Supplementary Material for

Policy Feedback, Energy Equity, and Climate Justice: Can Existing Policies Improve Solar Access for Low- and Moderate-Income Communities in the U.S.?

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LMI Solar Incentives

State-wide LMI solar incentives (through Solarize, Residential Property Assessed Clean Energy Programs (R-PACE), Financial rebate/ Smart e-loan/Solar rewards program, Multi/Single-Family Affordable Solar Housing (SASH) Program, or a Solar for All Community Solar Program/ Pilot programs as of 2019) was coded dichotomously (0- no LMI incentive, 1-LMI incentive adopted). States, like Rhode Island, have local LMI incentives, but these were not included in the data set since the policies are not state-wide.

The time to adoption was calculated based on a dichotomous event occurrence variable coded as 0 for each year when the state did not have an LMI solar incentive policy in place and 1 for the year the policy was adopted. Once a state adopts an LMI solar incentive, it was dropped from the data set. The data set begins in 2010, when the first state-wide adoption occurred, and includes data from over a decade until 2019. Therefore, a state that adopted an LMI solar incentive in 2010 will have a time to adoption of 0 years, while a state that adopted the policy in 2019 will have a time to adoption of 10 years. States that had not adopted an LMI solar incentive at the end of 2019 would have a time-to-adoption of 11 years. The mean time to adoption was 9.5 years with a standard deviation of 1.5 years.

Energy Efficiency Policies

This work focuses on two commonly adopted grid-level mechanisms that are typically implemented as mandates to a state's utility company for energy efficiency. These are lost revenue adjustment (LRA) programs and decoupling programs. An LRA program allows rate adjustment such that a utility, natural gas-based, electricity, or both, to recover any revenue that may be reduced specifically because of energy efficiency policies. The rationale is that while energy efficiency leads to financial benefits for the consumer, the producer incurs a loss from the sale of fewer units of energy. On the other hand, decoupling allows regulators to adjust utility rates so that the link between the amount of natural gas or electricity sold by the utility company does not form the basis of its revenue. In doing so, decoupling allows for electricity rates to fluctuate such that revenue is fully recovered and is indifferent to changes in sales due to any factor, including efficiency programs or weather patterns.

LRA requires utilities to pre-assess energy savings over a specific timeframe, while decoupling does not mandate so and is adjusted to demand. Unlike decoupling, LRA is also typically asymmetrical, *i.e.*, regulators do not make additional adjustments if the utility sells more energy than predicted for the year. In contrast, decoupling programs can result in savings and refunds or surcharges for customers to recover the revenue. For this paper, decoupling is considered more stringent since it accounts for factors outside of sales, like new standards and codes, and reduces the incentives for demand-side management programs.

Therefore, the states with no Loss Revenue Adjustment or decoupling measures were scored lowest (0), loss revenue adjustment for gas utilities was scored as 1, loss revenue adjustment for electricity utilities was scored as 2, loss revenue adjustment for electricity and gas utilities was scored as 3, decoupling revenue from the volume of sale for gas utilities were scored as 4, decoupling revenue from the volume of sale for electricity utilities was scored as 5, and those with decoupling for both gas and electricity utilities were scored the highest (6). The mean score for energy efficiency policies was 2.2, with a standard deviation of 1.8.

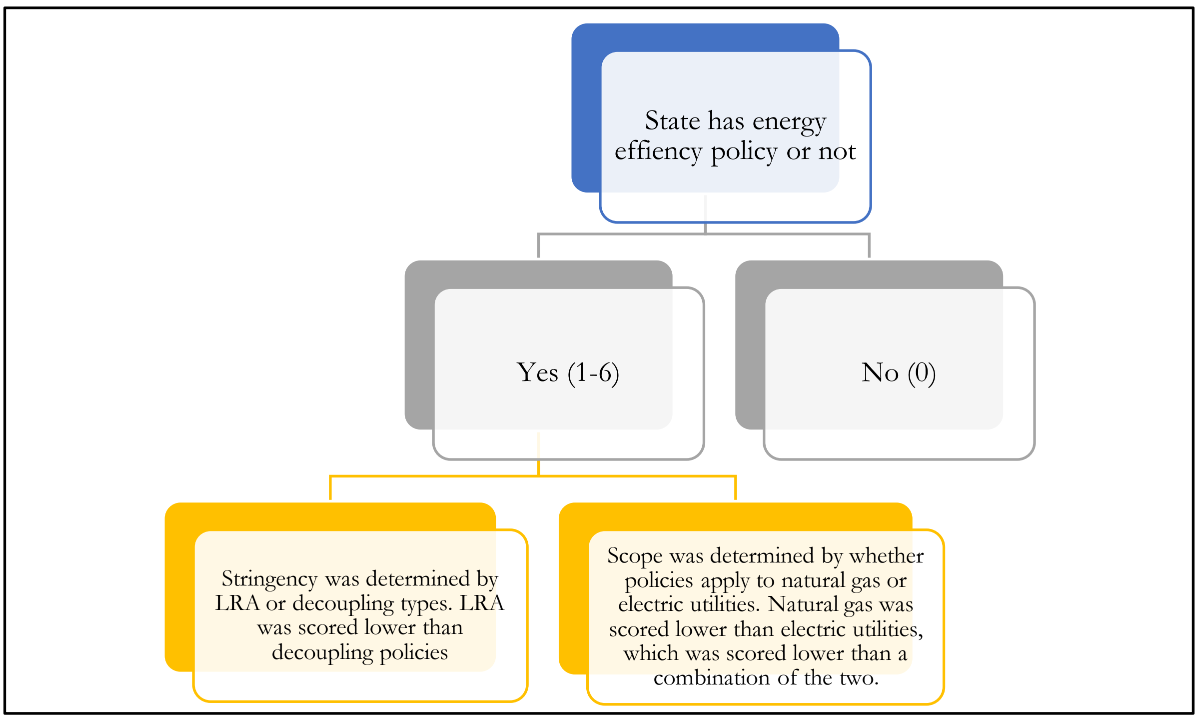

Figure S1. The ordinal scale for energy efficiency policies is based on policy choice and output that measured policy stringency and its scope.

Electricity Sector Portfolio Standards

Electricity sector portfolio standards were introduced with the dual objective of emissions reduction and supporting in-state renewable energy production to reduce the cost of electricity. Clean energy goals/ standards are those that encourage low-carbon electricity generation from all eligible sources, including fossil fuels and are less stringent than renewable energy goals/ standards that exclude fossil fuel-based energy. Instead, they are focused on a broad suite of renewable energy sources including wind, solar, hydro, geothermal, and biomass to encourage reduced reliance on fossil fuels. Alternative fuel goals/standards encourage alternative sources of thermal energy only and include production technologies such as combined heat and power (CHP) and energy-efficient steam technology. Alternative goals/standards encourage reduced reliance on fossil fuels and are, therefore, more stringent than clean energy goals, but less stringent than renewable energy goals/standards. Lastly, a goal is not statutory binding and only signals the intent to achieve a policy benchmark, but a standard is more stringent and is statutorily binding.

For this paper, the states with a goal were scored lower than states with statutory standards in place, and the clean energy goal/standard was scored lower than the alternate goal/standard, which was scored lower than the renewable portfolio goal or standard. Specifically, having no portfolio goal or standard was scored as 0, a clean energy goal was scored as 1, an alternative energy goal was scored as 2, a clean energy portfolio standard (CPS) was scored as 3, an alternative energy portfolio standard (APS) was scored as 4, renewable portfolio standard (RPS) was scored as 5, and a combination of all three, CPS, APS and RPS was scored as 6. The mean score for electricity sector portfolio standards for renewable energy was 2.3, with a standard deviation of 0.7.

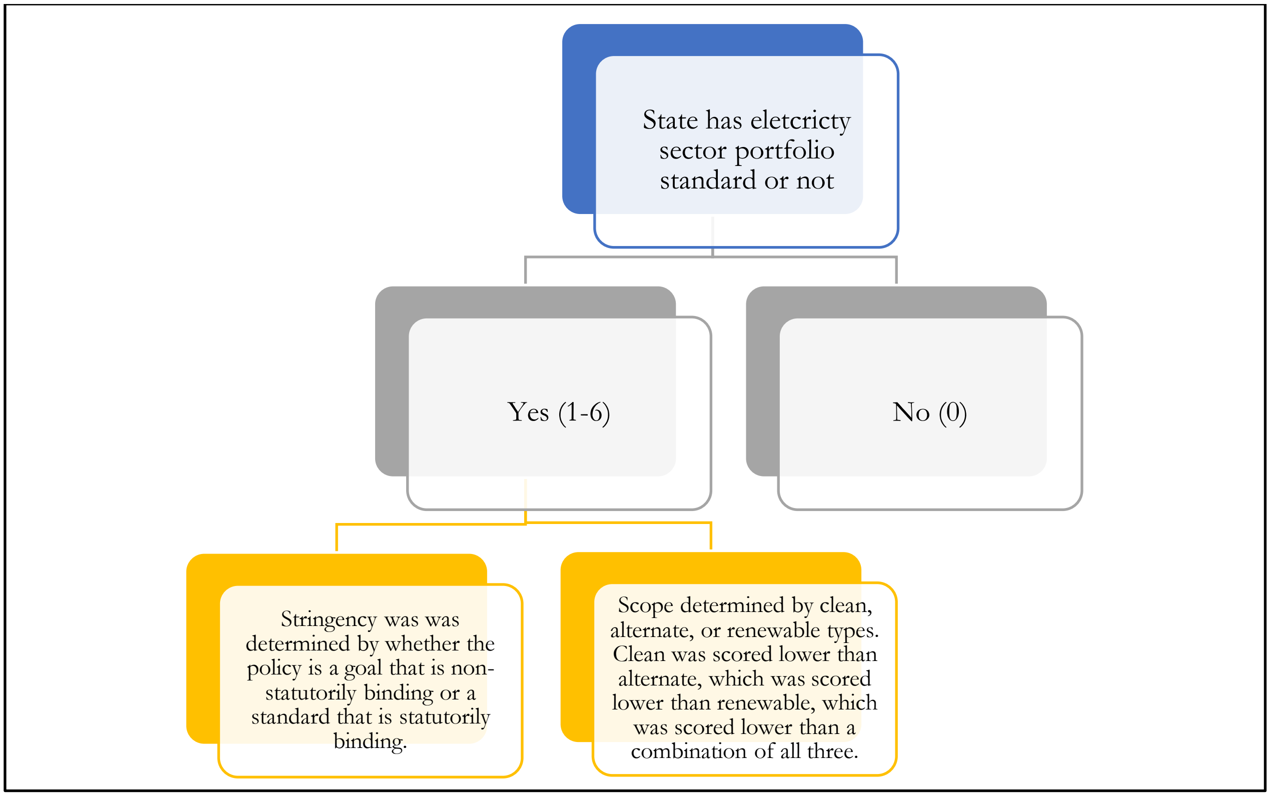

Figure S2. The ordinal scale for electricity sector portfolio standards is based on policy choice and output that measured policy stringency and its scope.

Share of Neighboring States with Energy Efficiency Policies and Portfolio Standards

The stringency of the policy was not considered for this variable, rather the share of neighboring states that have the policy (no-0, yes-1 for each state) was utilized such that the minimum score for each policy area could be 0, i.e., no neighboring state had the policy in place for a given year, and the maximum score for each policy area could be, i.e., all neighboring states have the said policy in place, albeit with varying stringency. The mean share of neighboring states that had energy efficiency policies in place was 0.5, with a standard deviation of 0.2, and the mean share of states that had electricity sector portfolio standards for renewable energy was 0.75, with a standard deviation of 0.1.

Other Explanatory Variables

Data from the Lawrence Berkeley National Laboratory Tracking the Sun database, the National Oceanic and Atmospheric Administration, and the US Energy Information Administration was used for the variables of the solar potential, calculated as the number of days of sunshine each year when solar energy can be harnessed. Further, to control for existing levels of solar energy production, the share of solar energy in the state's electricity mix was included in the analysis. Other energy sector internal determinants included the annual average price of residential electricity in cents per kWh. The data for this variable was sourced from the US Energy Information Administration. The analyses also controlled for other socioeconomic and political variables. These included the share of the population below the Federal Poverty Level in a state for each year from the US Census Bureau. Data on the number of renewable energy interest groups in the state for each year was sourced from the National Center for Charitable Statistics.

Political and policy impact measures were accounted for using executive and legislative control variables at the state level. Executive control was measured as the Governor's party, where a Republican governor was coded as 1, an Independent governor was 2, and a Democratic governor was coded as 3. Legislative control was measured as the party in control of the state Senate and House, wherein Republican control was coded as 1, split control was coded as 2, and Democratic control was coded as 3. Finally, the annual federal spending on renewable energy, measured in millions of USD, in each state was utilized to control for competing effects from vertical diffusion across different levels of the government.

Table S1. Descriptive Statistics of Key Variables

Variable	Unit of Measurement	Mean	Std. Deviation
Time to LMI	Year(s)	9.5	1.5
Efficiency policy	0-6 scale	2.2	1.8
Electricity sector portfolio standards	0-6 scale	2.3	0.7
Solar potential	Days per year	60.3	3.7
Share of solar in electricity	Percentage	0.3	0.1
Average annual electricity bill	USD per year	109.8	14.6
Renewable energy interest groups	Number	76.0	24.0
Share of population living below FPL	Percentage	13.5	2.4
Federal spending on renewable energy	Million USD	19.7	2.3
Governor's party	1-3 scale	1.7	1.3
Legislative control of state legislature	1-3 scale	1.6	1.4
Neighboring states efficiency policy	0-1 scale	0.5	0.2
Neighboring states electricity portfolio standards	0-1 scale	0.7	0.1

Table S2. Results from the Schoenfeld Residuals Diagnostic Test

Variable	Chi-sq. value	Degrees of freedom	P-value
Efficiency policy	1.1509	1	0.28
Electricity sector portfolio standards	2.1750	1	0.14
Solar potential	0.4938	1	0.48
Share of solar in electricity	1.1078	1	0.29
Average annual electricity bill	0.3470	1	0.56
Renewable energy interest groups	0.9323	1	0.33
Share of population living below FPL	1.2930	1	0.26
Federal spending on renewable energy	0.0790	1	0.78
Governor's party	1.3146	1	0.58
Legislative control of state legislature	5.5353	1	0.02
Neighboring states efficiency policy	0.0985	1	0.75
Neighboring states electricity portfolio standards	0.0135	1	0.91
Global	14.4786	12	0.27

Table S3. Results from the Model Specification of Treating Key Independent Variables as a Battery of Dummies[1]

	Dependent variable: Time to LMI adoption
Efficiency policy: LRA for natural gas	-18.544
	(13,048.740)
Efficiency policy: LRA for electricity	-14.790
	(11,771.250)
Efficiency policy: LRA for natural gas and electricity	-0.610
	(0.933)
Efficiency policy: Decoupling for natural gas	0.378
	(1.358)
Efficiency policy: Decoupling for electricity	0.863
	(1.000)
Efficiency policy: Decoupling for natural gas and electricity	0.185
	(0.786)
Portfolio Standard: Clean energy goal	0.708
	(0.654)
Portfolio Standard: Alternative energy goal	1.237
	(1.684)
Portfolio Standard: Clean energy standard	1.399
	(0.255)
Portfolio Standard: Alternative energy standard	3.145*
	(0.066)
Portfolio Standard: Renewable energy portfolio standard	3.243***
	(0.007)
Portfolio Standard: Clean + Alternate + Renewable energy portfolio standard	3.210*
	(0.073)
Solar Potential	-0.109*
	(0.015)
Share of Solar in Energy Mix	-0.201
	(0.974)
Average Annual Electricity Bill	0.029**
	(0.018)
Renewable Energy Interest Groups	0.0002
	(0.957)
Share of Population living below Federal Poverty Level	-0.234*
	(0.065)
Federal Spending on Renewable Energy	0.253
	(0.287)
Governor's Party	0.417
	(0.431)
Legislative Control	0.675
	(0.971)
Neighboring states- Efficiency Policies	0.908
	(0.315)
Neighboring states- Electricity Portfolio Standards	-2.286*
	(0.061)

Observations	406
R^2	0.107
Max. Possible R^2	0.339
Log Likelihood	-61.079
Wald Test	27.990 (df=21)
LR Test	45.775*** (df=21)
Score (Logrank) Test	49.979*** (df=21)
Note:	*p <0.1; **p<0.05; ***p<0.01

1. The baseline category is no energy efficiency policy and no electricity sector portfolio standards, respectively.

Table S4. Results from the Dynamic Logistic Regression

	Dependent variable: Probability of LMI adoption
Efficiency Policy	0.003
	(0.006)
Electricity Sector Portfolio Standards	0.017*
	(0.009)
Solar Potential	-0.003**
	(0.002)
Share of Solar in Energy Mix	2.259
	(51.253)
Average Annual Electricity Bill	0.002***
	(0.012)
Renewable Energy Interest Groups	-0.0001
	(0.0001)
Share of Population living below Federal Poverty Level	-0.008**
	(0.004)
Federal Spending on Renewable Energy	0.002
	(0.003)
Governor's Party	0.011
	(0.014)
Legislative Control	0.017
	(0.008)
Neighboring states- Efficiency Policies	0.019
	(0.046)
Neighboring states- Electricity Portfolio Standards	-0.030*
	(0.018)
Constant	0.036
	(0.162)
Observations	406
R^2	0.083
Adjusted R^2	0.055
F-statistic	35.700***
Note:	*p <0.1; **p<0.05; ***p<0.01