Solar aspirations and disinclinations: learning from 3600 households

Mithra Moezzi (Portland State University)
Kim Wolske (University of Michigan)
Ben Sigrin (NREL)
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Ben

- SEEDS & project overview

Mithra

- Data collection

Kim

- Results: Theories of interest among non-adopters

Mithra

- Trajectories & comparisons: a non-modeling approach to adoption and non-adoption
Project overview

Three year study to understand drivers and barriers of consumer adoption of rooftop solar

Goals:

• Drive down customer acquisition costs
• Deepen understanding of technology diffusion

Key Activities:

• Surveys of 3,600 households: Adopters, Considerers, and General Population
• Agent-Based modeling
• Market pilots
Data Collection Overview

*Mithra Moezzi*

Pre-review results: do not quote or cite without permission
What we collected via on-line surveys

- Surveyed ~3,600 single-family owner-occupied households in AZ, CA, NJ, and NY
- 450+ variables
- Three surveys:
  - General Population Survey
  - Considerer Survey
  - Adopter Survey
- Statistical properties complex

In addition, installer interviews by phone
### Sampling details for three surveys, four states

#### Results Part I

<table>
<thead>
<tr>
<th>Survey</th>
<th>Recruitment Source</th>
<th>When Fielded</th>
<th>Response Rate Estimate</th>
<th>Responses Passing Data Quality Checks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General Population Survey</strong></td>
<td>Panelists</td>
<td>June/July 2014</td>
<td>N/A</td>
<td>AZ 351</td>
</tr>
<tr>
<td><strong>Considerers Survey</strong></td>
<td>Lead Generators, Installers</td>
<td>Dec 2014 to April 2015</td>
<td>1.4%</td>
<td>AZ 13</td>
</tr>
<tr>
<td></td>
<td>Panelists</td>
<td>March 2015</td>
<td>N/A</td>
<td>AZ 100</td>
</tr>
<tr>
<td><strong>Adopter Survey</strong></td>
<td>Installers</td>
<td>Dec 2014 to April 2015</td>
<td>8.5%</td>
<td>AZ 34</td>
</tr>
<tr>
<td></td>
<td>Panelists</td>
<td>March/April 2015</td>
<td>N/A</td>
<td>AZ 75</td>
</tr>
</tbody>
</table>

**Grand Total**: 573 | 1706 | 607 | 706 | Total 3592

* Slightly different treatment of GPS respondents in Part 1 vs. Part 2, and thus somewhat different cases used.
What predicts initial interest in solar?

Results from General Population Survey

Kim Wolske, PhD
kswols@umich.edu

Collaborators:
Paul Stern, National Academy of Sciences
Tom Dietz, Michigan State University
How can we lower the soft costs of generating new leads?
Some common assumptions...

People Go Solar...

For the Planet.   To Save Money.   Because it’s Cool.
Some common assumptions...

People Go Solar...

For the Planet.

To Save Money.

Because it’s Cool.

Value-Belief-Norm theory
(Stern et al, 1999)

Theory of Planned Behavior
(Ajzen, 1991)

Diffusion of Innovations
(Rogers 2003)
1,156 respondents with complete data
Examined two types of Interest in PV:

Social Curiosity

Interest in Talking to Installer
Analytic strategy

• How much do socio-demographics alone explain?

• 3 Path Analyses:
  o VBN variables, controlling for socio-demographics
  o TPB variables, controlling for socio-demographics
  o DOI variables, controlling for socio-demographics

• Final integrated model to understand relative importance of different variables
• Explain 11% of variance in Interest. Significant predictors:
  – Age: Younger individuals more interested
  – Gender: Males more interested
  – High summer bills
  – Lower household incomes
  – Have experienced more power outages

• Once we control for psychological variables, only age and gender remain significant
1) Solar as an eco-friendly behavior?

Value-Belief-Norm Model (Stern *et al.*, 1999)

VBN: People who have strong altruistic and environmental values, believe the environment is threatened, and that they can do something to help, will feel a moral obligation to take action, and are more likely to pursue PV.
1) Solar as an eco-friendly behavior?

Value-Belief-Norm Model (Stern et al., 1999)

VBN: People who have strong altruistic and environmental values, believe the environment is threatened, and that they can do something to help, will feel a moral obligation to take action, and are more likely to pursue PV.
1) Solar as an eco-friendly behavior?

Value-Belief-Norm Model (Stern *et al.*, 1999)

![Diagram showing the Value-Belief-Norm Model](image)

- **Values**
  - Altruism/Pro-environmental
  - Self-interest
  - Traditionalism
  - Openness to change

- **Awareness of Consequences**
  - .69***

- **Personal Norm**
  - .45***
  - .23***

- **Social Curiosity**
  - .24***

- **Interest**
  - .41***

- Household Constraints
  - (Significant paths not shown)

- $R^2 = .36$
- $R^2_{Adj} = .35$

VBN explains 11% of variance after controlling for household constraints (excluding SC)
2) Solar as a consumer good?

Theory of Planned Behavior (Ajzen, 1991)

TPB: People decide whether to engage in a behavior after rationally weighing the pros and cons, taking into account their beliefs and attitudes about solar, social expectations and whether they think they’re capable of getting PV.
2) Solar as a consumer good?

Theory of Planned Behavior (Ajzen, 1991)

- **Attitudes**
  - Personal Benefits
  - Environmental Benefits
  - Perceived Risks
  - Waiting for Improvements
  - Concerns about Costs

- **Social Pressure**
  - Normative beliefs

- **Ability to Adopt**
  - Unsuitable home
  - May move

- **Social Curiosity**

- **Interest**
2) Solar as a consumer good?

Theory of Planned Behavior (Ajzen, 1991)

- **Attitudes**
  - Personal Benefits
  - Environmental Benefits
  - Perceived Risks
  - Waiting for Improvements
  - Concerns about Costs

- **Social Pressure**
  - Normative beliefs

- **Ability to Adopt**
  - Unsuitable home
  - May move

**Social Curiosity**

- **Interest**

- **R² = .45**
- **R²_adj = .44**

TPB explains 27% of variance after controlling for household constraints (excluding SC).
3) Solar as an innovative technology?

Diffusion of Innovations (Rogers, 2003)

- Consumer Innovativeness
  - Novelty seeking
  - Independent decision-makers

- Characteristics of the Innovation
  - Advantageous/Beneficial
  - Low Perceived Risk
  - Can try out
  - See others have adopted

- Social Curiosity

- Talk to Installer

DOI describes the process by which new innovations are adopted. Innovative, novelty-seeking consumers are likely to adopt first. Adoption and diffusion occur more quickly when people hold favorable impressions of the innovation.
3) Solar as an innovative technology?

Diffusion of Innovations (Rogers, 2003)

Innovativeness

Characteristics of the Innovation

- Consumer Novelty Seeking
- Consumer Ind. Judg. Making
- Observability: Can see others have adopted

Advantageous/ Beneficial

- Trialability (Want to try out)
- PV seems risky

Social Curiosity

- Interest

Household Constraints

(Significant paths not shown)

$R^2 = .45$

$R^2_{Adj} = .44$

DOI explains 28% of variance after controlling for household constraints (excluding SC)
Evidence that people evaluate PV in multiple ways:

- Environmental benefit
- Consumer good
- Innovative technology

But, which matter most for generating leads?
Integrated model

VALUES
- Altruism
- Self-interest
- Traditionalism
- Openness to Change

PERSONAL DISPOSITIONS
Pro-environmental Norm
- Awareness of consequences
- Personal norm

Consumer Innovativeness
- CNS
- CIJM

EXTERNAL INFLUENCES
- Observability
- PV marketing
- Trust in PV industry
- Trust social network

Beliefs
- Personal benefits/Relative advantage
- Environ. benefits
- Riskiness
- Cost concerns
- PV may improve
- Trialability

Subjective Norms
- Social Support

Perceived Behavioral Control
- Unsuitable home
- Might move

Controlling for:
- Household Constraints
Strongest Predictors:
- Personal benefits ($\beta = .25$)
- Novelty Seeking ($\beta = .17$)
- Trust in PV Industry ($\beta = .15$)

Predictors in Green have strong indirect effects:
People with strong pro-environmental norms more likely to believe PV will benefit them personally
What this means for generating leads

**WHO** to target?
- Innovative consumers/early adopters of technology
- Environmentally conscious*
  *Show how PV aligns with values but also demonstrate personal benefits

**WHAT** messaging?
- Make the financial and personal benefits clear. Show how PV meets needs and addresses concerns.

**HOW?**
- Tap trusted social networks and information sources
- Carefully structure incentive programs/policies
Trajectories and comparisons: a non-modeling approach to adoption and non-adoption

3-survey analysis

Mithra Moezzi, PhD
mithra@pdx.edu

Collaborators:
  Aaron Ingle, Portland State University
  Loren Lutzenhiser, Portland State University

Pre-review results: do not quote or cite without permission
Revising storylines

Why not modeling?

Who is not interested?
Who considers and then stops and why?
Who buys and why?

What do PV adopters think about their experiences?
What do households think is missing?
What changes will help for the future?

Meshing industry, installer, and researcher intel
Solar status by survey type

- Haven’t thought about installing PV: 38%
- Have thought about installing, with no installer contact or near-term plans: 48%
- Haven’t talked to installer but have installer near-term plans: 5%
- 2% with near-term plans
- 8% without near-term plans
- Have already talked to installer (11%)
- Have talked to installer but not installed
- Have installed
- Considerer
- GPS

NATIONAL RENEWABLE ENERGY LABORATORY
What can we learn from early adopters? What cautions to bear in mind?

“If there is a dream solar technology it is probably photovoltaics” – *Science* 1977

- Still early
- Government support, heavy subsidies
- PV is a weird product
  - Electricity already works
  - Lots of future uncertainty
- First let’s look at the 98%-99%

Where are we?

Luc Gallopin, Creative Commons
(https://www.flickr.com/photos/lucgaloppin/4952178612)
### The disinterested, the unaware, the antagonistic, the enthusiastic and in between

<table>
<thead>
<tr>
<th>Choices</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not Thought</td>
<td>38%</td>
</tr>
<tr>
<td><em>Have not thought about solar for my home</em></td>
<td></td>
</tr>
<tr>
<td><strong>Not Interested/Antagonistic</strong></td>
<td>13%</td>
</tr>
<tr>
<td><em>Not at all interested in how solar could work for my home</em></td>
<td></td>
</tr>
<tr>
<td><strong>Unaware</strong></td>
<td>25%</td>
</tr>
<tr>
<td><em>Haven't noticed much if anything about solar</em></td>
<td></td>
</tr>
<tr>
<td><strong>Thought Not Bought</strong></td>
<td>61%</td>
</tr>
<tr>
<td><em>Have thought about solar for my home</em></td>
<td></td>
</tr>
<tr>
<td><strong>Interested</strong></td>
<td>31%</td>
</tr>
<tr>
<td><em>Interested in talking to installer or in local experience</em></td>
<td></td>
</tr>
<tr>
<td><strong>Very Interested at least conceptually</strong></td>
<td>16%</td>
</tr>
<tr>
<td><em>Very interested in how solar could work for my home</em></td>
<td></td>
</tr>
<tr>
<td><strong>Near Term Plans</strong></td>
<td>7%</td>
</tr>
<tr>
<td><em>Plan to talk to installer in next 6 months</em></td>
<td></td>
</tr>
<tr>
<td><strong>Talked</strong></td>
<td>11%</td>
</tr>
<tr>
<td><em>Already talked to installer...similar to Considerer</em></td>
<td></td>
</tr>
<tr>
<td><strong>Have Installed</strong></td>
<td>&lt;1%</td>
</tr>
</tbody>
</table>

*Some categories below overlap.**

**Nationally; much higher in some locales -- 6% in California.
Lots of reasons to not buy: Which are “correct”? Which can be overcome? And how?

<table>
<thead>
<tr>
<th>Concern</th>
<th>Not Thought</th>
<th>Thought not Bought</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not compelling financially</td>
<td>66%</td>
<td>59%</td>
</tr>
<tr>
<td>Can't afford</td>
<td>35%</td>
<td>27%</td>
</tr>
<tr>
<td>Not at all interested in savings from solar</td>
<td>27%</td>
<td>4%</td>
</tr>
<tr>
<td>Low bills (electricity under $100/mo. summer &amp; winter)</td>
<td>36%</td>
<td>24%</td>
</tr>
<tr>
<td>May not be in home long enough*</td>
<td>57%</td>
<td>45%</td>
</tr>
<tr>
<td>Age over 75</td>
<td>20%</td>
<td>13%</td>
</tr>
<tr>
<td>Perceive conditions to be unsuitable **</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>HOA disallows</td>
<td>open mention</td>
<td>open mention</td>
</tr>
<tr>
<td>Perceive as hassle to install</td>
<td>32%</td>
<td>30%</td>
</tr>
</tbody>
</table>

**Average tenure in US: 13 years

** In New Jersey in particular, people mentioned the need to deal with trees on/around the property as adding expense or reducing appeal.

<table>
<thead>
<tr>
<th>Concern</th>
<th>Not Thought</th>
<th>Thought not Bought</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low trust in information sources**</td>
<td>49%</td>
<td>28%</td>
</tr>
<tr>
<td>Concerned with maintenance</td>
<td>19%</td>
<td>18%</td>
</tr>
<tr>
<td>Concerned with damage to roof</td>
<td>16%</td>
<td>15%</td>
</tr>
<tr>
<td>Mistrust technology</td>
<td>57%</td>
<td>47%</td>
</tr>
<tr>
<td>Perceive solar as risky</td>
<td>34%</td>
<td>31%</td>
</tr>
<tr>
<td>Not aligned w/ enviro, climate change causes</td>
<td>16%</td>
<td>7%</td>
</tr>
<tr>
<td>Embarrassed by visuals</td>
<td>9%</td>
<td>5%</td>
</tr>
<tr>
<td>Family/friends would not support</td>
<td>15%</td>
<td>8%</td>
</tr>
<tr>
<td>Think it's better to wait</td>
<td>41%</td>
<td>43%</td>
</tr>
</tbody>
</table>

***Most trusted friends and neighbors -- but universities, government, installers, trade organizations, utilities, environmental organizations, and online reviews: much less
What considerers say

"difficult to determine best route"

"the market is very confusing"

"all offers were more expensive than our monthly bill"

"you need to pay first and the wait for the incentives."

"there are no incentives for seniors, who can’t access the tax credits"

"I get 4-7 calls a week from solar companies, and I'm tired of it."

复杂决策

财务品质不与所有人匹配

烦恼
## Concerns and difficulties: what stops households when considering solar?

<table>
<thead>
<tr>
<th>How concerned were you about...?</th>
<th>Considerers (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>None or A Little</td>
</tr>
<tr>
<td>Affordability</td>
<td>19</td>
</tr>
<tr>
<td>Whether panels offered enough bang for buck</td>
<td>17</td>
</tr>
<tr>
<td>Equipment quality and reliability over time</td>
<td>16</td>
</tr>
<tr>
<td>Whether solar was a good financial decision</td>
<td>18</td>
</tr>
<tr>
<td>Taking on debt or signing a lease</td>
<td>25</td>
</tr>
<tr>
<td>Having to perform regular maintenance</td>
<td>25</td>
</tr>
<tr>
<td>Risk of damaging your roof</td>
<td>30</td>
</tr>
<tr>
<td>Might detract from home’s “curb appeal”</td>
<td>49</td>
</tr>
<tr>
<td>Might be harder to sell home with solar panels</td>
<td>54</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How much difficulty did you have with ...?</th>
<th>None or A Little</th>
<th>Stopped</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coming up with the money to get solar</td>
<td>35</td>
<td>55</td>
</tr>
<tr>
<td>Finding a trustworthy and competent installer</td>
<td>36</td>
<td>37</td>
</tr>
<tr>
<td>Suitability of your home site</td>
<td>43</td>
<td>36</td>
</tr>
<tr>
<td>Finding installer who would agree to do the work</td>
<td>58</td>
<td>26</td>
</tr>
<tr>
<td>Permitting, zoning, or neighborhood restrictions</td>
<td>58</td>
<td>22</td>
</tr>
<tr>
<td>Not everyone in your household being convinced</td>
<td>62</td>
<td>28</td>
</tr>
</tbody>
</table>

- Money stops more than half
- Only three difficulties & one concern that less than half say they experienced at least “some”
What are adopters like? State level ranges:

**Electricity Bills often high**
- 31%-43% with summer or winter bills > $275/mo. (vs. 18% GPS)
- 12%-21% with summer & winter bills < $100/mo. (vs. 29% GPS)

**Income often high**
- Except AZ, ~25% have income > $150K/year (vs. 12% GPS)

**Less female**
- Except AZ, 33%-36% female (vs. 60% GPS)

**Also**
- Lots of pools
- Lots of AC
- Over 40 (~80%)
- Often retired (33%+)
Decision pathways

Deliberative

Events

Opportunistic
Adopter types (but “money” is complex)

- 3-5% Environment Primarily
- 33% Environment + Money
- 39% Both, but Money over Environment
- 6% Money and not Environment
- Opportunistic
Adopter motives for considering solar: money, environment, technology, leadership ...

<table>
<thead>
<tr>
<th>Motive</th>
<th>“Extremely Important”</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lowering your total electricity costs</td>
<td>78%</td>
</tr>
<tr>
<td>Getting a good return on investment</td>
<td>33%</td>
</tr>
<tr>
<td>Adding to your home's market value</td>
<td>23%</td>
</tr>
<tr>
<td>Protection from rising electricity prices in the future</td>
<td>62%</td>
</tr>
<tr>
<td>Being able to use renewable energy</td>
<td>#3 50%</td>
</tr>
<tr>
<td>Being able to use a promising new technology</td>
<td>30%</td>
</tr>
<tr>
<td>Reducing your environmental impact</td>
<td>#4 43%</td>
</tr>
<tr>
<td>Setting a positive example for others in your community</td>
<td>26%</td>
</tr>
</tbody>
</table>
What prompted you to look into solar? What adopters say:

<table>
<thead>
<tr>
<th>Prompt</th>
<th>% of Adopters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy use/costs</strong></td>
<td></td>
</tr>
<tr>
<td>Looking for ways to reduce energy bills</td>
<td>88</td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td></td>
</tr>
<tr>
<td>Someone you know talked about it</td>
<td>32</td>
</tr>
<tr>
<td>Saw advertising or news article</td>
<td>22</td>
</tr>
<tr>
<td>Saw solar being installed on a home</td>
<td>21</td>
</tr>
<tr>
<td><strong>Approached</strong></td>
<td></td>
</tr>
<tr>
<td>Offered at a retail store, show, or event</td>
<td>7</td>
</tr>
<tr>
<td>Approached by an installer</td>
<td>54</td>
</tr>
<tr>
<td><strong>News about affordability</strong></td>
<td></td>
</tr>
<tr>
<td>Heard it was more affordable</td>
<td>63</td>
</tr>
<tr>
<td>Heard about low money down options</td>
<td>23</td>
</tr>
<tr>
<td><strong>Planning, events</strong></td>
<td></td>
</tr>
<tr>
<td>Planning for retirement</td>
<td>10</td>
</tr>
<tr>
<td>Came in to some money</td>
<td>2</td>
</tr>
<tr>
<td>Had group purchase opportunity</td>
<td>1</td>
</tr>
<tr>
<td><strong>Home changes</strong></td>
<td></td>
</tr>
<tr>
<td>Considering a major new energy use</td>
<td>6</td>
</tr>
<tr>
<td>Planning/doing other work on home</td>
<td>5</td>
</tr>
<tr>
<td>Bought a home/moved</td>
<td>4</td>
</tr>
</tbody>
</table>
## Environment vs. bills: comparing adopters to disinterested

<table>
<thead>
<tr>
<th></th>
<th>Low Environmental</th>
<th>High Environmental</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low Bills</strong>&lt;br&gt;Average &lt; $100/month</td>
<td>2% 5x more common among disinterested</td>
<td>10% Just as common among disinterested</td>
</tr>
<tr>
<td><strong>High Bills</strong>&lt;br&gt;Average &gt; $275/month</td>
<td>13% 1/6th as common among disinterested</td>
<td>46% 1/12 as common among disinterested</td>
</tr>
</tbody>
</table>

*Only respondents with strong opinions included (cells don’t add to 100%).*
Most adopters (especially buyers) happy so far. Some are in disbelief that it worked out so well.

With the state payment, federal tax credit, and loan...this was a no-brainer. It took me two months to believe it.”

I can’t understand why everybody doesn’t do it.

I tell other people that my panels were free, but nobody believes it.

Until we were contacted by our installers, everything we heard about solar was negative. But our experience has been great!

* 14% of leasers, 9% of buyers stated they had regrets
Adopters didn’t always know what they were getting into. Those paying no up-front costs might have researched less.

Very hard to figure out all the options.

I thought our PV system would provide us with power during an outage, but it didn’t help. We had no power during Sandy.

Installation was free. But with higher costs of electricity, my costs are twice what I expected. I am not some stupid environmentalist.

Overall I think the solar companies are dishonest, opportunistic, and unethical.

The true-up bill was a shocker. I want other people to know about this.

It’s been four months. I haven’t saved any money.
Varied triggers, interpretations of what solar is for

The only reason we installed was that it didn’t cost us anything.

It was the swimming pool pump that got me to install solar. We live in a very mild climate and don’t use heating or cooling.

Many of your questions had nothing to do with solar... global climate change, etc.

My decision to go solar was based on a couple of huge utility bills that were never explained.
Pre-post reported savings (see cautions!*)

Some savings (& non-savings) outside “pre-post”

People with low bills can’t (and don’t) save that much

*Cautions: pre-post differences for self-reported monthly bills, no annual-true up, early results for many adopters, etc.
How did solar come to be about money?
What else could be going on?
“We wanted to help the environment while maintaining our lifestyle”
Adopters summary

- On surface, top interest is saving money...but more is going on
- Who buys solar depends on who it is sold to & how
- For deliberators, personal benefits calculation is not easy
- Uncertainties difficult to overcome
- Some wanted better information & couldn’t find it
- Environment matters to most, but may be a vague notion
- Environmental politics can be negative hot-button
- Opportunism may be a big deal
- When it’s free, people may be less careful
- Some didn’t really know what they are getting into
- Little post-installation investigation on experiences, changes
- Most people are happy enough
- It’s still early days, market, conditions, incentives change
Non-adopters summary

• Modest majority say they’ve thought about getting solar
  o Most are “waiting” vs. actively seeking
  o Knowledge pretty low
  o Environmentally, “Thought-not-Bought” are similar to Adopters – except for “personal obligation” responses
  o Detailed circumstances matter
• Almost 4 in 10 say they haven’t thought about solar
  o Some unaware; some don’t like it or don’t think it fits
  o These “Not Thought” are different
• Middle-income and moderate users may have less to gain under current conditions
Questions & recommendations

• Should solar remain “being about money”?  
• What happens after installation? How do people change how they think about energy, and how (& how much) they use?  
• “If only I had known” ... “it’s very confusing” ... How can information quality be improved?  
• How do people know who to trust? Balanced info?  
• What technical or marketing changes might help unlock under-attended niches?  
• What happens when current incentives go away? How does this sync with moderate income, moderate usage?
Thank You

• Questions

• Thank you for attending the SEEDS Webinar Series

• For more information:

  Benjamin.Sigrin@NREL.gov
  http://www.nrel.gov/seeds
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