The Impact of City-level Permitting Processes on Residential PV Installation Prices and Development Times

An Empirical Analysis of Solar Systems in California Cities

Ryan Wiser and CG Dong

Lawrence Berkeley National Laboratory

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Presentation Overview

- Questions and Objective
- Literature Review
- Data Sources and Processing
- Variable Description and Summary
- Regression Analysis Results
- Interpretation and Predictions
- Conclusions
- Possible Future Extensions

Questions and Objective

- **How does the permitting process at the city level impact residential PV installation prices?**
- **How does the permitting process determine the time needed to develop a residential PV system?**

- **We make use of permitting process scores from the DOE Rooftop Solar Challenge, as well as California Solar Initiative (CSI) and U.S. Census data, to evaluate these questions**

Recent Focus on Permitting Issues To Reduce Non-Hardware "Soft" Costs

- **DOE's Rooftop Solar Challenge**
  - Engaging and funding diverse teams to reduce administrative barriers to PV
- **Solar Tech's Solar 3.0 National Platform for Process Innovation**
  - Goal is to lower soft costs of solar by helping cities streamline & standardize processes
- **SolarFreedomNow**
  - Advocates a single national policy to cut paperwork and red tape
- **Solar ABC's Expedited Permit Process Report**
  - "inexperience with PV has led many to implement unnecessarily complex and inconsistent permitting procedures."
- **Clean Power Finance's National Solar Permitting Database**
  - Serves as an online tool that compiles solar permitting requirements from around the U.S.
- **IREC's Field Inspection Guidelines for PV Systems**
  - "…providing a detailed checklist for the field inspector, fewer poorly designed and installed systems will be approved."
- **California Solar Permitting Guidebook**
  - "improving Permit Review and Approval for Small Solar Photovoltaic (PV) Systems"
- **State and Local Action to Streamline Processes: CA, CO, VT, etc.**

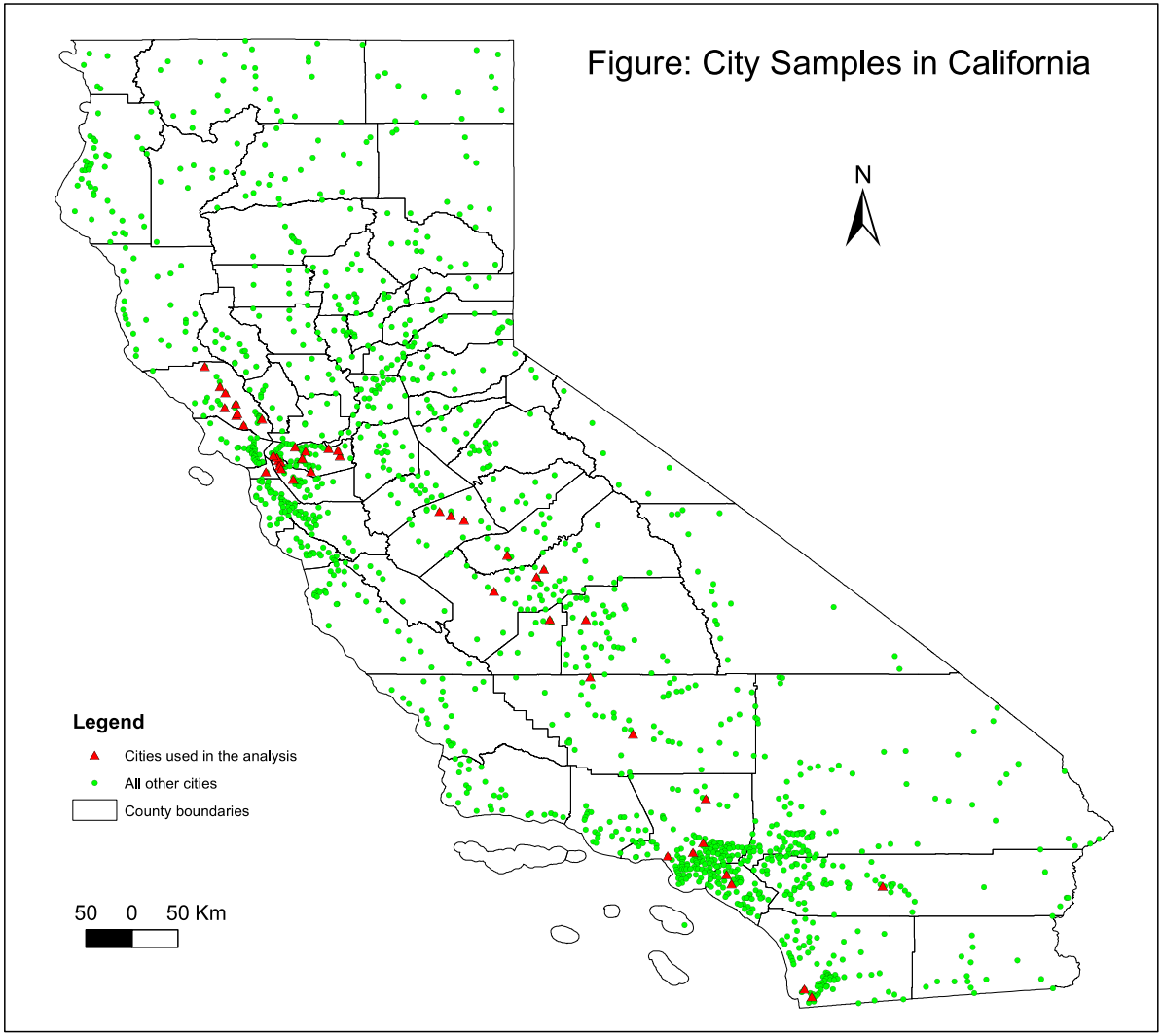
Our Analysis Builds on Literature that Estimates the Impact of Permitting

- **Sierra Club's California Solar Permit Fee Campaign**
  - Collects data to compare permit fees across northern and southern California cities
- **VoteSolar's Solar Permit Map**
  - Reports permitting data, specifically permitting fees and in some cases time to issuance
- **NREL U.S. Installer Survey**
  - Permitting, inspection, and interconnection labor accounts for $0.13/W on average, with a wide range around the average, and with additional fees averaging ~$0.09/W: ~$0.22/W total
- **LBNL German Installer Survey**
  - Total permitting, inspection, and interconnection costs ~$0.03/W in Germany, ~$0.20/W lower than in the U.S., on average, due to uniform and simplified regulatory structure
- **SunRun's Report on Impact of Local Permitting on the Cost of Solar Power**
  - Local permitting and inspection add $0.50 per watt, or $2,516 per residential install
  - PV installation delays as a result of permitting procedures average 3.5 weeks
- **Clean Power Finance's Installer Survey**
  - The labor costs of permitting (excluding permit fee) average roughly $0.11/W
  - Average permitting process requires 8 weeks
  - More than one-third of installers avoid jurisdictions with particularly challenging permitting procedures

Unique Data Source: Permitting Score from DOE Rooftop Solar Challenge

- DOE scored each city participating in the program in 2011 using a detailed questionnaire and specific weighting system
- DOE questionnaire inquired about (and subsequent scoring was based on) seven aspects of city permitting processes (through 21 questions), including: application, information access, process time, fees, best-practice processes, inspection, and communication with utility
  - DOE also scored, but we do not include in our analyses, the interconnection process, interconnection standard, net metering standard, financing options, and planning & zoning
- Total permitting process score could equal 460 for both residential and commercial sectors combined, but our analysis focuses on residential scores, which could total 250
- Final dataset contains scores for 44 cities in California, with residential permitting scores ranging from 71 to 223 and with a mean of 138
- Goal was to correlate these scores with system-level installed prices and development times for residential PV systems installed in 2011 in those same cities (3,277 total PV systems)

California Cities Included in Analysis



- 45 cities were assigned scores in CA based on the DOE Rooftop Solar Challenge Program
- Livingston was dropped because no PV systems were installed in 2011
- 44 cities (red triangles) represent 27% of CA population, and 20% of CA PV for systems under 10 kW installed in 2011
- Many CA cities located at the Bay area

Data: Permitting Process – Comparing Alternative Sources of Data

- **DOE Rooftop Solar Challenge Permitting Score (used)**
  - **Pros:** standard survey-based scoring; relatively comprehensive in scope; measured at same time in 2011
  - **Cons:** limited number of cities in California

- **Permitting Fees and Time-to-Issuance (investigated)**
  - **Vote Solar** (Solar Permit Map: Local Permitting Information for Small-scale PV Systems)
  - **Sierra Club/Loma Prieta Chapter** (Solar Permit Fee Campaign)
  - **Pros:** many more cities included in these data sources
  - **Cons:** measured at different times; largely focused on fees; less comprehensive and mixed data on time-to-issuance

Data: System Price, Development Time, and Other Regression Variables

- **System level solar PV development times (days)**
  - Approximated from CSI data
  - Start date = “Reservation Request Review Date”
  - End date = “Online Incentive Claim Request Submitted Date”
- **System level solar PV installation price ($/W)**
  - CSI; pre-incentive reported value
- **CSI also provides data on:**
  - PV system size, utility area, city, different dates in installation process, number of PV systems in city, whether third-party owned
- **City-level control variables**
  - Census Bureau: medHHincome, popdensity, education, etc.
  - Salary.com for average annual electrician wages

Data Processing

- Used city level residential permitting scores
- Focused on residential sector for permitting score, installation price, and development time
  - With specified sector as residential and system size <= 10 kW (excluded > 10 kW large-system outliers)
- Excluded – where possible – *appraised-value* third-party-owned PV systems; excluded *all* third-party-owned PV systems in some of the analysis that follows
- Only included PV systems installed in 2011 in relevant 44 cities, regardless of when incentive application began
- Total number of residential PV systems included in final dataset = 3,277, which represents roughly 16% of the CSI reported (residential) PV systems installed in 2011 (2,450 systems and 12% when all third-party-owned systems are excluded)

Variable Definitions

Variable Name	Definition	Unit
Priceperwatt	System level total installation price (pre-incentives) per watt (DC-STC)	nominal $ / W
ln(Develop_time)	Number of days between incentive application submittal and incentive request, logarithm form	log(days)
Res_permitting	DOE Solar Rooftop Challenge permitting score for residential sector for each city	integer / 100
Csize	System size centered	kW
Csize2	Square term of system size centered	kW^2
PGE	Indicator for systems located in the Pacific Gas and Electric (PG&E) service area	0 or 1
CCSE	Indicator for systems located in the California Center for Sustainable Energy (CCSE) area	0 or 1
SCE	Indicator for systems located in the Southern California Edison (SCE) area	0 or 1
Month_perstart	Continuous month number when the customer/installer applied for CSI incentives	Integer
Electrician	Average annual electrician wage for each city	nominal $ / 1,000
MedHHincome	Median household income for each city	nominal $ / 1,000
MedHHvalue	Median household value for each city	nominal $ / 10,000
Popdensity	Population density for each city	persons / Mile^2 / 100
Roomnumber	Median number of rooms per household for each city	decimal value
Installationdensity	Number of residential PV systems installed per city per unit of area from 2007 to 2011	systems / Mile^2 / 100
Weekcount	Number of PV systems applying for a CSI incentive within each week for each CSI administrator	integer / 10
College	% of population in city that has any college ed. (but has not earned a bachelor's degree)	percentage
Bachelor	% of population in city that has earned a bachelor's degree or above	percentage

Considered and evaluated many additional variables, and variable combinations, in the regression analysis. Final variables and regressions chosen based on hypothesis for variable impact, statistical significance, and model parsimony.

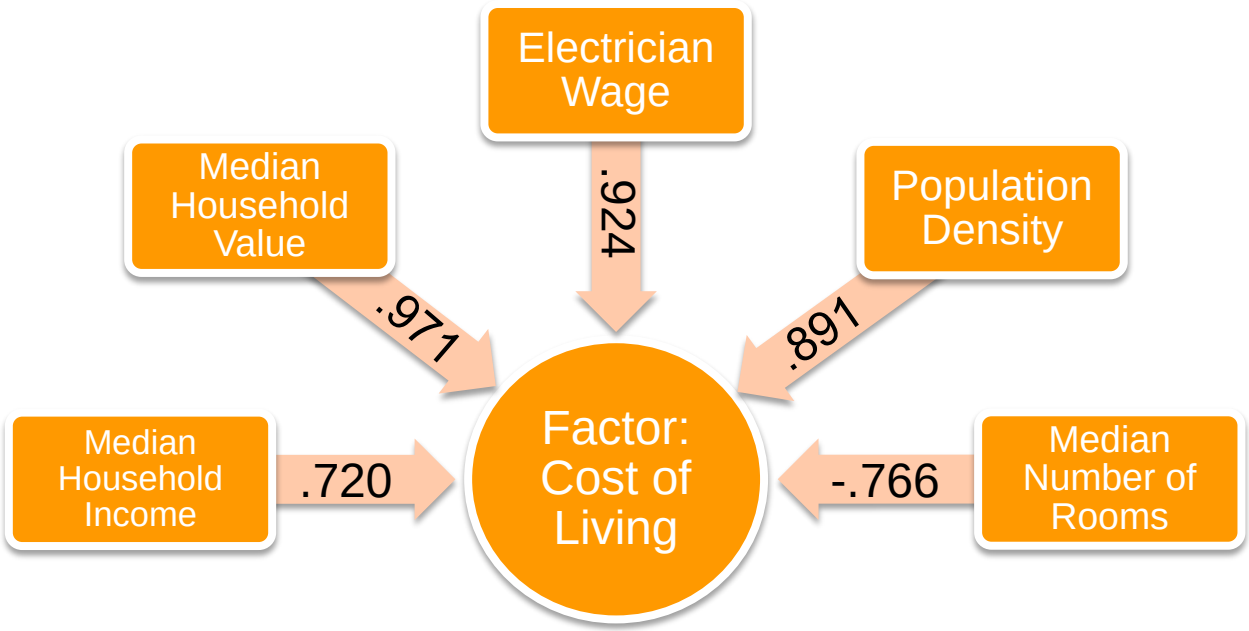
Variable Summary

Variable Name	Mean	Std. Dev.	Min	Max	Unit
Priceperwatt	6.620	1.459	2.371	13.841	nominal $ / W
Develop_time	4.571	0.797	0	6.454	log(days)
Res_permitting	1.517	0.349	0.71	2.23	# / 100
Csize	0	2.112	-3.477	5.373	kW
Csize2	4.459	5.442	0	28.865	kW^2
PGE	0.658	0.475	0	1	0 or 1
CCSE	0.204	0.403	0	1	0 or 1
SCE	0.139	0.346	0	1	0 or 1
Month_perstart	26.237	5.236	7	36	integer
Electrician	54.657	2.702	50.522	60.248	nominal $ / 1,000
MedHHincome	61.032	12.797	26.731	120.326	nominal $ / 1,000
MedHHvalue	48.359	17.268	16.140	98.550	nominal $ / 10,000
Popdensity	5.898	4.343	1.380	16.836	persons / mile^2 / 100
Roomnumber	4.984	0.556	3.4	6.6	decimal value
Installationdensity	0.224	0.350	0.002	1.910	systems / mile^2 / 100
Weekcount	4.091	4.208	0.1	27.8	Integer / 10
College	29.836	6.159	12.6	39.6	percentage
Bachelor	34.267	13.385	1.3	68.9	percentage

Note: Data summarizes the full dataset of 3,277 systems, not the smaller sample of 2,450 systems if one excludes all third-party-owned systems

Factor Analysis: Preparing for Regressions

- Principle component analysis (PCA) is applied to extract a common factor out of five relevant variables, which is called “Cost of Living”
- The factor loading numbers below represent both how the variables are weighted for the common factor and also the correlation between the variables and the factor
- This common factor, “Cost of Living”, represents each city with a range of -2 to +2, and it contains 73.87% of the variance contained in these five variables



Regression Models

- Three series of regression results presented in following three slides
  - **Installed Price #1:** relies on full dataset including customer-owned and non-appraised-value third-party-owned systems
  - **Installed Price #2:** relies on more limited dataset only including customer-owned systems (excluding all third-party-owned systems)
    - *addresses possible concern for reported price data from all third-party-owned systems, not only those that likely use appraised values*
  - **Development Time #1:** relies on full dataset including customer-owned and non-appraised-value third-party-owned systems
    - *no reason to believe that third-party-owned systems report time variables differently than customer-owned systems, so no need to create parallel set of results with all third-party owned systems excluded*
- All regressions use city-level weighting; final regression variables are chosen based on hypothesis for variable impact, statistical significance, and model parsimony; P1 and T1 regression results exclude core controls and results are therefore not reliable, whereas all other models include core controls but in varied ways

(Weighted) Regression on Installed Price: Improved Permit Scores Yield Lower Prices

- scale effect & decreasing return
- negative permitting effect on price once control for key variables
- highest cost in SCE territory
- price reduction over time
- cost of living effect_v1
- cost of living effect_v2
- competition or learning
- education effect
- goodness-of-fit

Priceperwatt	P1	P2	P3	P4	P5
csize	-0.394***	-0.349***	-0.347***	-0.349***	-0.349***
	(0.016)	(0.019)	(0.019)	(0.019)	(0.019)
csize2	0.079***	0.068***	0.068***	0.069***	0.069***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
res_permitting	0.281***	-0.176**	-0.212***	-0.268***	-0.185*
	(0.075)	(0.073)	(0.079)	(0.090)	(0.100)
PGE	-0.462***	-0.626***	-0.566***	-0.671***	-0.564***
	(0.089)	(0.087)	(0.089)	(0.087)	(0.094)
CCSE	-0.467***	-0.449***	-0.302***	-0.395***	-0.366***
	(0.103)	(0.104)	(0.111)	(0.124)	(0.124)
month_perstart	-0.017***	-0.012**	-0.012**	-0.012**	-0.012**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
factor_costofliving		0.270***	0.383***		
		(0.035)	(0.061)		
electrician				0.071***	0.046*
				(0.022)	(0.024)
medHHincome				0.006*	0.015***
				(0.003)	(0.005)
roomnumber				-0.169**	-0.295**
				(0.085)	(0.127)
installationdensity			-0.036		0.041
			(0.068)		(0.080)
college			0.004		-0.008
			(0.006)		(0.007)
bachelor			-0.009***		-0.010**
			(0.003)		(0.004)
N	3277	3277	3277	3277	3277
r2_a	0.328	0.343	0.343	0.342	0.342
df_m	6	7	10	9	12

Regression on Installed Price: Improved Permit Scores Yield Lower Prices (no third-party systems)

- scale effect & decreasing return
- negative permitting effect on price once control for key variables
- highest cost in SCE territory
- price reduction over time
- cost of living effect_v1
- cost of living effect_v2
- competition or learning
- education effect
- goodness-of-fit

Priceperwatt	P1_v2	P2_v2	P3_v2	P4_v2	P5_v2
csize	-0.438***	-0.389***	-0.389***	-0.389***	-0.389***
	(0.020)	(0.024)	(0.024)	(0.024)	(0.024)
csize2	0.081***	0.069***	0.069***	0.070***	0.070***
	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
res_permitting	0.04	-0.280***	-0.332***	-0.508***	-0.448***
	(0.086)	(0.087)	(0.095)	(0.106)	(0.121)
PGE	-0.759***	-0.936***	-0.791***	-1.159***	-1.093***
	(0.140)	(0.138)	(0.149)	(0.146)	(0.176)
CCSE	-0.722***	-0.725***	-0.337	-0.558***	-0.536***
	(0.150)	(0.150)	(0.207)	(0.165)	(0.205)
month_perstart	-0.013*	-0.006	-0.006	-0.007	-0.007
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
factor_costofliving		0.265***	0.397***		
		(0.038)	(0.065)		
electrician				0.133***	0.119***
				(0.030)	(0.034)
medHHincome				0.001	0.004
				(0.004)	(0.007)
roomnumber				0.067	0.026
				(0.118)	(0.205)
installationdensity			-0.096		-0.008
			(0.059)		(0.065)
college			-0.0002		-0.006
			(0.007)		(0.008)
bachelor			-0.012***		-0.004
			(0.004)		(0.005)
N	2450	2450	2450	2450	2450
r2_a	0.297	0.313	0.313	0.313	0.312
df_m	6	7	10	9	12

(Weighted) Regression on Development Time: Improved Permit Scores Yield Lower Time

- insignificant size effect
- negative permitting effect on time once control for key variables
- utility territory effect varies depending on control variables
- cost of living effect
- time is more valuable
- high population density slows process
- incentive application congestion effect
- learning, competition, or congestion
- education effect
- goodness-of-fit

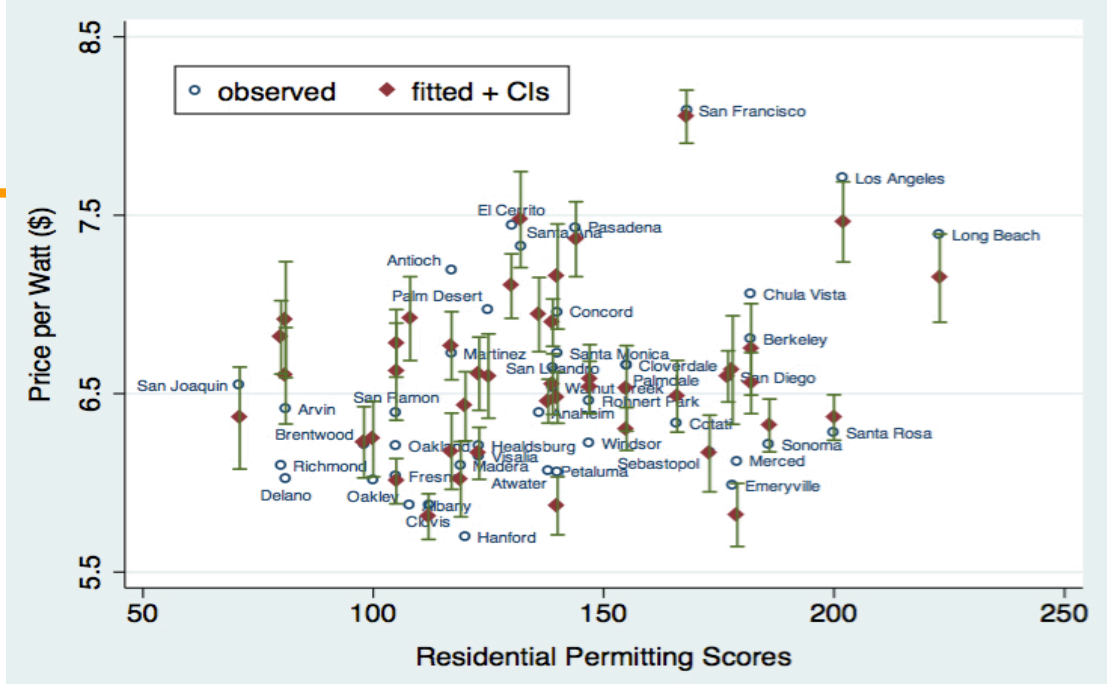
Ln (Develop Time)	T1	T2	T3	T4	T5
csize	-0.034***	0.006	0.007	0.011	0.008
	(0.009)	(0.010)	(0.009)	(0.010)	(0.009)
res_permitting	0.104*	-0.354***	-0.193***	-0.097*	-0.101*
	(0.055)	(0.059)	(0.057)	(0.052)	(0.052)
PGE	0.210***	0.026	-0.166***	0.117**	-0.173***
	(0.046)	(0.046)	(0.052)	(0.047)	(0.052)
CCSE	-0.214***	-0.185***	-0.103*	0.045	-0.013
	(0.052)	(0.051)	(0.058)	(0.055)	(0.059)
factor_costofliving		0.263***	0.201***		
		(0.020)	(0.035)		
medHHincome				-0.005***	-0.006***
				(0.001)	(0.002)
popdensity				0.066***	0.059***
				(0.004)	(0.006)
weekcount			0.066***		0.065***
			(0.003)		(0.003)
installationdensity			0.074*		-0.008
			(0.041)		(0.043)
college			-0.019***		0.004
			(0.004)		(0.004)
bachelor			-0.009***		0.001
			(0.002)		(0.002)
N	3277	3277	3277	3277	3277
r2_a	0.067	0.125	0.212	0.143	0.221
df_m	4	5	9	6	10

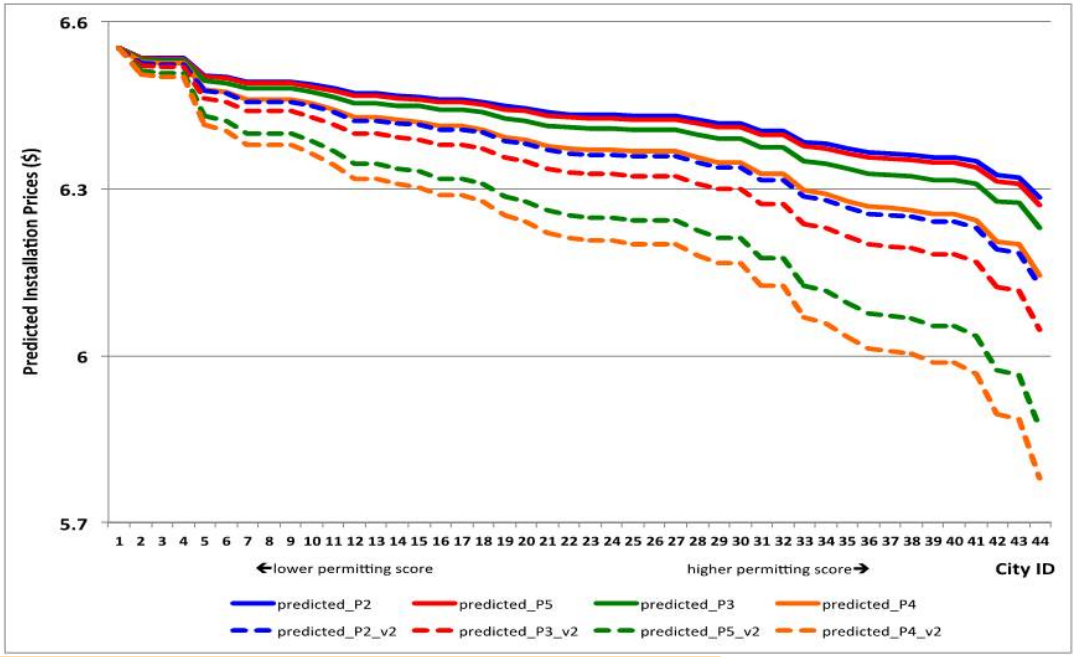
Predicted Prices

- Predicted prices reasonably close to observed prices and within confidence intervals,

  CIs = Yhat ± $Z_{95\%}$* s.e.(Yhat)

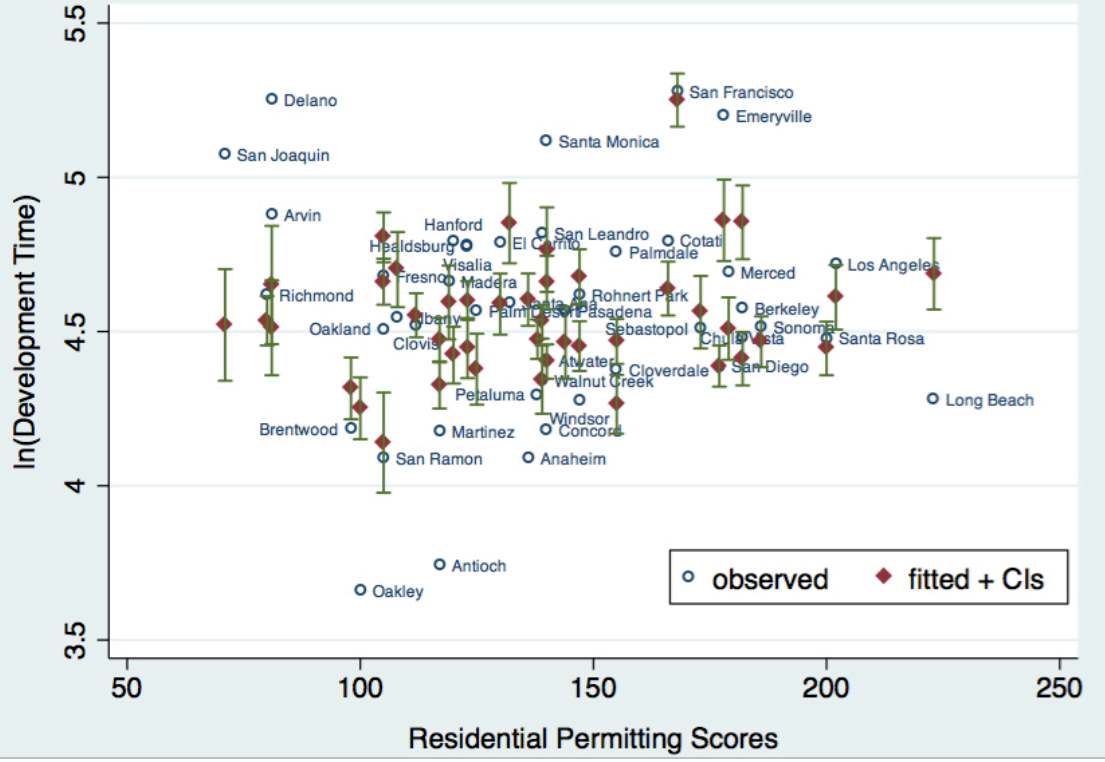
- Some cities with high cost of living also have high permitting scores
- Considering models P2-P5, as applied to full sample and the more limited customer-owned sample, different permitting processes (with permit score the proxy) are found to **cause PV installed price differences among cities of as much as $0.27 to $0.77/W, depending on the model chosen (4% to 12% of median PV prices)**

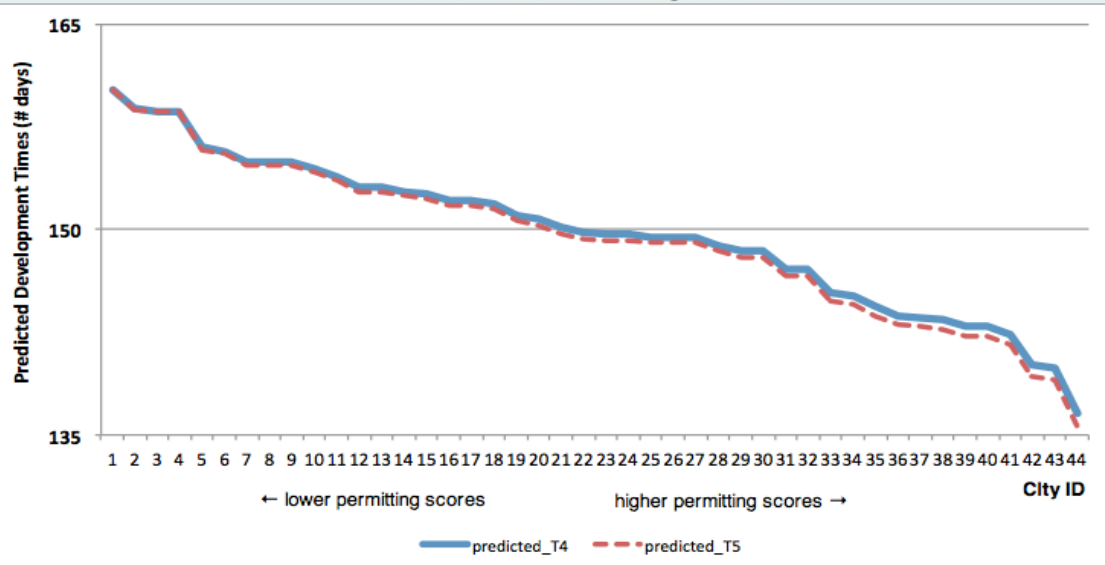




Predicted Time

- More unknowns about development time yield less accurate predictions
- Considering models T4-T5, different permitting processes (with permit score the proxy) are found **to cause development time differences among cities of up to 24 days (25% of the median development time)**
- These findings are substantially less robust and more uncertain than the previously shown impact of permitting score on prices





Conclusions

- Non-hardware business process (or “soft”) costs account for well over 50% of the installed price of residential PV in the U.S.
- City-level permitting processes appear to have a significant impact on both average installation prices and project development times
- Among the sample analyzed here, the best permitting practice is found to:
  - **reduce average system price by $0.27 to $0.77/W (4%-12%)**
  - **shorten development time by around 24 days (25%)**
  - both relative to the worst case in the California sample
  - results for development time are less robust than for system prices
- Findings provide some confirmation of the scoring mechanism used in the DOE Rooftop Solar Challenge, and illustrate the potential benefits of streamlining city-level permitting procedures

Possible Future Extensions

- Seek additional datasets in order to evaluate impacts over a broader range of cities/states
- Expand from the residential to the commercial sector
- Further assess the robustness of the results for development time
- Evaluate impact of permitting scores on the amount of PV installation at the city level, and/or PV installers' interest in those cities
- Evaluate the impact of the DOE Rooftop Solar Challenge Program on all of these permitting-impact variables, once multiple years of data on permitting scores are available
- Evaluate other action areas beyond permitting (e.g., interconnection, planning and zoning)

For Further Information

Download the report:

http://emp.lbl.gov/research-areas/renewable-energy

Contact the authors:

Ryan Wiser, RHWiser@lbl.gov

CG Dong, CGDong@lbl.gov