Selling Into The Sun:
Price Premium Analysis of a Multi-State Dataset of Solar Homes

Report Summary

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LBNL
Jan 22, 2014

This work was supported by the Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Office) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231
Questions

• Because of the large number of registrants for today’s webinar, questions will be handled via the chat window after the presentation is complete.
• They will be answered in the order they are received.
• If there is not time to answer all of the questions during the 1-hour webinar, they will be answered via email.
Agenda

- Background
- Research Questions
- Methodology
- Data
- Results
- Conclusions, Next Steps & Outreach
- Other PV Real Estate News
## Previous Literature

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year</th>
<th>Location</th>
<th>PV Sample Size</th>
<th>Sample Period</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farhar &amp; Coburn</td>
<td>2008</td>
<td>San Diego, CA</td>
<td>15</td>
<td>2001-2005</td>
<td>Comparison of Means</td>
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<tr>
<td>Watkins</td>
<td>2011</td>
<td>Multi-Cities, OR</td>
<td>23</td>
<td>2005-2010</td>
<td>Appraisals</td>
</tr>
<tr>
<td>Hoen, Wiser et al.</td>
<td>2011</td>
<td>Multi-Cities, CA</td>
<td>1,894</td>
<td>2000-2009</td>
<td>Hedonic Model</td>
</tr>
<tr>
<td>Dasturp et al.</td>
<td>2012</td>
<td>San Diego &amp; Sacramento, CA</td>
<td>329</td>
<td>1997-2010</td>
<td>Hedonic Model</td>
</tr>
<tr>
<td>Desmarais</td>
<td>2013</td>
<td>Denver, CO</td>
<td>30</td>
<td>2011-2013</td>
<td>Appraisals</td>
</tr>
</tbody>
</table>

Previous literature is fairly thin, focused on California mostly, some small samples, and rarely includes the most recent period.
Literature Limitations

A number of areas have not been well covered in the nascent literature:

- Statistical measurement of premiums outside CA
- Premiums over time: e.g., pre & post-housing bubble
- New vs. existing home premiums
- PV system depreciation as they age
- Premiums vs. income and cost appraisal methods
- “Green cachet”: marginal effects for larger systems
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Research Questions That An Analysis Of Broader Dataset Of PV Homes Could Answer

1. Are PV home premiums evident for a broader group of PV homes than has been studied previously both inside and outside of California and through 2013?

2. Are PV home premiums outside of California similar to those within California?

3. How do PV home premiums compare to contributory values estimated using cost and income methods?

4. How did the size of the premium change over the study period, as gross PV system prices decreased and during housing market swings?

5. Are premiums for new PV homes similar to existing PV home premiums?

6. Is there evidence of a “green cachet” for PV homes above the amount paid for each additional watt added?

7. How does the age of the PV system influence the size of the PV premium?
Selling Into The Sun: Price Premium Analysis of a Multi-State Dataset of Solar Homes

**Purpose**
Using actual sales prices, provide broadly applicable statistical evidence as to whether, and to what degree, host-owned PV systems increase the value of residential properties in multiple geographic markets in the U.S.

**Relevance**
Provide solar stakeholders, especially those focused on valuation of PV containing properties, broad-based statistically defensible information about existence and magnitude of possible premiums for these properties.

**Research Team**
Led by LBNL, the team includes academic and appraising/valuation experts, including those professionally familiar with the valuation of PV properties.

**Timeline**
# Selling Into The Sun:
Price Premium Analysis of a Multi-State Dataset of Solar Homes

<table>
<thead>
<tr>
<th>Research Team</th>
<th>Affiliation</th>
<th>Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ben Hoen</td>
<td>Lawrence Berkeley National Laboratory</td>
<td>Project Lead</td>
</tr>
<tr>
<td>Sandra Adomatis</td>
<td>Adomatis Appraisal Services</td>
<td>Appraising, Green Attribute Valuation</td>
</tr>
<tr>
<td>Tom Jackson</td>
<td>Texas A&amp;M, Real Property Analytics</td>
<td>Appraising, Hedonic Models</td>
</tr>
<tr>
<td>Joshua Graff-Zivin</td>
<td>University of California at San Diego</td>
<td>Econometric Modelling, Stata</td>
</tr>
<tr>
<td>Mark Thayer</td>
<td>San Diego State University</td>
<td>Econometric Modelling</td>
</tr>
<tr>
<td>Geoffrey Klise</td>
<td>Sandia National Laboratory</td>
<td>PV Value Co-Creator, PV Property Valuation</td>
</tr>
<tr>
<td>Ryan Wiser</td>
<td>Lawrence Berkeley National Laboratory</td>
<td>Renewable Energy Policy, Modelling</td>
</tr>
</tbody>
</table>
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How Does One Accurately Measure The Treatment Effect Of Having PV On Homes?

PV and Non-PV Homes can differ by:
Location, Size, Age, Condition, Parcel Size, Etc.
These Differences Can Be Estimated (i.e., Controlled For) Via A Hedonic Model

\[ P = f (L, N, T, PV) \]

Where:

\[ P \] = Sale Price
\[ L \] = Home/Parcel Specific Variables
\[ N \] = Neighborhood Variables
\[ T \] = Time: Market Inflation and Deflation
\[ PV \] = If the Home Has PV or Not
Hedonic Models Can Be Estimated To Test A Variety Of Research Questions

- Overall PV home premium (in $/watts)
- Premium * CA/Rest of US
- Premium * New/Existing
- Premium * Age of the PV System
- Premium * Year of the Sale
- Premium in $/Watts and $/Watts\(^2\)
Data “Matching” Is Used To Ensure PV Homes Are Otherwise “Similar” To Non-PV Homes

Each PV home is “Matched” to non-PV homes via:

- Same block group (“location”)
- Same sale year (“time”)
- Similar Size, Age and Parcel Size (“type of home”)
- Similar ratios of assessed value of land to total assessed value ("within neighborhood location")

This helps control for correlated omitted variables
We Compare Premiums To Income & Cost Estimates To Better Understand “Market Value”

Hedonic Model Premiums

a.k.a. sales comparison approach

Vs.

Income Approach

&

Cost Approach

Income Approach using PV Value®:
Present value of stream of energy cost savings

Cost Approach:
Installed costs of PV systems at time of sale: “Gross” or “Net” (less federal, state and utility incentives)
Robustness Models Can Be Used To Examine If Results Are Robust To Sample And/Or Model Specification

**PV Only Model:**
PV Homes are compared to other PV homes

**Repeat Model:**
Selling prices of the same home are compared, once before and once after PV is installed.
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Largest Dataset Assembled To Date - Spans 12 Years Through 2013 And Across 8 States

<table>
<thead>
<tr>
<th>Sale Year</th>
<th>Non-PV Homes</th>
<th>PV Homes</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>107</td>
<td>18</td>
<td>125</td>
</tr>
<tr>
<td>2003</td>
<td>196</td>
<td>31</td>
<td>227</td>
</tr>
<tr>
<td>2004</td>
<td>238</td>
<td>53</td>
<td>291</td>
</tr>
<tr>
<td>2005</td>
<td>197</td>
<td>56</td>
<td>253</td>
</tr>
<tr>
<td>2006</td>
<td>348</td>
<td>64</td>
<td>412</td>
</tr>
<tr>
<td>2007</td>
<td>818</td>
<td>242</td>
<td>1,060</td>
</tr>
<tr>
<td>2008</td>
<td>1,251</td>
<td>453</td>
<td>1,704</td>
</tr>
<tr>
<td>2009</td>
<td>1,762</td>
<td>429</td>
<td>2,191</td>
</tr>
<tr>
<td>2010</td>
<td>2,751</td>
<td>504</td>
<td>3,255</td>
</tr>
<tr>
<td>2011</td>
<td>3,341</td>
<td>642</td>
<td>3,983</td>
</tr>
<tr>
<td>2012</td>
<td>3,928</td>
<td>694</td>
<td>4,622</td>
</tr>
<tr>
<td>2013</td>
<td>3,934</td>
<td>765</td>
<td>4,699</td>
</tr>
<tr>
<td>Total</td>
<td>18,871</td>
<td>3,951</td>
<td>22,822</td>
</tr>
</tbody>
</table>

Total 22,822 Homes
- 3,951 PV
- 18,871 Non-PV

Note: Each PV sale has at least one “matching” non-PV sale in the same census block group and year
Selling Prices Range From $165K to Almost $900K With A Mean Of $460K

<table>
<thead>
<tr>
<th>variable</th>
<th>description</th>
<th>N</th>
<th>mean</th>
<th>sd</th>
<th>min</th>
<th>median</th>
<th>max</th>
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<tbody>
<tr>
<td>sy</td>
<td>year of sale</td>
<td>22822</td>
<td>2010</td>
<td>2</td>
<td>2002</td>
<td>2011</td>
<td>2013</td>
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<tr>
<td>syq</td>
<td>year and quarter of sale (yyyyq)</td>
<td>22822</td>
<td>20103</td>
<td>23</td>
<td>20021</td>
<td>20112</td>
<td>20134</td>
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<tr>
<td>sp</td>
<td>price of sale (dollars)</td>
<td>22822</td>
<td>$459,319</td>
<td>$197,009</td>
<td>$165,500</td>
<td>$416,500</td>
<td>$899,500</td>
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<tr>
<td>lnsp</td>
<td>natural log of sale price</td>
<td>22822</td>
<td>12.94</td>
<td>0.44</td>
<td>12.02</td>
<td>12.94</td>
<td>13.71</td>
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<tr>
<td>sfla</td>
<td>living area (square feet)</td>
<td>22822</td>
<td>2,321</td>
<td>712</td>
<td>1,001</td>
<td>2,208</td>
<td>4,990</td>
</tr>
<tr>
<td>sfla1000</td>
<td>living area (in 1000s of square feet)</td>
<td>22822</td>
<td>2.3</td>
<td>0.7</td>
<td>1.0</td>
<td>2.2</td>
<td>5.0</td>
</tr>
<tr>
<td>acres</td>
<td>size of parcel (in acres)</td>
<td>22822</td>
<td>0.42</td>
<td>0.88</td>
<td>0.05</td>
<td>0.18</td>
<td>9.99</td>
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<tr>
<td>age</td>
<td>age of the home at time of sale (years)</td>
<td>22822</td>
<td>17</td>
<td>21</td>
<td>(2)</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>agesq1000</td>
<td>age of the home squared (in 1000s of years)</td>
<td>22822</td>
<td>0.7</td>
<td>1.3</td>
<td>0</td>
<td>0.1</td>
<td>10.0</td>
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<tr>
<td>pv</td>
<td>if the home has a PV system (1 if yes)</td>
<td>22822</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>1</td>
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<tr>
<td>size</td>
<td>size of the PV system (kilowatts)</td>
<td>3951</td>
<td>3.6</td>
<td>2.0</td>
<td>0.1</td>
<td>2.8</td>
<td>14.9</td>
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<tr>
<td>pamage</td>
<td>age of the PV system at time of sale (years)</td>
<td>3951</td>
<td>2.7</td>
<td>2.9</td>
<td>(0.5)</td>
<td>2.2</td>
<td>13.4</td>
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<tr>
<td>income</td>
<td>average PV Value estimate ($/watt)</td>
<td>3951</td>
<td>$2.93</td>
<td>$0.57</td>
<td>$1.18</td>
<td>$2.92</td>
<td>$4.98</td>
</tr>
<tr>
<td>netcost</td>
<td>net cost estimate ($/watt)</td>
<td>3951</td>
<td>$4.14</td>
<td>$0.93</td>
<td>$1.07</td>
<td>$4.04</td>
<td>$7.95</td>
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<tr>
<td>grosscost</td>
<td>gross cost estimate ($/watt)</td>
<td>3951</td>
<td>$6.90</td>
<td>$1.50</td>
<td>$3.15</td>
<td>$6.92</td>
<td>$11.83</td>
</tr>
</tbody>
</table>

And PV System Size and Age cover a wide range, as do the income, “gross” cost and “net” cost estimates
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Overall Models Performed Very Well

22,822 Cases: 18,871 Non-PV, 3,951 PV

Extremely High $R^2$ and Adjusted $R^2$

Highly Statistically Significant and Appropriately Leveled And Signed Controlling Home and Site Characteristics

Highly Statistically Significant and Appropriately Leveled And Signed Inflation/Deflation Variables
Size Of PV System Is Strongly Related To Price of Home

Highly Statistically Significant Effect

Effect Represents:
A 0.92% increase in value for each kW installed on a PV home, over the average price of a non-PV home

Equates To:
$4.18/watt increase over the average non-PV home value of $456,378

Equates To A Range Between: $3.56/watt and $4.80/watt
PV Only And Repeat Robustness Models Conform With Base Hedonic Results

Although Repeat Model results are not statistically significant, they equate to a similar $/watt premium.
Premium Is Not Statistically Different From Net Cost Estimate

And is lower than the Gross Cost and higher than the Income estimates

If the Income estimate uses a weighted electricity rate, to account for California tiered rates, it falls in-line with the Premium.
We Find Similar Relationships In California And In The Rest Of The US

![Graph showing PV Premium, PV Value - Income, Net Cost, and Gross Cost for All Homes, California, and Rest of US. The error bars represent 95% confidence intervals.](image-url)
And because new home builders cannot claim the Federal ITC, the “builder’s Net Cost” would be higher, implying, potentially, some discounting of PV systems by builders.
Over The Sample Period, Premiums Are Stable and Highly Correlated With Net Cost

Error bars represent 95% confidence intervals

Premiums seem to be independent of Gross Cost estimates
There is a clear decrease in price for older systems. There is less clarity as systems age into their second decade.

The graph shows the following:

- **$ Per Watt (DC) Installed of PV**
- **Age of PV System Quartiles (Years)**
  - 0.5-2.4 years ($\chi = 1.6$ yrs)
  - 2.4-3.8 years ($\chi = 3.1$ yrs)
  - 3.8-5.9 years ($\chi = 4.8$ yrs)
  - 5.9-14 years ($\chi = 7.8$ yrs)

The error bars represent 95% confidence intervals.

Key lines:
- **PV Premium ($/watt)**
- **PV Value - Income ($/watt)**
- **Net Cost ($/watt)**
- **Gross Cost ($/watt)**
Highest Marginal $/Watt Premiums Exist For Smallest Systems

This might indicate a “green cache” is present for all systems with an additional premiums for each kW added.
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Conclusions

• PV consistently adds value ~ $4/watt in our sample
• Clear premiums both in/outside CA and thru 2013
• “Net” cost estimates are better proxy than “gross”
• Income estimates should account for tiered rates
• New and existing homes have similar premiums
• Some evidence of new-home builder discounting of PV systems
• PV systems significantly depreciate as they age
• Unclear how value holds up in second decade
• Larger PV systems receive incrementally less of a premium - “green cachet” might exist
Next Steps & Outreach

• Submit paper to journal in spring 2015

• Conferences/Webinars:
  – NAHB in January, 2015
  – PV America in March, 2014
  – Appraisal Institute Webinar: Late Spring 2015
  – SPI in June, 2015?
  – Greenbuild in November 2015?

• Other outreach ideas?
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AI Residential Green & E.E. Addendum

- Appraisers
- Builders
- Real Estate Agents
- Energy Raters
- Sellers

The direct link for the fillable PDF “AI Residential Green and Energy Efficient Addendum” is http://www.appraisalinstitute.org/assets/1/7/Interactive820.04-ResidentialGreenandEnergyEffecientAddendum.pdf
NAR Helped Develop And Promote MLS Fields To Capture Green Features

www.realtor.org
“Fannie Mae will purchase or securitize a mortgage loan on a property with solar panels.”

“If the property owner is the owner of the solar panels, standard eligibility requirements apply (for example, appraisal, insurance, and title).”

“If the solar panels are leased...The solar panels may not be included in the appraised value of the property.”
HUD’s FHA Has Also Recognized Solar’s Value (In Their Draft Handbook – To Be Released In Early 2015)

Solar Energy Systems

“A mortgagee may add the cost of a solar energy system to the mortgage up to 20 percent above than the maximum insurable mortgage limit.”

“Costs for new solar systems may be added to an FHA-insured base mortgage, for the following Sections of the Act and transaction types:

• Section 203(b)
• Purchase Transaction
• Rate and Term Refinances and Simple Refinance”
Thank You

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This work was supported by the Office of Energy Efficiency and Renewable Energy (Solar Energy Technologies Office) of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231