Utah	Utah Clean Energy
Vermont	Renewable Energy Vermont
Vermont	Renewable Energy Resource Center for Vermont
Vermont	Solarize Norwich
Vermont	Co-op Power Southern Vermont
Vermont	VPIRG
Virginia	Mid-Atlantic Solar Energy Society
Virginia	Hampton Roads Solar Group
Virginia	VA SUN
Washington	Northwest Sustainable Energy For Economic Development
Washington	Solarize Seattle: Northwest
Washington	Solarize Mukilteo
Washington	Go Solar
Washington	Solar Washington
Washington	Solarize Washington
Washington	Sustainable Magnolia
Washington	Sustainable Queen Anne
Washington	Washington Local Energy Alliance
West Virginia	New Vision Renewable Energy
West Virginia	WV SUN
Wisconsin	Solarize Marshfield
Wisconsin	Wisconsin Solar Energy Industries Association
Wisconsin	Renew Wisconsin
Wisconsin	Grow Solar Wisconsin
Kentucky	Kentucky Solar Energy Society

References

Arndt, J., 1967. Role of product-related conversations in the diffusion of a new product. J. Mark. Res. 4 (3), 291–295.

ASES (2013). National Solar Tour. 〈http://www.ases.org/solar-tour/〉 (accessed 24.07.13).

Axsen, J., Mountain, D.C., Jaccard, M., 2009. Combining stated and revealed choice research to simulate the neighbor effect: the case of hybrid-electric vehicles. Resource Energy Econ. 31 (3), 221–238.

Banerjee, A., et al. 2012. The Diffusion of Microfinance. NBER Working Paper No. 17743.

Barbose, G., Darghouth, N., Wiser, R., 2012. Tracking the Sun V: A Historical Summary of the Installed Price of Photovoltaics in the United States from 1998 to 2011. Environmental Energy Technologies Division, Lawrence Berkeley National Laboratory, Berkeley, CA, United States. LBNL-5919E. November.

Bass, F.M., 1969. A new product growth model for consumer durables. Manage. Sci. 15, 215–227.

Bollinger, B., Gillingham, K., 2012. Peer effects in the diffusion of solar photovoltaic panels. Market. Sci. 31, 800–812.
Brass, J.N., 2012. Why do NGOs go where they go? Evidence from Kenya. World Dev. 40 (2), 387–401.
Brock, W.A., Durlauf, S.N., 2001. Interactions-based models. Handbook of Econometrics, vol. 5; , pp. 3297–3380.
Christakis, N.A., Fowler, J.H., 2008. The collective dynamics of smoking in a large social network. N. Engl. J. Med. 358 (21), 2249–2258.
Coleman, J., Katz, E., Menzel, H., 1957. The diffusion of an innovation among physicians. Sociometry 20, 253–270.
Cox, D.N., Evans, G., Lease, H.J., 2007. The influence of information and beliefs about technology on the acceptance of novel food technologies: a conjoint study of farmed prawn concepts. J. Food Qual. Prefer. 18 (5), 813823.
DC SUN (2013). *DC Solar United Neighborhoods*. Available from: ⟨https://sites.google.com/site/dcsolarunitedneighborhoods/⟩ (accessed 01.08.13).
DiMaggio, P., Louch, H., 1998. Socially embedded consumer transactions: for what kinds of purchases do people most often use networks? Am. Sociol. Rev., 619–637
DSIRE, 2013. *Business Energy Investment Tax Credit (ITC)*. Retrieved June 1, 2013, from Database of State Incentives for Renewables & Efficiency: ⟨www.dsireusa.org⟩.
EIA (Energy Information Agency, U.S.), 2013. Electric Power Monthly: With Data for September 2013
EIA (Energy Information Agency, U.S.), 2012. Annual Energy Review 2011. Released: September 2012.
Eichler, A. 2011. Solar Power Shines in San Antonio as Texas Green Movement Gains Momentum. Published in *The Huffington Post* on September 26, 2011. Available from: ⟨http://www.huffingtonpost.com/2011/09/26/solar-power-san-antonio_n_981147.html⟩ (accessed 19.12.13).
Feldman, D., Barbose, G., Margolis, R., Wiser, R., Darghouth, N., Goodrich, A., 2012. Photovoltaic (PV) Pricing Trends: Historical, Recent, and Near-Term Projections. National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory (November).
Fruttero, A., Gauri, V., 2005. The strategic choices of NGOs: location decisions in rural Bangladesh. J. Dev. Stud. 41 (5), 759–787.
Gallup (2013). Americans Want More Emphasis on Solar, Wind, Natural Gas. ⟨http://www.gallup.com/poll/161519/americans-emphasis-solar-wind-natural-gas.aspx⟩ (accessed 07.31.13).
Goodrich, A., James, T., Woodhouse, M., 2012. Residential, Commercial, and Utility-Scale Photovoltaic (PV) System Prices in the United States: Current Drivers and Cost-Reduction Opportunities. Golden, CO: U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy; National Renewable Energy Laboratory.
GTM, 2012a. SEIA/GTM Research U.S. Solar Market Insight Report Q3 2012. Published December 11, 2012. ⟨http://www.seia.org/research-resources/solar-market-insight-report-2012-q3⟩ (accessed 13.12.12).
GTM, 2012b. Solar PV Balance of System (BOS) Markets: Technologies, Costs and Leading Companies, 2013–2016. GTM Research. Published November 15, 2012. ⟨http://www.greentechmedia.com/research/report/solar-pv-bos-2013⟩ (accessed 07.02.13).
GTM, 2013. U.S. Solar Market Insight Q1 2013 Report Executive Summary. GTM Research.
Hartmann, W.R., et al., 2008. Modeling social interactions: identification, empirical methods and policy implications. Market. Lett. 19 (3–4), 287–304.
ICLEI, 2012. Case Study: City-led Solarization in Beavorton, OR (August 2012). Available from: ⟨http://www.icleiusa.org/action-center/learn-from-others/case-study-city-led-solarization-in-beaverton-or⟩.
Jackson, M.O., Watts, A., 2002. The evolution of social and economic networks. J. Econ. Theory 106 (2), 265–295.
Manski, C., 1993. Identification of endogenous social effects: the reflection problem. Rev. Econ. Stud. 60, 531–542.
Manski, C., 2000. Economic Analysis of Social Interactions. NBER Working Paper No. 7580. ⟨http://papers.nber.org/papers/w7580.pdf⟩.
Manski, C., 2010. Identification of Treatment Response with Social Interactions. Cemmap Working Paper, No. CWP01/10, http://dx.doi.org/10.1920/wp.cem.2010.0110.
Margolis, R., Zuboy, J., 2006. Nontechnical barriers to solar energy use: review of recent literature. National Renewable Energy Laboratory, U.S. Department of Energy, Golden, CO p. 2006
MassCEC (2012). Solarize Mass Program Update. Massachusetts Clean Energy Center. ⟨http://www.solarizemass.com/index.cfm/page/About-Solarize/pid/12858⟩ (accessed 21.02.13).
Moffitt, R.A., 2001. Policy interventions, low-level equilibria, and social interactions. Soc. Dyn., 45–82
Narayanan, S., Nair, H., 2011. Estimating Causal Installed-Base Effects: A Bias-Correction Approach. Available at SSRN 1958051.
Nelson, P., 1970. Information and consumer behavior. J. Polit. Econ. 78 (2), 311–329.
Newell, R., Kerr, S., 2003. Policy-induced technology adoption: evidence from the U.S. lead phase-down. J. Ind. Econ. 51 (3), 317–343.
Oster, E., Thornton, R., 2009. Determinants of Technology Adoption: Private Value and Peer Effects in Menstrual Cup Take-Up. NBER Working Paper No. 14828. ⟨http://www.nber.org/papers/w14828.pdf⟩.
Rai, V., Robinson, S.A., 2013. Effective information channels for reducing costs of environmentally-friendly technologies: evidence from residential PV markets. Environ. Res. Lett. 8 (1), 14044.
Rai, V., et al., 2014. Demand-Pull and Innovation in the U.S. Solar Market. *Energy Policy*. Working Paper Draft (22 July 2013), in preparation. Available from: ⟨http://ssrn.com/abstract=2297140⟩, http://dx.doi.org/10.2139/ssrn.2297140.
Renewables International, 2012. PV Prices Down 66% Since 2006. Published August 30, 2012. ⟨http://www.renewablesinternational.net/pv-prices-down-66-since-2006/150/510/56052/⟩ (accessed 15.01.13).
Rogers, E., 2003. Diffusion of Innovations. Free Press, New York (5th ed.)
Scott, J., Carrington, P. (Eds.), 2011. The SAGE Handbook of Social Network Analysis. SAGE Publications, London
Seel, J., Barbose, G., Wiser, R., 2013 Why are residential PV prices in Germany so much lower than in the United States? Lawrence Berkeley National Laboratory (February, Revision), Berkeley, CA, United States.
SEIA, 2012. America Votes Solar – National Solar Survey 2012. Solar Energy Industries Association. Published Online: October 8, 2012. ⟨http://seia.org/research-resources/america-votes-solar-national-solar-survey-2012⟩ (accessed 18.01.13).
Sharp, J., Mobley, C., Hammond, C., Withington, C., Drew, S., Stringfield, S., Stipanovic, N., 2012. A Mixed Methods Sampling Methodology for a Multisite Case Study. J. Mixed Methods Res. 6 (1), 34–54.
Shih, L.H., Chou, T.Y., 2011. Customer concerns about uncertainty and willingness to pay in leasing solar power systems. Int. J. Environ. Sci. Technol. 8 (3), 523–532.
Skyrms, B., Pemantle, R., 2009. A dynamic model of social network formation. In Adaptive Networks. Springer, Berlin Heidelberg, pp. 231–251
SmartPower (2013). Let's Solarize: Solarize Connecticut Phase 1 Report (September 2013). Available from: ⟨http://www.smartpower.org/our-research/reports⟩.
Solar Beaverton (2013). Beavorton Oregon: Solar Beavorton. Available from: ⟨http://www.beavertonoregon.gov/index.aspx?NID=412⟩ (accessed 19.12.13).
Solar Oregon (2013). Solar Oregon: Solar Communities. Available from: ⟨http://solaroregon.org/residential-solar/solarize-communities⟩ (accessed 30.11.13).
Stern, P.C., 1992. What psychology knows about energy conservation. Am. Psycho. 47 (10), 1224–1232.
Stern, P.C., 2000. Toward a coherent theory of environmentally significant behavior. J. Soc. Issues 56 (3), 407–424.
U.S. DOE, 2011. Solar in Action. San Antonio, TZ. Solar America Cities. Available from: ⟨www1.eere.energy.gov/solar/pdfs/51058_sanantonio.pdf⟩.
U.S. DOE, 2012. SunShot Vision Study. Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy, Washington, DC
VoteSolar, 2013. The Vote Solar Initiative: Who We Are. ⟨http://votesolar.org/who-we-are/⟩ (accessed 31.07.13).
Wilson, C., Dowlatabadi, H., 2007. Models of decision making and residential energy use. Annu. Rev. Environ. Resour. 32, 169–203.