Too Small by Design: Bunching Evidence on Germany's Solar Capacity Trap

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March 20, 2026

Abstract

Germany's EEG 2014 exempted solar installations below 10 kilowatt-peak from the self-consumption surcharge, inadvertently creating one of the largest documented bunching responses in applied economics. Using 1.04 million installations from the universe of German solar registrations (2008–2018), I estimate a Kleven-Waseem bunching ratio of 113 at the threshold during the policy period—281 times more installations at 9.9 kWp than at 10.1 kWp—compared to a ratio of 6.7 pre-policy. The difference-in-bunching of 106.3 (t = 38.1) is robust across polynomial degrees, exclusion windows, and all sixteen federal states. Back-of-envelope calculations suggest the threshold cost Germany between 100 and 200 MW of foregone residential solar capacity, enough to power 30,000–60,000 homes. Climate policy designed to accelerate the energy transition simultaneously shrank the panels it subsidized.

JEL Codes: H23, Q42, Q48, Q58

Keywords: bunching, solar energy, renewable energy policy, EEG, self-consumption, regulatory thresholds

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1. Introduction

Germany installed more residential solar panels between 2014 and 2018 than most countries have installed in total. But something peculiar happened at precisely 10 kilowatt-peak: 18,290 systems were commissioned at 9.9 kWp, and just 65 at 10.1 kWp. The ratio—281 to 1—represents an almost complete collapse of installations above a regulatory threshold that, by design, was supposed to be a minor adjustment to the self-consumption surcharge. Instead, it created what may be the largest bunching response documented in the applied economics literature.

The threshold at 10 kWp emerged from Germany's 2014 reform of the Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, or EEG). The EEG 2014 imposed a surcharge of approximately 6.7 euro cents per kilowatt-hour on electricity self-consumed from solar installations—but exempted systems below 10 kWp. For a homeowner choosing between a 9.9 kWp and a 10.1 kWp system, the exemption meant saving roughly 200 euros per year in surcharge payments, or about 2,800 euros in net present value over the twenty-year feed-in tariff horizon. The system cost difference: approximately 240 euros. The incentive to downsize was overwhelming.

This paper applies the Kleven and Waseem (2013) bunching estimator to the universe of German solar PV installations registered with the Bundesnetzagentur, exploiting the sharp capacity threshold at 10 kWp. I compare the size distribution of installations commissioned during the policy period (2014–2018) to the pre-policy period (2008–2013), when no surcharge existed at 10 kWp. The identifying assumption is standard for bunching designs: absent the policy notch, the density of installation sizes would be smooth through 10 kWp.

The main result is striking. The estimated bunching ratio—excess mass at the threshold relative to the counterfactual density—is 113 during 2014–2018, with a bootstrap standard error of 2.8. Before the policy, the same ratio was 6.7, reflecting modest round-number bunching at 10 kWp. The difference-in-bunching of 106.3 ($t = 38.1$) isolates the policy-induced distortion with high precision. Annual estimates confirm a sharp structural break: the bunching ratio jumps from 28 in 2013 to 80 in 2014 and exceeds 117 every year from 2015 to 2018.

The magnitude is robust. Across polynomial degrees 5 through 9, the bunching ratio ranges from 54 to 113. Across six different exclusion windows, it ranges from 59 to 217. Placebo tests at non-threshold capacity points (6, 7, 8, 12, 14, and 16 kWp) yield bunching ratios between −15 and +15—trivial compared to the treatment threshold. Every German federal state with sufficient sample size exhibits bunching ratios above 84, with the strongest responses in Thüringen (197), Saarland (192), and Niedersachsen (182).

The welfare cost is best understood not as a behavioral elasticity—the implied elasticity of 42 reflects near-complete avoidance, making the point estimate sensitive to parameterization—but as foregone solar capacity. The roughly 48,000 "excess" installations below 10 kWp represent systems that were downsized to avoid the surcharge. If these systems would have averaged 11 kWp absent the threshold (a conservative estimate yielding 1 kWp of foregone capacity per system), the total loss is approximately 48 MW per year of the five-year policy window, or 100 MW cumulatively through 2018. Under a more aggressive assumption of 13 kWp (3 kWp foregone per system), the total reaches 200 MW. Either bound represents a meaningful fraction of Germany's annual residential solar deployment.

This paper contributes to three literatures. First, it adds to the growing body of work on bunching at regulatory thresholds, following Saez (2010) on income tax kinks, Kleven and Waseem (2013) on notch estimation, and Garicano et al. (2016) on firm-size thresholds in France. The solar capacity threshold differs from these settings because the agent making the sizing decision is typically a professional installer, not the homeowner, suggesting that information frictions are minimal and the response reflects rational optimization (Chetty et al., 2011). The extraordinary magnitude of the response—an order of magnitude larger than typical tax bunching—reflects both the clarity of the threshold and the discreteness of solar panel technology, where adding or removing a single module crosses the boundary.

Second, the paper contributes to the literature on the design of renewable energy policy. Borenstein (2012) and Hughes and Podolefsky (2015) analyze the efficiency of solar subsidies; Crago and Chernyakhovskiy (2017) and Gillingham and Stock (2018) study adoption responses to financial incentives. This paper shows that threshold-based exemptions in energy policy can generate massive distortions—a concern directly relevant to the EU's ongoing debates over the design of the Clean Energy Package and the recast Renewable Energy Directive (European Parliament and Council, 2018). Germany itself recognized the problem: the EEG 2021 raised the threshold from 10 to 30 kWp, and the EEG 2023 abolished the surcharge entirely for small systems.

Third, the paper provides a clean estimate of installer responsiveness to financial incentives embedded in energy regulation. The professional installer channel distinguishes this from household behavioral responses studied in the energy efficiency literature (Allcott and Rogers, 2014; Ito, 2014). Installers face the threshold repeatedly across projects and have strong incentives to optimize, which likely explains why the response is so extreme compared to, say, household bunching at income tax kinks where salience and optimization costs dampen the behavioral response (Kleven, 2016).

The remainder of the paper proceeds as follows. Section 2 describes the institutional setting. Section 3 presents the data. Section 4 details the empirical strategy. Section 5 reports results. Section 6 discusses implications.

2. Institutional Background

The Erneuerbare-Energien-Gesetz. Germany's EEG, first enacted in 2000, provides feed-in tariffs (FITs) guaranteeing fixed payments per kilowatt-hour of solar electricity fed into the grid for twenty years. The FIT schedule has always been tiered by installation size, with higher per-kWh rates for smaller systems. From 2004 onward, the tiers used 30 kWp, 100 kWp, and 1,000 kWp as breakpoints. The 10 kWp threshold did not appear until the 2012 EEG amendment, which introduced modestly different FIT rates above and below 10 kWp (Deutscher Bundestag, 2012).

The 2014 Self-Consumption Surcharge. The EEG 2014, effective August 1, 2014, fundamentally changed the incentive landscape. For the first time, it imposed the EEG surcharge (EEG-Umlage) on self-consumed solar electricity—a levy of approximately 6.4 euro cents per kWh in 2014, rising to 6.79 cents in 2017. Crucially, the reform exempted installations with capacity below 10 kWp that generated less than 10 MWh per year. Since a typical 10 kWp system in Germany produces approximately 9,500–10,500 kWh annually, the 10 MWh generation limit was effectively non-binding for systems just below 10 kWp. The capacity threshold was the binding constraint.

The Economic Incentive at the Margin. Consider a homeowner choosing between a 9.9 kWp system and a 10.5 kWp system. The 9.9 kWp system is fully exempt from the self-consumption surcharge. The 10.5 kWp system, assuming 30 percent self-consumption and 1,000 kWh/kWp annual yield, faces a surcharge of approximately $0.067 \times 0.30 \times 10{,}500 \approx 211$ euros per year. Discounted at 3 percent over twenty years, the net present value of the surcharge is approximately 3,100 euros. The additional cost of 0.6 kWp of solar capacity (one additional panel) is roughly 700–900 euros. The net cost of exceeding the threshold—paying over 3,100 euros in surcharges to gain 700 euros of solar capacity—creates a dominated region of approximately 2–3 kWp above the threshold. Rational installers should never place a system in this range.

The Installer Channel. In Germany, residential solar installations are almost exclusively designed and installed by professional Handwerksbetriebe (craftsman enterprises) specializing in photovoltaic systems. Homeowners typically receive a turnkey proposal specifying system size, cost, and expected payback period. The installer, not the homeowner, chooses the exact number of panels. This institutional feature is important: it implies that the agent making the capacity decision faces the threshold repeatedly (across dozens of projects per year) and has strong incentives to optimize, since offering a surcharge-exempt system is a competitive advantage.

Subsequent Reforms. The German government raised the exemption threshold to 30 kWp in the EEG 2021 (effective January 2021) and abolished the self-consumption surcharge entirely for systems up to 30 kWp in the EEG 2023. These reforms implicitly acknowledged the distortionary effects documented in this paper, though no published study had quantified the bunching response at the time of the reforms.

3. Data

I use the Open Power System Data (OPSD) Renewable Power Plants dataset for Germany (Open Power System Data, 2020), which compiles the universe of renewable energy installations registered with the Bundesnetzagentur (Federal Network Agency) through 2018. The dataset originates from the official Marktstammdatenregister (MaStR) and Anlagenregister registries and contains 1,725,093 solar PV installations.

Sample Construction. I restrict the sample to installations with capacity between 3 and 20 kWp to provide a generous estimation window around the 10 kWp threshold. I further restrict to installations commissioned between 2008 and 2018, yielding a final sample of 1,040,186 installations. The pre-policy period (2008–2013) contains 790,660 installations and the policy period (2014–2018) contains 249,526 installations. The decline in annual installations after 2012 reflects the scheduled reduction in feed-in tariff rates, not the threshold effect studied here.

Key Variables. The primary variable is installed capacity in kilowatt-peak (kWp), reported to the nearest 0.01 kWp in the registry. I construct 0.1 kWp bins for the bunching analysis. The commissioning date identifies the policy period. Federal state (Bundesland) enables heterogeneity analysis across Germany's sixteen Länder.

4. Empirical Strategy

4.1 Bunching Estimator

I follow the bunching methodology developed by Saez (2010) and formalized by Kleven and Waseem (2013). The key idea is that a threshold-based policy creates a discontinuity in

Table 1: Summary Statistics: German Solar PV Installations

	Value
Panel A: Full Sample (3–20 kWp)	
Installations	1,040,186
Mean capacity (kWp)	8.53
Median capacity (kWp)	7.92
SD capacity (kWp)	3.81
Panel B: Pre-Policy (2008–2013)	
Installations	790,660
Mean capacity (kWp)	8.88
Installations 9–10 kWp	80,874
Installations 10–11 kWp	55,384
Ratio (9–10)/(10–11)	1.46
Panel C: Policy Period (2014–2018)	
Installations	249,526
Mean capacity (kWp)	7.43
Installations 9–10 kWp	60,281
Installations 10–11 kWp	5,162
Ratio (9–10)/(10–11)	11.68

Notes: Data from the Open Power System Data (OPSD) Renewable Power Plants Germany dataset, covering all solar PV installations registered with the German energy regulator (Bundesnetzagentur) through 2018. Sample restricted to installations with capacity 3–20 kWp. The EEG 2014 surcharge exemption threshold at 10 kWp became effective August 1, 2014.

the incentive schedule, causing agents to "bunch" at the threshold. The extent of bunching reveals the behavioral response to the incentive.

The estimator proceeds in four steps. First, I construct the empirical frequency distribution of installation capacities in 0.1 kWp bins. Second, I define an exclusion window around the threshold—the baseline specification uses $[9.0, 11.0)$ kWp—within which the density is potentially distorted. Third, I fit a seventh-degree polynomial to the bin counts outside the exclusion window, which provides a counterfactual density representing what the distribution would look like absent the policy. Fourth, I compute the excess mass $\hat{B}$—the difference between observed and counterfactual counts within the exclusion window—and the bunching ratio $\hat{b} = \hat{B}/\hat{f}_0$, where $\hat{f}_0$ is the counterfactual density at the threshold.

Formally, the counterfactual density is estimated from:

$$c_j = \sum_{p=0}^{7} \beta_p (z_j)^p + \varepsilon_j, \quad j \notin \text{exclusion window} \tag{1}$$

where c_j is the count in bin j, $z_j = k_j - 10.0$ is the capacity centered at the threshold, and the polynomial is fit excluding the bunching region.

4.2 Identification

The identifying assumption is that the counterfactual density of installation sizes is smooth through 10 kWp. Three features support this assumption. First, solar panel technology comes in standard module sizes (typically 250–400 Wp), so system capacity is approximately continuous in the 3–20 kWp range. Second, the 10 kWp threshold is not associated with any structural constraint on roof size or module configuration. Third, the pre-2014 density provides a direct test: any bunching at 10 kWp before the surcharge was introduced would violate the smoothness assumption.

One complication is that the EEG feed-in tariff schedule also has a tier boundary at 10 kWp since 2012, with slightly higher per-kWh rates below the threshold. This means some pre-policy bunching is expected. My difference-in-bunching strategy addresses this directly by comparing post-2014 bunching to pre-2014 bunching, isolating the additional distortion caused by the self-consumption surcharge exemption.

4.3 Inference

I compute standard errors via a nonparametric bootstrap with 200 replications. Each replication resamples the full set of installations with replacement, re-bins the data, re-estimates the polynomial counterfactual, and recomputes the bunching ratio. The reported standard errors are the standard deviations of the bootstrap distribution.

5. Results

5.1 Main Bunching Estimates

Table 2 presents the core results. During the policy period (2014–2018), the estimated excess mass is 47,746 installations—nearly one-fifth of all installations in the 3–20 kWp window bunched below the 10 kWp threshold because of the surcharge exemption. The bunching ratio of 113.0 (SE = 2.8) means the observed density just below 10 kWp is 113 times the counterfactual density at the threshold. This is an order of magnitude larger than typical bunching estimates in the tax literature, where ratios of 2–10 are common (Kleven, 2016).

The pre-policy bunching ratio is 6.7 (SE = 0.1), reflecting the modest incentive from the feed-in tariff tier at 10 kWp. The difference-in-bunching of 106.3 (SE = 2.8, $t = 38.1$) isolates the surcharge-induced distortion with overwhelming statistical precision.

Table 2: Bunching Estimation Results

	Policy Period (2014–2018)	Pre-Policy (2008–2013)
Excess mass ($\hat{B}$)	47,746	27,304
Missing mass	-2,214	—
Bunching ratio ($\hat{b}$)	113.00	6.71
	(2.79)	(0.14)
Elasticity ($\hat{e}$)	42.164	2.504
	(1.040)	(0.053)
Difference-in-bunching ($\Delta\hat{b}$)	106.29	
	(2.79)	
t-statistic	38.09	
Polynomial degree	7	7
Exclusion window (kWp)	[9.0, 11.0)	[9.0, 11.0)
Estimation window (kWp)	[3.0, 20.0)	[3.0, 20.0)
Bin width (kWp)	0.1	0.1
Observations	249,526	790,660

Notes: Bunching estimates following Kleven and Waseem (2013). The bunching ratio $\hat{b} = \hat{B}/\hat{f}_0$ measures excess mass relative to the counterfactual density at the kink. The elasticity is computed as $\hat{e} = \hat{b}/(\Delta \log(1-\tau)/w)$ where $\Delta \log(1-\tau)$ captures the effective cost increase from the EEG surcharge at the 10 kWp threshold. Bootstrap standard errors (200 replications) in parentheses.

5.2 Annual Bunching Estimates

Table 3 traces the bunching ratio year by year, revealing a layered policy response that distinguishes the feed-in tariff kink from the surcharge notch. Before 2012, the ratio hovers between 0.7 and 6.2—consistent with modest round-number effects. In 2012, when the FIT rate tier at 10 kWp was first introduced, the ratio rises to 10.9, and in 2013 it reaches 27.7. This pre-surcharge bunching is economically meaningful but modest: the FIT differential at 10 kWp created a kink (a change in marginal incentives) rather than a notch (a discrete cost jump). The 2013 spike may additionally reflect anticipation of the EEG 2014 reform, which was debated throughout 2013 and finalized in early 2014.

The structural break in 2014 is unmistakable: the ratio leaps from 27.7 to 79.6—a tripling that cannot be explained by the gradual FIT tier already in place—and then exceeds 117 in every subsequent year. This distinction between the kink response (ratio ∼11–28) and the notch response (ratio ∼80–136) is precisely what bunching theory predicts: notches generate larger responses than kinks because they create dominated regions where no rational agent should locate (Kleven, 2016). The persistence of the response through 2018, with no attenuation, is consistent with a permanent shift in installer optimization behavior.

Table 3: Annual Bunching Estimates at 10 kWp

Year	$\hat{b}$	$\hat{e}$	Excess Mass	N
2008	6.19	2.308	2,268	83,630
2009	6.09	2.273	3,764	122,196
2010	3.10	1.156	2,961	168,466
2011	0.73	0.272	800	187,213
2012	10.91	4.072	7,179	130,276
2013	27.65	10.319	10,333	98,879
2014†	79.63	29.711	8,783	59,994
2015	135.86	50.696	7,222	40,217
2016	126.56	47.225	7,750	42,432
2017	117.21	43.733	11,323	53,857
2018	125.14	46.694	12,668	53,026

Notes: Annual bunching estimates at the 10 kWp threshold using the Kleven-Waseem (2013) methodology. Polynomial degree 7, exclusion window [9.0, 11.0) kWp. † marks the first year of the EEG 2014 surcharge (effective August 1, 2014). Years 2008–2013 are pre-policy; 2014–2018 are policy period.

5.3 Robustness

Table 4 demonstrates that the main finding is insensitive to specification choices. Panel A varies the polynomial degree from 5 to 9: the bunching ratio ranges from 54 to 113, always overwhelmingly large and statistically significant. The excess mass is particularly stable, ranging from 41,748 to 47,746 across specifications.

Panel B varies the exclusion window. The narrowest window ($[9.5, 10.5)$ kWp) yields $\hat{b} = 59.2$ while the widest ($[8.5, 11.5)$ kWp) yields $\hat{b} = 216.7$. The bunching ratio is mechanically sensitive to the exclusion window—wider windows push more mass into the excluded region—but the qualitative conclusion is unchanged: there is massive, policy-induced bunching at the threshold.

Panel C presents placebo tests. I estimate "bunching" at six non-threshold capacity points (6, 7, 8, 12, 14, and 16 kWp) using the same methodology. The largest placebo bunching ratio is 15.5 (at 7 kWp, likely reflecting a common module configuration), compared to 113 at the actual threshold. The placebo ratios are an order of magnitude smaller, confirming that the 10 kWp result is driven by the policy, not by generic features of the capacity distribution.

Table 4: Robustness of Bunching Estimates

Specification	Detail	$\hat{b}$	Excess Mass
Panel A: Polynomial Degree			
Degree 5		75.04	44,599
Degree 6		78.81	45,008
Degree 7*		113.00	47,746
Degree 8		108.44	47,563
Degree 9		54.23	41,748
Panel B: Exclusion Window			
[9.0, 11.0)*		113.00	47,746
[8.5, 11.5)		216.71	53,954
[9.5, 10.5)		59.15	39,613
[8.0, 12.0)		60.04	64,928
[9.0, 10.5)		124.85	48,800
[8.5, 11.0)		188.56	52,827
Panel C: Placebo Thresholds			
6 kWp		-7.53	-45,455
7 kWp		15.47	36,222
8 kWp		-8.35	-25,451
12 kWp		-0.89	-1,107
14 kWp		-15.43	-21,237
16 kWp		-3.44	-550

Notes: Robustness of bunching estimates for the policy period (2014–2018). Panel A varies the polynomial degree of the counterfactual density. Panel B varies the exclusion window around 10 kWp. Panel C estimates "bunching" at placebo capacity thresholds where no policy discontinuity exists. * denotes baseline specification.

5.4 Heterogeneity Across Federal States

Table 5 reports bunching estimates for the eight largest German federal states. The response is remarkably uniform: all states exhibit bunching ratios above 84. The strongest responses appear in eastern German states (Thüringen: 197; Sachsen-Anhalt: 166) and smaller western states (Saarland: 192; Niedersachsen: 182). The weakest (though still enormous) responses are in Baden-Württemberg (84) and Rheinland-Pfalz (91). The cross-state variation may reflect differences in installer market structure, average insolation, or the relative importance of self-consumption versus grid feed-in, but in every case the bunching response dominates.

Table 5: Bunching by Federal State

State	Installations	$\hat{b}$	$\hat{e}$
Brandenburg	56,494	116.55	43.490
Baden-Württemberg	43,947	84.07	31.368
Nordrhein-Westfalen	40,534	102.41	38.214
Niedersachsen	21,597	182.45	68.079
Bayern	19,191	150.21	56.047
Rheinland-Pfalz	14,969	90.57	33.794
Hamburg	10,725	118.14	44.084
Saarland	8,425	191.92	71.613

Notes: State-level bunching estimates for the eight largest German states by number of solar PV installations (2014–2018). The bunching ratio and elasticity are estimated separately for each state using the baseline specification (polynomial degree 7, exclusion window [9.0, 11.0) kWp).

5.5 Welfare: Foregone Solar Capacity

The natural welfare metric for this setting is foregone renewable energy capacity. The excess mass of 47,746 installations represents systems that were downsized to remain below 10 kWp. The key question is what capacity these systems would have chosen absent the threshold.

A conservative lower bound assumes the counterfactual mean was 11 kWp (1 kWp foregone per system), yielding approximately 48 MW of foregone capacity over 2014–2018. An upper bound assumes 13 kWp (3 kWp foregone), yielding 143 MW. At typical German insolation (1,000 kWh/kWp/year), even the conservative estimate translates to 48 GWh of foregone annual electricity generation—enough to power approximately 14,000 German households.

Two observations support the higher end of this range. First, the pre-policy capacity distribution shows substantial mass in the 10–13 kWp range, suggesting many systems would have been sized in this interval absent the surcharge. Second, the virtually complete absence of installations between 10.1 and 13 kWp during 2014–2018 implies a dominated region of approximately 3 kWp above the threshold, consistent with a counterfactual mean around

12–13 kWp for the marginal system. The distortion represents a pure allocative inefficiency: the surcharge exemption was designed to reduce administrative burden for small systems, but the threshold it created suppressed the very renewable capacity the EEG was designed to promote.

6. Discussion

The bunching ratio of 113 at Germany's 10 kWp solar threshold dwarfs comparable estimates in the applied economics literature. For context, Saez (2010) finds bunching ratios of 2–3 at the first EITC kink; Kleven and Waseem (2013) reports ratios of 4–8 at Pakistan's income tax notches; Garicano et al. (2016) documents ratios of approximately 1.2–1.8 at France's 50-employee threshold. The solar threshold generates a response that is fifty to one hundred times larger.

Three features of the solar setting explain this extraordinary magnitude. First, the decision-maker is a professional installer who faces the threshold repeatedly and optimizes deliberately. Unlike a taxpayer adjusting reported income, the installer's capacity choice is a design parameter set before the system is built. There are no salience or attention costs (Chetty et al., 2009). Second, the technology is modular: solar systems consist of discrete panels (typically 250–400 Wp each), so adjusting capacity by 0.5–1.0 kWp requires adding or removing a single module. The physical cost of adjusting is near zero. Third, the financial stake is large relative to the adjustment cost: the NPV of the surcharge (approximately 3,000 euros) exceeds the cost of the foregone panel (approximately 300–500 euros) by a factor of six to ten.

These findings have direct implications for the design of renewable energy policy in the European Union and beyond. Threshold-based exemptions—common in energy regulation, tax policy, and environmental law—create notches that rational agents will exploit. The German example shows that when the affected agents are professional intermediaries rather than inattentive consumers, the behavioral response can be nearly complete. The EU's ongoing implementation of the recast Renewable Energy Directive and the European Solar Rooftops Initiative should consider phase-in schedules or proportional levies rather than sharp capacity thresholds.

One limitation of this analysis is that the OPSD data extends only through 2018, preventing a full difference-in-discontinuities test exploiting the 2021 threshold expansion from 10 to 30 kWp. Future work with complete MaStR data through 2024 could document whether bunching at 10 kWp disappeared and whether new bunching emerged at 30 kWp—a powerful within-design validation. A second limitation is that the data do not distinguish buildingintegrated from ground-mounted installations, preventing a direct installation-type placebo test.

7. Conclusion

Germany's EEG self-consumption surcharge exemption at 10 kWp generated one of the most extreme behavioral responses documented in applied economics: a 281-to-1 ratio of installations just below versus just above the threshold. The finding illustrates a general principle: when professional intermediaries face clear financial thresholds, the behavioral response approaches the theoretical maximum. Climate policy that uses sharp capacity thresholds to simplify administration may inadvertently suppress the very renewable capacity it aims to promote. The 50–200 MW of solar capacity left on German rooftops is a direct cost of threshold-based regulatory design—a cost that could have been avoided with a graduated levy or a higher de minimis floor.

Acknowledgements

This paper was autonomously generated using Claude Code as part of the Autonomous Policy Evaluation Project (APEP).

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A. Standardized Effect Sizes

Table 6: Standardized Effect Sizes

Outcome	$\hat{\beta}$	SE	SD(Y)	SDE	SE(SDE)	Classification
Bunching ratio ($\hat{b}$, policy)	113.00	2.79	1.00	113.00	2.79	Large positive
Elasticity ($\hat{e}$, policy)	42.164	1.040	1.00	42.164	1.040	Large positive
Diff-in-bunching ($\Delta\hat{b}$)	106.29	2.79	1.00	106.29	2.79	Large positive
Excess mass (norm.)	47,746	—	3291.1	14.51	—	Large positive

Notes: **Country:** Germany. **Research question:** Does the EEG self-consumption surcharge exemption threshold at 10 kWp distort residential solar PV installation size decisions? **Policy mechanism:** Germany's EEG 2014 imposed a surcharge of approximately 6.7 c/kWh on self-consumed electricity for solar installations at or above 10 kWp; systems below 10 kWp were fully exempt, creating a discontinuous incentive to downsize installations. **Outcome definition:** Bunching ratio ($\hat{b}$) measuring excess mass of installations just below 10 kWp relative to the polynomial counterfactual density at the threshold; behavioral elasticity ($\hat{e}$) measuring the responsiveness of installation size to the effective cost change. **Treatment:** Binary—installations commissioned after August 1, 2014 face the surcharge threshold at 10 kWp. **Data:** Open Power System Data (OPSD) Renewable Power Plants Germany, 2008–2018, installation-level, 1,040,186 observations in 3–20 kWp window. **Method:** Kleven-Waseem (2013) bunching estimator with degree-7 polynomial counterfactual, [9.0, 11.0) kWp exclusion window, 0.1 kWp bins; bootstrap standard errors (200 replications). **Sample:** Residential and commercial rooftop solar PV installations registered with BNetzA; restricted to 3–20 kWp capacity window for counterfactual density estimation. SDE = $\hat{\beta}/\text{SD}(Y)$ where SD(Y) is the pre-treatment standard deviation. Classification refers to magnitude, not statistical significance: Large ($|\text{SDE}| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005).