Center for Sustainable Energy CALIFORNIA

Third-Party Owned PV system diffusion in San Diego County

Ria Langheim, Research Analyst

July 17, 2014
Esri International User Conference, San Diego

Center for Sustainable Energy CALIFORNIA

SEEDS Research Collaboration

Solar **E**nergy **E**volution and **D**iffusion **S**tudies (SEEDS)

1 of the Key research questions :

What are the most important variables in predicting an individual's decision to purchase or lease solar PV?

SunShot U.S. Department of Energy

Sandia National Laboratories

NREL National Renewable Energy Laboratory

Wharton University of Pennsylvania

Vanderbilt

www.energycenter.org

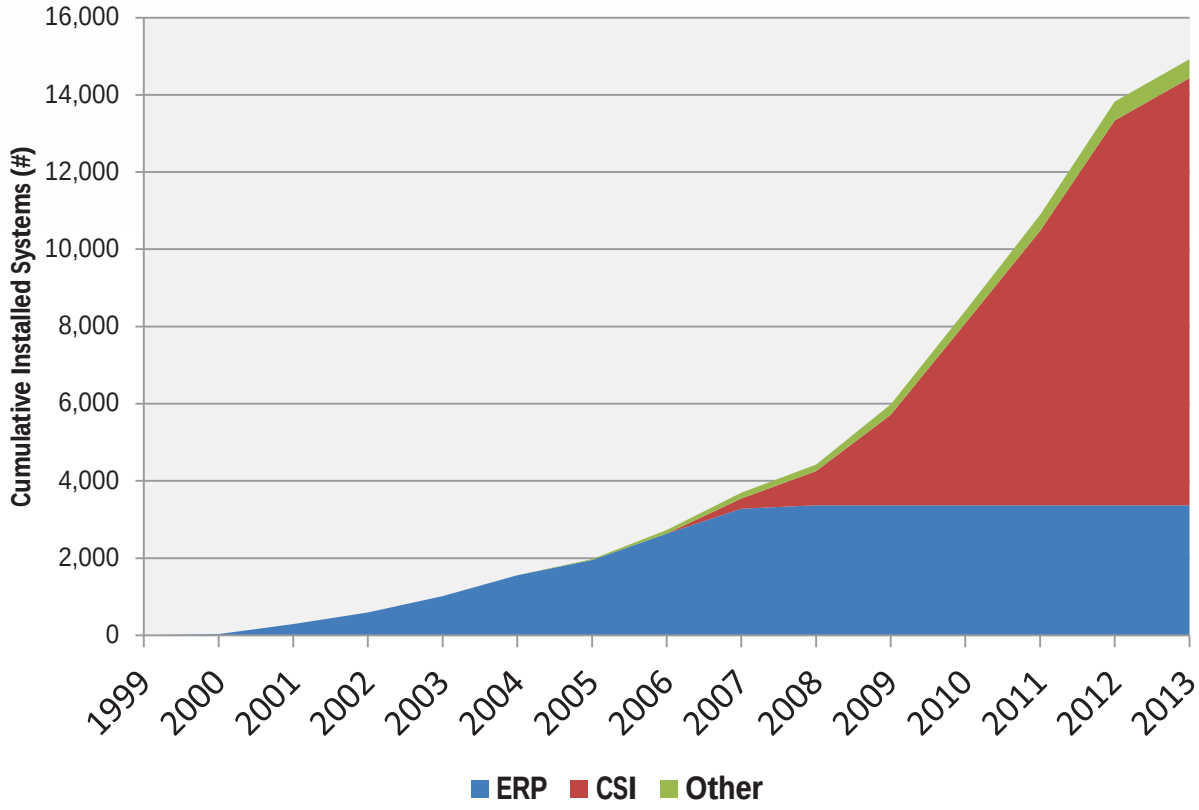
Third-Party Owned PV systems

- **What are Third-Party Owned PV systems?**
  - Third-party PV companies own and operate customer-sited PV systems and either lease PV equipment (Lease) or sell PV electricity to the building occupant (PPA)

- **Advantages of TPO systems:**
  - can remove several adoption barriers for residential consumers:
    - Little to no money down upfront
    - eliminate technology risk and complexity
    - simplify PV costs into easily understandable products (monthly bill vs. pay back period) (Drury et al. 2012)

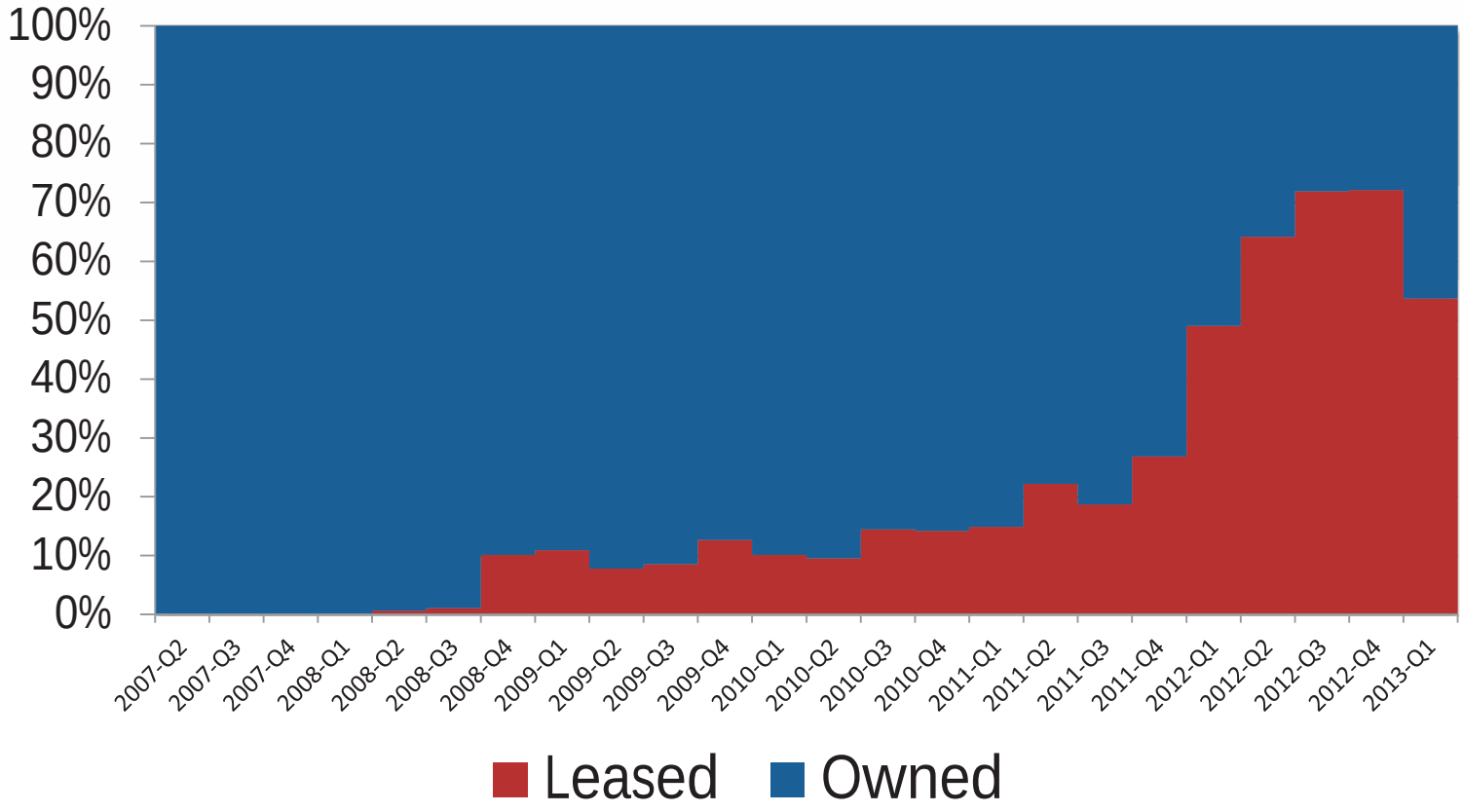
Market Growth and Composition

- Residential Installations in San Diego County

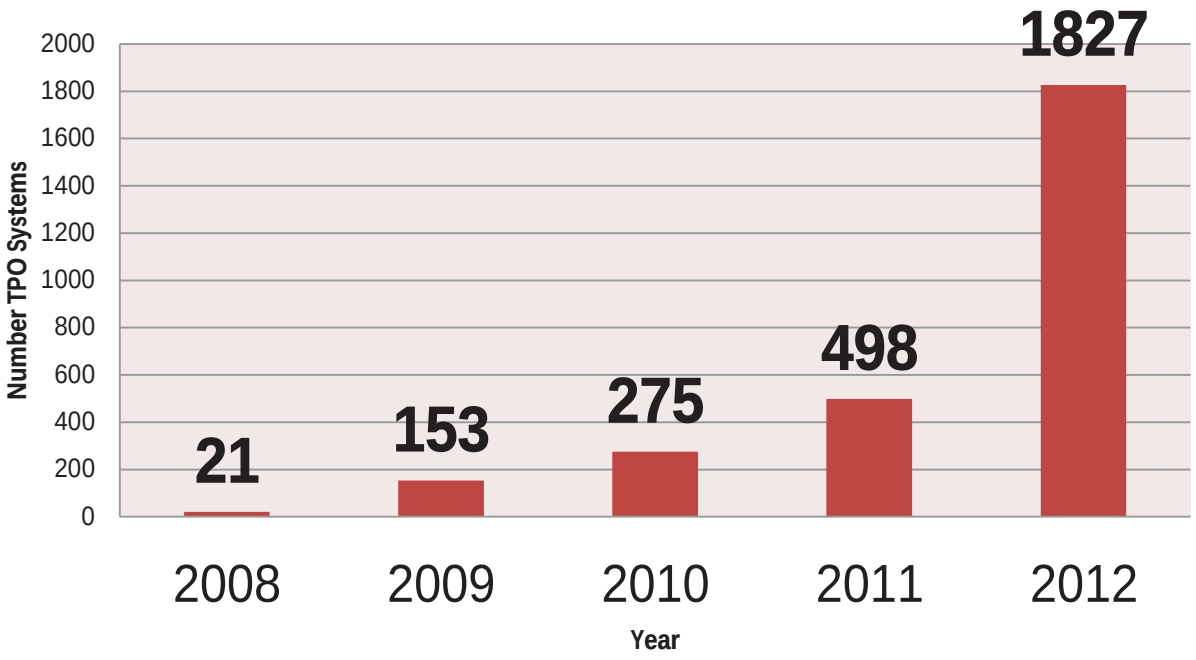


Center for Sustainable Energy CALIFORNIA

System Ownership over time San Diego County



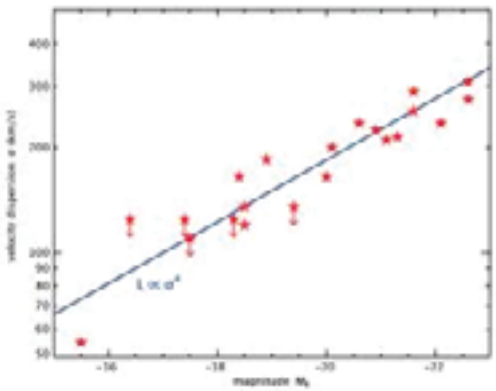
TPO Installations in San Diego County



Research Question

- How are TPO systems distributed in San Diego County?

- What is driving the adoption of TPO PV systems?
  - What is the relationship between demographics and TPO diffusion in San Diego County?



Center for Sustainable Energy CALIFORNIA

Method

How are TPO systems distributed in San Diego County?

- Cluster analysis (Moran's I)

What is driving the adoption of TPO PV systems?

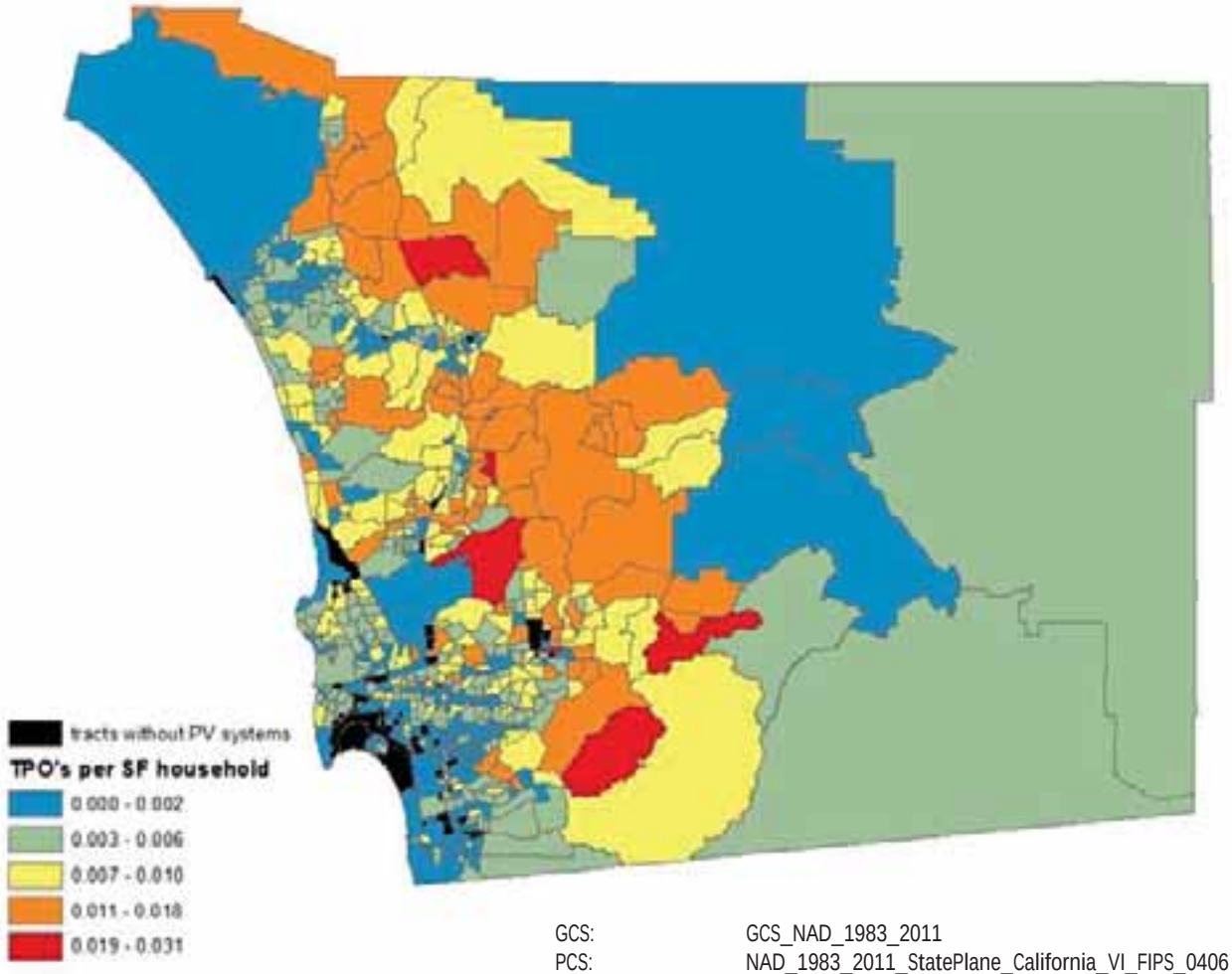
- OLS Regressions
- Geographically Weighted Regression (GWR)

Unit of Analysis: TPO systems= TPOs weighted for single family homes (SFH)on Census Tract level

Data

- PV adoption data
  - CSI database and Emerging Renewables Program (1998-2013)
- Demographics
  - Income, education, age, native
  - 2010 American Community Survey 5 year estimates
- Shapefiles for census tracts and San Diego County boundary
  - United States Census Bureau
- Data processing:
  - For modeling: we removed Census Tracts with SFH <25

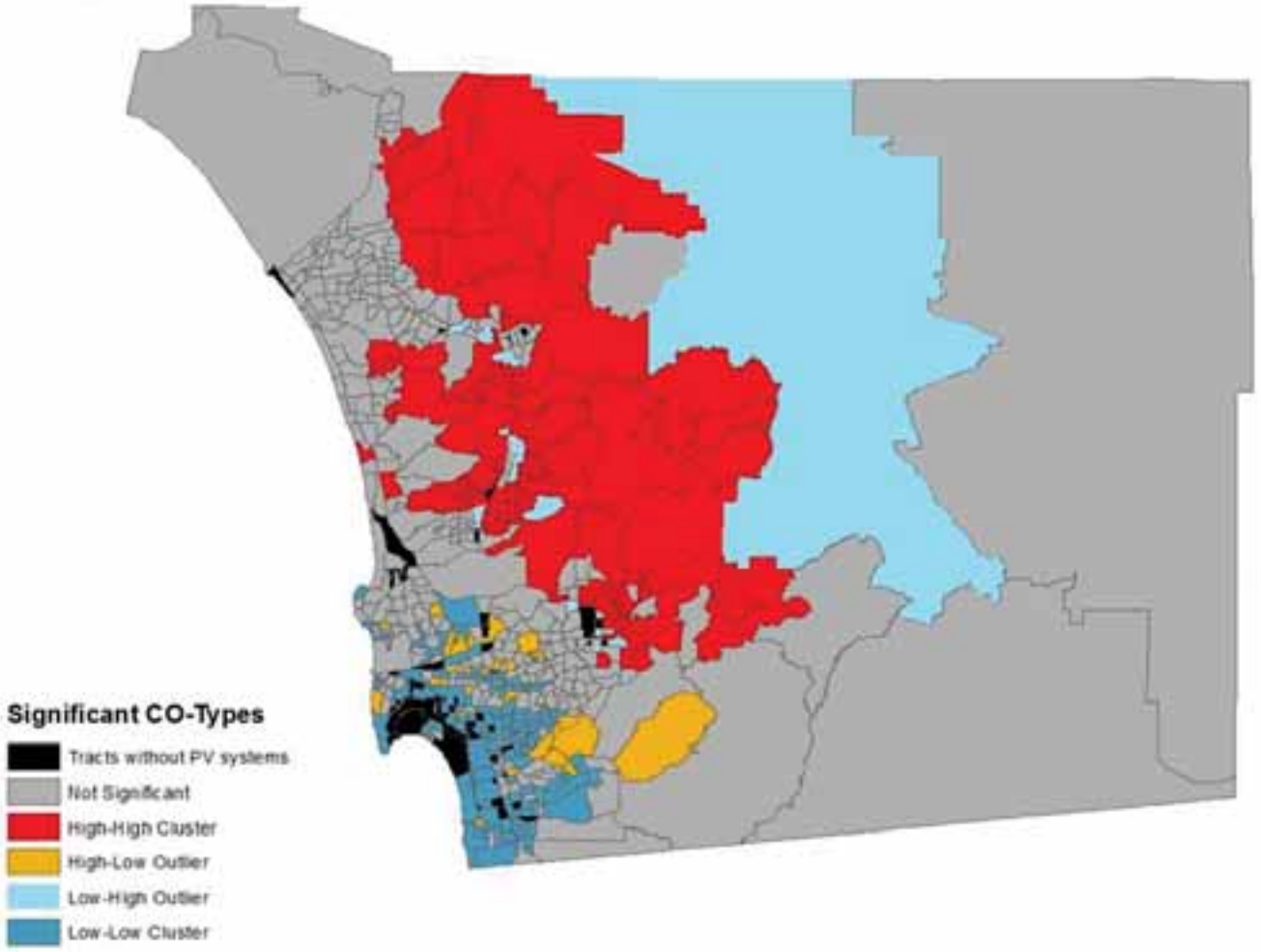
TPO systems adoption (2008-2012)



GCS: GCS_NAD_1983_2011
PCS: NAD_1983_2011_StatePlane_California_VI_FIPS_0406

Center for Sustainable Energy CALIFORNIA

Cluster Analysis (Moran's I)



Geographical Weighted Regression

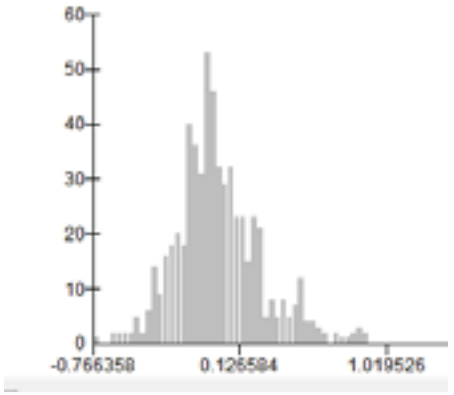
What is driving the adoption of TPO PV systems?

- OLS model testing
  - demographic variables: income, education, age, native born
  - Assumptions (e.g. Multicollinearity, non-linear relationships, normal distribution)

- OLS Regression model:

TPO (2008-2012)= constant+ median income + native

R^2 =0.2498
R^2 (adjusted)= 0.2472

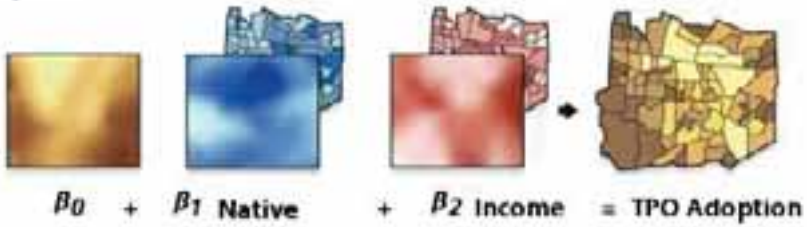


Distribution of regression residuals

Geographical Weighted Regression

- GWR: a local form of linear regression used to model spatially varying relationships

$R^2 = 0.54$



Source: www.resources.esri.com (modified)

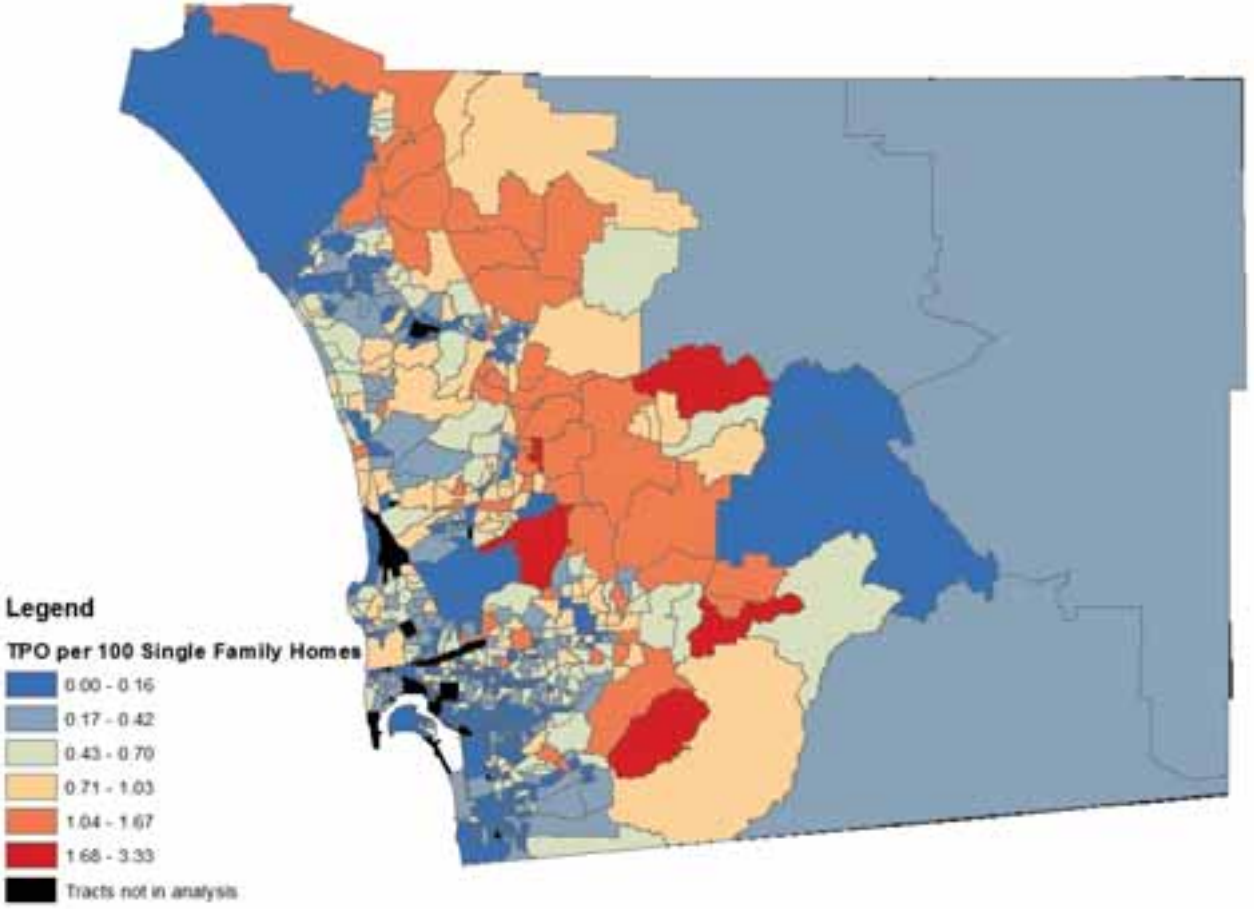
- Inputs and tests
  - Adaptive kernel
  - Bandwidth 40 neighbors

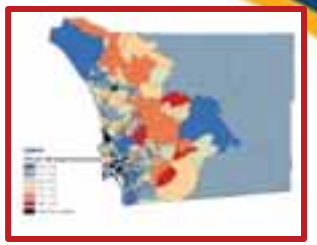
-> Tested for spatial autocorrelation, standard deviation of residuals

Center for Sustainable Energy CALIFORNIA

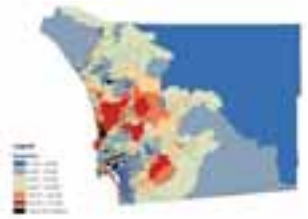
GWR inputs:

Dependent Variable: Adoption of TPO systems





Y



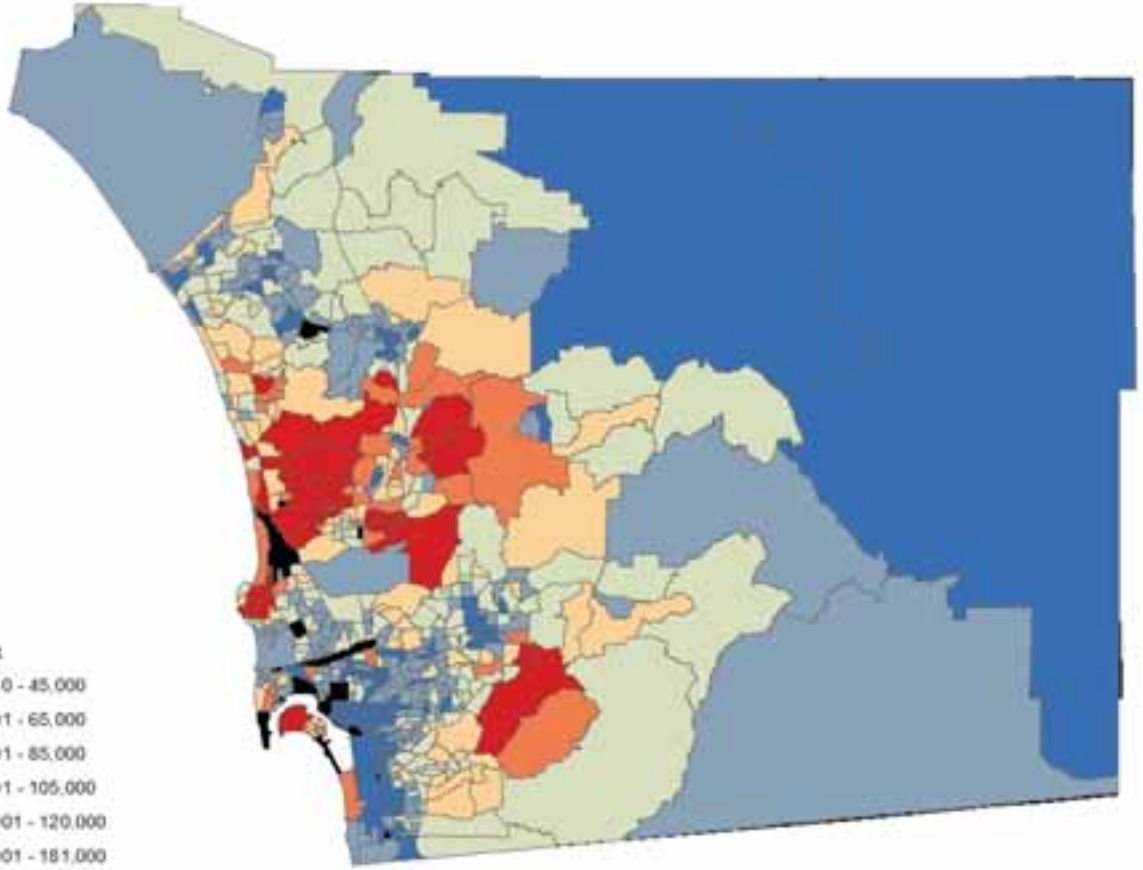
X1

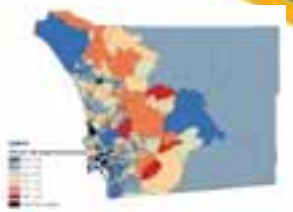
X2

R2

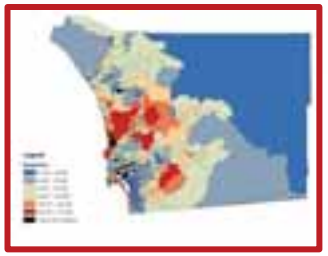
GWR inputs:

Independent Variable: Median Income





Y



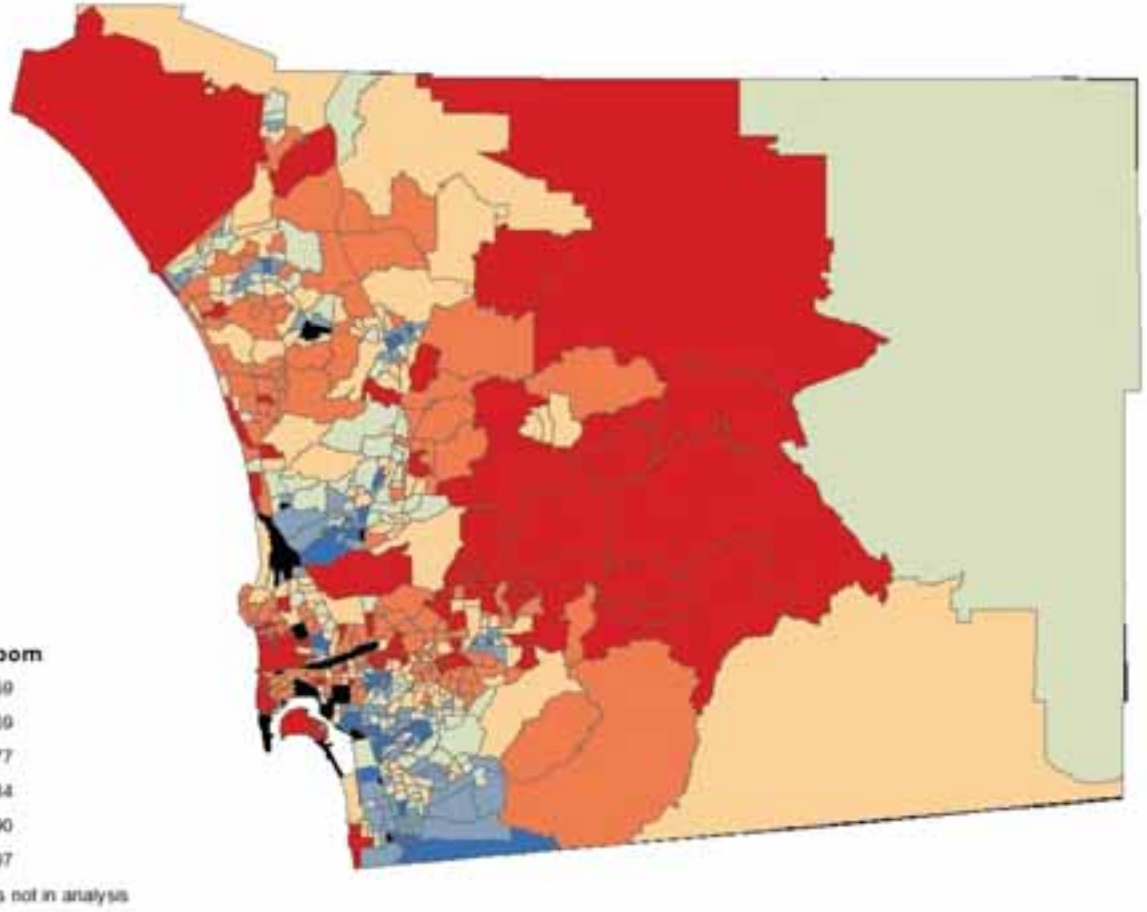
X1

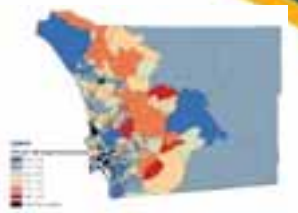
X2

R2

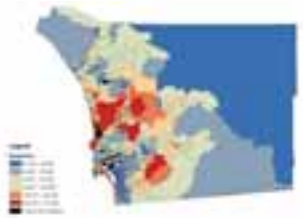
GWR inputs:

Independent Variable: Percentage native born

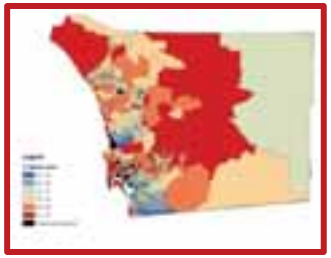




Y



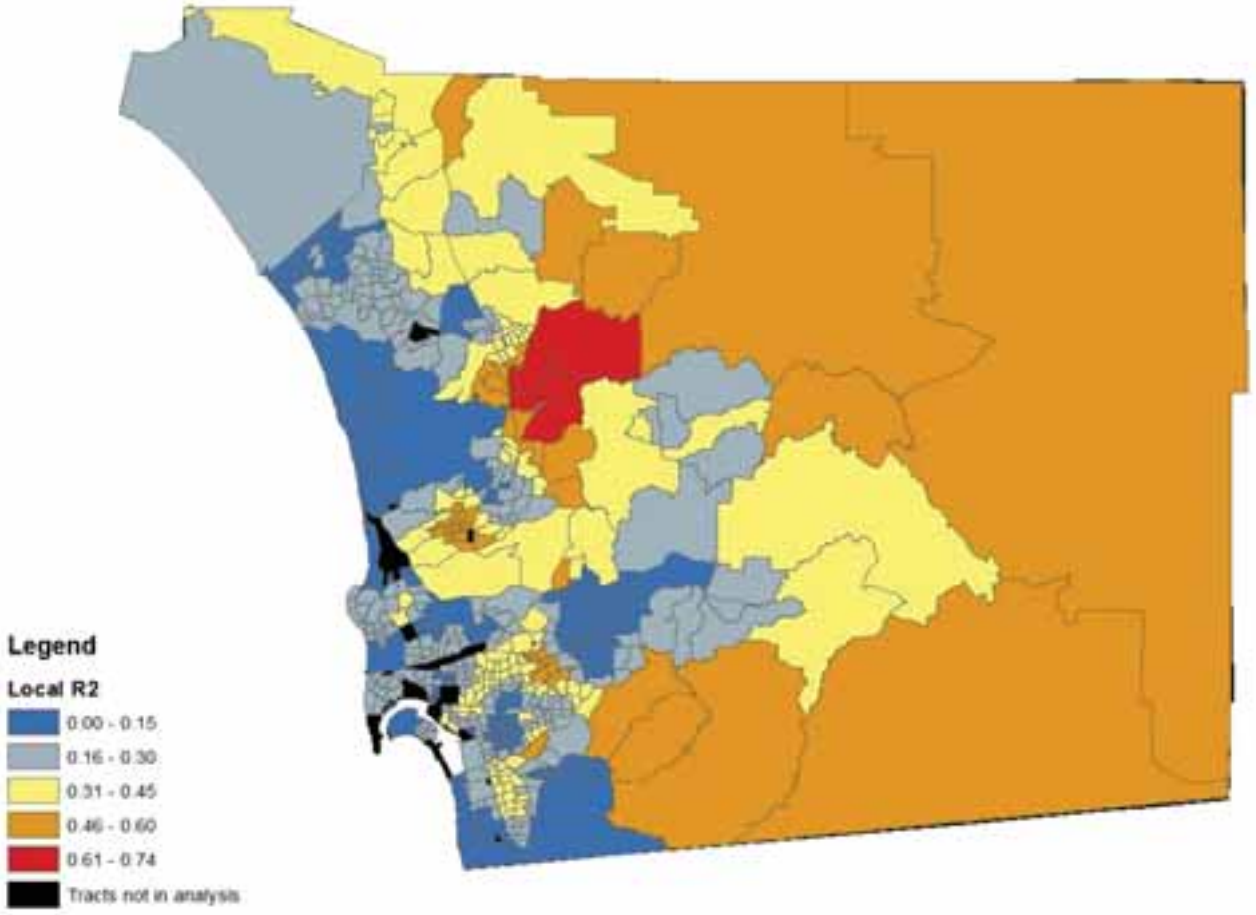
X1

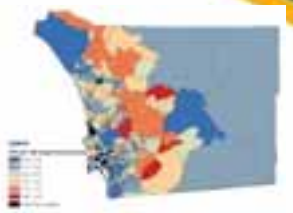


X2

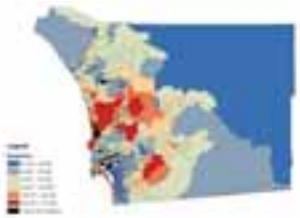
R2

GWR Results:
Local R^2

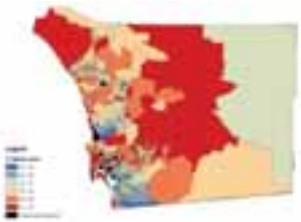




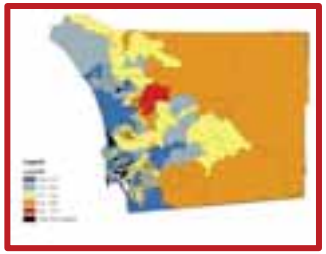
Y



X1



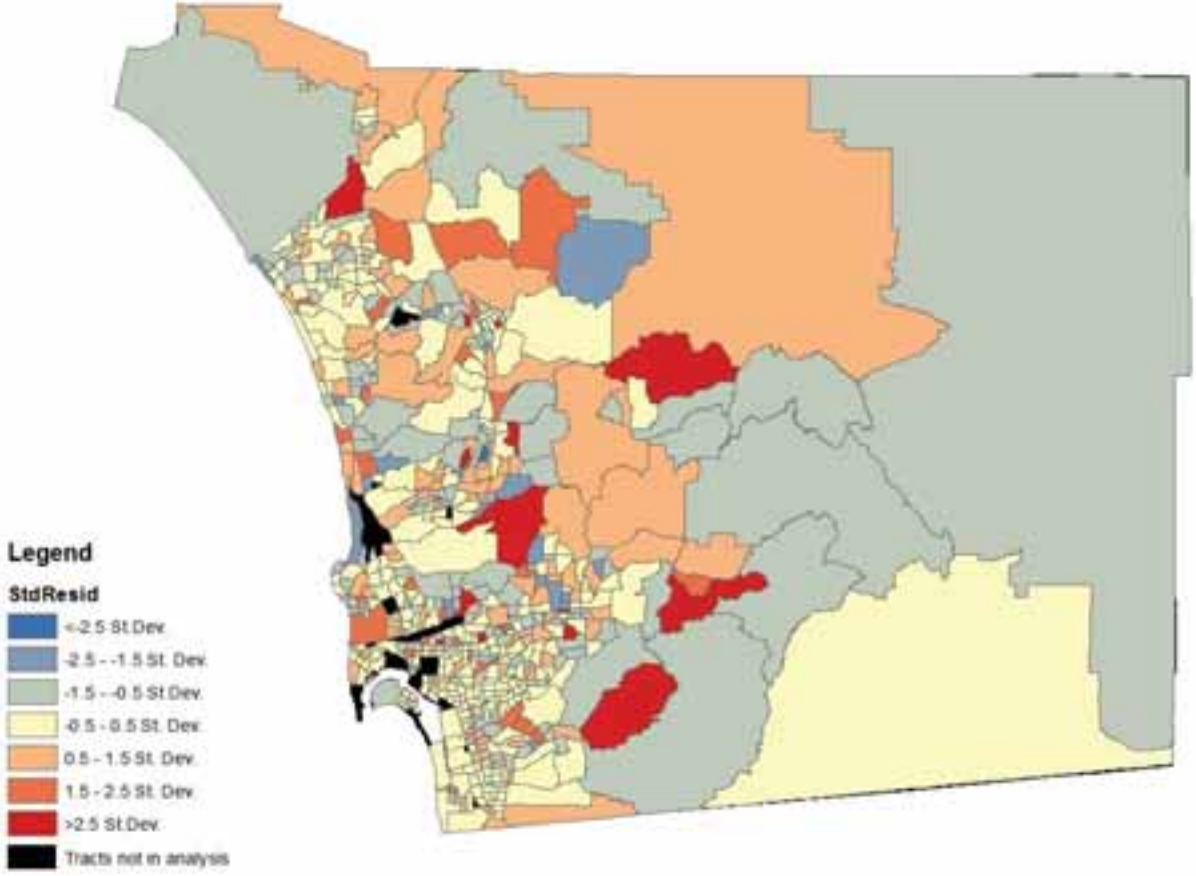
X2



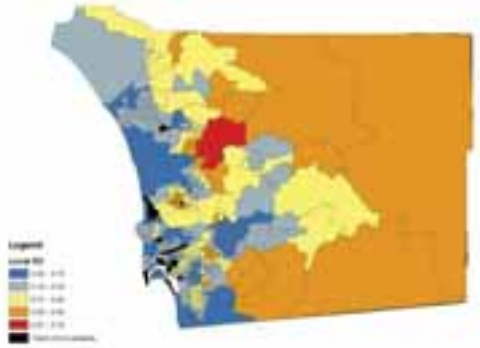
R2

Center for Sustainable Energy CALIFORNIA

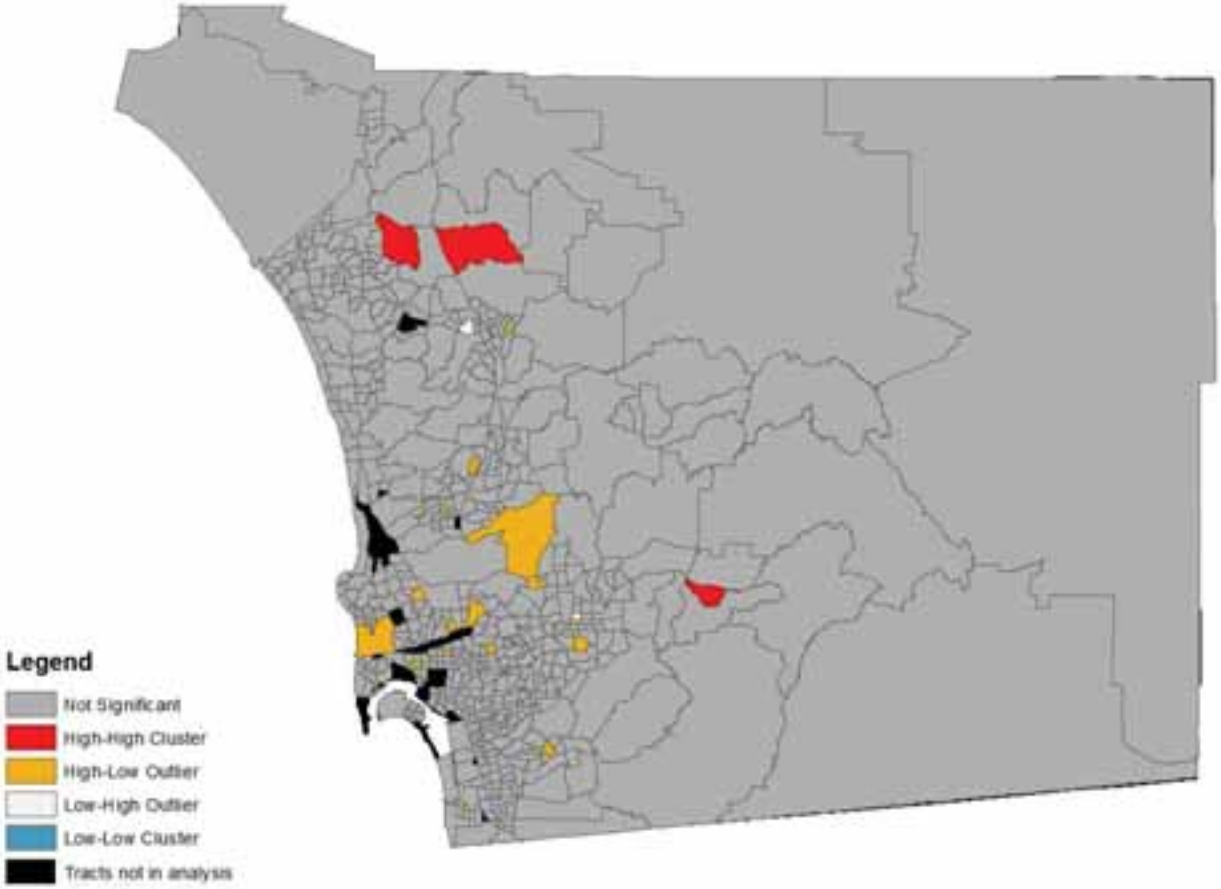
GWR Results:
Standard Deviation of Residuals



R2



GWR Results:
Test for spatial autocorrelation



Center for Sustainable Energy CALIFORNIA

Conclusions

- The number of TPO systems in San Diego County increased rapidly over the past 6 years
- Significant clustering of TPO PV adoption in San Diego County
- The diffusion of TPO systems can be partially explained by looking at demographics such as income and percentage of people born in the US
- GWR:
  - Improved explanatory power
  - Explanatory power varies significantly across space:
    -> some areas can be explained better than others by demographics

Center for Sustainable Energy CALIFORNIA

References

- Drury, Easan et al.(2012) The transformation of southern California's residential photovoltaics market through third-party ownership. *Energy Policy*, Volume 42: 681–690.
- Mitchell, Andy (2005) The ESRI Guide to GIS Analysis. Volume 2: Spatial Measurements and Statistics. Redlands: ESRI Press.
- Rai, Varun and Benjamin Sigrin (2013) Diffusion of environmentally-friendly energy technologies: buy versus lease differences in residential PV markets. *Environ. Res. Lett.* 8 01402.
- http://resources.arcgis.com

Center for Sustainable Energy CALIFORNIA

Thank you

Ria Langheim

Ria.Langheim (at) energycenter (dot) org

www.energycenter.org