STATE-LEVEL DRIVERS OF DISTRIBUTED PV DEPLOYMENT

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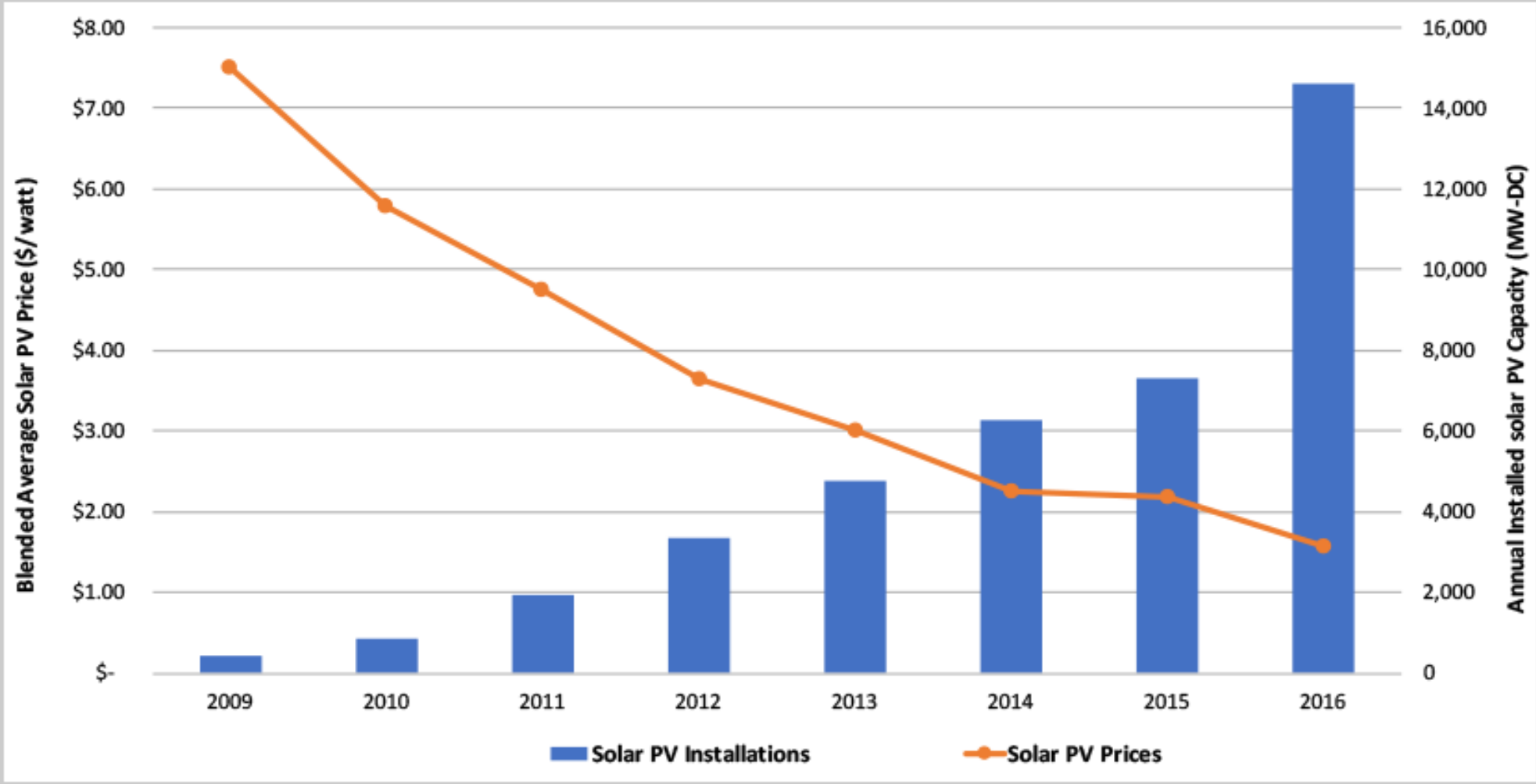
Introduction

- Solar photovoltaic (PV) systems
  - Decreasing costs
  - Increasing deployment
- Diverse public policy approaches to encourage solar PV (e.g., NEM, RPS, tax credits/exemptions, loans, etc.)
- Best practices to encourage non-utility PV at the state level remains an unresolved issue

Installed PV Capacity in U.S.



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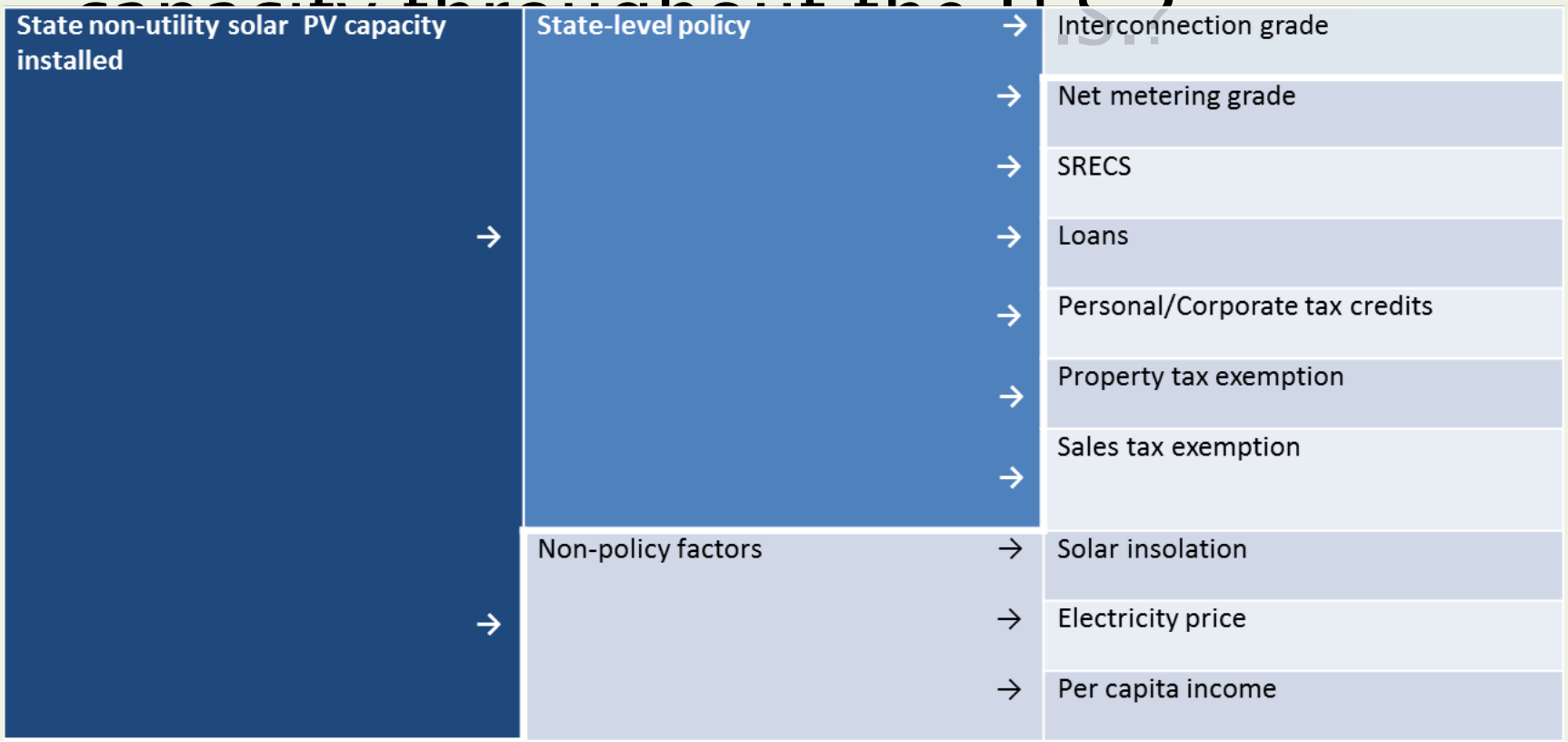
Drivers of Solar PV in Prior Studies

Authors (Year)	NEM	Inter-connection	RPS/SRECS	Loans	Tax Credits	Prop. Tax Ex.	Sales Tax Ex.	Insolation / PV Potential	Electricity Prices	Demographic Factors
Carley, 2009b			√	√	X	X	X	√	X	√[a]
Doris and Gelman, 2011[b]		X	√		√[c]		X			√
Krasko and Doris, 2013	√	√	√							√
Sarzynski et al., 2012[d]	X		√			X	X		√	X
Shrimali and Kniefel, 2011			√						X	X
Steward and Doris, 2014	√	√	√					C	C	C
Steward et al., 2014	√	√	√					C	C	C

[a] GDP brings forth a positive result, income and educational attainment were dropped from the model due to insignificance
[b] NEM and electricity price variables dropped from model due to multicollinearity
[c] Personal tax incentives are positively associated with PV capacity, yet corporate tax incentives show a negative relationship
[d] Cash incentives resulted in greater PV market deployment, but not property and sales tax incentives

Research Question

- What are the key state-level policies and non-policy determinants that drive non-utility solar PV installed capacity throughout the U.S.?



Methodology

- Multiple linear regression analysis in hierarchical fashion
- Cross-sectional data from the years 2012–2013, 102 observations. SPSS, Version 23

$$\log \text{NON\_UTILITY\_PV} = \beta_0 + \beta_1 \log \text{INTERCONNECTION} + \beta_2 \log \text{NEM} + \beta_3 \text{SRECS} + \beta_4 \text{LOANS} + \beta_5 \text{TAX\_CREDITS} + \beta_6 \text{PROPERTY\_TAX\_EXEMPTION} + \beta_7 \text{SALES\_TAX\_EXEMPTION} + \beta_8 \text{DEREGULATION} + \beta_9 \text{YEAR} + \beta_{10} \log \text{INSOLATION} + \beta_{10} \log \text{ELECTRICITY\_COST} + \beta_{11} \log \text{INCOME} + \text{error}$$

In which:

- NON_UTILITY_PV = Grid-connected, newly installed solar PV (MW_{DC}) per capita (res. and comm.) **(IREC)**
- INTERCONNECTION = Interconnection score from Freeing the Grid report **(FTG)**
- NEM = Net metering score from the Freeing the Grid report **(FTG)**
- SRECS = 1 if customers can sell credits within an SREC market, 0 if otherwise **(SRECTrade)**
- LOANS = 1 if state loan programs exist, 0 if otherwise **(DSIRE)**
- TAX_CREDITS = 1 if personal and/or corporate income tax credit exists, 0 if otherwise **(DSIRE)**
- PROPERTY_TAX_EXEMPTION = 1 if property tax exemption exists, 0 if otherwise **(DSIRE)**
- SALES_TAX_EXEMPTION = 1 if sales tax exemption exists, 0 if otherwise **(DSIRE)**
- DEREGULATION = 1 if deregulated electricity market, 0 if regulated **(EIA)**
- YEAR = 1 for 2013, 0 for 2012
- INSOLATION = Average yearly solar insolation measurement ($kWh/m^2/day$) **(NREL)**

Summary Statistics: All Variable Values By U.S. State

Variable	Minimum	Maximum	Mean	Std. Deviation
NON UTILITY PV	.00	10.02	.55	1.371
INTERCONNECTION	-5.50	27.50	9.67	8.354
NEM	.00	25.00	11.34	6.808
SRECS	.00	1.00	.31	.466
LOANS	.00	1.00	.45	.500
TAX CREDITS	.00	1.00	.40	.493
PROPERTY TAX EXEMPTION	.00	1.00	.53	.502
SALES TAX EXEMPTION	.00	1.00	.40	.493
DEREGULATION	.00	1.00	.31	.466
INSOLATION	2.42	5.45	4.24	.530
ELECTRICITY COST	6.90	34.04	10.67	4.055
INCOME	33.45	75.95	44.24	7.827

Impacts On Non-Utility Installed PV Capacity

Variable	Model 1: Market-Opening Policy	Model 2: All State Policy	Model 3: All Factors (Policy and Non-Policy Determinants)
INTERCONNECTION	.051	.058	-.010
NEM	.138***	.150***	.096***
SRECS	–	-.091	.094
LOANS	–	-.005	.003
TAX CREDITS	–	.189**	.134**
PROPERTY TAX EXEMPTION	–	.001	.066
SALES TAX EXEMPTION	–	.013	.018
DEREGULATION	–	–	-.079
YEAR	–	–	-.041
INSOLATION	–	–	1.523***
ELECTRICITY COST	–	–	1.222***
INCOME	–	–	.044
Constant	-.104	-.195	-5.619***
R^2	0.156	0.215	0.705
Adjusted R^2	0.139	0.156	0.665

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Standardized Correlates

Variable	Model 1: Market-Opening Policy	Model 2: All State Policy	Model 3: All Factors (Policy and Non-Policy Determinants)
INTERCONNECTION	.145	.167	-.030
NEM	.303***	.330***	.211***
SRECS	–	-.095	.098
LOANS	–	-.005	.003
TAX CREDITS	–	.210**	.149**
PROPERTY TAX EXEMPTION	–	.001	.074
SALES TAX EXEMPTION	–	.014	.020
DEREGULATION	–	–	-.083
YEAR			-.047
INSOLATION	–	–	.358***
ELECTRICITY COST	–	–	.710***
INCOME	–	–	.016
Constant	-.104	-.195	-5.619***
Adjusted R^2	0.139	0.156	0.665

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$

Why Poor Results For Other Policies?

- Such policies may be popular among states that wish to kick-start nascent solar markets, and a lag may occur before they become effective

- Loans and tax exemptions may be deemed unnecessary in pro-solar states that have instead adopted more aggressive personal or corporate income tax credits

- SREC market prices dropped considerably from 2011-2013, and such markets are typically only found on the East Coast of the U.S.

Conclusions

- PV capacity growth is largest in states with high electricity costs and better solar insolation resources
- Better NEM policies and the availability of personal or corporate income tax credits for solar PV systems are significant positive drivers of capacity growth
- Evidence indicates that states should develop better NEM policies and tax credits, particularly in states where non-policy

State	Solar Favorability Index	Insolation Score	Electricity Price (cents/kWh)
Hawaii	168.57	5.13	32.86
California	79.13	4.98	15.89
New York	62.12	3.76	16.52
Arizona	59.73	5.45	10.96
Connecticut	58.90	3.80	15.50
New Jersey	57.75	3.95	14.62
Massachusetts	57.49	3.90	14.74
New Mexico	55.19	5.40	10.22
Rhode Island	54.21	3.90	13.90
New Hampshire	54.02	3.90	13.85
Vermont	53.32	3.70	14.41
Colorado	50.85	4.88	10.42
D.C.	50.36	4.20	11.99
Nevada	50.20	5.02	10.00
Florida	49.39	4.80	10.29
Maryland	48.84	4.00	12.21
Georgia	47.22	4.58	10.31
Kansas	46.62	4.63	10.07
Missouri	45.67	4.30	10.62
Texas	44.68	4.91	9.10
Delaware	44.57	4.10	10.87
Michigan	43.56	3.72	11.71
Wisconsin	43.31	3.86	11.22
Maine	43.24	3.75	11.53
Alabama	42.54	4.45	9.56
Utah	42.48	4.80	8.85
North Carolina	42.48	4.42	9.61
Tennessee	41.41	4.30	9.63
Nebraska	41.19	4.34	9.49
Virginia	39.33	4.22	9.32
Alaska	39.18	2.42	16.19
South Dakota	39.17	4.18	9.37
Oklahoma	38.78	4.65	8.34
Pennsylvania	38.63	3.84	10.06
Louisiana	38.61	4.58	8.43
Minnesota	37.90	3.76	10.08
Arkansas	37.63	4.55	8.27
Iowa	36.90	4.05	9.11
Ohio	36.33	3.80	9.56
Idaho	35.45	4.35	8.15
Indiana	35.28	4.00	8.82
North Dakota	34.67	3.90	8.89
Montana	34.34	3.92	8.76
Wyoming	33.79	4.44	7.61
Illinois	32.84	4.00	8.21
Oregon	32.50	3.92	8.29
Kentucky	31.91	4.07	7.84
West Virginia	30.69	3.87	7.93
Washington	24.40	3.50	6.97
Average	***46.54***	***4.24***	***10.98***

Implications for Ohio

Variable	Ohio Value (2013) (Rank)
NON UTILITY PV	0.12 (t-25th)
INTERCONNECTION	19 (18th)
NET METERING	15 (18th)
SRECS	1 (t-first)
LOANS	1 (t-first)
TAX CREDITS	0 (t-last)
PROPERTY TAX EXEMPTION	1 (t-first)
SALES TAX EXEMPTION	0 (t-last)
INSOLATION	3.80 (44th)
ELECTRICITY COST	9.56 (t-30th)
INCOME	41.05 (30th)

- Low solar insolation and electricity costs in Ohio have hindered PV installations
- Respectable interconnection standards and NEM policies
- However, the lack of tax credits has obstructed PV deployment in the state
  - Model indicates that a state w/tax credits would expect an increase of 0.326 MW/ 100,000
  - Ohio (pop. 11.59 M) had 13.5 MW of newly-installed PV capacity in 2013
  - With tax credits, the results suggest an additional 37.8

Questions?

For additional questions/comments concerning this research, please email me at michaudg@ohio.edu

Thank you