From Pledges to Performance? Evidence on U.S. Electricity Firms' Voluntary Emission Targets *

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Abstract

Using a novel dataset on large U.S. electricity firms' voluntary greenhouse gas targets and power plant emissions, we examine the association between corporate emission targets and emission behavior. We find that emissions decline significantly three years after target announcements, driven by generation reallocation away from carbon-intensive units and increased investment in renewables. The effects are stronger for firms with shorter target horizons, more ambitious reduction goals, and older generating units. Overall, the evidence suggests that electricity firms' emission targets are associated with substantive operational changes rather than symbolic pledges.

Keywords*: carbon emissions, net-zero targets, power plants, voluntary commitments*

JEL Classification*: G38, M14, Q56*

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1 Introduction

Over the past decade, corporations have become increasingly active participants in global decarbonization efforts, with a rapidly growing number of firms pledging greenhouse gas emissions reduction targets, including net-zero goals. By 2023, nearly one-third of firms in the Russell 3000 Index had adopted at least one such target. Electricity firms have been at the forefront of this trend: by the early 2020s, firms with stated carbon targets accounted for more than 70 percent of electricity generation among publicly listed utilities, driven by regulatory oversight, investor scrutiny, and technological opportunities for decarbonization. While state-level policies such as renewable portfolio standards (RPS) and cap-and-trade programs cover substantial portions of U.S. electricity generation, voluntary corporate targets now govern a comparable share of production. Yet unlike regulatory mandates, these commitments are self-imposed and unenforced. This raises a fundamental question for climate policy and corporate governance: do voluntary corporate climate commitments translate into meaningful reductions in real emissions, and how do they interact with existing public regulation?

In this paper, we study firms' operational and investment responses following the announcement of corporate carbon commitments, focusing on the U.S. electricity sector from 2006 to 2022. This setting offers several advantages for identifying commitment effects. First, the electricity sector accounts for roughly one-quarter of national greenhouse gas emissions and has been the primary driver of U.S. decarbonization over the past 15 years.[1] Electricity firms also adopted emissions targets earlier than most other industries, with some commitments dating to the early 2000s, providing a long post-commitment horizon over which to trace behavioral responses. Second, the sector operates within a heterogeneous regulatory environment: large investor-owned utilities own and operate generating assets across multiple states, exposing them simultaneously to a patchwork of state-level climate policies,

[1] U.S. Energy Information Administration, "Carbon Dioxide Emissions from the U.S. Power Sector Have Declined 28% Since 2005," *Today in Energy*, October 29, 2018.

market conditions, and regulatory mandates. This variation allows us to examine how voluntary commitments interact with existing public regulation. Third, and most important for identification, emissions in this sector are produced by identifiable generating units, allowing us to observe physical production, emissions, and capacity at the generator level rather than relying on firm-level aggregates that may reflect offsets, scope boundary choices, or other accounting adjustments. Because firms that adopt commitments may differ systematically from those that do not, selection at the firm level is the central identification challenge in our setting. Working at the generator level substantially mitigates this concern: generator fixed effects and rich observable controls allow us to compare physically similar assets across committed and non-committed firms, absorbing the time-invariant heterogeneity that drives firm-level selection.

Using a novel dataset linking firm-level climate commitments from the Harvard Salata Institute Net-Zero Database to generator-level operations from the EIA and EPA, we document three central findings.

First, we show that corporate carbon commitments are followed by large and persistent declines in emissions at fossil-fuel generators. Emissions at generators owned by committed firms begin to fall approximately three years after a target announcement and decline by roughly 30 percent by the fourth post-announcement year, corresponding to reductions of approximately 95,000 metric tons of CO_2 per generator annually relative to pre-announcement levels. Committed and non-committed generators exhibit parallel emission trends in the three years preceding announcement, supporting the interpretation that these declines reflect post-announcement behavioral change rather than pre-existing trajectories. That roughly half of the historical commitments in our sample with past-due target dates are met underscores that these operational changes are neither automatic nor guaranteed, and that the announcement of a target does not mechanically determine its operational consequences.

Second, we examine how firms achieve these reductions by tracing adjustments along multiple operational and investment margins. Emission declines are driven primarily by

reallocation of generation away from carbon-intensive units, not by improvements in operational efficiency. Generation from fossil-fuel units falls by roughly 30 percent following commitment announcements, while output from renewable generators is unchanged. Within the gas fleet, reductions are concentrated entirely at combustion turbine units, where emissions and generation fall by roughly 50 percent; combined-cycle units show no comparable response. This within-fuel-type pattern is difficult to reconcile with demand shocks or uniform generation curtailment and instead points to deliberate dispatch reallocation toward less carbon-intensive assets. By contrast, emission intensity and fuel efficiency show no persistent post-announcement change, confirming that firms rely on output shifting rather than capital-intensive retrofits in the medium run.

Third, we show that commitments are associated with longer-run portfolio reallocation toward low-carbon technologies. At the plant level, firms that adopt targets expand their renewable generator counts while simultaneously reducing fossil-fuel capacity, particularly at large conventional plants. These patterns reflect gradual but deliberate changes in firms' generation portfolios, achieved through incremental renewable investment and capacity downsizing of carbon-intensive assets rather than widespread plant retirements.

Beyond the baseline results, we document systematic heterogeneity in the emission response that is consistent with firms treating voluntary targets as operational constraints rather than reputational signals. Shorter-horizon commitments generate larger near-term emission reductions than longer-horizon pledges, and more ambitious targets are associated with larger cumulative responses. Older generators experience disproportionately larger post-announcement declines, consistent with firms prioritizing curtailment of their least efficient units. Finally, emission reductions following voluntary commitment announcements are larger and more precisely estimated in states without binding climate regulation than in regulated states. This pattern suggests that voluntary targets operate as a substitute for public policy where formal incentives are absent, rather than simply reinforcing existing mandates.

The main identification challenge is the voluntary nature of corporate carbon commitments. We address it through several complementary strategies. Our baseline specification includes generator and year fixed effects, rich generator-level controls, and state-by-year fixed effects, restricting comparisons to physically similar assets in similar regulatory environments and substantially reducing the scope for firm-level selection bias. The event-study design, with a three-year pre-announcement window, confirms the absence of differential pre-trends between committed and non-committed generators, providing the most direct available evidence against pre-existing divergence. Results are robust to implementing the Callaway and Sant'Anna (2021) estimator, which uses not-yet-treated firms as the comparison group and is robust to treatment effect heterogeneity under staggered adoption, and to capacity-weighted regressions that account for scale differences across generators. Across all specifications, post-announcement emission declines are large, statistically significant, and stable in magnitude. Because adoption remains voluntary, we interpret the estimates as systematic associations between commitment adoption and operational behavior rather than causal effects of an externally imposed mandate.

This paper contributes to the emerging literature on corporate climate commitments. Bolton and Kacperczyk (2024) examines the role of firm-level commitments in reducing carbon emissions using CDP data and a global sample of firms, finding limited aggregate effects. Our paper differs in two respects consequential for identification and inference. We work at the generator rather than the firm level, enabling within-firm comparisons across assets and direct control for asset-level characteristics that determine emissions trajectories; and we use a commitment dataset extending to the early 2000s, a decade before CDP coverage begins, providing a substantially longer post-commitment observation window. Our results further go beyond documenting aggregate emission declines to identify the specific operational margins — generation reallocation, portfolio adjustment, and their interaction with asset and commitment characteristics — through which firms respond. Related work explores which commitment features predict reductions (Ioannou et al., 2016), the financial implications of

climate target adoption (Aldy et al., 2025), and the role of commitments in shaping access to finance and lending (Sastry et al., 2024).

The paper also contributes to the literature on firm responses to climate-related policies. Yang et al. (2021) shows that the EPA's mandatory greenhouse gas disclosure program reduced emission rates at covered power plants while inducing emissions reallocation. Ramadorai and Zeni (2024) develops a theoretical framework showing that firms' abatement choices depend on beliefs about future regulation, with empirical support using the Paris Agreement as an event. Our findings complement these by documenting that voluntary commitments generate operational responses of comparable magnitude and by characterizing the mechanisms through which such responses occur. The result that voluntary targets are most effective in less regulated environments speaks directly to the question of how voluntary and regulatory instruments interact (Coglianese et al., 2020; Linn and McCormack, 2019).

The remainder of the paper is organized as follows. Section 2 provides background on corporate climate commitments in the U.S. electricity sector. Section 3 describes the data and presents summary statistics. Section 4 develops the conceptual framework and empirical strategy. Section 5 presents the results, including mechanisms, heterogeneity, and policy interactions. Section 6 concludes.

2 Institutional Background

2.1 Corporate Carbon Commitments

In the absence of comprehensive federal climate legislation, large U.S. corporations have increasingly adopted voluntary greenhouse gas reduction targets as a primary vehicle for communicating and implementing emissions strategies. These commitments are self-imposed, publicly disclosed, and carry no direct legal enforcement mechanism. They take three principal forms in our sample. *Carbon reduction targets* pledge a percentage or absolute reduction in emissions relative to a specified baseline year, with horizons ranging from a few years to

several decades. *Net-zero targets* commit to eliminating net emissions by a stated year, typically 2050. *Carbon neutrality pledges* rely on offsets, renewable energy certificates, or emissions trading to balance residual emissions without necessarily eliminating them at the source.[2] Firms often hold multiple commitment types simultaneously and update earlier pledges over time; we return to this pattern in Section 2.4.

Voluntary disclosure platforms have supported but not defined commitment adoption. The Carbon Disclosure Project has provided a standardized channel for firm-level emissions reporting since 2000, and the Science Based Targets initiative, launched in 2015, introduced a science-aligned benchmark for evaluating pledge ambition. Our commitment data are drawn from the Harvard Salata Institute Net-Zero Database, which compiles quantitative emissions targets announced by firms in the Russell 3000 Index through systematic review of sustainability reports, corporate websites, and regulatory filings. Relative to CDP and SBTi, this database extends coverage back to the early 2000s for electricity firms, adding roughly a decade of pre-existing commitments that would otherwise be absent from the sample.

2.2 The Electricity Sector

The U.S. electricity sector accounts for approximately one-quarter of national greenhouse gas emissions, making it the largest single source of domestic CO_2.[3] Its role in the broader decarbonization effort extends beyond this direct contribution: electrification of transportation, buildings, and industry makes low-carbon power generation a prerequisite for economy-wide emissions reductions.

Three features of the electricity sector make it well-suited for studying whether voluntary commitments affect firm behavior. First, electricity firms were among the earliest corporate adopters of quantitative carbon commitments, with some targets dating to the early 2000s. This gives us a substantially longer post-commitment observation window than most other

[2] Our analysis focuses exclusively on quantitative, company-wide targets directed at scope 1 emissions. Qualitative commitments, subsidiary-level goals, and scope 2 or 3 pledges are excluded.

[3] *Inventory of U.S. Greenhouse Gas Emissions and Sinks*, U.S. Environmental Protection Agency.

industries would permit and enables us to trace both short- and medium-run behavioral responses.

Second, large investor-owned utilities operate heterogeneous fleets of generating assets across multiple states, simultaneously subject to state-level renewable portfolio standards (RPS), regional carbon cap-and-trade programs, federal environmental regulation, and wholesale electricity market rules. This regulatory heterogeneity generates variation in the policy environment facing otherwise comparable generators within the same firm, allowing us to examine how voluntary commitments interact with binding public policy.

Third, and most directly relevant to the research design, emissions in electricity generation are produced by identifiable physical assets and are monitored continuously at the generator level. This feature is important for two reasons. On identification: because carbon commitments are voluntarily adopted, firms that commit may differ systematically from those that do not, creating a selection problem that is difficult to resolve using firm-level data alone. Working at the generator level allows us to compare units of similar fuel type, size, age, and regulatory exposure across committed and non-committed firms, and to use generator fixed effects to absorb time-invariant heterogeneity in ways that firm-level analysis cannot. On mechanism: generator-level data allow us to observe actual CO_2 production associated with specific operational decisions, rather than firm-level aggregates that may incorporate offset purchases, accounting adjustments, or scope boundary choices, and to separately identify reallocation across existing assets from efficiency improvements within them. We discuss the formal identification strategy in Section 4.2.

2.3 Descriptive Trends

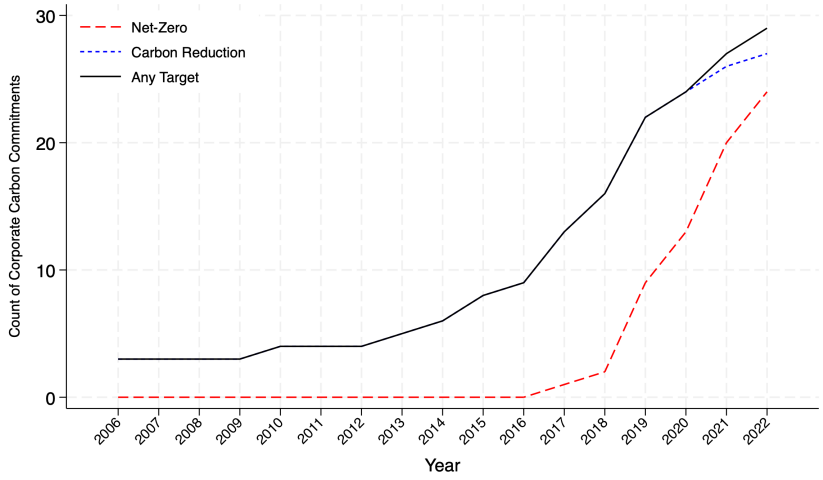
Figure 1a plots the cumulative count of Russell 3000 electricity firms announcing at least one quantitative carbon commitment over our sample period, disaggregated by commitment type. Adoption began well before the Paris Agreement. American Electric Power announced a quantitative carbon reduction goal in 2003, committing to a 4 percent reduction relative

to its 1998–2001 baseline by 2006. Entergy and Xcel Energy adopted comparable pledges in 2005. These early commitments were uniformly short-horizon carbon reduction targets. Net-zero pledges are essentially absent before 2016, as reflected by the close correspondence between the total commitment count and the carbon reduction series through the late 2010s. Adoption accelerated sharply after 2015, coinciding with the Paris Agreement. Net-zero commitments, which account for nearly all new announcements after 2018, displace carbon reduction targets as the dominant commitment form. By 2022, the majority of publicly listed electricity firms in the Russell 3000 had adopted at least one quantitative target, though adoption timing varies considerably across firms.

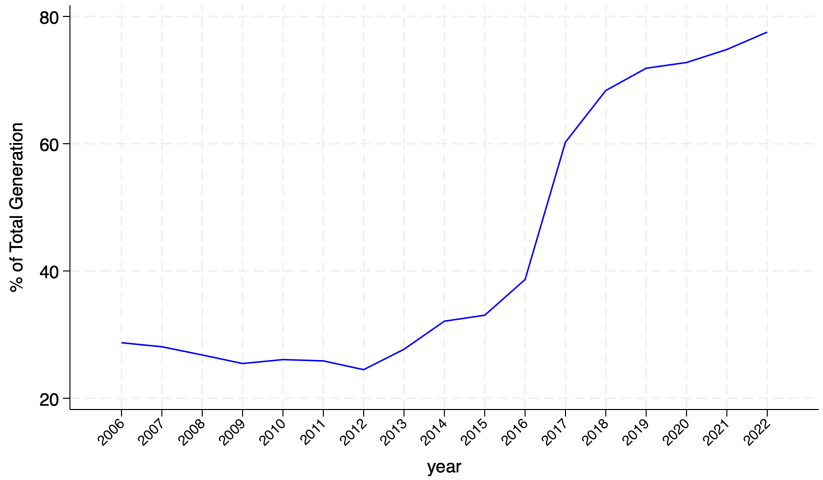
Figure 1b shows the share of total generation within Russell 3000 electricity firms produced by committed firms in each year. This share rises from roughly 25 percent in 2006–2013 to over 70 percent by the early 2020s, reflecting both adoption by large incumbent utilities and the expansion of committed firms' generation capacity. Voluntary carbon commitments now govern the production decisions of firms responsible for the majority of electricity output among publicly listed U.S. utilities.

Figure 2 places these developments in the broader context of the U.S. power sector. Aggregate U.S. electricity generation increases modestly over our sample period. Generation in RPS states expands rapidly in the late 2000s and continues to grow more gradually thereafter, while generation in cap-and-trade states remains relatively stable. Generation by Russell 3000 firms with carbon commitments rises gradually prior to 2016 and then increases sharply, reflecting the rapid expansion of committed firms' operational footprint documented in Figure 2a.

Figure 2b presents corresponding trends in CO_2 emissions. Total U.S. power sector emissions decline substantially over the sample period, consistent with the well-documented shift away from coal toward natural gas and renewables. Emissions in cap-and-trade states remain low and relatively flat throughout the period, while emissions in RPS states decline steadily beginning in the late 2000s. Emissions associated with generators owned by Russell 3000



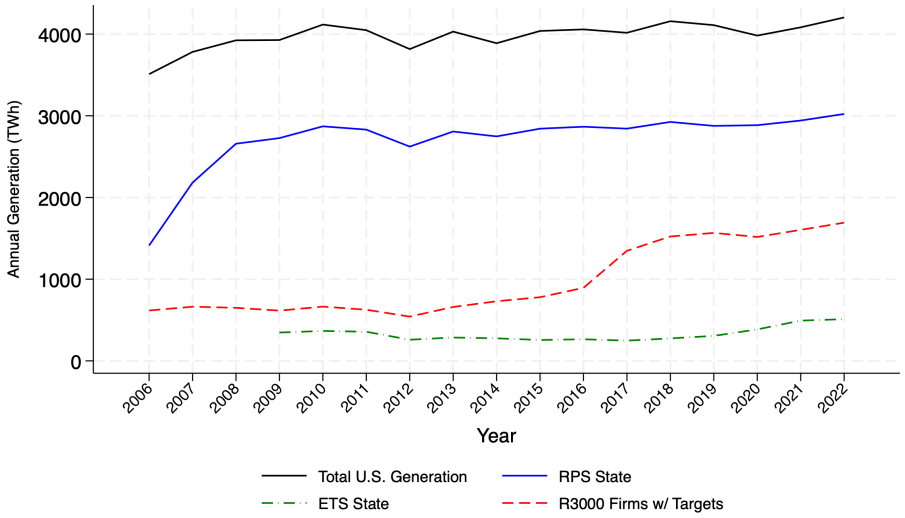
(a) Adoption of Corporate Climate Targets



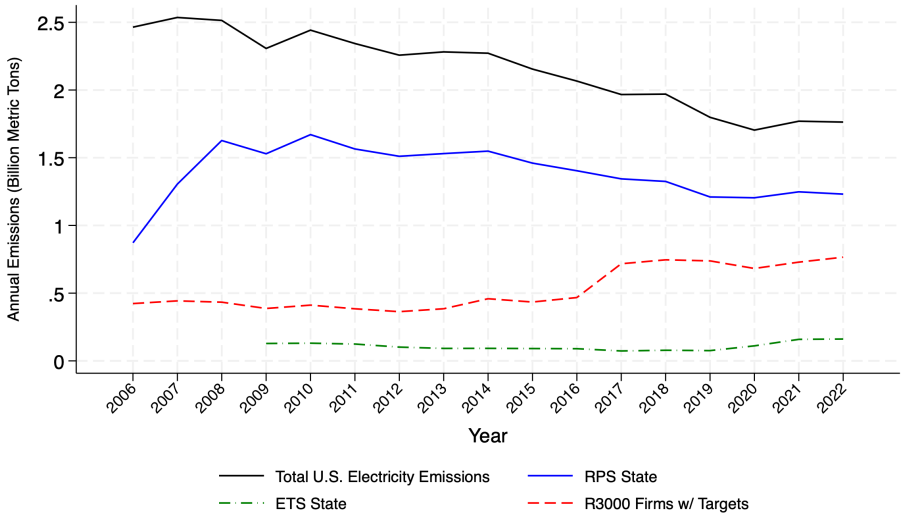
(b) Share of Electricity Generation by Target-Adopting Firms

Figure 1: Corporate Climate Targets and Their Coverage of Electricity Generation

This figure documents the adoption and economic significance of corporate climate targets among publicly listed electricity firms. Panel (a) plots the cumulative number of Russell 3000 electricity firms announcing quantitative carbon reduction, carbon neutrality, or net-zero targets by type. Panel (b) shows the share of total electricity generation within Russell 3000 electricity firms accounted for by firms that have announced at least one target. Corporate climate target data are from the Harvard Salata Institute Net-Zero Database. Electricity generation data are from the U.S. Energy Information Administration (EIA).



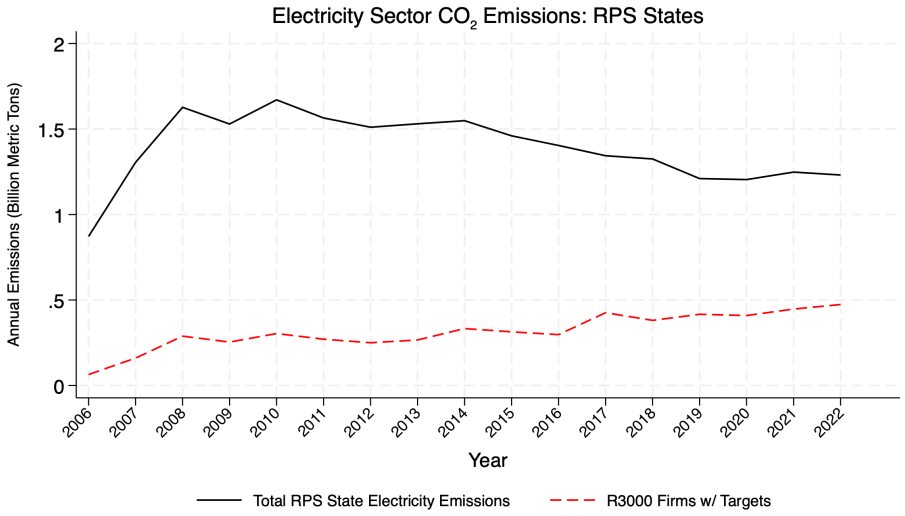
(a) U.S. Electricity Generation



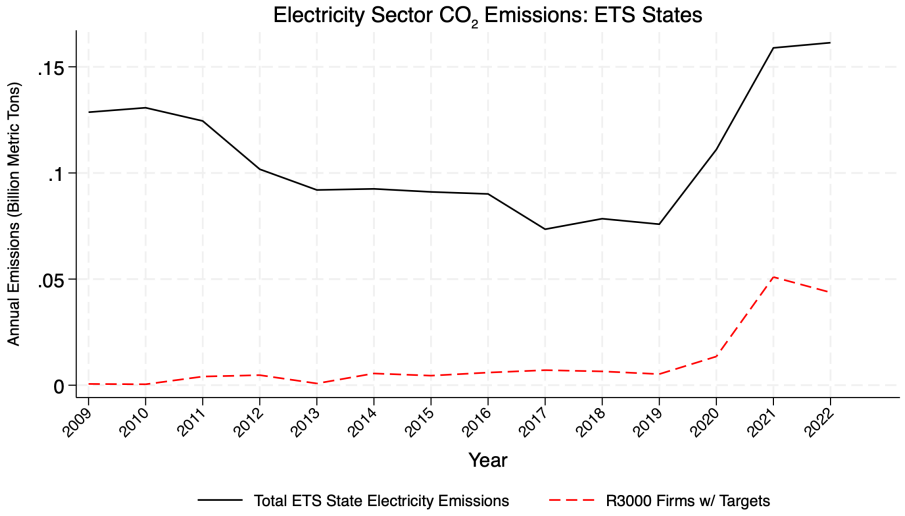
(b) U.S. Electricity Sector CO_2 Emissions

Figure 2: U.S. Electricity Generation and Emissions by Policy Group and Climate Targets

Panel (a) shows total U.S. electricity generation over time, with separate series for generation in renewable portfolio standard (RPS) states, emission trading system (ETS) states, and generators owned by Russell 3000 electricity firms that have announced corporate climate targets. Panel (b) presents corresponding trends in carbon dioxide emissions, measured in billion metric tons. ETS states correspond to California and states participating in the Regional Greenhouse Gas Initiative (RGGI). Data on generation and emissions are from the U.S. Energy Information Administration (EIA); corporate target data are from the Harvard Salata Institute Net-Zero Database.



(a) CO_2 Emissions: RPS States



(b) CO_2 Emissions: ETS States

Figure 3: Electricity Sector CO_2 Emissions by Policy Environment
Panel (a) restricts to RPS states and shows total RPS-state electricity emissions alongside emissions from generators owned by Russell 3000 firms with voluntary targets, illustrating the share of regulated-state emissions accounted for by committed firms. Panel (b) presents the analogous figure for ETS states. Data sources are as in Figure 2.

committed firms follow a distinct pattern: they increase after 2016, despite the overall downward trend in aggregate emissions. This divergence reflects changes in the ownership and operational scale of committed firms rather than a reversal of sector-wide decarbonization, and it underscores why aggregate sectoral trends are insufficient to assess the behavioral implications of corporate commitments.

Figures 3a and 3b sharpen this point by examining emissions within specific policy environments. Figure 3a restricts to RPS states and shows the share of RPS-state emissions accounted for by Russell 3000 committed firms over time. Figure 3b presents the analogous series for cap-and-trade states. Together, these panels illustrate that within both regulated and less regulated environments, committed firms have come to account for an increasing share of relevant emissions, making their operational responses to voluntary commitments consequential for aggregate sector outcomes.

Three observations from these descriptive trends motivate the empirical analysis that follows. First, voluntary corporate commitments have become widespread among firms responsible for a large and growing share of electricity generation, making their behavioral effects economically significant. Second, committed and non-committed firms coexist within overlapping regulatory environments, providing the variation needed to separate the effects of voluntary commitments from those of binding public policy. Third, trends in generation and emissions differ systematically across ownership groups and policy regimes, confirming that aggregate sectoral trends are uninformative about commitment-specific behavioral responses and motivating the generator-level event-study design we develop in Section 4.2.

2.4 Do Firms Deliver on Their Commitments?

To assess whether these commitments translate into verifiable operational change, we evaluate performance against the subset of targets with stated deadlines on or before 2025. This yields 88 targets across 24 firms.[4] Of these, 45 percent are met, 45 percent are not met, and

[4]Evaluation requires constructing a firm-level emissions series comparable to the commitment metric. For absolute reduction targets, we measure total emissions from our generator-level data relative to the specified

the remainder cannot be evaluated with available data.

The roughly even split between met and unmet targets is itself informative for the empirical design. It indicates that the relationship between commitment adoption and realized emissions reductions is not mechanical: firms adopt targets but do not uniformly achieve them, implying that the announcement of a target does not determine its operational consequences. How commitments translate into generator-level production and investment decisions is therefore an empirical question rather than an accounting identity, and the answer likely depends on commitment characteristics, asset features, and the surrounding regulatory environment.

We observe two notable patterns. First, met and unmet targets are distributed across firms of varying scale and fuel mix, and across both early and late committers. Duke Energy met multiple interim intensity reduction goals, Entergy met its 2010 reduction target, and Xcel Energy consistently met or exceeded its successive short-horizon pledges. At the same time, several firms fell short of ambitious absolute reduction targets, particularly those involving large tonnage reductions on short timelines.

Second, firms that meet an early target almost universally set a subsequent, more ambitious one. Duke Energy followed its met intensity targets with a net-zero commitment for 2050 and an intermediate 80 percent reduction goal. Entergy escalated from its met 2010 goal to a net-zero target by 2050. Xcel Energy ratcheted its pledged reductions over more than a decade, from a 14 percent intensity reduction by 2009 to 60 percent by 2030 and ultimately to a net-zero commitment. Firms that miss targets also, in most cases, establish successor goals. This pattern of successive commitment revision is consistent with commitments functioning as iterated instruments conditioned on prior performance, and it supports treating the first quantitative announcement as the economically relevant treatment event. The initial commitment is the moment at which a firm publicly signals a change in

baseline. For intensity targets, we construct an emissions-per-MWh series. Cases where the base year falls outside our data or where the commitment metric cannot be mapped to our data are classified as insufficient data.

its emissions trajectory; subsequent updates reflect refinement of that signal. We discuss the implications of this for identification, including the possibility of anticipatory responses, in Section 4.2.

2.5 State-Level Climate Policy

Electricity firms' voluntary commitments coexist with a fragmented but consequential set of state-level climate policies. As of 2022, 30 states had active renewable portfolio standards requiring utilities to source a specified share of electricity from renewables, with mandated shares and compliance timelines varying substantially across states. California and nine northeastern states participating in the Regional Greenhouse Gas Initiative (RGGI) operate binding cap-and-trade programs that price CO_2 emissions from power generation. Because investor-owned utilities typically own generating assets across multiple states, individual firms simultaneously face a combination of binding renewable mandates, carbon prices, and minimal state-level climate regulation, depending on where their generators are located.

This regulatory heterogeneity has two direct implications for the analysis. State-level policies affect baseline abatement incentives and the marginal cost of different compliance strategies, conditioning how firms implement voluntary commitments. At the same time, the variation in regulatory environments across generators owned by the same firm provides identifying variation for examining whether voluntary and regulatory instruments operate as complements or substitutes. We exploit this variation in Section 5.

3 Data and Sample

3.1 Data Sources

Generator Data. We collect generator-level information on electricity generation, installed capacity, primary fuel type, emissions, geographic location, generator age, fuel consumption, and operating status from the U.S. Energy Information Administration (EIA) Form 860

and Form 923, together with emissions data from the EPA's Clean Air Markets Program Database (CAMPD). In addition to reported emissions, we construct consistent generator-level carbon dioxide emissions by combining fuel consumption data with standard emissions factors. This approach ensures comparability across generators and over time, particularly for units not continuously covered by emissions monitoring programs.[5]

Corporate Commitment Data. Data on corporate carbon commitments are sourced from the Harvard Salata Institute's Net-Zero Cluster, which compiles a novel dataset on emissions-related targets announced by firms in the Russell 3000 Index. The dataset is constructed through systematic review of firms' public disclosures, including sustainability reports, corporate websites, and regulatory filings, and records the timing and characteristics of each announced commitment at the firm-year level. To be included in our analysis, a commitment must specify a quantitative target: a carbon reduction, carbon neutrality, or net-zero target. Purely qualitative statements are excluded. For each firm, we identify the first year in which a qualifying target is announced and record key attributes of the commitment, including the stated target horizon and target amount.

State Climate Policy Data. Information on state-level renewable portfolio standards (RPS) is obtained from the National Conference of State Legislatures (NCSL) RPS and renewable energy goals database. Using these data, we construct a panel indicator for RPS participation based on the year of adoption and adjust for states that subsequently repealed or modified their mandates. Participation in cap-and-trade programs is identified based on membership in the Regional Greenhouse Gas Initiative (RGGI) and California's cap-and-trade program. These policy indicators allow us to characterize the regulatory environment faced by electricity generators over time.

[5]Details on the EIA sample construction are provided at `https://github.com/etrieschman/netzero/tree/main`.

3.2 Sample Construction

We merge generator-level data with firm-level carbon commitment information by identifying the ultimate parent companies of EIA-listed electricity generators. Ownership links are established using Capital IQ, the WRDS subsidiary database, and the YourEconomy Time Series (YTS) database, supplemented by manual verification based on firm names, operating locations, and regulatory filings. This procedure allows us to map individual generating units to publicly listed electricity firms in the Russell 3000 Index.

Our analysis focuses on the period 2006–2022 and includes all reporting generators owned by Russell 3000 electricity firms. The resulting sample is smaller than the full EIA universe because we exclude generators owned by federal and local government agencies, privately held firms, and diversified conglomerates whose operations extend beyond the electricity sector. In particular, we exclude firms such as Berkshire Hathaway Energy, whose diversified ownership structure and investment strategies differ fundamentally from those of standalone electricity firms and whose decarbonization decisions are not readily comparable. Despite these exclusions, the sample remains economically meaningful, accounting for nearly 40% of total U.S. electricity generation in 2022.

To construct a consistent panel for empirical analysis, we further exclude generators with nameplate capacity below 10 MW, units that are not yet operational (as indicated by generator age), and generators that report zero electricity production in all years. These restrictions reduce measurement error and ensure that observed changes in emissions and generation reflect meaningful operational decisions. Appendix A provides additional details on the data cleaning and filtering procedures.

The final dataset consists of 54,208 generator-year observations covering 5,207 unique generators over the period 2006–2022.

3.3 Summary Statistics

Table 1 reports descriptive statistics for the generator-year panel comprising 54,208 observations across 5,207 unique generators from 2006 to 2022. The average *Capacity* is 178 megawatts (MW), with a standard deviation of 236 MW, indicating substantial heterogeneity in scale within the electricity sector. To account for this variation, we classify generators into five capacity bins: 0–50 MW, 50–100 MW, 100–250 MW, 250–500 MW, and above 500 MW. The mean *Capacity Bin* value of 2 suggests that most generators fall in the medium-size category. Average annual electricity *Generation* is approximately 691,000 megawatt-hours (MWh), with a median of 93,854 MWh. Average annual carbon *Emissions* amount to about 361,000 metric tons, with a highly skewed distribution driven by large fossil-fuel plants. *Capacity Utilization*, measured as the ratio of generation to capacity, has an average value of 27%. *Emission Intensity*, defined as emissions per unit of electricity generated, has an average value of 58%.

At the bottom of the table, we report the distribution of generators and generator-year observations by primary energy source. Fossil-fuel generators dominate the sample, accounting for 3,662 unique units and 40,173 generator-year observations. Renewable generators represent 1,405 units and 12,167 generator-year observations, while nuclear and other sources contribute 102 (1,390 generator-year) and 53 (388 generator-year) observations, respectively.

Table 1: Summary Statistics

Generator-Year Level

	Count	Mean	Std. Dev.	25th Pct.	Median	75th Pct.
Nameplate Capacity (MW)	53,520	179	237	40	90	199
Net Generation (MWh)	53,520	699,263	1,552,472	12,019	97,568	651,402
Emissions (Ton)	53,520	363,763	904,405	0	9,957	281,010
Capacity Utilization (%)	53,520	27	26	2	23	47
Emission Intensity (%)	50,902	58	43	0	61	92
Capacity Bin	53,520	2	1	1	2	3

By Energy Source	Generator	Generator-Year
Fossil Fuels	3,628	39,575
Renewable	1,405	12,167
Nuclear	102	1,390
Other	53	388
Total	5,188	53,520

4 Research Design

4.1 Conceptual Framework

Section 2.4 documents that roughly half of electricity firms' historical commitments are met and half are not, indicating that the relationship between commitment adoption and realized emissions reductions is not mechanical. How a firm-level pledge translates into operational and investment decisions at individual generating units is therefore an open empirical question. This section develops a conceptual framework that organizes the margins through which such translation may occur and guides the empirical analysis.

Corporate carbon commitments impose voluntary, forward-looking constraints on firms' emissions trajectories. In the electricity sector, where production relies on heterogeneous fleets of generating assets, meeting such commitments does not involve a single adjustment but instead requires reallocating production and investment across assets that differ in emissions intensity, operating costs, technological flexibility, and regulatory exposure. We consider three broad channels through which an electricity firm may reduce emissions following

a commitment announcement.

First, firms may reallocate generation across existing units, shifting output away from higher-emitting generators toward lower-emitting or zero-emitting units within their current fleet. This adjustment operates along the intensive margin, relies primarily on operational flexibility rather than capital investment, and can be implemented relatively quickly. Second, firms may pursue operational efficiency improvements at fossil-fuel generators, such as retrofits or process changes that reduce emissions per unit of output. While also operating along the intensive margin, these actions typically involve nontrivial capital costs, regulatory approval, and implementation lags. Third, firms may undertake portfolio reallocation by investing in renewable generation and gradually downsizing or retiring carbon-intensive assets. This extensive-margin response reflects longer-term capital allocation decisions and unfolds over multiple years.

These margins are not mutually exclusive, but they generate distinct empirical signatures. Generation reallocation implies declines in fossil-fuel output and emissions without corresponding improvements in emission intensity. Efficiency improvements imply reductions in emission intensity holding output constant. Portfolio reallocation should manifest as growth in renewable capacity and contraction of fossil-fuel assets over time. The relative importance of each margin may depend on commitment characteristics, including target horizon and ambition, as well as asset characteristics such as fuel type, technology, and generator age.

An important feature of the electricity sector is that firms operate within a heterogeneous policy environment shaped by state-level climate regulation, including renewable portfolio standards and cap-and-trade programs. As described in Section 2.5, these policies affect baseline incentives, compliance costs, and the marginal attractiveness of different abatement strategies, conditioning how firms implement voluntary commitments. Public policy therefore acts as an overlay that shapes the feasibility of different adjustment margins rather than mechanically determining firms' responses. Identical commitments may consequently induce

different operational and investment responses across regulatory environments, a pattern we test explicitly in Section 5.

Although commitments are adopted at the firm level, their implementation occurs through asset-level decisions that aggregate to firm-level emissions outcomes. The empirical analysis therefore aligns the unit of observation with the relevant economic margin under study: generator-level outcomes for operational adjustments and plant-level outcomes for portfolio reallocation, as illustrated in Figure 4.

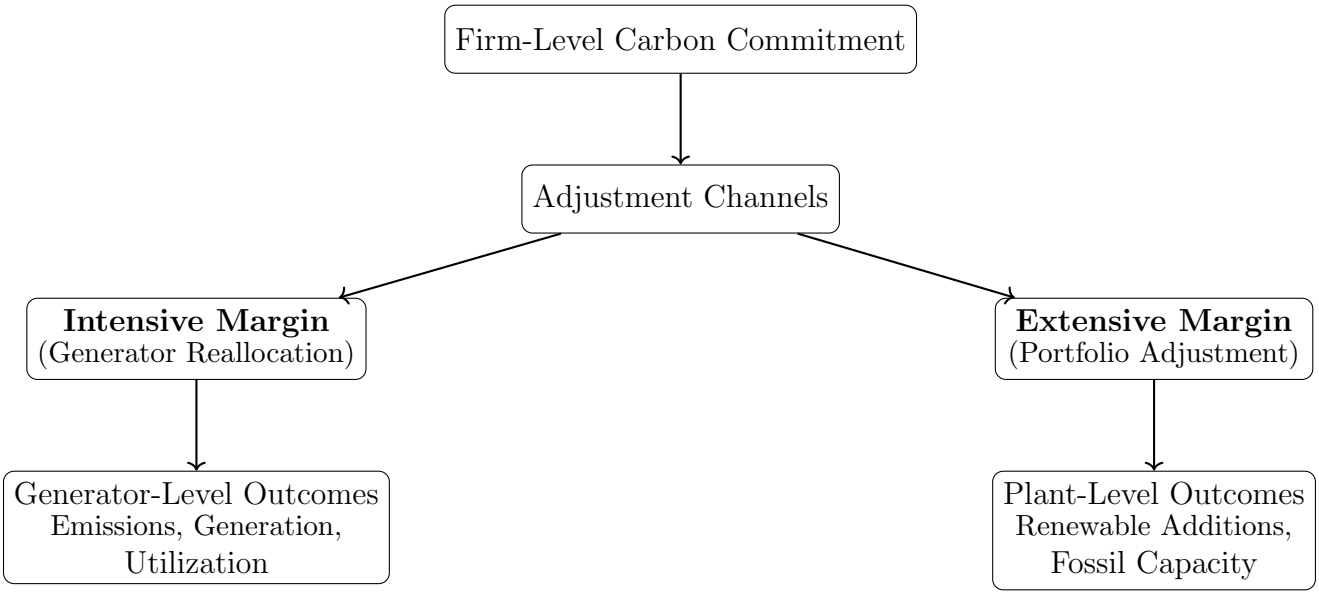


Figure 4: Conceptual Framework. Corporate carbon commitments are adopted at the firm level but implemented through generator-level operational adjustments (intensive margin) and longer-run portfolio reallocation (extensive margin).

4.2 Empirical Model

Unit of analysis and treatment definition. Commitments are adopted at the firm level, but meeting them requires operational decisions at individual generating units. As discussed in Section 2.1, firm-level emissions aggregates obscure this: they may incorporate offsets or renewable energy certificate retirements with no physical production counterpart, and they mask within-firm reallocation across assets, which the framework identifies as the primary short-run adjustment channel.

Working at the generator level also addresses the selection problem inherent in voluntary adoption. Committed firms tend to be larger, face greater investor scrutiny, and operate disproportionately in states with active climate policy. These firm-level differences can generate spurious associations between commitment status and emissions trends in a firm-level design. At the generator level, selection operates differently: generators are physical assets with directly observable characteristics, fuel type, age, capacity, and technology, that can be matched across committed and non-committed firms. The comparison is thus between physically similar assets facing similar environments, substantially narrowing the scope for selection-driven confounds relative to a firm-level design.

We define treatment using the first year a firm announces a quantitative carbon commitment. Section 2.4 shows that firms that meet early targets almost universally escalate to more ambitious ones, while those that fall short revise rather than abandon. Subsequent announcements therefore reflect refinements of a trajectory initiated at the first commitment, not independent events.

Identification. We estimate a staggered difference-in-differences design comparing generator-level outcomes at committed firms to those at non-committed or not-yet-treated firms. The identifying assumption is that, absent a commitment, generators at committed firms would have followed parallel trends to the comparison group. We assess this directly through pre-announcement dynamics. Because adoption is voluntary, the estimates should be interpreted as systematic associations between commitment adoption and operational behavior rather than causal effects of an externally imposed policy.

The central identification challenge is firm-level selection. Three design features address it. First, generator-level fixed effects and rich controls narrow comparisons to physically similar assets, substantially reducing selection bias relative to firm-level analysis. Second, the pre-trend test provides direct evidence against pre-existing divergence. Third, we implement the Callaway and Sant'Anna (2021) estimator as a robustness check, using not-yet-treated

firms as the comparison group and avoiding the negative-weighting problem of the standard two-way fixed effects estimator under staggered adoption.

We estimate:

$$y_{gt} = \alpha_g + \lambda_t + \sum_{\substack{k=-3 \\ k\neq -1}}^{4} \beta_k \cdot \mathbf{1}[\text{Year since commitment}_{gt} = k] + X'_{gt}\delta + \varepsilon_{gt} \tag{1}$$

where y_{gt} is the log outcome for generator g in year t, and $\text{Year since commitment}_{gt} = t - T_g^*$ measures years elapsed since the firm's first commitment announcement in year T_g^*. The period $k = -1$ is omitted; all β_k are interpreted relative to the year prior to announcement. Generator fixed effects α_g absorb time-invariant heterogeneity across units; year fixed effects λ_t absorb common shocks. Controls X_{gt} include generator age, primary fuel type, capacity bin, and a multiple-fuel indicator.[6] Standard errors are clustered at the firm level. For extensive-margin outcomes, we aggregate to the plant level, replace generator with plant fixed effects, and estimate generator counts using a Poisson specification. The post-announcement coefficients β_k $(k > 0)$ trace the dynamic response to commitment adoption; the pre-announcement coefficients $(k < 0)$ test for differential pre-trends.

5 Empirical Results

5.1 Corporate Climate Commitments and Generator-Level Emissions

We begin by examining whether corporate carbon commitment announcements are associated with subsequent changes in emissions at the generating-unit level. Although commitments are adopted at the firm level, emissions are produced by individual generators, and adjustments to meet firm-level goals must be implemented through changes in generator operation, utilization, or investment. Focusing on generator-level outcomes therefore allows

[6] Fuel types are classified at a granular level, including coal, natural gas, petroleum, solar, and wind, rather than a simple fossil-renewable binary, ensuring that fuel-type controls absorb within-category heterogeneity in emissions intensity.

us to observe the physical channels through which firms translate stated commitments into realized emission reductions. Table 2 reports event-study estimates with the logarithm of annual generator emissions as the dependent variable. The sample is restricted to fossil-fuel generators, which account for nearly all operational emissions in the electricity sector.

Column (1) presents the baseline specification described in Equation 1. Emissions at generators owned by committed firms decline gradually following target announcements, becoming statistically and economically significant three years after the announcement. The fourth year post-announcement estimate implies a roughly 30% decline in emissions. The estimated reductions correspond to roughly 95 thousand tons of CO_2 per generator-year, relative to the year-before-announcement mean.[7] The absence of statistically significant coefficients (see Figure 5) in the pre-announcement period suggests that these declines do not reflect differential pre-trends.

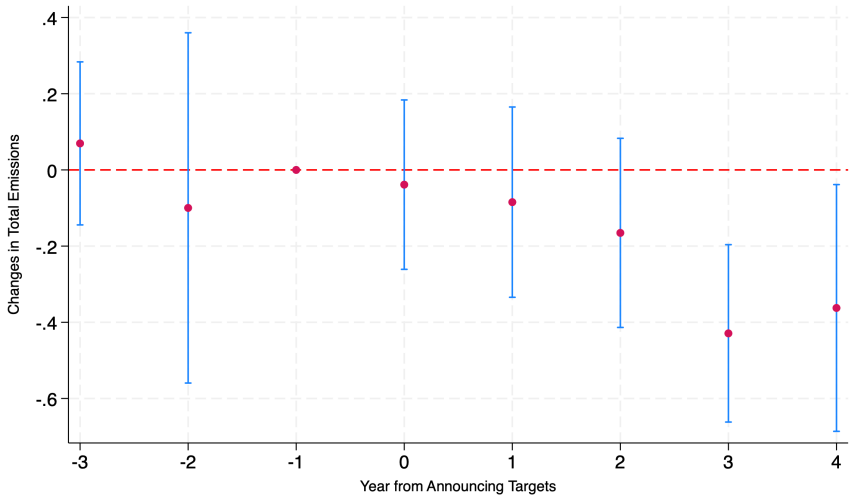


Figure 5: Generator-Level Emissions
This figure presents event study estimates and 95% confidence intervals from the staggered DiD regression in Equation 1, using generator-level data from 2006 to 2022 on the fossil fuel subsample. The outcome variable is the logarithm of emissions plus one. Standard errors are clustered at the firm level.

These magnitudes are economically meaningful. Nearly all initial commitments in the sample are quantitative carbon reduction targets, with an average pledged reduction of

[7]Implied tons avoided are computed as $(1 - \exp(\beta))$ times mean pre-announcement emissions.

roughly 45 percent.[8] The observed emission declines therefore represent a substantial share of firms' stated objectives, consistent with commitments being followed by real operational adjustments rather than symbolic announcements. For example, Southern Company announced a target to reduce carbon emissions by 50 percent from 2007 levels by 2030 and to achieve net-zero emissions by 2050.

Table 2: Emission Targets Adoption and Generator-Level Emissions

	Dependent Variable: ln(Emissions)			
	(1)	(2)	(3)	(4)
	Fossil Fuel Generators			
3-Year Pre-Announcement	0.07	0.11	0.14	0.12
	(0.11)	(0.11)	(0.16)	(0.22)
2-Year Pre-Announcement	-0.10	0.12	0.09	0.29**
	(0.23)	(0.08)	(0.11)	(0.11)
Year of Announcement	-0.04	-0.15	-0.13	-0.17
	(0.11)	(0.13)	(0.09)	(0.14)
1-Year Post-Announcement	-0.08	-0.24*	-0.22**	-0.26*
	(0.12)	(0.13)	(0.10)	(0.15)
2-Year Post-Announcement	-0.17	-0.21	-0.05	-0.22
	(0.12)	(0.14)	(0.13)	(0.20)
3-Year Post-Announcement	-0.43***	-0.38***	-0.22*	-0.33*
	(0.12)	(0.12)	(0.13)	(0.18)
4-Year Post-Announcement	-0.36**	-0.41**	-0.28**	-0.45**
	(0.16)	(0.17)	(0.14)	(0.21)
Generator FE	Y	Y	Y	Y
Year FE	Y	Y	Absorbed	Absorbed
State-Year FE	N	N	Y	Y
Balanced Sample	N	Y	N	Y
Controls	Y	Y	Y	Y
R^2	0.83	0.87	0.85	0.88
# Generator-Year	39575	18518	39529	18518
# Firms	58	43	58	43

This table reports OLS estimation results from the event study regression in Equation 1, using generator-level data from fossil fuel generators from 2006 to 2022. The outcome variable is the natural logarithm of emissions plus one. Control variables include fuel type, capacity bin, and multiple fuels indicator. Column (3) include fewer observations due to missing observations on the *state* variable. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

To address concerns that these estimates may be driven by changes in sample composition, such as the entry of newer, cleaner units or the retirement of older, coal-fired generators, Column (2) restricts the analysis to a balanced panel of generators that operate continuously

[8]The average pledged reduction is based on manually collected data from firms' sustainability reports. To compute this average, we exclude absolute carbon reduction targets – commitments to reduce total emissions by a fixed amount rather than a percentage – which account for about 27% of the sample. For intensity-based targets, we standardize reduction amounts where feasible but note that firms use varying base years (e.g., 2005, 2010, or 2015), limiting cross-firm comparability. The 45% figure should therefore be interpreted as an approximate benchmark for the scale of firms' stated reductions rather than a precise aggregate measure.

throughout the sample period. The results are similar in magnitude and timing, indicating that the baseline findings are not driven by generator entry or exit.

Columns (3) and (4) further include state-by-year fixed effects to account for time-varying heterogeneity in regulatory environments, fuel markets, and climate policies across states. While the estimated coefficients are modestly smaller in these specifications, emissions remain significantly lower in the post-announcement period. These results confirm that the observed emission reductions are not driven by differential exposure to state-level policies or other unobserved state-specific shocks.

Across all specifications, we find no evidence of systematic pre-trends in emissions in the years leading up to commitment announcements. Taken together, these results indicate that corporate carbon commitments are associated with large and persistent reductions in generator-level emissions. The lagged response is consistent with the operational and planning frictions inherent in electricity generation and suggests that climate commitments serve as a trigger for subsequent adjustments rather than reflecting pre-existing downward trends.

5.2 Mechanisms: How Do Firms Reduce Emissions

Having established that emissions decline following commitment announcements, we next examine how firms achieve these reductions. Guided by the conceptual framework in Section 4.1 and Figure 4, we evaluate three potential margins of adjustment: reallocation of generation across existing units, changes in operational efficiency, and longer-run portfolio reallocation toward renewable energy. We begin with the most immediate margin: changes in how firms dispatch their existing generation assets.

5.2.1 Reallocation of generation across units

A natural first response to a carbon commitment is to shift generation away from higher-emitting units within a firm's existing fleet. Table 3 examines changes in electricity gener-

ation following commitment announcements, using the logarithm of net generation as the dependent variable. Results are reported separately for all generators, renewable generators, and fossil-fuel generators.

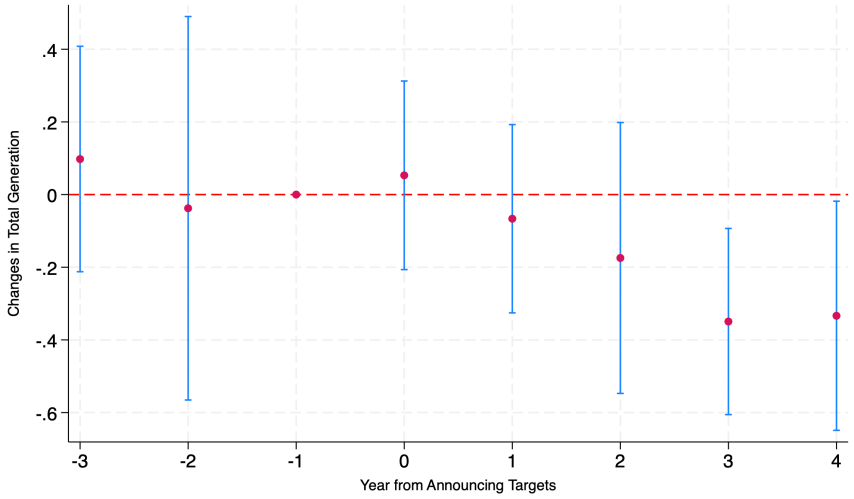


Figure 6: Generator-Level Net Generation
This figure presents event study estimates and 95% confidence intervals from the staggered DiD regression in Equation 1, using generator-level data from 2006 to 2022 on the fossil fuel subsample. The outcome variable is the logarithm of generation plus one. Standard errors are clustered at the firm level.

For the full sample, Column (1) shows a substantial decline in generation beginning three years after the announcement. The estimated coefficient of -0.26 implies a reduction of approximately 23 percent in output at treated generators relative to the pre-announcement period. Disaggregating by fuel type reveals that this effect is entirely driven by fossil-fuel units. As shown in Column (3) and Figure 6, generation from fossil-fuel generators declines sharply starting three years after the announcement and remains persistently lower thereafter.

In contrast, Column (2) shows no statistically significant change in generation at renewable generators at any horizon. Taken together, these results indicate that committed firms primarily reduce emissions by curtailing output from fossil-fuel generators rather than by reducing overall electricity production. The timing and magnitude of these generation declines closely mirror the emission reductions documented in Table 2, reinforcing the inter-

pretation that emission reductions operate through selective reallocation of generation away from higher-emitting assets.

Table 3: Emission Targets Adoption and Generator-Level Net Generation

	Dependent Variable: ln(Generation)		
	(1) *All Generators*	(2) *Renewable*	(3) *Fossil Fuel*
3-Year Pre-Announcement	-0.05	-0.26	0.10
	(0.21)	(0.48)	(0.15)
2-Year Pre-Announcement	-0.02	0.10	-0.04
	(0.18)	(0.10)	(0.26)
Year of Announcement	-0.04	-0.20	0.05
	(0.11)	(0.14)	(0.13)
1-Year Post-Announcement	-0.10	-0.14	-0.07
	(0.12)	(0.17)	(0.13)
2-Year Post-Announcement	-0.14	0.08	-0.17
	(0.16)	(0.18)	(0.19)
3-Year Post-Announcement	-0.26**	0.14	-0.35***
	(0.13)	(0.22)	(0.13)
4-Year Post-Announcement	-0.19	0.33	-0.33**
	(0.13)	(0.24)	(0.16)
Generator FE	Y	Y	Y
Year FE	Y	Y	Y
Controls	Y	Y	Y
R^2	0.79	0.57	0.80
# Generator-Year	53520	12167	39575
# Firms	64	49	58

This table reports OLS estimation results from the event study regression in Equation 1, using generator-level data from 2006 to 2022. The outcome variable is the natural logarithm of generation plus one. Control variables include age, fuel type, capacity bin, and multiple fuels indicator. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

To further isolate within-firm reallocation along this margin, we examine heterogeneity within gas-fired generation.

Gas generators. We distinguish between combustion turbine (CT) and combined-cycle (CC) gas units, which differ markedly in efficiency and emissions intensity. Table 4 shows that post-announcement adjustments are concentrated almost entirely among CT units. Following commitment announcements, CT generators experience large and persistent declines in both emissions and generation. By the fourth post-announcement year, emissions at CT units fall by roughly 50 percent, accompanied by a similarly sized reduction in output. These effects are statistically significant throughout the post-announcement period.

In contrast, we find no statistically significant changes in emissions or generation at

combined-cycle units at any horizon. This pattern indicates that firms reduce emissions from gas generation primarily by curtailing output at the most emissions-intensive units, rather than by uniformly scaling back gas generation or improving operational efficiency across all units.

Table 4: Generator-Level Emissions: Gas Generator Subsample

Dependent Variable:	**Ln(Emissions)**			**Ln(Generation)**		
	(1) *All Gas*	(2) *CT*	(3) *CC*	(4) *All Gas*	(5) *CT*	(6) *CC*
Year of Announcement	-0.17	-0.31**	0.06	-0.10	-0.28*	0.14
	(0.11)	(0.15)	(0.11)	(0.14)	(0.17)	(0.15)
1-Year Post-Announcement	-0.17	-0.39**	0.06	-0.19	-0.36*	-0.12
	(0.13)	(0.16)	(0.17)	(0.17)	(0.20)	(0.22)
2-Year Post-Announcement	-0.21*	-0.39**	-0.04	-0.22	-0.38**	-0.16
	(0.12)	(0.16)	(0.16)	(0.16)	(0.18)	(0.23)
3-Year Post-Announcement	-0.36***	-0.56**	-0.08	-0.32**	-0.56**	-0.10
	(0.11)	(0.21)	(0.19)	(0.15)	(0.22)	(0.29)
4-Year Post-Announcement	-0.35**	-0.61**	-0.09	-0.29	-0.61**	0.04
	(0.15)	(0.25)	(0.18)	(0.18)	(0.26)	(0.23)
Generator FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Balanced Sample	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
R^2	0.81	0.67	0.75	0.82	0.71	0.62
# Generator-Year	12883	6919	4504	12883	6919	4504
# Firms	39	33	28	39	33	28

This table reports changes in emissions and net generation following target announcements for the two types of gas generator using the regression specified in Equation 1, based on generator-level data from 2006–2022. Control variables include age, fuel type, capacity bin, and multiple fuels indicator. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

5.2.2 Operational efficiency improvements

We next examine whether firms reduce emissions by improving the efficiency of existing generators. Such improvements could reflect technological upgrades, turbine retrofits, or enhanced pollution control systems that increase carbon efficiency at the generator level. This mechanism captures changes along the intensive margin, where committed firms enhance the performance of individual assets rather than shifting production across units.

Table 5 reports the estimated effects of commitment announcements on three operational outcomes: emission intensity, capacity utilization, and fuel efficiency. Across specifications, we find little evidence that firms systematically improve generator-level efficiency following

commitment adoption.

Columns (1) and (2) show that emission intensity does not decline persistently in the post-announcement period. While there are small and occasionally statistically significant reductions around the time of announcement, these effects do not grow over time and disappear when the sample is restricted the balanced sample. This pattern contrasts sharply with the large and persistent declines in total emissions documented earlier and suggests that emission reductions are not driven by improvements in emissions per unit of output.

Columns (3) and (4) instead show pronounced declines in capacity utilization. Beginning three years after the announcement, capacity utilization falls by approximately 13 percent, indicating that fossil-fuel generators owned by committed firms operate at lower load factors following commitment adoption. Combined with the generation results in Table 3, this evidence points to reduced utilization of existing fossil assets rather than efficiency gains within those assets.[9] Finally, Columns (5) and (6) show no evidence of sustained improvements in fuel efficiency.

Taken together, these results indicate that operational efficiency improvements play a limited role in explaining post-commitment emission reductions. Instead, firms primarily adjust emissions by scaling back utilization of carbon-intensive generators, consistent with the reallocation mechanism documented above. This pattern likely reflects the high capital costs, long planning horizons, and regulatory constraints associated with efficiency-enhancing retrofits, which make such investments less responsive to voluntary commitments in the short to medium run.

5.2.3 Investment in renewable energy

Finally, we examine whether firms adjust their generation portfolios following commitment announcements. Unlike short-term operational adjustments, this mechanism captures long-

[9]Generator capacity remains largely stable over time; fewer than 15 percent of generators in the sample experience capacity changes during the study period.

Table 5: Emission Targets Adoption and Generator-Level Intensity Measures

Dependent Variable:	**Ln(Emission Intensity)**		**Ln(Capacity Utilization)**		**Ln(Fuel Efficiency)**	
	(1)	(2)	(3)	(4)	(5)	(6)
			Fossil Fuel Generators			
Year of Announcement	-0.07*	-0.06	0.04	0.02	0.06	0.05
	(0.04)	(0.04)	(0.09)	(0.08)	(0.04)	(0.04)
1-Year Post-Announcement	-0.04	-0.03	-0.01	-0.07	0.02	0.01
	(0.03)	(0.04)	(0.08)	(0.09)	(0.03)	(0.04)
2-Year Post-Announcement	-0.07**	-0.06	0.01	-0.02	0.04	0.05
	(0.04)	(0.05)	(0.08)	(0.09)	(0.04)	(0.05)
3-Year Post-Announcement	-0.02	-0.02	-0.13	-0.24***	-0.01	0.01
	(0.03)	(0.04)	(0.09)	(0.08)	(0.03)	(0.04)
4-Year Post-Announcement	-0.01	-0.02	-0.05	-0.15	-0.00	0.01
	(0.03)	(0.04)	(0.12)	(0.13)	(0.03)	(0.04)
Generator FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Balanced Sample	N	Y	N	Y	N	Y
Controls	Y	Y	Y	Y	Y	Y
R^2	0.84	0.83	0.90	0.91	0.86	0.84
# Generator-Year	37265	17973	37271	17976	35839	17587
# Firms	58	43	58	43	58	43

This table reports OLS estimation results from the event study regression in Equation 1, using generator-level data from 2006 to 2022. The outcome variables are the natural logarithm of emission intensity and capacity utilization. Control variables include age, fuel type, capacity bin, and multiple fuels indicator. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

term transition along the extensive margin, where firms reshape their production base toward low-carbon technologies. Using plant-level data, we analyze changes in the number of generators and total installed capacity.

Generator Count. Power plants typically operate multiple generators to enhance reliability, efficiency, and operational flexibility.[10] Changes in the number of active generators capture extensive-margin adjustments through the addition of new units or the retirement of existing ones. Table 6 reports Poisson regression estimates of the effect of commitment announcements on plant-level generator counts. Column (1) shows a modest increase in the total number of generators following commitment adoption. The point estimates imply an increase of roughly 2–3 percent in generator counts within two years after the announcement, although the effects attenuate at longer horizons. Columns (2) and (3) decompose these changes by fuel type. The expansion is driven entirely by renewable generators. Re-

[10]In our sample, over half of plants operate more than one generator. Fossil fuel plants often comprise multiple turbine–boiler units to allow staggered maintenance and flexible dispatch, while renewable plants consist of multiple wind turbines or photovoltaic arrays that collectively form a single generating plant.

newable generator counts increase steadily following commitment announcements, becoming statistically significant within one year and reaching approximately 4 percent by the fourth post-announcement year. In contrast, fossil-fuel generator counts remain flat throughout the post-announcement period, with small and statistically insignificant coefficients at all horizons. These patterns indicate that committed firms expand their generation portfolios primarily through incremental additions of renewable units rather than through accelerated retirements of fossil generators. The absence of differential declines in fossil generator counts likely reflects the contemporaneous industry-wide trends in coal plant closures that affect both committed and non-committed firms.

Table 6: Emission Targets Adoption and Plant-Level Generator Count

	Dependent Variable: Count of Generators		
	(1) *Total*	(2) *Renewable*	(3) *Fossil Fuel*
3-Year Pre-Announcement	-0.007	-0.030	0.013
	(0.017)	(0.019)	(0.023)
2-Year Pre-Announcement	0.015	0.001	0.026
	(0.013)	(0.006)	(0.027)
Year of Announcement	0.017**	0.015	0.007
	(0.008)	(0.013)	(0.007)
1-Year Post-Announcement	0.022**	0.023*	0.007
	(0.010)	(0.013)	(0.008)
2-Year Post-Announcement	0.024*	0.028*	0.004
	(0.013)	(0.014)	(0.010)
3-Year Post-Announcement	0.024	0.033**	0.001
	(0.015)	(0.016)	(0.013)
4-Year Post-Announcement	0.027	0.039**	-0.005
	(0.018)	(0.019)	(0.014)
Plant FE	Y	Y	Y
Year FE	Y	Y	Y
Controls	Y	Y	Y
Pseudo R^2	0.39	0.34	0.39
# Plant-Year	32758	16987	13232
# Firms	77	64	65

This table reports estimation results from the event study regression in Equation 1, estimated using a Poisson model with plant-level data from 2006 to 2022. The outcome variable is the count of active generators. Control variables include the capacity bin and plant age. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Capacity Investment. While generator counts capture changes in the number of operating units, plant-level capacity provides a more comprehensive measure of investment by reflecting the scale of both existing and newly installed assets. Table 7 reports event-study estimates using the logarithm of total plant capacity as the dependent variable. Column (1)

shows no detectable change in aggregate plant capacity following commitment announcements. Column (2) restricts the analysis to the balanced sample, isolating within-plant adjustments. In this specification, total capacity declines modestly but persistently, with estimates implying a reduction of roughly 2–4 percent beginning one year after the announcement. Columns (3) and (4) examine renewable plants separately. The estimates indicate weak increase of about 3 percent appearing four years after the announcement. In contrast, Columns (5) and (6) show pronounced capacity contraction at fossil fuel plants. Among continuously operating fossil plants, capacity declines by approximately 4–6 percent starting in the first post-announcement year and persists thereafter. The fact that these effects are concentrated in the balanced sample indicates that capacity reductions primarily reflect downsizing or partial repowering of existing plants rather than plant retirements or closures.

Table 7: Emission Targets Adoption and Plant-Level Capacity Investment

	Dependent Variable: Ln(Capacity)					
	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample		*Renewable Plants*		*Fossil Fuel Plants*	
Year of Announcement	0.00	-0.01	0.01	-0.00	-0.01	-0.02**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
1-Year Post-Announcement	-0.00	-0.02**	0.01	0.00	-0.02	-0.04***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2-Year Post-Announcement	-0.00	-0.02**	0.01	0.01	-0.03	-0.05***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.02)
3-Year Post-Announcement	-0.00	-0.04**	0.02	-0.01	-0.04	-0.06**
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
4-Year Post-Announcement	0.00	-0.03*	0.03*	0.02	-0.03	-0.06**
	(0.02)	(0.01)	(0.02)	(0.01)	(0.02)	(0.02)
Plant FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Balanced Sample	N	Y	N	Y	N	Y
Controls	Y	Y	Y	Y	Y	Y
R^2	0.99	0.99	0.99	0.99	0.99	0.98
# Plant-Year	32758	16253	16987	6605	13232	8573
# Firms	77	55	64	38	65	52

This table reports OLS estimation results from the event study regression in Equation 1, using plant-level data from 2006 to 2022. The outcome variable is the natural logarithm of plant capacity. Control variables include plant age. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Taken together with the generator-count results, these findings point to a consistent adjustment pattern: committed firms expand the number of renewable generators while si-

multaneously scaling down the capacity of fossil fuel plants. This asymmetry suggests that firms pursue decarbonization through modular renewable investments and gradual capacity contraction on the fossil side, rather than through abrupt plant closures. Overall, the evidence is consistent with a measured but deliberate reallocation of generation portfolios toward lower-carbon technologies following the adoption of corporate climate commitments.

5.3 Heterogeneous Effects

We next examine whether the emission response to corporate carbon commitments varies systematically with features of the commitments themselves or with generator characteristics. Such heterogeneity sheds light on the conditions under which voluntary targets translate into measurable operational change. Table 8 reports estimates from specifications that interact the event-study indicators with three dimensions: target horizon, target ambition, and generator age.

Target Horizon. Column (1) distinguishes between short-horizon commitments, defined as targets with a stated horizon of fewer than five years, and longer-term commitments. The median target horizon in our sample is nine years. The results indicate that generators covered by short-horizon targets experience substantially larger near-term emission reductions. The interaction effects are negative and statistically significant beginning in the announcement year and remain sizable in the first post-announcement year. These patterns suggest that nearer deadlines induce more immediate operational responses, consistent with firms prioritizing short-run adjustments when facing tighter timelines.

Target Ambition. Column (2) explores heterogeneity by target ambition, classifying commitments that pledge reductions of at least 50 percent, including net-zero targets, as highly ambitious. The interaction terms reveal that ambitious commitments are associated with larger emission reductions that emerge over longer horizons. This delayed response is consistent with the longer planning and investment cycles required to meet more stringent goals.

Generator Age. Column (3) examines heterogeneity by generator age, comparing generators older than the sample median to younger units. The results show that emission reductions are significantly larger for older generators, with interaction effects becoming strongly negative two years after the announcement and growing in magnitude thereafter. This pattern suggests that firms disproportionately curtail output at older, less efficient, and more emissions-intensive assets when responding to carbon commitments.

Table 8: Heterogeneous Effects of Target Announcements on Emissions

	Dependent Variable: Ln(Emissions)		
	(1)	(2)	(3)
Interaction Variable (Z)	*Target Length* <5	*Target Amount* $>50\%$	*Age* $>$ *Median*
Year of Announcement	0.01	-0.09	0.06
	(0.11)	(0.11)	(0.17)
1-Year Post-Announcement	-0.01	-0.19	0.09
	(0.10)	(0.12)	(0.15)
2-Year Post-Announcement	-0.21	-0.13	0.05
	(0.13)	(0.14)	(0.16)
3-Year Post-Announcement	-0.49***	-0.38***	-0.11
	(0.13)	(0.13)	(0.15)
4-Year Post-Announcement	-0.37**	-0.35*	-0.09
	(0.18)	(0.19)	(0.17)
Year of Announcement x Z	-0.30**	-0.28	-0.28
	(0.13)	(0.22)	(0.27)
1-Year Post-Announcement x Z	-0.44***	-0.31	-0.47**
	(0.12)	(0.20)	(0.23)
2-Year Post-Announcement x Z	0.12	-0.48*	-0.52***
	(0.22)	(0.27)	(0.18)
3-Year Post-Announcement x Z	0.19	-0.03	-0.76***
	(0.19)	(0.22)	(0.18)
4-Year Post-Announcement x Z	-0.04	-0.57**	-0.66***
	(0.25)	(0.26)	(0.17)
Generator FE	Y	Y	Y
Year FE	Y	Y	Y
Balanced Sample	Y	Y	Y
Controls	Y	Y	Y
R^2	0.84	0.87	0.84
# Generator-Year	39575	18518	39575
# Firms	58	43	58

This table reports OLS estimates from the heterogeneous effects analysis, where each specification interacts the treatment indicators with an interaction variable Z. Each column corresponds to a different Z: target length (Column 1), target amount (Column 2), and generator age (Column 3). The dependent variable is the logarithm of emissions. All regressions include generator and year fixed effects, as well as controls for generator age, fuel type, capacity bin, and a multiple-fuel indicator. Standard errors are clustered at the firm level and reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Taken together, these results indicate that the effects of corporate climate commitments are not uniform across assets or commitments. Near-term reductions are driven primarily by short-horizon targets and by adjustments at older generators, while more ambitious com-

mitments generate larger but slower-moving emission declines. This heterogeneity reinforces the interpretation that firms respond strategically to voluntary targets, choosing adjustment margins that reflect both the stringency of the commitment and the characteristics of their existing generation portfolios.

5.4 Voluntary Carbon Commitments and State Climate Policies

Electricity firms operate within a heterogeneous regulatory environment in which voluntary corporate commitments coexist with state-level climate policies. Two of the most prominent policy instruments in the U.S. power sector are renewable portfolio standards (RPS) and cap-and-trade programs, which directly affect firms' generation choices and emissions. An important question is whether the emission reductions associated with voluntary corporate commitments differ systematically across these policy environments.

In the baseline analysis, we account for differential regulatory exposure by including state-by-year fixed effects, ensuring that the estimated effects of voluntary commitments are identified from within-state variation over time. In this section, we extend that analysis by examining whether the dynamic response to voluntary commitments differs across regulatory regimes. Specifically, we estimate our baseline event-study specification separately for generators located in states with and without RPS policies, and analogously for states with and without cap-and-trade programs.

Figure 7 presents event-study estimates for fossil-fuel generators located in RPS and non-RPS states. In both subsamples, emissions decline following commitment announcements. However, the magnitude and precision of the post-announcement effects differ across policy environments. In non-RPS states, emissions decline sharply beginning one year after the announcement and continue to fall over the post-announcement period, with relatively tight confidence intervals. In contrast, generators in RPS states exhibit smaller and less precisely estimated reductions.

Figure 8 shows analogous results for states with cap-and-trade programs, defined as par-

ticipation in the Regional Greenhouse Gas Initiative (RGGI) or California's cap-and-trade system.[11] As with RPS, emission reductions following voluntary commitment announcements are observed in both regulated and non-regulated states. However, the post-announcement declines are again larger and more precisely estimated in states without cap-and-trade policies, while estimates for regulated states are closer to zero and accompanied by wider confidence intervals.

Taken together, these patterns suggest that the marginal effect of voluntary corporate commitments depends on the surrounding policy environment. In states with binding climate regulation, public policies already constrain emissions and generation choices, potentially limiting the scope for additional short-run emission reductions attributable to voluntary commitments. In contrast, in states with weaker or no binding climate policies, voluntary commitments appear to play a more pronounced role in shaping firms' operational behavior.

Importantly, these findings should not be interpreted as evidence that voluntary commitments are ineffective in regulated states. Rather, they indicate that voluntary targets may operate differently across institutional contexts, reinforcing existing regulatory constraints in some settings while substituting for public policy in others. This interaction between private commitments and public regulation highlights the importance of accounting for policy environment when evaluating the effectiveness of voluntary corporate climate action.

[11] Cap-and-trade states are identified based on participation in RGGI or California's emissions trading program during the sample period.

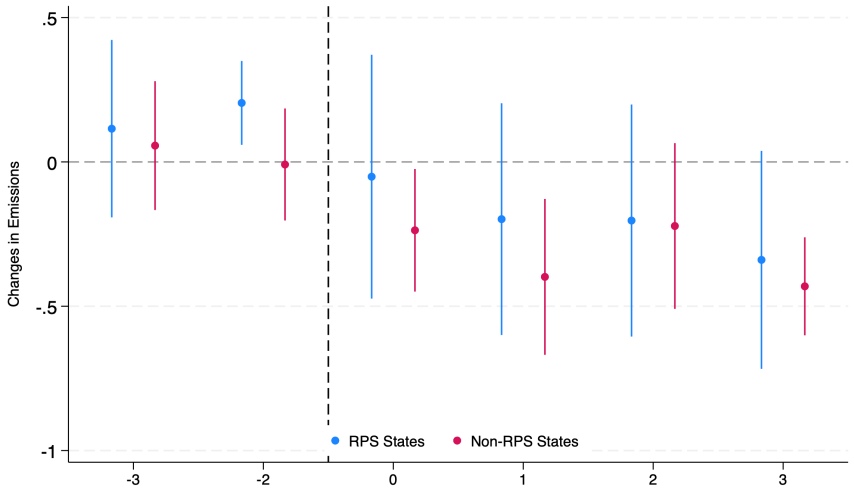


Figure 7: Voluntary Targets and Emissions by RPS States
This figure reports event-study estimates of the effect of corporate carbon commitment announcements on generator-level emissions, estimated separately for generators located in RPS states and non-RPS states. Coefficients are normalized relative to the year prior to announcement. Error bars represent 95% confidence intervals based on standard errors clustered at the firm level.

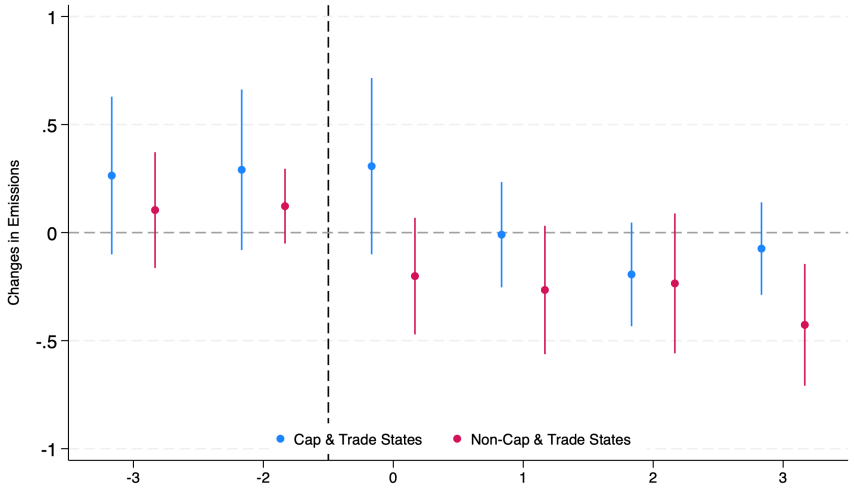


Figure 8: Voluntary Targets and Emissions by Cap & Trade States
This figure reports event-study estimates of the effect of corporate carbon commitment announcements on generator-level emissions, estimated separately for generators located in cap-and-trade states (RGGI and California) and non-cap-and-trade states. Coefficients are normalized relative to the year prior to announcement. Error bars represent 95% confidence intervals based on standard errors clustered at the firm level.

5.5 Robustness

Given the staggered adoption of carbon commitments, the heterogeneity documented above, and the interaction with regulatory environments, we conduct a series of robustness checks to assess the sensitivity of our results to alternative estimation strategies and sample definitions.

Callaway and Sant'Anna (2021) Recent econometric research has shown that the standard two-way fixed effects (TWFE) model may produce biased estimates when treatment effects are heterogeneous across units. In settings with staggered adoption, where units are treated at different points in time, the TWFE estimator effectively computes a weighted average effect, potentially assigning negative weights and leading to biased inference. To address this concern, we implement the method in Callaway and Sant'Anna (2021) and present the results in Figure 11 and Column (1) of Table 9. Consistent with our baseline findings, we observe similar post-commitment reductions in emissions of following target announcements.

Weighted Regressions Recognizing that generators in our sample vary substantially in size, we conduct an additional robustness test in which observations are weighted by generator capacity in our baseline regression. The results are shown in Figure 12 and Column (2) of Table 9. While the coefficients are smaller than our unweighted estimates, they remain statistically significant, indicating that variation in generator size does not fully drive our findings.

6 Conclusion

The recent growth in corporate carbon commitments highlights the increasing role of the private sector in addressing climate change. While these voluntary pledges signal intent, questions remain about whether they translate into meaningful reductions in emissions and structural changes in firm behavior. By examining electricity firms, a sector central to national decarbonization efforts and rich in detailed operational data, this paper provides evi-

Table 9: Emission Targets Adoption and Generator-Level Emissions (Robustness)

	Dependent Variable: Ln(Emissions)	
	(1)	(2)
	Callaway and Sant'Anna (2021)	*Weighted Regressions*
3-Year Pre-Announcement	-0.02	-0.06
	(0.05)	(0.07)
2-Year Pre-Announcement	-0.02	-0.06
	(0.04)	(0.09)
Year of Announcement	0.00	-0.06
	(0.04)	(0.06)
1-Year Post-Announcement	-0.07	-0.29*
	(0.05)	(0.16)
2-Year Post-Announcement	-0.08	-0.25***
	(0.07)	(0.09)
3-Year Post-Announcement	-0.41***	-0.30***
	(0.09)	(0.10)
4-Year Post-Announcement	-0.32***	-0.23**
	(0.10)	(0.10)
Generator FE	Y	Y
Year FE	Y	Y
Balanced Sample	Y	N
Controls	Y	Y
N	29506	39575

This table reports robustness check results for the OLS event study regression described in Equation 1, using generator-level data from 2006 to 2022. The dependent variable is the natural logarithm of emissions plus one. Column (1) implements the estimator proposed by Callaway and Sant'Anna (2021). Column (2) presents results from a weighted regression, where observations are weighted by generator capacity to account for size differences. Control variables include generator age, fuel type, capacity bin, and an indicator for multiple fuels. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

dence that corporate commitments can influence both operational decisions and investment patterns. Our findings suggest that firms act on their pledges by reallocating generation away from high-emitting units and expanding renewable capacity, reflecting deliberate portfolio adjustments aligned with long-term decarbonization objectives. At the same time, we find limited evidence of efficiency enhancements or accelerated retirement of coal units, indicating that firms remain cautious with costly capital-intensive interventions and favor strategies that leverage operational flexibility and modular investments.

Beyond documenting these behavioral responses, our analysis highlights the mechanisms through which corporate commitments operate, including reallocation of production, operational adjustments, and investment in low-carbon technologies. These findings suggest that firms are not merely signaling intentions but are engaging in tangible strategies to achieve their climate objectives. The results also raise important considerations for policymakers and investors regarding the credibility, monitoring, and enforcement of voluntary targets, as well as the potential synergies with regulatory and market-based climate instruments.

Future research could build on this work in several directions. Expanding the analysis to other sectors would help determine the generalizability of these patterns, particularly in industries with less regulatory oversight or limited data availability. Further investigation into how external incentives, such as carbon pricing, renewable subsidies, or shareholder pressures, interact with voluntary corporate commitments could clarify the conditions under which pledges are most effective. Additionally, examining the broader economic and technological impacts of these commitments, including innovation, investment patterns, and financial performance, could provide a more holistic understanding of the role of firms in advancing decarbonization. As corporate climate pledges continue to proliferate, continued empirical analysis will be essential to inform both policy design and corporate strategy, ensuring that commitments lead to meaningful environmental outcomes.

7 Additional Tables/Plots

Table 10: State Policy Effects of Emission Targets Adoption on Generator-Level Emissions

	Dependent Variable: Ln(Emissions)		
State Policy:	RPS	REC Price	RGGI Price
	(1)	(2)	(3)
	Fossil Fuel Generators		
Year of Announcement	0.04	-0.22**	-0.04
	(0.15)	(0.09)	(0.10)
1-Year Post-Announcement	-0.09	-0.01	-0.05
	(0.17)	(0.20)	(0.12)
2-Year Post-Announcement	0.01	0.09	-0.12
	(0.18)	(0.27)	(0.12)
3-Year Post-Announcement	-0.32	0.08	-0.37***
	(0.23)	(0.13)	(0.12)
4-Year Post-Announcement	-0.36*	0.18	-0.30*
	(0.19)	(0.14)	(0.15)
Year of Announcement x State Policy	-0.11	2.47***	0.46**
	(0.18)	(0.37)	(0.21)
1-Year Post-Announcement x State Policy	0.06	1.32	-0.14
	(0.21)	(0.95)	(0.16)
2-Year Post-Announcement x State Policy	-0.22	-0.50	-0.24
	(0.22)	(1.35)	(0.20)
3-Year Post-Announcement x State Policy	-0.11	1.24	-0.09
	(0.32)	(1.15)	(0.22)
4-Year Post-Announcement x State Policy	0.06	-1.40	-0.46***
	(0.18)	(1.15)	(0.15)
Generator FE	Y	Y	Y
Year FE	Y	Y	Y
Controls	Y	Y	Y
N	39569	10112	39569
R^2	0.83	0.85	0.83

This table reports OLS estimation results from the event study regression in Equation 1, using generator-level data from fossil fuel generators from 2006 to 2022. The outcome variable is the natural logarithm of emissions plus one. Control variables include fuel type, capacity bin, and multiple fuels indicator. Standard errors clustered at the firm level are reported in parentheses. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

	Dependent Variable: Count of Generators								
State Policy:	RPS			REC Price			RGGI Price		
	(1) *Total*	(2) *Ren.*	(3) *Fossil*	(4) *Total*	(5) *Ren.*	(6) *Fossil*	(7) *Total*	(8) *Ren.*	(9) *Fossil*
3-Year Pre-Ann.	-0.01	-0.03	0.01	-0.02*	0.01	-0.04**	0.00	-0.02	0.02
	(0.02)	(0.02)	(0.02)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
2-Year Pre-Ann.	0.02	0.00	0.03	-0.02	0.00	-0.03*	0.02	0.02	0.03
	(0.01)	(0.01)	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.02)	(0.03)
Year of Ann.	-0.01	0.02	-0.04	-0.00	-0.03**	-0.00	0.01***	0.01	0.00
	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
1-Year Post-Ann.	-0.01	0.02	-0.05	-0.01	-0.02	-0.01	0.02**	0.02*	0.00
	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
2-Year Post-Ann.	-0.01	0.02	-0.05	-0.02	-0.02	-0.01	0.02**	0.03**	-0.00
	(0.02)	(0.01)	(0.04)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)
3-Year Post-Ann.	-0.00	0.02	-0.04	-0.02*	-0.02	-0.02	0.02*	0.03**	-0.00
	(0.02)	(0.02)	(0.03)	(0.01)	(0.02)	(0.02)	(0.01)	(0.01)	(0.01)
4-Year Post-Ann.	-0.00	0.02	-0.05	-0.05***	-0.03	-0.06***	0.02	0.04**	-0.01
	(0.02)	(0.02)	(0.04)	(0.02)	(0.04)	(0.02)	(0.01)	(0.01)	(0.01)
Year of Ann. x State Policy	0.04	-0.00	0.07	0.00	0.49***	-0.01	0.12	0.12	-0.19
	(0.03)	(0.03)	(0.04)	(0.03)	(0.14)	(0.06)	(0.16)	(0.15)	(0.27)
2-Year Post Ann. x State Policy	0.05	0.00	0.09*	0.06	0.07	0.04	0.04	-0.02	-0.30
	(0.03)	(0.03)	(0.05)	(0.04)	(0.12)	(0.05)	(0.17)	(0.16)	(0.27)
3-Year Post Ann. x State Policy	0.05	0.01	0.08	0.11*	0.10	0.10	-0.01	-0.10	-0.30
	(0.04)	(0.03)	(0.05)	(0.06)	(0.09)	(0.08)	(0.17)	(0.15)	(0.29)
4-Year Post Ann. x State Policy	0.03	0.01	0.06	-0.00	0.08	0.02	0.20	0.05	-0.41
	(0.03)	(0.03)	(0.04)	(0.06)	(0.16)	(0.09)	(0.14)	(0.16)	(0.35)
5-Year Post Ann. x State Policy	0.04	0.03	0.07	0.08*	0.07	0.23***	0.21**	-0.00	-0.41
	(0.03)	(0.03)	(0.05)	(0.05)	(0.15)	(0.06)	(0.10)	(0.17)	(0.35)
State Policy	-0.03	-0.03	-0.05	-0.05*	0.12	-0.06**	0.59***	0.46*	1.63***
	(0.03)	(0.03)	(0.03)	(0.03)	(0.11)	(0.03)	(0.15)	(0.24)	(0.50)
N	32292.00	16780.00	13251.00	7386.00	2796.00	3318.00	32292.00	16780.00	13251.00
r2									

Table 11: Firm-Level Generation

	(1)	(2)	(3)	(4)	(5)	(6)
					Generation Mix	
	Log(Emi)	Log(Emi.Intensity)	Log(Gen)	Renewable %	Gas %	Coal%
pre_3	-0.644	-0.034	0.023	0.154	-0.182	0.017
	(0.500)	(0.023)	(0.188)	(0.103)	(0.185)	(0.094)
pre_2	-0.095	-0.024*	0.184	0.081	-0.085	0.060
	(0.103)	(0.013)	(0.119)	(0.084)	(0.079)	(0.040)
post_1	-0.131	0.016**	-0.086	-0.055	0.001	-0.089
	(0.240)	(0.007)	(0.073)	(0.074)	(0.047)	(0.102)
post_2	-0.266	-0.002	-0.260	0.098	-0.064	-0.190
	(0.310)	(0.014)	(0.179)	(0.104)	(0.106)	(0.122)
post_3	-0.239	0.004	-0.326	0.130	-0.076	-0.179
	(0.414)	(0.021)	(0.237)	(0.146)	(0.159)	(0.116)
post_4	-0.086	0.022	-0.492	-0.090	0.267	-0.333**
	(0.564)	(0.025)	(0.299)	(0.229)	(0.213)	(0.159)
post_5	-0.134	0.014	-0.518	-0.075	0.239	-0.420**
	(0.593)	(0.029)	(0.356)	(0.265)	(0.228)	(0.200)
N	819	807	819	807	807	807
Year FE	Y	Y	Y	Y	Y	Y
Firm FE	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
R^2						

Standard errors in parentheses
Standard errors clustered at the firm level. Sample period 2006-2022.
Additional outcome variables, fuel efficiency, capacity utilization, no significant result
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

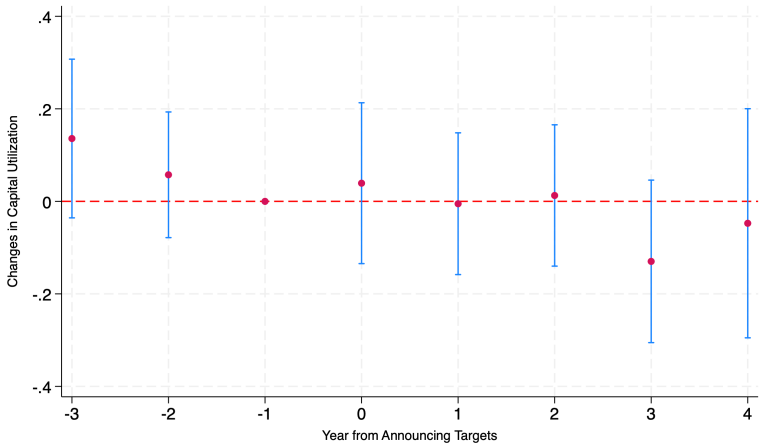


Figure 9: Generator-Level Capacity Utilization
This figure presents event study estimates and 95% confidence intervals from the staggered DiD regression in Equation 1, using generator-level data from 2006 to 2022 on the fossil fuel subsample. The outcome variable is the natural logarithm of capacity utilization. Standard errors are clustered at the firm level.

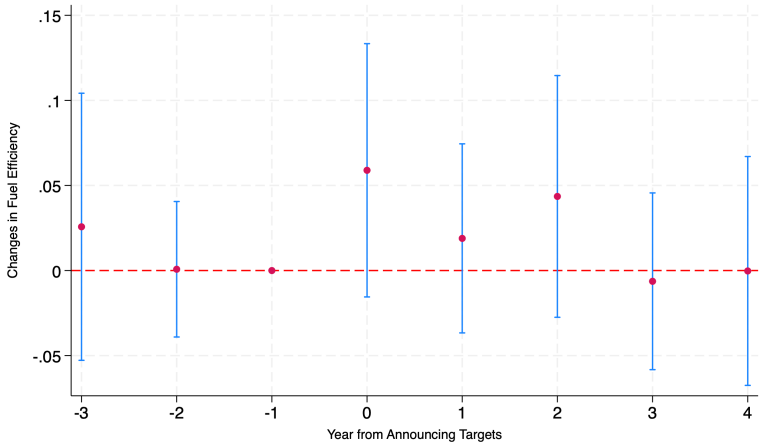


Figure 10: Generator-Level Fuel Efficiency
This figure presents event study estimates and 95% confidence intervals from the staggered DiD regression in Equation 1, using generator-level data from 2006 to 2022 on the fossil fuel subsample. The outcome variable is the natural logarithm of fuel efficiency. Standard errors are clustered at the firm level.

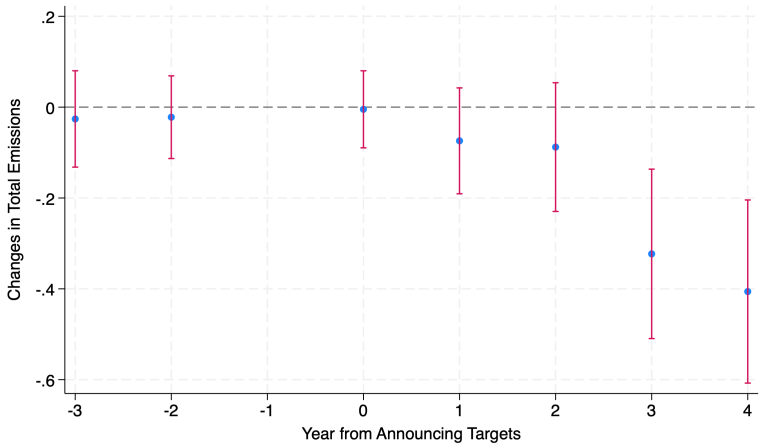


Figure 11: Generator-Level Emissions (Callaway and Sant'Anna, 2021)
This figure presents coefficient estimates following the method of Callaway and Sant'Anna (2021), using generator-level data from 2006 to 2022 and treating the not-yet-committed firms as the control group. The outcome variable is the natural logarithm of emissions. Standard errors are clustered at the firm level.

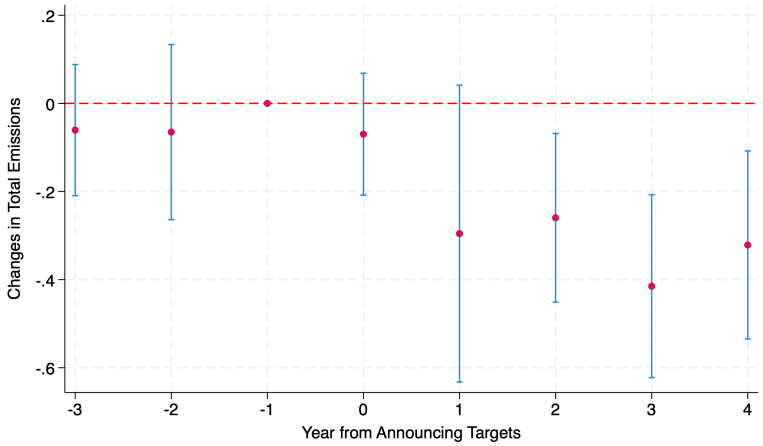


Figure 12: Generator-Level Emissions (Weighted Regressions)
This figure presents event study estimates and 95% confidence intervals from the staggered DiD regression in Equation 1, using generator-level data from 2006 to 2022, and weighting observations by generator size. The outcome variable is the natural logarithm of emissions. Standard errors are clustered at the firm level.

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Appendix A: Sample Construction

	Data Construction Details	N	Unique Generators
1	Full generator-year panel (2006–2022)	369,639	42,281
2	Owned by Russell 3000 Index electricity firms	97,477	10,407
3	Exclude small generators (capacity <10 MW)	64,201	6,805
4	Retain only generators with non-negative age	60,910	6,305
5	Drop generators with zero generation in all years	53,773	5,188
6	Drop generators with missing emissions data	53,520	5,167

Appendix B: Variable Definitions

Variable	Definition
Generator-Level Variables	
Capacity	Installed generating capacity in megawatts, as reported on EIA Form 860.
Age	Generator age in years, computed as the calendar year minus the year of first commercial operation, as reported on EIA Form 860.
Capacity Bin	Categorical variable indicating nameplate capacity tier: 1 = (0, 50] MW; 2 = (50, 100] MW; 3 = (100, 250] MW; 4 = (250, 500] MW; 5 = >500 MW.
Fuel Type	Primary energy source: fossil fuels (coal, natural gas, petroleum), renewable (wind, solar, hydro, geothermal, biomass), nuclear, and other.as reported on EIA Form 860.
Multiple Fuels	Binary indicator equal to one if the generator is capable of operating on more than one fuel source, as reported on EIA Form 860.
Net Generation	Annual net electricity generation in megawatt-hours, from EIA Form 923.
Emissions	Annual carbon dioxide emissions in metric tons. Primary source is the EPA Clean Air Markets Program Database (CAMPD); where monitoring data are unavailable, emissions are imputed from EIA-reported fuel consumption using standard EPA emission factors.
Capacity Utilization	Ratio of annual net generation to maximum potential generation, computed as Generation/(Capacity $\times$ 8,760) $\times$ 100.

Variable	Definition
Emission Intensity	Ratio of annual CO_2 emissions to net generation, computed as Emissions/Generation $\times$ 100.
Fuel Efficiency	Net generation per unit of fuel consumed, computed as net generation divided by total fuel consumed , from EIA Form 923.
Firm-Level Commitment Variables	
Target Horizon	Length of the commitment in years, computed as the stated target year minus the announcement year.
Target Amount	Pledged percentage reduction in emissions relative to the firm's stated baseline year. Applicable to carbon reduction targets only; absolute-quantity and net-zero targets are excluded.
Plant-Level Variables	
Generator Count	Number of active generators at the plant in a given year.
Plant Capacity	Sum of capacity across all active generators at the plant.
State Policy Variables	
RPS Indicator	Binary variable equal to one if the generator's state had an active Renewable Portfolio Standard in the relevant year, based on the National Conference of State Legislatures (NCSL) database. Updated to reflect the year of adoption and any subsequent repeal or modification.

Variable	Definition
Cap-and-Trade Indicator	Binary variable equal to one if the generator's state participates in the Regional Greenhouse Gas Initiative (RGGI) or California's cap-and-trade program in the relevant year.