Decision-Making and Behavior Change in Residential Adopters of Solar PV

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The Project

Decision-Making and Behavior Change in PV Adopters

• **Influence of contextual and attitudinal factors**
  – Impact of electricity rates, incentives, and socio-demographics (income, home value, environmental beliefs, etc.)

• **Uncertainties and non-monetary costs, and information networks**
  – Individual discount rates
  – Information networks

• **Post-installation experience**
  – Awareness of electricity use
  – Behavior change
    • Rebound or Ripple
    • Load-shifting
Main Lines of Inquiry

• Financial aspects

• Sources of information

• Post-installation experience

• Buy vs lease
  - Cross-cutting evaluation of differences between buyers and leasers across the three dimensions above: finances; information; post-installation experience

• Zip-code level modeling of diffusion drivers and adoption curves
  - Econometric modeling
  - S-curve parametric modeling
  - Agent-based simulation and modeling
Data

• Program data collected by utilities

• Survey of PV owners
  – Completed in Texas during Aug-Nov 2011
    • 365 completed responses, covering installations between 2004-2011
    • ~20% of the target population (existing rooftop PV owners). >30% response

• Data collected on
  – System details
  – Decision-making process
  – Financial aspects
  – Sources of information
  – Post-installation experience
  – Environmental attitude
  – Demographics
Basic Demographics

Compared to the average population, PV adopters earn more, are more educated, and are older

• Median 2011 household income of sample is between $85k-$115k
  – Median 2009 household income in Texas was $48,286 (Census 2010)

• Over 80% of the PV adopter sample has at least a bachelor’s degree
  – 25.4% of Texas residents have a bachelor’s or higher degree (Census 2010)

• Mean age of sample is 52 years (s.d. 11.4 years)
  – Median age of Texas residents in 2010 was 33.6 years (Census 2010)
# Motivation to Install PV

All Responders

<table>
<thead>
<tr>
<th></th>
<th>General interest</th>
<th>Financial investment</th>
<th>Environmental impact</th>
<th>Influence of neighbors</th>
<th>Influence of acquaintance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not important at all</td>
<td>3.57%</td>
<td>4.35%</td>
<td>5.90%</td>
<td>72.05%</td>
<td>79.69%</td>
</tr>
<tr>
<td>Somewhat important</td>
<td>7.40%</td>
<td>6.91%</td>
<td>10.00%</td>
<td>11.79%</td>
<td>4.88%</td>
</tr>
<tr>
<td>Moderately important</td>
<td>17.35%</td>
<td>17.14%</td>
<td>14.62%</td>
<td>8.97%</td>
<td>8.23%</td>
</tr>
<tr>
<td>Very important</td>
<td>34.44%</td>
<td>33.25%</td>
<td>22.82%</td>
<td>5.90%</td>
<td>4.88%</td>
</tr>
<tr>
<td>Extremely important</td>
<td>37.24%</td>
<td>38.36%</td>
<td>46.67%</td>
<td>1.28%</td>
<td>2.31%</td>
</tr>
</tbody>
</table>

Total 100.00% 100.00% 100.00% 100.00% 100.00%

PV adopters pay close attention to financial/investment aspects of PV
Financial Attractiveness Post-Installation

- At the time of installation
  - 68% report that they thought investment was financially attractive
  - 14% report they thought that the investment was not attractive

![Financial Attractiveness Rating Chart]

All Responders: Financial Attractiveness of PV System
Information Overload

• Relatively easy to find information on solar PV

• But it takes considerable amount of time and effort

• Trustworthiness of information the main reason for extra time and effort
  - Centralized info by a trusted “3rd party” (Government-University?)
Owners Who Contact Others Report Positive Experience and Valuable Information

Respondents Who Talked to Other Owners, Talking Was Useful
Value of Information and Contacts More Important for Buyers Than Leasers

<table>
<thead>
<tr>
<th>Talking to Other Owners is Unnecessary</th>
<th>Bought</th>
<th>Leased</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Percent</td>
</tr>
<tr>
<td>Agree and Strongly Agree</td>
<td>98</td>
<td>50.78%</td>
</tr>
<tr>
<td>Disagree and Strongly Disagree</td>
<td>95</td>
<td>49.22%</td>
</tr>
<tr>
<td>Total</td>
<td>193</td>
<td>100.00%</td>
</tr>
</tbody>
</table>

- Research effort: Lower for leasing
- Consideration time: Lower for leasing by 2-3 months
- The leasing model makes information gathering redundant along several dimensions, especially on performance and O&M
Role of Peer Effects

- **Contact in neighborhood** most effective in reducing decision time and effort

- Those who contacted other PV owners in their neighborhood took about 4 months less in arriving at the decision to install PV

Graphics borrowed from Charles Macal
# Financial Metrics

## Help With Financial Calculations

<table>
<thead>
<tr>
<th>All Responders</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neighbor</td>
<td>10</td>
<td>2.72%</td>
</tr>
<tr>
<td>Family</td>
<td>10</td>
<td>2.72%</td>
</tr>
<tr>
<td>Contractor</td>
<td>164</td>
<td>44.69%</td>
</tr>
<tr>
<td>Online</td>
<td>26</td>
<td>7.08%</td>
</tr>
<tr>
<td>Utility</td>
<td>17</td>
<td>4.63%</td>
</tr>
<tr>
<td>Non-profit</td>
<td>7</td>
<td>1.91%</td>
</tr>
<tr>
<td>Myself</td>
<td>212</td>
<td>57.77%</td>
</tr>
<tr>
<td>No Calculations</td>
<td>27</td>
<td>7.36%</td>
</tr>
<tr>
<td>Number of Responders</td>
<td>367</td>
<td></td>
</tr>
</tbody>
</table>

## Reported Payback Period

<table>
<thead>
<tr>
<th>Payback Period in Years</th>
<th>All Others</th>
<th>Austin Energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>5-7</td>
<td>40</td>
<td>32</td>
</tr>
<tr>
<td>8-10</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>11-13</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>14-16</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>17-19</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>More than 19</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

## All Responders

<table>
<thead>
<tr>
<th>All Responders</th>
<th>Number</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV</td>
<td>37</td>
<td>11.78%</td>
</tr>
<tr>
<td>IRR</td>
<td>113</td>
<td>35.99%</td>
</tr>
<tr>
<td>Payback Period</td>
<td>274</td>
<td>87.26%</td>
</tr>
<tr>
<td>None</td>
<td>23</td>
<td>7.32%</td>
</tr>
<tr>
<td>Number of Responders</td>
<td>314</td>
<td></td>
</tr>
</tbody>
</table>
Example Electricity Profile for 12,000 kWh/yr  
[4 kW system in August]

\[
R_k = \sum_{j}^{12} \sum_{i}^{24} f_{BAU}(c_{ijk}) - f_{PV}(c_{ijk} - g_{ijk})
\]

Electricity Used (kWh/hr/month)
Expectations of System Payback: Baseline Scenario
Comparison of Modeled and Consumer-Predicted Payback Period

Model Calculated Payback Period (years) vs. Consumer’s Reported Payback Period (years)

- Too Optimistic
- Too Pessimistic

Dots for Bought, Triangles for Leased
Scenario 5 (Very Optimistic): Comparison of Modeled and Consumer-Predicted Payback Period

Model Calculated Payback Period (years)

Consumer-Predicted Payback Period (years)

Too Optimistic

Too Pessimistic

Bought ▲ Leased
Leasers and Buyers Report Similar Implied NPVs

Distribution of Implied NPV/kW

Percentage of Sample

Implied NPV/kW

$0/kW  $200/kW  $400/kW  $600/kW  $800/kW  $1000/kW  $1200/kW  $1400/kW  $1600/kW

Buy  Lease
Reported Behavior Change: Energy Conservation

“I am much, much, much, much, more aware of how much energy I use each month.”

“I try to "leverage" the array's input in relation to total electrical consumption so my array will provide 25% of all our power needs.”
Perception of Decrease in Electricity Consumption Appears to be Random
Load-Shifting into Peak Hours

“I am more apt to use power-consuming appliances (washer/drier, etc) when the sun is up, to take advantage of the cost offset.”

![Load-Shifting Behavior Chart]

- Laundry: 27
- Dishwasher: 24
- AC: 14
- Vacuuming: 6
- No change: 60

Percent

Activity
Key Takeaways

• Effective information channels
  - Centralized clearinghouse for information by a “trusted 3rd party”
  - Neighborhood contacts

• Buy vs. lease
  - Buyers more optimistic (lower discount rate) than leasers
  - Leasing option increases the pool of potential adopters

• Post-installation experience
  - High level of satisfaction with decision to install
  - Increased awareness
  - Some evidence of load-shifting into peak hours