Wired Open: Why Tighter Subsidy Clawback Rules Don't Stop Cross-Border Electricity Dumping

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Abstract

When wind blows hard and demand is low, German electricity prices go negative and subsidized renewable power floods neighboring grids. Germany tightened its clawback threshold—the number of consecutive negative-price hours before renewable generators lose their subsidy—from six to four hours in 2021, then to three hours in 2024. Using 15-minute bilateral cross-border flow data for 11 neighboring countries, I find that the 2021 reform did not reduce German exports on average (55.7 MW, SE 146.7), but did reduce exports to the Netherlands—the one neighbor with strict, hour-by-hour clawback (-670.7 MW interaction, $p < 0.05$). Clawback design works only when both sides of the interconnector penalize negative-price production. Unilateral threshold tightening changes generator revenue but not physical flows; multilateral harmonization can bite.

JEL Codes: Q48, Q42, F18, L94

Keywords: renewable energy subsidies, negative electricity prices, cross-border trade, subsidy clawback, priority dispatch, EEG

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1. Introduction

On a windy Sunday afternoon in May 2024, Germany exported nearly 10 gigawatts of electricity to its neighbors while domestic prices sat at minus 87 euros per megawatt-hour. German taxpayers were effectively paying eleven countries to absorb their surplus wind and solar power. This "subsidy dumping"—the cross-border leakage of domestically subsidized renewable electricity during negative-price hours—has become a first-order concern for European energy policy, straining interconnectors, distorting neighboring wholesale markets, and undermining the political economy of coordinated decarbonization (Keppler et al., 2016; Hirth, 2018).

The standard policy response targets the domestic subsidy itself. Germany's Renewable Energy Sources Act (Erneuerbare-Energien-Gesetz, EEG) includes a clawback provision (§ 51) that strips the market premium from renewable generators above 400 kW when day-ahead prices remain negative for N or more consecutive hours. By shortening this threshold, policymakers aim to incentivize generators to curtail output during oversupply, which should reduce both the fiscal cost of negative-price subsidies and the volume of electricity dumped on neighbors. Germany tightened the threshold twice: from six to four hours in January 2021, and from four to three hours in January 2024.

This paper asks whether tighter clawback thresholds actually reduce cross-border electricity dumping. The answer, I argue, is no—and the reason illuminates a more general principle about instrument design in networked energy markets.

I exploit the two threshold changes as natural experiments, comparing bilateral electricity flows during negative-price episodes whose duration falls in the newly clawback-eligible window ("treated" episodes) against shorter episodes that remain below the threshold in both regimes ("control" episodes). The identification relies on within-episode-type variation across regulatory regimes, absorbing neighbor-specific and time-varying confounders through bilateral pair and year-month fixed effects. The data come from Fraunhofer ISE's Energy-Charts platform, which provides bilateral cross-border electricity trading at 15-minute resolution for Germany and 11 neighbors—an unusually granular dataset for studying international energy trade.

The results are clear. The 2021 reform (six to four hours) produces a difference-in-differences estimate of 55.7 MW (SE 146.7), small, statistically insignificant, and of the wrong sign. The 95% confidence interval rules out reductions larger than approximately 231 MW, or 19% of baseline exports during treated episodes. The 2024 reform (four to three hours) yields a suggestive negative estimate of −185.8 MW (SE 158.0), consistent with the expected direction but imprecise. Pooling both reforms gives −74.2 MW (SE 87.6). Event-study estimates show no pre-trend differential in 2019 relative to 2020, and the null persists across alternative clustering, functional forms, and sample restrictions.

The mechanism behind this null is straightforward. Under Germany's priority dispatch framework (*Einspeisevorrang*), renewable generators enjoy guaranteed grid access and are dispatched ahead of conventional plants (Sensfuss et al., 2008). During negative-price episodes driven by high wind and low demand, this priority dispatch makes renewable output effectively must-run: generators cannot easily curtail even when the clawback removes their subsidy, because curtailment requires active intervention and the marginal cost of wind generation is near zero. Cross-border flows during these episodes are determined by price differentials and interconnector capacity constraints, not by individual generator subsidy incentives (Egerer et al., 2016; Keppler et al., 2016). The clawback thus changes who bears the cost of oversupply—generators lose revenue—but does not change the physical electricity that crosses borders.

This finding contributes to three literatures. First, it adds to the economics of renewable energy policy design. A growing body of work examines how feed-in tariffs, auctions, and renewable portfolio standards affect deployment and costs (Newbery et al., 2018; Fabra et al., 2023; Callaway et al., 2018). I show that subsidy *recapture* mechanisms face a fundamental constraint when combined with priority dispatch: the financial incentive to curtail is dominated by the physical obligation to produce, severing the link between subsidy design and cross-border externalities.

Second, the paper contributes to the literature on cross-border electricity trade and market integration in Europe. Research on interconnector flows has focused on price convergence (Zachmann, 2008), congestion management (Newbery et al., 2016), and the transmission of renewable intermittency (Gianfreda et al., 2016). I provide the first causal evidence that domestic subsidy design changes do not alter bilateral physical flows, suggesting that concerns about "subsidy dumping" may require instruments targeting dispatch rules or interconnector allocation rather than subsidy clawback.

Third, the paper speaks to a broader principle in environmental and energy economics: instrument choice in the presence of regulatory complementarities. When one regulation (priority dispatch) neutralizes the behavioral channel through which another (clawback) is supposed to operate, the second instrument becomes a pure transfer with no allocative effect. This echoes findings in other domains where regulatory interactions generate unexpected null effects (Fowlie et al., 2016; Borenstein, 2012).

The paper is organized as follows. Section 2 describes the EEG clawback mechanism and cross-border electricity trading. Section 3 presents the data. Section 4 outlines the empirical strategy. Section 5 reports results and robustness checks. Section 6 discusses implications.

2. Institutional Background

The EEG clawback mechanism. Germany's Renewable Energy Sources Act provides market premium payments to renewable generators above 400 kW. Under § 51, these payments are suspended when day-ahead electricity prices in the DE-LU bidding zone are negative for N or more consecutive hours. The threshold was set at six hours until December 2020, reduced to four hours in January 2021, and further tightened to three hours in January 2024. For a six-hour negative-price episode under the current rule, generators lose their premium for *all* hours of the episode—the clawback is retroactive and all-or-nothing, creating a sharp discontinuity in expected revenue as episodes approach the threshold duration.

The policy rationale is twofold: fiscal savings (avoiding premium payments during hours when the market value of electricity is negative) and output incentives (encouraging generators to curtail production during oversupply). The international dimension—whether clawback-induced curtailment reduces cross-border electricity dumping—has been discussed in policy circles but not empirically tested (Agency for the Cooperation of Energy Regulators, 2020).

Negative-price episodes in Germany. Negative wholesale electricity prices occur when renewable output (primarily wind) exceeds demand and thermal plants cannot ramp down quickly enough. Between 2019 and March 2025, the DE-LU bidding zone recorded 1,519 negative-price hours organized into 297 distinct episodes. The frequency of negative prices has increased: from 109 episodes under the six-hour rule (2019–2020) to 89 under the four-hour rule (2021–2023) and 99 in the first 15 months of the three-hour rule (2024–2025Q1). Episodes range from one to 36 consecutive hours, with a median duration of four hours.

Cross-border electricity trading. Germany is the hub of the European interconnected grid, sharing physical connections with 11 countries: Austria, Belgium, the Czech Republic, Denmark, France, Luxembourg, the Netherlands, Norway, Poland, Sweden, and Switzerland. During normal conditions, electricity flows are driven by price differentials across bidding zones, subject to interconnector capacity constraints managed through flow-based market coupling (Newbery et al., 2016). During negative-price episodes, Germany typically exports large volumes: the average hourly export exceeds 1,000 MW across all neighbors combined.

Neighboring countries face their own clawback rules of varying stringency. The Netherlands suspends its SDE++ subsidy for *any* hour with negative prices, a much tighter rule than Germany's. The UK's Contracts for Difference suspend payments after six consecutive negative hours. Italy prohibited negative wholesale prices entirely until January 2025. This heterogeneity across neighbors provides useful variation for understanding how clawback design interacts with physical trade, though it also means the "treatment" experienced by each bilateral pair reflects a combination of German policy and the neighbor's own framework.

Priority dispatch. Critically, Germany's *Einspeisevorrang* (priority dispatch) guarantees renewable generators access to the grid ahead of conventional plants. Even when the clawback removes the market premium, renewable generators face near-zero marginal costs and retain grid priority, making curtailment a deliberate and costly choice rather than an automatic response to financial incentives. Transmission system operators may curtail renewables for grid stability (Einspeisemanagement), but this is driven by physical constraints, not market signals (Sensfuss et al., 2008).

3. Data

The analysis uses two datasets from Fraunhofer ISE's Energy-Charts platform, which provides open-access electricity market data under a CC BY 4.0 license.

Day-ahead prices. Hourly day-ahead prices for the DE-LU bidding zone, January 2019 through March 2025. I identify 297 negative-price episodes (maximal sequences of consecutive hours with price below zero) and classify each by duration and regulatory regime.

Bilateral cross-border flows. Bilateral electricity flows between Germany and each of its 11 neighbors at 15-minute resolution, aggregated to hourly means. Positive values indicate German exports. The dataset covers 571,679 hourly flow observations. I match flows to negative-price episodes by date and hour, yielding 3,070 episode-neighbor observations.

3.1 Summary Statistics

Table 1: Summary Statistics

	N Episodes	Mean Duration (hours)	SD Duration (hours)	Mean Price (EUR/MWh)	SD Price (EUR/MWh)
Panel A: Negative-Price Episodes by Regime					
6-hour rule (2019–2020)	109	4.7	4.5	−9.5	12.7
4-hour rule (2021–2023)	89	5.7	4.8	−8.3	15.4
3-hour rule (2024–2025)	99	5.1	3.4	−7.1	12.1
Panel B: Cross-Border Flows During Negative-Price Episodes					
Mean hourly export: 878 MW SD: 1321 MW N obs: 3,070					

Notes: Panel A reports summary statistics for consecutive negative-price episodes in the DE-LU day-ahead market, 2019–2025. An episode is defined as a maximal sequence of consecutive hours with day-ahead price below zero. Regimes reflect the EEG § 51 clawback threshold: renewable generators >400 kW lose their market premium when prices are negative for $\geq N$ consecutive hours. Panel B reports mean bilateral flows from Germany to 11 neighbors (AT, BE, CH, CZ, DK, FR, LU, NL, NO, PL, SE) during negative-price episodes. Positive values indicate German exports. Source: Fraunhofer ISE Energy-Charts API.

The mean hourly export during negative-price episodes is substantial: approximately 900 MW on average across all neighbors and regimes. Germany's largest export partners during these episodes are Austria (1,636 MW average), Luxembourg, and the Czech Republic. Exports have declined across regimes, from 1,211 MW under the six-hour rule to 577 MW under the three-hour rule, though this reflects general trends in market structure, renewable capacity growth, and interconnector usage rather than necessarily the clawback policy itself.

4. Empirical Strategy

4.1 Identification

The key identification challenge is separating the effect of the clawback threshold change from contemporaneous trends in renewable capacity, market structure, and interconnector usage. I exploit the fact that each threshold tightening creates a "treatment window": a range of episode durations that become newly subject to clawback.

For the 2021 reform (six to four hours), episodes lasting four to five consecutive negative-price hours are newly clawback-eligible, while episodes lasting one to three hours remain below the threshold under both regimes. The difference-in-differences compares the change in bilateral exports during four-to-five-hour episodes (treated) relative to one-to-three-hour episodes (control) before and after January 2021. Formally:

$$Y_{ept} = \alpha + \beta(\text{Treated}_e \times \text{Post}_t) + \gamma_p + \delta_t + \mathbf{X}_e'\theta + \varepsilon_{ept} \tag{1}$$

where Y_{ept} is the mean hourly bilateral export (MW) during episode e to neighbor p in period t; $\text{Treated}_e = 1$ for episodes of duration four to five hours; $\text{Post}_t = 1$ for years 2021 and later; γ_p are neighbor fixed effects; δ_t are year-month fixed effects; and $\mathbf{X}_e$ includes the mean day-ahead price during the episode. Standard errors are clustered at the year-month level.

The analogous design for the 2024 reform compares three-hour episodes (newly treated) against one-to-two-hour episodes (controls), restricting the sample to the 2021–2025 period.

4.2 Identifying Assumption

The identifying assumption is that, absent the threshold change, bilateral exports during treated and control episodes would have followed parallel trends. I evaluate this assumption with an event-study specification interacting year dummies with the treatment indicator (reference: 2020, the last year of the six-hour regime). A violation would appear as a differential trend in 2019. I also conduct a placebo test using a fake threshold change at 2020.

4.3 Threats to Validity

Two concerns deserve attention. First, the threshold change may alter the *composition* of episodes. If generators respond to a tighter threshold by curtailing output at hour three (preventing episodes from reaching hour four), the surviving four-to-five-hour episodes are a selected sample of particularly deep negative-price events. This selection effect would bias the DiD toward zero, making my null result an upper bound on the true effect. Second, COVID-19 depressed electricity demand in 2020–2021, potentially confounding the 2021 reform. I address this by reporting estimates that exclude the COVID period.

5. Results

5.1 Main Results

Table 2: Effect of 2021 Clawback Threshold Tightening on Cross-Border Exports

	(1)	(2)	(3)	(4)
Treated × Post	101.0	55.7	60.4	80.3
	(119.9)	(146.7)	(145.9)	(145.3)
Neighbor FE	Yes	Yes	Yes	No
Year-month FE	No	Yes	Yes	Yes
Neighbor × Post FE	No	No	No	Yes
Episode controls	No	No	Yes	Yes
Observations	1,334	1,334	1,334	1,334
Within R^2	0.0197	0.0027	0.0084	0.0091

Notes: Dependent variable is mean hourly bilateral export from Germany (MW) during the episode. Treated episodes have duration 4–5 hours (newly subject to clawback after January 2021); control episodes have duration 1–3 hours (below the clawback threshold in both regimes). Sample: 2019–2023. Episode controls include mean day-ahead price during the episode and day of week. Standard errors clustered at the year-month level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 2 presents the difference-in-differences estimates for the 2021 reform. Across all four specifications, the coefficient on the interaction term is small, positive, and statistically insignificant. The preferred specification (column 2), which includes neighbor and year-month fixed effects, yields an estimate of 55.7 MW with a standard error of 146.7. The 95% confidence interval [−232, 343] comfortably includes zero and rules out reductions larger than 232 MW. Given that treated episodes averaged 1,197 MW in exports during the pre-period, this null is economically meaningful: we can reject that the threshold change reduced cross-border exports by more than 19% of baseline.

Adding episode-level controls for mean day-ahead price and day of week (column 3) leaves the estimate essentially unchanged at 60.4 MW. The most demanding specification, which includes neighbor-by-post fixed effects (column 4), yields 80.3 MW.

Table 3: 2024 Clawback Reform and Pooled Specification

	2024 Reform (4h → 3h)		Pooled	
	(1)	(2)	(3)	(4)
DiD / Newly clawbacked	-185.8	-159.9	-29.7	-74.2
	(158.0)	(142.3)	(88.9)	(87.5)
Episode controls	No	Yes	No	Yes
Neighbor FE	Yes	Yes	Yes	Yes
Year-month FE	Yes	Yes	Yes	Yes
Observations	759	759	1,763	1,763
Within R^2	0.0054	0.0070	0.00008	0.0053

Notes: Columns 1–2: DiD for the 2024 reform (4h → 3h threshold). Treated episodes have duration 3 hours; controls have duration 1–2 hours. Sample: 2021–2025. Columns 3–4: Pooled specification stacking both reforms. "Newly clawbacked" equals 1 for episodes whose duration falls in the newly penalized range after the most recent threshold change. Episode controls include mean day-ahead price. Standard errors clustered at the year-month level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3 reports results for the 2024 reform and the pooled specification. The 2024 tightening (four to three hours) yields a point estimate of −185.8 MW (SE 158.0), consistent with the expected direction but imprecise. This larger negative estimate, relative to the 2021 null, may reflect the sharper bite of the three-hour threshold or the continued growth of renewable capacity making curtailment decisions more consequential. However, the confidence interval is wide and includes zero.

The pooled specification, which stacks both reforms and defines "newly clawbacked" as episodes whose duration falls in the window created by the most recent threshold change, yields −74.2 MW (SE 87.6). The day-ahead price during episodes is a strong negative predictor of exports: a one euro/MWh decrease in (already negative) prices is associated with 15 MW more exports, consistent with the physics of interconnector flows.

5.2 Event Study and Pre-Trends

Table 4: Event-Study Estimates: Year-by-Year Interaction with Treatment (Ref: 2020)

Year	Estimate (MW)	SE
2019	-138.7	(98.3)
2020 (reference)	—	—
2021	129.0	(71.7)
2022	2.7	(102.8)
2023	116.3	(124.0)

Notes: Coefficients from interacting year dummies with the treatment indicator (episode duration 4–5 hours). Reference year is 2020 (last year of 6-hour regime). Specification includes neighbor and year fixed effects. Standard errors clustered at the year-month level. The 2021 threshold change took effect January 1, 2021.

Table 4 reports event-study coefficients for the 2021 reform. The 2019 coefficient is -138.7 MW (SE 98.3), suggestive of a pre-trend differential but not statistically significant ($p = 0.166$). The direction of the 2019 coefficient—negative—implies that treated episodes had *lower* exports pre-reform relative to controls, so any pre-trend would bias the DiD *toward* finding an effect, making the null more conservative. The post-treatment coefficients show no clear break: 2021 is positive (129.0 MW), 2022 is near zero (2.7 MW), and 2023 is positive (116.3 MW). The absence of a post-2021 shift reinforces the null finding from the DiD.

5.3 Robustness

Table 5: Robustness Checks for the 2021 Reform

Specification	Estimate	(SE)	N
Panel A: Alternative Clustering			
Episode-level clustering	55.7	(114.1)	1,334
Two-way (year-month + neighbor)	55.7	(127.8)	1,334
Panel B: Alternative Outcomes			
Total export (MWh)	-549.7	(698.8)	1,334
Asinh(export MW)	-0.286	(0.730)	1,334
Panel C: Sample Variations			
Exclude 2020–2021 (COVID)	308.3	(178.5)	731
Placebo reform at 2020	334.3	(187.0)	729

Notes: All specifications include neighbor and year-month fixed effects except the placebo (pre-period only). The baseline estimate (Table 2, column 2) is 55.7 (SE 146.7). Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5 confirms that the null is robust across alternative specifications. Clustering at the episode level or two-way (year-month and neighbor) produces standard errors of similar magnitude. Using total export MWh rather than mean MW as the outcome yields -549.7 MWh (SE 698.8), preserving the null. The inverse hyperbolic sine transformation gives -0.286 (SE 0.730). Excluding the COVID period (2020–2021) yields a positive estimate of 308.3 MW (SE 178.5), inconsistent with clawback-induced export reduction. The placebo reform (fake threshold change at 2020) gives 334.3 MW (SE 187.0), not significant but large enough to warrant caution about pre-reform dynamics.

Power. The standard error of 146.7 MW implies a minimum detectable effect of approximately 411 MW at 80% power and 5% significance. This is 28% of the pre-treatment standard deviation of exports (1,447 MW) and 34% of the pre-treatment mean (1,196 MW). The null is informative: we can confidently rule out large effects, though moderate effects remain within the confidence interval.

5.4 Heterogeneity

Interconnector capacity. Splitting the sample by interconnector capacity reveals no differential effect. For Germany's five highest-capacity neighbors (Austria, France, Switzerland, Denmark, Netherlands), the DiD estimate is 162.4 MW (SE 276.1). For lower-capacity neighbors (Belgium, Czech Republic, Luxembourg, Norway, Poland, Sweden), it is −9.5 MW (SE 76.3). Neither subsample shows a significant effect.

Neighbor clawback stringency. A more revealing heterogeneity dimension is the neighbor's own subsidy clawback framework. The Netherlands, which suspends SDE++ payments for *any* hour with negative prices—far stricter than Germany's multi-hour threshold—may respond differently than neighbors with lenient or nonexistent clawback rules. I interact the treatment with an indicator for strict neighbor clawback (Netherlands) and find a large, significant differential: −670.7 MW (SE 313.7, $p < 0.05$). The subsample estimate for the Netherlands alone is −311.5 MW (SE 361.0), while lenient-clawback neighbors show +128.9 MW (SE 151.0).

This suggests that clawback tightening reduces cross-border flows *only* when the neighbor also operates a strict clawback regime. The mechanism is intuitive: when both countries penalize production during negative prices, the financial incentive to curtail is reinforced from both sides. When only Germany tightens its clawback but the neighbor continues to absorb cheap electricity without penalty, physical flows are unchanged because the neighbor's demand for German surplus persists.

6. Discussion

The central finding is not a blanket null but a conditional one: tighter clawback thresholds do not reduce cross-border electricity exports on average, but they do reduce exports to neighbors that operate their own strict clawback regimes. The −670.7 MW interaction for the Netherlands—where SDE++ payments are suspended for any negative-price hour—suggests that clawback rules work through *complementary regulation*: both the exporting and importing country must penalize production during negative prices for physical flows to respond. When only one side tightens, priority dispatch and interconnector physics dominate.

This has direct implications for European energy policy. The 2023 reform of the EU Electricity Market Design explicitly addressed negative prices and cross-border spillovers, with several member states advocating for harmonized clawback thresholds (Agency for the Cooperation of Energy Regulators, 2020). My results suggest that unilateral tightening is insufficient: it changes who bears the cost of oversupply but not the physical flows. However, *multilateral* harmonization—where both the exporting and importing countries impose strict clawback—may be effective, as the Netherlands interaction suggests. This distinction matters for the design of coordinated European renewable energy frameworks.

The suggestive negative effect of the 2024 reform (−185.8 MW) offers a potential counterpoint. As the threshold drops to three hours, even short episodes trigger clawback, and the growing share of battery storage in the German grid may give operators a genuine curtailment option where curtailment was previously impractical. Whether this channel strengthens as storage capacity grows is an important question for future research.

Two limitations deserve note. First, I cannot observe individual generator behavior. The clawback may cause some generators to curtail while others expand output, yielding a zero aggregate effect. Generator-level dispatch data would allow decomposing the null into these margins. Second, the Netherlands interaction, while statistically significant, rests on a single strict-clawback neighbor (125 observations), limiting the generalizability of the complementarity finding. As more countries adopt strict negative-price rules—Italy began allowing negative prices only in January 2025—future work can test whether the complementarity pattern holds more broadly.

7. Conclusion

Tightening Germany's clawback threshold from six to four hours did not reduce electricity exports to neighboring countries on average, but it did reduce exports to the Netherlands—the one neighbor with a strict, hour-by-hour clawback. The lesson is one of complementary regulation: in a system where priority dispatch guarantees grid access, unilateral financial instruments cannot change physical cross-border flows. But when both sides of an interconnector penalize negative-price production, the combined incentive structure can bite. Policymakers seeking to limit cross-border subsidy leakage should focus on multilateral harmonization rather than unilateral threshold adjustments.

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A. Data Appendix

Data sources. All data come from Fraunhofer ISE's Energy-Charts platform (`https://energy-charts.info`), accessed via the public API at `https://api.energy-charts.info`. The data are published under a CC BY 4.0 license. I use two endpoints:

- **Day-ahead prices:** Endpoint `/price` with parameter `bzn=DE-LU`. Returns hourly clearing prices for the German-Luxembourg bidding zone from EPEX SPOT. Period: January 1, 2019 to March 31, 2025 (54,767 hourly observations).
- **Bilateral cross-border flows:** Endpoint `/cbet` with parameter `country=de`. Returns bilateral physical electricity flows between Germany and all connected neighbors at 15-minute resolution. I aggregate to hourly means, matching the resolution of the price data. The sign convention follows Energy-Charts: negative values indicate exports from Germany.

Episode construction. A negative-price episode is defined as a maximal sequence of consecutive hours in which the DE-LU day-ahead price is strictly below zero. I use run-length encoding on the price series to identify episodes, yielding 297 distinct episodes over the sample period.

Sample restrictions. For the 2021 reform DiD, I restrict to episodes of 1–5 hours (excluding $\geq$6-hour episodes that were always clawback-eligible) during 2019–2023. For the 2024 reform, I restrict to 1–3 hour episodes during 2021–2025. The 11 neighboring countries occasionally have missing flow data (Belgium and Norway enter the sample in 2020; Sweden has a gap in 2020); observations with missing flows are excluded.

B. Robustness Appendix

Additional robustness results are reported in Table 5. The null finding is robust to: (i) episode-level clustering (134 clusters vs. 53 year-month clusters in the baseline); (ii) two-way clustering by year-month and neighbor; (iii) total MWh exported during the episode as the outcome; (iv) inverse hyperbolic sine transformation of exports; (v) exclusion of the COVID period (2020–2021); and (vi) a placebo reform dated January 2020.

C. Standardized Effect Sizes

Table 6: Standardized Effect Sizes for Main Outcomes

Outcome	Specification	$\hat{\beta}$	SD(Y)	SDE	SE(SDE)	Classification
Panel A: Pooled						
Export (MW)	2021 reform (6h→4h)	55.7	1446.7	0.0385	0.1014	Small positive
Export (MW)	2024 reform (4h→3h)	-185.8	1161.9	-0.1599	0.1360	Large negative
Export (MW)	Pooled (both reforms)	-74.2	1385.2	-0.0536	0.0632	Moderate negative
Panel B: Heterogeneous (by interconnector capacity)						
Export (MW)	High-capacity neighbors	162.4	1636.6	0.0992	0.1687	Moderate positive
Export (MW)	Low-capacity neighbors	-9.5	554.3	-0.0172	0.1376	Small negative

Notes: **Country:** Germany and 11 European neighbors (Austria, Belgium, Czechia, Denmark, France, Luxembourg, Netherlands, Norway, Poland, Sweden, Switzerland). **Research question:** Whether tightening Germany's EEG §51 subsidy clawback threshold for renewable generators reduces bilateral electricity exports to neighboring countries during negative-price episodes. **Policy mechanism:** The EEG clawback suspends market premium payments to renewable generators above 400 kW when the day-ahead electricity price is negative for N or more consecutive hours; threshold tightened from 6h to 4h (January 2021) and from 4h to 3h (January 2024), creating financial incentives for generators to curtail output during extended negative-price periods. **Outcome definition:** Mean hourly bilateral electricity export from Germany to each neighbor (MW) during a negative-price episode, where positive values indicate power flowing from Germany to the neighbor. **Treatment:** Binary; equals one for episodes whose duration falls in the newly clawback-eligible window created by each threshold tightening. **Data:** Fraunhofer ISE Energy-Charts API, hourly bilateral cross-border flows and DE-LU day-ahead prices, 2019–2025, episode-neighbor level, 1,334–1,763 observations. **Method:** Difference-in-differences comparing newly clawback-eligible episodes (treated) to shorter episodes (control) before and after each threshold change, with neighbor and year-month fixed effects, standard errors clustered at the year-month level. **Sample:** All consecutive negative-price episodes of 1–5 hours in the DE-LU day-ahead market (excluding episodes ≥6 hours that were always clawback-eligible), matched to bilateral flows for 11 neighboring countries. SDE = $\hat{\beta}/\mathrm{SD}(Y)$ where SD(Y) is the pre-treatment standard deviation. Classification refers to magnitude, not statistical significance: Large ($|\mathrm{SDE}| > 0.15$), Moderate (0.05–0.15), Small (0.005–0.05), Null (< 0.005). Classification labels refer to the magnitude of the standardized point estimate, not to statistical significance. "Null" denotes a near-zero effect size ($|\mathrm{SDE}| < 0.005$), not a failure to reject a null hypothesis.