

# Books versus Atmosphere: Corporate Boundary Change and the Measurement of U.S. Electric Utility Decarbonisation, 2018–2023

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**Abstract.** Most of the largest U.S. electric power parents announced net-zero or deep carbon-reduction targets between 2018 and 2023, and reported emissions fell over the same period. Corporate emission reductions and atmospheric abatement are not equivalent, because the corporate boundary moves when ownership shares change hands. A facility-level panel from the U.S. Environmental Protection Agency Greenhouse Gas Reporting Program for 2018–2023 allocates emissions to parent companies by reported ownership share under a label-level crosswalk, and decomposes each parent's change into an operating change on shares held in both years, shares that departed, and shares newly held. Across the 43 parents emitting at least 10 Mt CO<sub>2</sub>e in either year, headline changes range from –100% to +22%, and 36 parents reduced. One reduction reflects a change in reported parent attribution rather than a transaction; excluding it, gross reduction across the remaining 35 reducing parents is 312.6 Mt CO<sub>2</sub>e, of which departed shares accounted for 59.2 Mt of 2023 emissions, or 19.0%. Including it gives 325.0 Mt, 69.4 Mt and 21.4%. The effect is concentrated: four of the 35 exceed a 50% transfer ratio while seventeen show none. Disclosure rules should require ownership-driven emission changes to be reported separately from operational ones.

**Keywords:** Corporate climate targets, net zero, electric utilities, greenhouse gas accounting, divestiture, emissions disclosure.

## 1. Introduction

In June 2021 the Public Service Enterprise Group (PSEG) advanced its net-zero target from 2050 to 2030 [1]. The company lists divestiture first among the measures behind that reduction: since 2005, it states, combined Scope 1 and 2 emissions fell “by 89% by divesting in fossil generation, improving energy efficiency and modernizing our electricity and natural gas networks” [2]. PSEG's 2018 generation portfolio carried 12.4 Mt CO<sub>2</sub>e of attributed emissions: about 7.4 Mt in the 6,750 MW fossil fleet sold to a private-equity buyer in 2022, the remainder in jointly owned coal interests that left earlier. The 2018 shares applied to the same facilities' 2023 emissions give 10.6 Mt. By 2023 PSEG's GHGRP-attributed generation emissions were zero.

Large U.S. utilities announced net-zero commitments in a concentrated wave between 2018 and 2023, and U.S. power-sector emissions declined over the following years. Attributing that decline is difficult because fuel prices, state clean-energy mandates, retirement schedules and voluntary commitments moved together. A prior problem has received less attention: whether the corporate-level series used to assess pledge progress measures what it is taken to measure. When an ownership share is sold, the emissions attributed to the seller fall by the full amount of that share even if the plant operates unchanged, unless the seller judges the transaction significant enough to recalculate its base year [3].

Three literatures bear on this and are rarely connected. Studies of corporate climate targets test whether target-setters subsequently reduce emissions, using cross-sector samples and, in most cases, self-reported or vendor-compiled data [4–7]. Studies of the U.S. power sector model committed emissions from the existing generator fleet [8], but the pledge itself does not enter such models as an object of measurement. A third strand, centred on the asset market for polluting facilities, supplies a

candidate mechanism [9], though it rests on toxic-release rather than greenhouse-gas data and is not tested within the U.S. electricity sector.

How much of the reduction in GHGRP-attributed generation emissions of large U.S. electric power parent companies between 2018 and 2023 reflects lower emissions from shares the parent still held, rather than shares that departed while the underlying assets continued to operate? Mandatory facility-level reporting carries the ownership detail that voluntary corporate disclosure omits, and 2018–2023 is an early window in which the pledges whose *ex ante* potential Godlevskaya, Galik and Kaufman [10] estimated can be assessed *ex post*. The boundary pattern that Duchin, Gao and Xu [9] document for toxic releases appears in greenhouse-gas terms within this sector, and the resulting divergence is concentrated rather than general.

## 2. Literature Review

Whether voluntary corporate targets deliver abatement remains contested. Godlevskaya et al. [10] estimate that 36 U.S. utility pledges in place by December 2020 could cut emissions by roughly one-third of 2018 U.S. power-sector emissions, with about one-seventh already required by state policy. Ruiz Manuel and Blok [4] find the Scope 1 and 2 emissions of 102 large initiative members fell 35.6% over 2015–2019, with reductions concentrated in a few emissions-intensive firms. Dahlmann, Branicki and Brammer [5] find no overall association between target-setting and emissions; only ambitious, long-horizon, absolute targets are associated with reductions. Against these, Salerno and Sampagnaro [6] report only weak difference-in-differences evidence for science-based targets, and observe that reduction effort rises before announcement and may stabilise afterwards. Bolton and Kacperczyk [7] find committing firms do reduce emissions but already have lower absolute emissions, indicating selection. Jiang, Kim and Lu [11] show that of 1,041 firms with targets ending in 2020, 88 failed and the targets of a further 320 disappeared from disclosure, with no observable market reaction.

The basis of this discussion is the corporate-level reported series, and their accuracy has also been doubted. Duchin, Gao and Xu [9] analysed 888 divestitures of polluting plants by connecting transaction records with the EPA Toxics Release Inventory, found that toxic releases did not decrease after the sale, buyers faced reduced environmental pressure, and sellers obtained a higher environmental rating; thus, the asset market allowed firms to redraw boundaries without consequences for pollution. Whether the same holds for greenhouse gases has received less attention. The previous cases in this area are older than that. Kim and Lyon [12] have shown that the participants in the U.S. Department of Energy's voluntary greenhouse gas registry increased total emissions while reporting reductions, whereas non-participating entities reduced theirs. Stanny [13] has compared U.S. utility CDP disclosures with mandatory EPA reports and found that the figures are inconsistent, boundary-dependent and largely unverified. Therefore, the mandatory report will serve as the dependent variable.

The pledge wave began with Xcel Energy in December 2018; twenty-two of the twenty-six identified targets were announced by the end of 2021. State clean-electricity mandates advanced over the same years, which is one reason attribution is contested. State-level decomposition for 1990–2015 attributes roughly 60% of the post-2005 decline to gas displacing coal and petroleum and about 30% to renewables [14]. This literature does not ask whether the firm-level series is stable enough to support the pledge-progress inferences drawn from it.

## 3. Data and Method

### 3.1. Data

The EPA Greenhouse Gas Reporting Program (GHGRP) power-plant sector supplies reporting years 2018 through 2023, retrieved through the Envirofacts REST interface from tables `pub_facts_sector_ghg_emission`, filtered on `sector_id = 3`, and `pub_dim_facility`, from which facility name, state, NAICS code and the parent-company string are taken [15]. The raw facility-year panel

is rebuildable from these two tables; the EIA-860M retired-generator worksheet [16] validates exits only, and neither source supplies the crosswalk or the pledge coding. GHGRP reporting is mandatory for facilities whose emissions reach the 25,000 t CO<sub>2</sub>e per year threshold, and for units already monitoring under the Acid Rain Program irrespective of that threshold. The programme prescribes calculation methods and records each facility's parent company or companies with ownership percentages. Reporters that fall below the threshold must continue to report until the off-ramp conditions of 40 CFR §98.2 are met, so a facility does not leave the programme in the year its emissions first fall. Emissions cover all greenhouse gases and are expressed as CO<sub>2</sub>e, excluding biogenic CO<sub>2</sub>, which the programme reports separately and which is not part of a facility's reported total; the panel totals reproduce the published sector figures of 1,814.8 Mt for 2018 and 1,471.5 Mt for 2023. Including biogenic CO<sub>2</sub> would raise each annual total by 6.8 to 8.7 Mt and would move the headline transfer ratio by less than 0.1 percentage points. The panel contains 1,380 facilities in 2018 and 1,312 in 2023. The sector includes cogeneration and industrial power producers as well as electric utilities, so results are reported for parent companies.

### 3.2. Parent-company panel

The programme records facility emissions for the calendar year and the parent company or companies as reported for that year, so ownership is a year-end attribute; a share that changes during a year is therefore assigned to whichever parent the facility reports at year end. Facility emissions are allocated to parents in proportion to that reported ownership share; where a percentage is blank, which occurs for 23 facilities in 2018 and 21 in 2023 and mostly involves federal entities, the residual is assigned to the unlabelled parent. Reported parent names change for three reasons, separated and documented in a label-level crosswalk covering 1,029 case-folded labels, representing 1,114 exact spellings reported over the window: relabelling of the same entity; roll-up of a subsidiary belonging to the same group in both years; and transactions inside the window, which are not harmonised. Labels are grouped by a normalised key stripping legal-form suffixes and punctuation, with an explicit override table for corporate relationships, so that each assignment rests on a named label rather than on a matching rule. Accordingly SCANA is kept separate from Dominion Energy, which acquired it in January 2019; Lightstone Generation, a Blackstone and ArcLight joint venture, is kept separate from LS Power; and the Ohio Valley Electric Corporation is kept separate from American Electric Power. Facilities reported under the federal "US Government" label are assigned to the Tennessee Valley Authority except for four non-TVA federal facilities identified by facility name.

### 3.3. Decomposition

For parent  $p$  and facility  $i$ , let  $s$  denote ownership share and  $E$  facility emissions, with subscripts for 2018 and 2023, and let  $m = \min(s_{18}, s_{23})$ . The decomposition operates on ownership share-units rather than whole facilities, so that partial changes in ownership are not misread as operating changes.

$$op = \sum_i m(E_{23} - E_{18}) \quad (1)$$

$$D = \sum_i \max(s_{18} - s_{23}, 0)E_{18}; A = \sum_i \max(s_{23} - s_{18}, 0)E_{23} \quad (2)$$

The three terms are exactly additive.

$$E_{p,23} - E_{p,18} = op - D + A \quad (3)$$

A fourth quantity,  $D_{live}$ , is a diagnostic rather than an additive term. It applies the same departed-share weights as  $D$  but values them at 2023 emissions, so it measures what those shares would have contributed had they remained on the parent's books; it is not a component of  $D$  and does not enter the identity. The boundary-adjusted change and the transfer ratio follow.

$$D_{live} = \sum_i \max(s_{18} - s_{23}, 0)E_{23} \quad (4)$$

$$\text{Adjusted change} = \frac{(E_{p,23} - E_{p,18}) + D_{live}}{E_{p,18}} \times 100 \quad (5)$$

$$\text{Transfer ratio} = \frac{D_{\text{live}}}{E_{p,18} - E_{p,23}} \times 100 \quad (6)$$

Both the adjusted change and the transfer ratio are only defined for parents with a headline reduction; adding departed emissions back to a parent whose emissions increased is not defined. The upper limit of the ratio is not 100%; when the departed shares' emissions in 2023 exceed the total reduction by the parent company, it will be over 100%. The adjustment is intentionally one-sided; it corrects departures but omits arrivals because the acquirer's baseline treatment is also disputed; thus, it serves as a diagnostic tool rather than a full restatement, and these are accounting decompositions rather than causal estimates. The 43 parents included in the sample emit 10 Mt CO<sub>2</sub>e or more in one of the two years.

### 3.4. Pledge coding and whole-facility validation

Announcement year, target year, baseline year, nearest interim milestone and target form come from company releases and sustainability reports; entries that could not be verified are marked n.i. A facility that leaves the programme, whether through closure or through the §98.2 off-ramp, disappears from the panel and could be mistaken for a retirement. All 50 facilities that left the panel and emitted more than 0.3 Mt in 2018 were matched against the EIA-860M inventory [16], using exact and normalised plant names, then token-subset and fuzzy matching, then manual resolution of documented name variants; 49, representing 108.0 Mt of 108.4 Mt, match at least one generator retired at the plant between 2018 and 2023, as Table 1 summarises. A generator match does not establish whole-facility closure, and threshold entry, multi-year reporting cessation and endpoint truncation can bias the ratio in either direction.

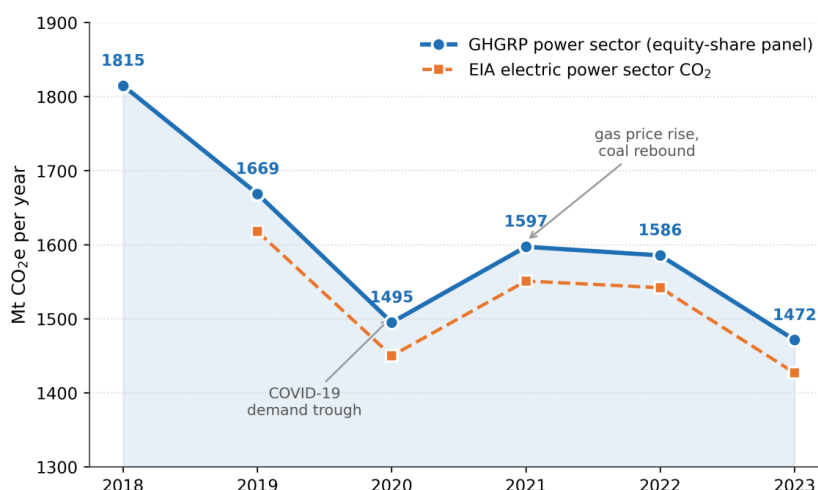
**Table 1.** Validation of disappearing facilities against the EIA-860M generator inventory.

| Category                                             | Facilities | Mt CO <sub>2</sub> e (2018) |
|------------------------------------------------------|------------|-----------------------------|
| Present in 2018, absent from the 2023 panel          | 140        | 113.6                       |
| Of these, emitting more than 0.3 Mt in 2018          | 50         | 108.4                       |
| Matched to at least one retired generator, 2018–2023 | 49         | 108.0                       |
| Not matched                                          | 1          | 0.4                         |

## 4. Results

### 4.1. Sector aggregate

As shown in Fig. 1, the amount of panel emissions has fallen from 1.815 billion tonnes of CO<sub>2</sub>e in 2018 to 1.472 billion tonnes in 2023, a decrease of 18.9 per cent. The path was not always falling; a 2020 dip occurred due to a pandemic-related reduction in demand, and a partial recovery took place in 2021–2022 after rising gas prices. The series is in line with the independently compiled EIA electric power sector CO<sub>2</sub> series [17], and shows a stable offset of 45–51 Mt from 2019 to 2023, consistent with the wider coverage of the GHGRP.



**Fig. 1** Reported power-sector greenhouse gas emissions, 2018–2023: GHGRP equity-share panel and the EIA electric power sector CO<sub>2</sub> series.

#### 4.2. Parent-level headline changes

Headline changes for the 43 parents range from -100% at PSEG, SCANA and Ohio Valley Electric Corporation, to +22% at ArcLight Capital. Thirty-six decreased and seven increased. Table 2 shows the twelve largest parents by 2018 emissions and all parents with a transfer ratio exceeding 50%. For the long-term target in force at the end of 2023, the baseline years are 2000–2019 and the target years are 2030–2050. A change in the headline does not indicate that a parent has closed plants; it may have sold its shares or reduced output at the shares it retained.

**Table 2.** Pledge attributes and emission change, 2018–2023. Emissions in Mt CO<sub>2</sub>e; Headline, Transfer, Adjusted in per cent. Rows: the twelve largest parents by 2018 emissions plus every parent with a transfer ratio above 50%. n.i. = not identified in the disclosures reviewed; n.a. = not applicable, the adjustment being defined only for reductions.

| Parent company             | Ann. | Target | Base | 2018  | 2023 | Headline | Transfer | Adjusted |
|----------------------------|------|--------|------|-------|------|----------|----------|----------|
| Vistra                     | 2020 | 2050   | 2010 | 114.3 | 86.3 | -24.5    | 0        | -24.4    |
| Southern Company           | 2020 | 2050   | 2007 | 99.2  | 75.9 | -23.5    | 24       | -17.9    |
| Duke Energy                | 2019 | 2050   | 2005 | 96.8  | 72.3 | -25.3    | 0        | -25.3    |
| American Electric Power    | 2022 | 2045   | 2005 | 69.7  | 48.8 | -30.0    | 15       | -25.6    |
| Berkshire Hathaway Energy  | n.i. | n.i.   | n.i. | 68.8  | 50.0 | -27.3    | 6        | -25.7    |
| Tennessee Valley Authority | 2021 | 2050   | 2005 | 47.8  | 38.0 | -20.5    | 0        | -20.5    |
| Xcel Energy                | 2018 | 2050   | 2005 | 46.6  | 35.6 | -23.5    | 0        | -23.5    |
| Calpine                    | n.i. | n.i.   | n.i. | 39.3  | 47.7 | +21.5    | n.a.     | n.a.     |
| NRG Energy                 | 2019 | 2050   | 2014 | 39.2  | 22.5 | -42.7    | 16       | -36.1    |
| NextEra Energy             | 2022 | 2045   | 2005 | 39.2  | 42.4 | +8.3     | n.a.     | n.a.     |
| Entergy                    | 2020 | 2050   | 2000 | 37.3  | 38.1 | +2.1     | n.a.     | n.a.     |
| FirstEnergy                | 2020 | 2050   | 2019 | 32.8  | 15.3 | -53.5    | 36       | -34.0    |
| LS Power                   | n.i. | n.i.   | n.i. | 19.4  | 16.4 | -15.7    | 216      | +18.2    |
| PSEG                       | 2021 | 2030   | n.i. | 12.4  | 0.0  | -100.0   | 85       | -15.1    |
| Ohio Valley Electric Corp  | n.i. | n.i.   | n.i. | 12.4  | 0.0  | -100.0   | 82       | -17.8    |
| SCANA                      | n.i. | n.i.   | n.i. | 11.6  | 0.0  | -100.0   | 78       | -22.3    |
| Great River Energy         | n.i. | n.i.   | n.i. | 10.4  | 0.5  | -95.4    | 78       | -21.3    |

#### 4.3. Decomposition

Table 3 separates the components. The patterns are heterogeneous. Duke Energy's reduction of 24.5 Mt is 97.9% operating change, with 0.3 Mt of departing shares and no departed emissions persisting; Xcel Energy is 97.5% operating, with a residual 0.03 Mt. Shares carrying 25.3 Mt of Vistra's 2018 emissions left its books and are associated with 0.02 Mt in 2023, consistent with the units having ceased to report. FirstEnergy's 17.5 Mt reduction is dominated by 15.2 Mt of departing

shares, of which 6.4 Mt was still being emitted in 2023, while retained shares contributed only 2.4 Mt of the reduction. Increases are equally structured: NextEra Energy took on shares carrying 8.3 Mt of 2023 emissions, mainly through its January 2019 purchase of Gulf Power from Southern Company and newly built gas capacity, and Entergy 8.8 Mt from new gas stations and one acquisition. Southern Company and NextEra thus record emissions from the same assets on opposite sides of their respective ledgers. Dominion Energy's 10.0 Mt of newly held shares is dominated by the SCANA acquisition.

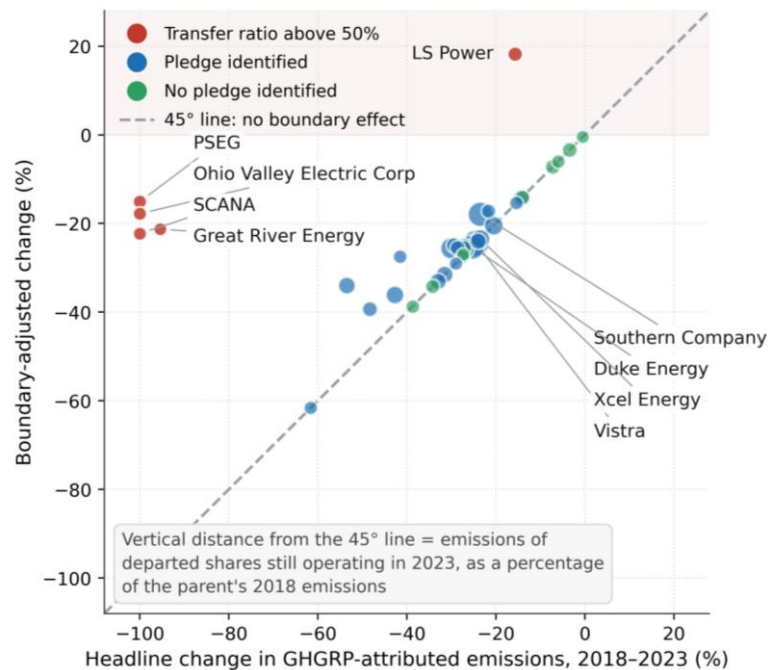
**Table 3.** Share-unit decomposition, 2018–2023 (Mt CO<sub>2</sub>e). *op* = operating change on shares held in both years; *D* = departed shares at 2018 emissions; *D*<sub>live</sub> = the same shares at 2023; *A* = newly held shares at 2023.

| Parent company             | <i>op</i> | <i>D</i> | <i>D</i> <sub>live</sub> | <i>A</i> |
|----------------------------|-----------|----------|--------------------------|----------|
| Vistra                     | −3.1      | 25.3     | 0.0                      | 0.4      |
| Southern Company           | −10.7     | 14.8     | 5.6                      | 2.1      |
| Duke Energy                | −24.5     | 0.3      | 0.0                      | 0.2      |
| American Electric Power    | −20.1     | 11.0     | 3.0                      | 10.2     |
| Berkshire Hathaway Energy  | −15.0     | 3.8      | 1.1                      | 0.0      |
| Tennessee Valley Authority | −9.8      | 0.0      | 0.0                      | 0.0      |
| Xcel Energy                | −11.1     | 0.1      | 0.0                      | 0.2      |
| Calpine                    | +9.0      | 0.8      | 0.7                      | 0.2      |
| NRG Energy                 | −12.5     | 4.5      | 2.6                      | 0.2      |
| NextEra Energy             | −3.0      | 2.1      | 1.1                      | 8.3      |
| Entergy                    | −7.0      | 0.9      | 0.2                      | 8.8      |
| FirstEnergy                | −2.4      | 15.2     | 6.4                      | 0.0      |
| LS Power                   | −0.4      | 8.1      | 6.6                      | 5.5      |
| PSEG                       | 0.0       | 12.4     | 10.6                     | 0.0      |
| Ohio Valley Electric Corp  | 0.0       | 12.4     | 10.2                     | 0.0      |
| SCANA                      | 0.0       | 11.6     | 9.0                      | 0.0      |
| Great River Energy         | −0.4      | 9.6      | 7.7                      | 0.0      |

#### 4.4. Headline versus boundary-adjusted change

One of the 36 reducing parents is Ohio Valley Electric Corporation; it has been identified as a change in reported parent attribution rather than a transaction and is reported separately. The remaining 35 reducing parents have a gross reduction of 312.6 Mt CO<sub>2</sub>e, of which departed ownership shares accounted for 59.2 Mt of 2023 emissions, or 19.0%. Counting the attribution changes in addition to genuine transactions gives 36 reducing parents, 325.0 Mt and 69.4 Mt, at a ratio of 21.4%. The company's two plants, Kyger Creek and Clifty Creek, had not been sold, yet the 2018 filing attributed them entirely to the corporation and the 2023 filing solely to American Electric Power. American Electric Power's change is symmetrically in the 10.2 Mt of newly held shares, and this accounts for the entire discrepancy between the two estimates.

The effect is concentrated. Transfer ratios exceed 50% for four reducing parents on the primary definition — PSEG at 85%, SCANA at 78%, Great River Energy at 78%, and LS Power, whose ratio exceeds 100% because departed shares emitted more than its total reduction — with the Ohio Valley Electric Corporation at 82% adding a fifth on the wider definition. Seventeen reducing parents show exactly zero. Fig. 2 plots headline against boundary-adjusted change for the 36 reducing parents; seventeen lie exactly on the 45-degree line and the largest departures from it are PSEG, SCANA, Great River Energy, the Ohio Valley Electric Corporation and LS Power.



**Fig. 2** Headline versus boundary-adjusted change in GHGRP-attributed emissions, 2018–2023. Only the 36 reducing parents are plotted, the adjustment being defined for reductions. Marker area is proportional to 2018 emissions.

Small omissions in the crosswalk move the result: merging parents by name prefix omits Florida Power & Light, Kansas City Power & Light and Southwestern Electric Power, and thus NextEra Energy's change is +17.8% instead of +8.3%.

The adjustment will change some of the above. PSEG's headline -100% becomes -15.1%; SCANA's -100% becomes -22.3%; FirstEnergy's -53.5% becomes -34.0%; Southern Company's -23.5% becomes -17.9%. Parents whose reductions were due to retirement or reduced operation - Duke, Xcel, Vistra, DTE, Ameren and the Tennessee Valley Authority - were essentially unaffected. Four out of the five parents with a transfer ratio over 50% have not indicated a pledge; PSEG is the exception and has the earliest target year in the sample. The sample size is too small to determine if the pledge status and boundary exposure are associated.

#### 4.5. Robustness

As shown in Table 4, the transfer ratio is sensitive to the size threshold and relatively insensitive to the sector definition. Lowering the threshold from 10 Mt to 5 Mt increases it from 19.0% to 23.8% for 53 reducing parents, and raising it to 15 and 20 Mt reduces this to 12.1% and 9.8%. The impact is more severe for small parents, and a single divested plant accounts for a larger proportion of their total emissions compared to large parents. Restricting the panel to NAICS 221112, which accounted for 98.1% of the 2018 and 97.6% of the 2023 panel emissions, reduces the headline ratio only to 18.6%, and thus cogeneration and industrial producers do not drive the result.

Endpoint comparison cannot detect ownership changes that reverse within the window. Annual shares are calculated for all parent-facility combinations using the crosswalk in Section 3.2, and labels that only appear in intermediate years have been extended. A combination is an intra-window reversal when its 2018 and 2023 shares are equal but differ by more than 1 percentage point; its emissions are this difference multiplied by the facility's 2023 emissions. That definition has 151 combinations of the 110 parents and 116 facilities, totaling 52.7 Mt. Only five of the 110 are in the reported sample, and the largest is ArcLight Capital at 1.1 Mt; therefore, intra-window reversals are insignificant for the parents whose ratios are reported. The estimate is sensitive to label harmonisation; if the crosswalk is restricted to labels reported in 2018 or 2023 and those unique to 2019–2022 are excluded, it rises to 78.9 Mt. Therefore, the endpoints are used as the foundation for the main analysis.

**Table 4.** Transfer ratio under alternative size thresholds and sector definitions.

| Specification                        | n  | Reducers | Gross (Mt) | $D_{live}$ (Mt) | Ratio (%) |
|--------------------------------------|----|----------|------------|-----------------|-----------|
| Full panel, $\geq 5$ Mt              | 68 | 53       | 371.6      | 88.4            | 23.8      |
| Full panel, $\geq 10$ Mt (primary)   | 42 | 35       | 312.6      | 59.2            | 19.0      |
| Full panel, $\geq 15$ Mt             | 29 | 23       | 248.9      | 30.1            | 12.1      |
| Full panel, $\geq 20$ Mt             | 21 | 17       | 232.1      | 22.7            | 9.8       |
| NAICS 221112 only, $\geq 10$ Mt      | 42 | 35       | 312.6      | 58.2            | 18.6      |
| Full panel, $\geq 10$ Mt, incl. OVEC | 43 | 36       | 325.0      | 69.4            | 21.4      |

#### 4.6. Reconciling reported and measured emissions

Company-reported Scope 1 exceeds the generation-only measure, as Table 5 sets out, because the reported figures use wider boundaries: PSEG reported 1.88 Mt for 2022, of which 1.28 Mt is itself attributed to power generation, against zero GHGRP-attributed generation emissions [2]. Southern Company's third-party-reviewed statement [18] gives 79.26 Mt for 2023 against 75.86 Mt here, a difference of 3.40 Mt consistent with the inclusion of gas distribution, mobile and fugitive sources. Salt River Project's Climate Registry filing, verified to reasonable assurance, gives 16.30 Mt against 15.88 Mt [19].

**Table 5.** Company-reported Scope 1 against the equity-share generation-only measure (Mt CO<sub>2</sub>e).

The final column states the scope each company reports, not an itemisation of the difference.

| Company            | Year | Reported Scope 1 | Equity-share measure | Difference | Scope of the reported figure                                  |
|--------------------|------|------------------|----------------------|------------|---------------------------------------------------------------|
| Southern Company   | 2023 | 79.26            | 75.86                | +3.40      | Enterprise Scope 1, equity share, electric and gas operations |
| Salt River Project | 2023 | 16.30            | 15.88                | +0.42      | Entity Scope 1, equity share; stationary, mobile and fugitive |
| PSEG               | 2022 | 1.88             | 0.00                 | +1.88      | Enterprise Scope 1; 1.28 Mt of it power generation            |

Company series are also revised between reporting vintages. The 2021 and 2024 editions of Southern Company's ESG data download report 2017 Scope 1 as 97.5 and 101.2 Mt respectively, and 2018 as 102.2 and 102.6 Mt. Both vintages consolidate on an equity-share basis, so the revision reflects changes in source coverage and calculation method rather than in consolidation. A company-year figure is therefore a function of reporting vintage as well as of physical emissions, an instance of the broader reliability concern that Kim and Lyon [12] and Stanny [13] raise about voluntary corporate disclosure.

#### 4.7. Cases

PSEG is the clearest case of boundary-driven reduction and involves two transactions. Its coal interests, accounting for 22.8% of Keystone and 22.5% of Conemaugh, were responsible for 5.1 million tonnes of attributable 2018 emissions and left its books between 2018 and 2019; the wholly-owned gas fleet carrying the remaining 7.4 million tonnes passed in 2022 to ArcLight Energy Partners and was reported under the ArcLight Capital roll-up. Operating change on retained shares is zero; the whole 12.4 Mt decrease is due to departures, and 10.6 Mt of this kept being emitted. In June 2021, between the two sales, the company advanced its net-zero date by twenty years [1].

Duke Energy is not the same. Expressing operating change as a share of gross component movement,  $|op| + D + A$ , Duke is 97.9% operating and Xcel Energy 97.5%: for both, almost nothing crossed the boundary, so the reported reduction and the change in what their assets emitted nearly coincide.

Southern Company is mixed. Out of the 14.8 million tonnes of departed shares, 5.6 million tonnes were related to those shares in 2023, and facilities Southern owned in 2018 accounted for 4.5 million tonnes on NextEra's 2023 books after the Gulf Power sale; however, the Gorgas retirement was genuine. Its transfer ratio is 23.8% and the adjusted change is -17.9%.

NextEra Energy has an unusually specific pledge - no offsets and five-yearly milestones by 2045- but its measured generation emissions have risen by 8.3%, or 3.2 Mt, due to acquisitions and new construction. Pledge ambition and the measured trajectory are not the same.

Cases follow the diverse-case logic of Seawright and Gerring [20] and are not a basis for population frequencies.

## 5. Discussion

Whether pledges caused abatement remains undetermined. The evidence bears instead on when the corporate series used to adjudicate that question is a poor proxy for what happened to the assets. Seventeen of the thirty-five reducing parents show no departed emissions; for four the departed component dominates. Pooling corporate emission trajectories without boundary adjustment is close to correct in aggregate across this sample but materially different for individual firms, which matters most where firms make public progress claims.

The findings show an analogous boundary pattern in greenhouse-gas terms within one sector, alongside the toxic-release evidence of Duchin, Gao and Xu [9], while bounding its size. Divestiture-driven reduction is real, but across this sample it does not account for most of the reported reduction. Emissions increases also arrived through acquisition and new build at pledging firms including NextEra Energy and Entergy, a second problem of the same kind; the diagnostic is deliberately one-sided, since a symmetric treatment would require a view on how an acquirer's base year is restated, which the GHG Protocol makes contingent on each company's own significance threshold [3].

Disclosure frameworks should require emission changes arising from ownership transactions to be reported separately from operational changes. Base-year recalculation under the GHG Protocol [3] addresses structural change but does not require the two components to be shown apart, which is what a reader assessing pledge progress needs.

Some deficiencies bear on the results. Parent-company fields are self-reported, and the crosswalk contains judgment; thus, every assignment is based on a named label rather than a matching rule. The variable is an equity-share attribution of GHGRP facility emissions, not a company's own Scope 1 inventory, and its organisational boundary and source coverage differ; endpoint comparisons also omit intra-window sales and reacquisitions. The panel covers Scope 1 emissions of owned generation only, so only a part of the net-zero commitment is covered. Population statements are only applied to parents over 10 Mt, and the ratio reaches 23.8% at a 5 Mt mark. The window shows the pandemic demand shock and the 2021-2022 gas price increase, and the design is descriptive throughout.

## 6. Conclusion

Between 2018 and 2023, most of the fall in GHGRP-attributed emissions at large U.S. electric power parents came from facilities in which they still held the same shares. For four of the thirty-five reducing parents, more than half were taken instead from shares that had left while the underlying facilities were still emitting, and these cases are identifiable from public data. The diagnostic is one-sided, so it does not determine what occurred to the atmospheric concentrations but only which reported reductions are consistent with a drop in emissions from the assets in question. Extending the panel to the first cohort of 2030 target years would determine if the pattern persists as the deadline approaches.

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