

THE EU ETS IN NUMBERS

A COMPONENTISED RECONSTRUCTION OF THE CAP, 2008–2026

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Independent Research Note · Working Paper 02 / 2026 · Carbon Risk & Capital Allocation Series

DRAFT v0.3 — aviation integrated · July 2026 · model data

Companion to Working Paper 01 / 2026 on carbon pricing as a risk factor. All cap components, reconciliations and figures are generated from the platform's primary-source document store and regenerate when the data changes.

ABSTRACT

The European Union Emissions Trading System (EU ETS) is often summarised as a steadily declining cap on greenhouse-gas emissions. The reality is more textured. Over 18 years the cap has been re-anchored twice, adjusted by linear reduction factors of three different magnitudes, and reshaped by mechanisms including NER 300 monetisation, back-loading, the Market Stability Reserve, maritime inclusion, and the United Kingdom's exit. This paper traces those movements year by year, naming each component with reference to the primary Commission documents that define it. The reading guide is a pair of figures that plot the componentised cap against the European Environment Agency's reported allocations: one for the main system at its 1,500–2,000 Mt scale, and one for aviation's parallel track at its own, order-of-magnitude smaller scale.

The motivation is forward modelling: scenario projections of the cap, the Market Stability Reserve, and auction revenues can only be built on top of a model of what the cap actually was. Constructing that model requires reconciling data from several independent sources — annual Commission carbon-market reports, technical Staff Working Documents, the European Environment Agency's registry data, and the individual legal instruments that authorise each mechanism. No single source publishes the whole picture.

Scope. The figures and analysis cover the full ETS-1: the stationary and maritime scope (`stationary_maritime` in our data model) in sections 3–5, and, from this version (v0.3), aviation (`aviation`) in section 6. Aviation is part of the same trading system but ran for twelve years as a parallel track — reported separately, auctioned under its own allowance type (the EUAA), and capped by different arithmetic — with structural features of its own: provisional 2012 inclusion, the stop-the-clock derogation, free-allocation phase-out 2024–2026, the Sustainable Aviation Fuel reserve, and consolidation into the general allowance pool in December 2024. Figure 1 retains the stationary + maritime scale; the aviation track, an order of magnitude smaller, is plotted at its own scale in Figure 2.

1. THE CAP MOST PEOPLE DESCRIBE

A typical explanation of the EU ETS cap runs as follows. From 2013, the cap is set at an EU-wide level and reduced each year by a fixed percentage — the Linear Reduction Factor (LRF) — which was 1.74 % a year from 2013, rose to 2.2 % from 2021, and rose again to 4.3 % from 2024 as part of the Fit for 55 package. The cap declines smoothly toward climate-neutrality by 2050.

This is true, but partial. The smooth-decline picture omits at least nine material mechanisms that have moved the cap year by year:

- The 2008–2012 cap was set not by an EU-wide rule but by 27 National Allocation Plans (NAPs); it had no LRF and, in practice, rose over the phase.
- The NER 300 fund monetised 300 million allowances in two tranches in 2013 and 2014.
- Back-loading withdrew 900 million allowances from auctions over 2014–2016.
- The Market Stability Reserve has withdrawn allowances from circulation each year since 2019.
- The 2020 figures in EEA’s registry include retroactive allocations from earlier years — 48 Mt of UK 2019 free allocation released after the Withdrawal Agreement was settled, plus end-of-Phase-3 closure-related reconciliations — that conceptually belong to earlier years.
- Phase 4 reset the cap downwards to a new anchor in 2021.
- The United Kingdom left the system at the end of 2020.
- Several Phase 4 fund pools (Innovation Fund, Modernisation Fund, Phase 4 NER, RRF/REPowerEU, Social Climate Fund, aviation SAF reserve) draw from the cap and auction it on their own multi-year schedules.
- The 2024 reform rebased the cap down by 90 million allowances, added 78 million for maritime inclusion, and replaced the old LRF with a steeper one.

Each of these has primary-source documentation in the form of a Directive, a Decision, a Communication, or a Staff Working Document; each has a measurable effect; and each is needed if the cap is to add up. The next sections walk through them in order, anchored to a single figure that places all of them together.

2. THE CAP THAT ACTUALLY WAS

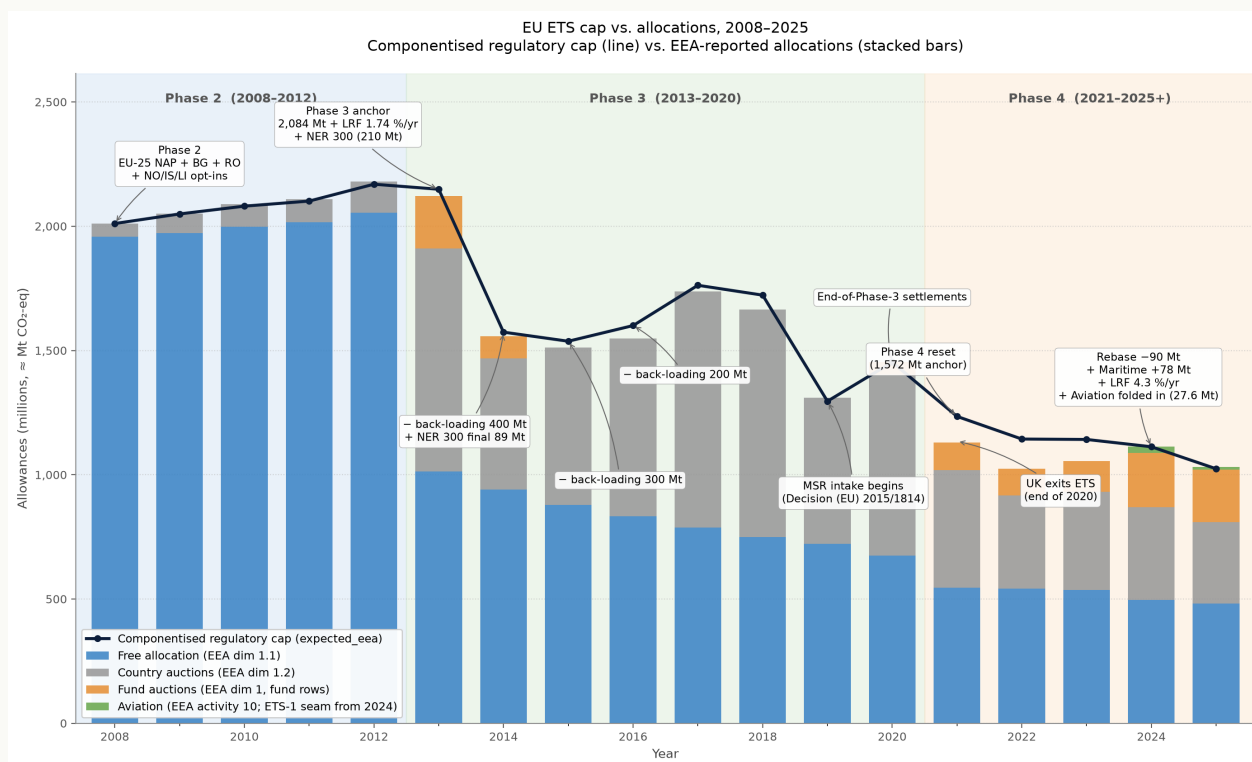


Figure 1 — EU ETS cap vs. allocations, 2008–2025. Componentised regulatory cap (line) vs. EEA-reported allocations (stacked bars); ETS-1 total from 2024.

Reading the figure. The line is the componentised regulatory cap — the EU-wide cap reconstructed year by year from its constituent components. The stacked bars are the EEA-reported allocations: free allocation to installations (blue), allowances auctioned by Member States (grey), allowances auctioned by funds such as the Innovation Fund, the Modernisation Fund, and the EIB-managed NER 300 sales (orange), and — from 2024 only — aviation (green; see below). The background shading marks the three phases. The visible gap between the line and the top of each bar is the residual — the part of the cap not yet accounted for in registry data — and is discussed in §7. “Registry” throughout this paper means the Union Registry, the EU ETS’s central accounting ledger in which every allowance is issued, held, and surrendered; the EEA publishes its dataset from the registry’s public transaction log (the EUTL), and all bar series in both figures are EEA-reported registry data — no exchange data enters either figure.

The figure covers the stationary and maritime scope of the EU ETS up to 2023, and the ETS-1 total from 2024 — the seam sits at the legal consolidation date, when EUAs and EUAAs became fungible and aviation joined the single supply pool (§6.5). From 2024 the cap line adds the Commission-published aviation quantities, and the green segment carries whatever the EEA books under the aviation activity code in that year: in 2024 that is both aviation free allocation and the final EUAA auctions; from 2025 the merged auction calendar means the EEA records aviation-origin auction volumes under the general activity code — inside the grey country-auctions segment — so the green segment contains only the remaining aviation free allocation, and disappears with full auctioning in 2026. Nothing is counted twice, and the bar total is always the EEA-reported ETS-1 issuance. The parallel aviation era before 2024 — which does not belong on this axis, at 2–4 % of the stationary scale — is plotted at its own scale in Figure 2

(§6). The y-axis is in millions of allowances, which under EU ETS accounting is equivalent to millions of tonnes of CO₂-equivalent (one allowance = one tonne CO₂eq surrender entitlement).

The next three sections walk through the figure phase by phase for the stationary track; §6 does the same for aviation.

3. PHASE 2 (2008–2012): THE NAP REGIME

Phase 2 of the EU ETS was governed by National Allocation Plans: each Member State submitted a five-year cap and per-installation allocation schedule to the Commission, which was reviewed and (often) reduced. The EU-wide cap for Phase 2 was the sum of the 27 NAPs (plus the three opting-in non-EU EEA states — Norway, Iceland, Liechtenstein — that joined the system from 2008). There was no Linear Reduction Factor; there was no requirement for annual issuance to follow any downward trajectory; and each NAP included a New Entrants Reserve (NER) — a pool of allowances set aside specifically for installations that came online or expanded capacity during the phase.

The line on Figure 1 rises slightly across Phase 2, from about 2,011 Mt in 2008 to 2,169 Mt in 2012. This is genuine, not an artefact. Three effects combine to produce the rise:

- **NER drawdowns:** new installations entering the system each year drew allowances from their Member State's NER. As more installations accumulated, year-on-year NER issuance grew, and the final-year drawdown cluster (installations that had banked NER entitlements drawing them down before the phase closed) shows in the +62 Mt step between 2011 and 2012.
- **NAP revisions:** Estonia and Poland (among others) successfully challenged the Commission's reduction of their proposed NAPs at the General Court in 2009. The resulting upward revisions are baked into the EEA-reported issuance series.
- **The EEA-EFTA opt-ins:** Norway, Iceland, and Liechtenstein joined the system in 2008 via EEA Joint Committee decisions; their contributions are small but visible.

The rising Phase 2 cap is one of the historically important features of the ETS. It is also the reason the system was redesigned: the NAP regime, combined with the 2008 financial crisis, produced a structural surplus that subsequent Phase 3 mechanisms (back-loading, the MSR) were designed to address.

Primary sources: Directive 2003/87/EC (the framework directive establishing the ETS); EEA Joint Committee Decisions extending the system to Norway, Iceland, and Liechtenstein from 2008; per-MS Commission Decisions on each Phase 2 NAP (to be itemised as roadmap item 11).

4. PHASE 3 (2013–2020): A HARMONISED CAP WITH INTERVENTIONS

Phase 3 replaced 27 NAPs with a single EU-wide cap, set at a constant anchor and reduced by an LRF of 1.74 % each year. The anchor and the LRF together define the year-by-year cap budget. But the actual issuance schedule was modified by several Commission interventions: NER 300 monetisation, back-loading, and the Market Stability Reserve. The final-year (2020) figure also reflects a data-convention quirk that materially changes its registry total.

4.1 The Phase 3 anchor and the LRF

Phase 3's anchor was 2,084,301,856 allowances, set under Article 9 of the revised ETS Directive (Directive 2009/29/EC, the 2009 amendment to 2003/87/EC). The annual cap was the anchor minus a cumulative reduction of $1.74\% \times \text{the anchor per year}$ — exactly 36,266,852 allowances of reduction per year. The line on Figure 1 shows this as a smooth decline from 2013 to 2020, modulated by the interventions below.

The drop from the rising 2012 level (~2,169 Mt) to the Phase 3 anchor at 2013 (~2,084 Mt) is the most visible structural break in the chart. It is the moment the EU moved from 27 negotiated caps to a single legally-defined cap.

4.2 NER 300

The New Entrants Reserve 300 (NER 300) was a carve-out of 300 million allowances from the Phase 3 reserve, established under Article 10a(8) of the revised ETS Directive and Decision 2010/670/EU. Its purpose was to fund demonstration projects in renewable-energy and carbon-capture technologies.

“Monetisation” in this context means the conversion of the allowances into cash by selling them on the market. Rather than handing the 300 million allowances directly to project beneficiaries, the Commission set them aside in a reserve and appointed the European Investment Bank to sell them on the secondary market through a structured tranche programme. The proceeds — paid in euros — then funded the project grants. The mechanism therefore turns allowances (which only have value to ETS-covered installations) into a general-purpose funding stream usable by any innovation project. It is a distinct concept from the regular Member State auctioning programme: NER 300 sales were managed centrally by the EIB to fund a specific EU-level mechanism, whereas Member State auctions feed national treasuries.

The EIB monetised the allowances in two tranches: about 210 million in 2013 and about 89 million in 2014, raising roughly €2.1 billion at the prevailing EUA prices. The proceeds funded 38 projects.

NER 300 is a one-time inflow in the model: it adds to the year's expected EEA total (and shows up as orange fund-auction bars in 2013 and 2014 on Figure 1) but is not part of the structural cap. It is the direct predecessor of today's Innovation Fund, which operates on the same monetisation principle at larger scale.

4.3 Back-loading

By 2013, EUA prices had collapsed under the combined weight of the Phase 2 surplus, the 2008 financial crisis, and a faster-than-expected uptake of renewable-energy incentives. The Commission introduced back-loading as a short-term price-support measure: 900 million allowances were withheld from the auction schedule over 2014–2016 (400, 300, and 200 Mt respectively), to be released back to the market later. The legal basis was Decision 1359/2013/EU, amending Annex 1 of Directive 2003/87/EC to clarify the provisions on auction timing.

The three notches in the Figure 1 cap line in 2014, 2015, and 2016 are the back-loading withdrawals. The released allowances were eventually absorbed by the Market Stability Reserve when it became operational, so the “release later” half of back-loading never literally happened — they were re-routed to the MSR.

4.4 The Market Stability Reserve

The Market Stability Reserve (MSR) is the EU ETS’s structural oversupply-correction mechanism. It was established by Decision (EU) 2015/1814 and became operational on 1 January 2019. The MSR observes the total number of allowances in circulation (TNAC) — published annually by the Commission in a Communication — and withdraws a fixed fraction of any surplus from upcoming auctions, accumulating allowances in the reserve. When the surplus falls below a lower threshold, allowances are released back to the market.

In practice, the MSR has been withdrawing allowances every year since operations began. Strictly speaking the MSR does not change the statutory cap; it changes the auction supply by diverting allowances from the auctioning calendar into the reserve. In Figure 1 the MSR appears as a reduction to the effective issuance path because that is the quantity that reconciles against the registry-reported total. Throughout this paper, “the cap” therefore refers to the cap available to the market in each year rather than the cap-as-legislated.

A subtle but important detail: the MSR’s reporting period is 1 September to 31 August (rather than the calendar year), to align with the publication cadence of the previous-year TNAC. Our model attributes MSR intake to calendar years using an 8/12 + 4/12 weighted split between the two overlapping reporting periods, with the per-Member-State year-by-year figures sourced from technical Staff Working Documents (SWD(2021) 308, SWD(2023) 346, SWD(2024) 264, SWD(2025) 388).

4.5 The 2020 registry cut-off

The 2020 figure in EEA’s registry data is the first full registry-based extract of an end-of-Phase-3 year, and it carries a structural surplus of roughly 190 Mt against the cap budget less MSR intake. Under footnote 29 of COM(2021) 962, the 2019 and 2020 columns are both registry-derived with a 30 June + 1 year cut-off, so the surplus is not a cut-off-date asymmetry between the two years. Two specific mechanisms account for the bulk of the surplus. First, footnote 31 of COM(2021) 962 discloses that 48 Mt of UK 2019 free allocation, suspended in 2019 under the safeguard measures associated with the United Kingdom’s withdrawal, was released into the 2020 registry column once the Withdrawal Agreement was settled. Second, end-of-Phase-3 closure-related recoveries, partial-cessation adjustments, and NER pool reconciliations that span 2013–2020 are formally settled in the registry in the final year of the phase rather than being attributed back to the year they conceptually relate to.

The model treats the combined surplus as a reporting-timing adjustment rather than as a structural increase in the cap. We represent it through a `phase3_closures_recovered_2020` reconciliation component, derived from COM(2021) 962’s discussion of end-of-phase closure mechanics and from the UK-specific disclosure in footnote 31. The component should be read as a modelling device used to align registry totals with the underlying cap structure, not as a separate regulatory allowance budget. With it included, the line and bar reconcile at 2020; without it, the 2020 residual would be visibly positive.

Primary sources for Phase 3: Directive 2003/87/EC as amended by Directive 2009/29/EC (Phase 3 anchor + 1.74 % LRF); Decision 2010/670/EU (NER 300); Decision 1359/2013/EU (back-loading); Decision (EU) 2015/1814 (MSR); COM(2021) 962 (carbon-market report for 2020); SWD(2021) 308, SWD(2023) 346, SWD(2024) 264, SWD(2025) 388 (per-Member-State MSR intake).

5. PHASE 4 (2021–2025+): STRUCTURAL REFORM

Phase 4 begins with a substantially lower cap. Directive (EU) 2018/410 amended the ETS Directive to set a new anchor of 1,571,583,007 allowances and to raise the LRF from 1.74 % to 2.2 %, effective from 2021. The cap line on Figure 1 drops from the end of Phase 3 (~1,287 Mt in 2020 after MSR intake) to the new Phase 4 starting level. The Fit for 55 package (Directive (EU) 2023/959) reformed the cap again, with rebases and sector additions taking effect from 2024.

5.1 The Phase 4 anchor and Brexit

Two unrelated events coincide at the boundary between Phase 3 and Phase 4 on 1 January 2021. The first is the structural cap reset: the Phase 4 anchor, fixed by Decision (EU) 2020/1722, sets the EU-wide cap budget at the new lower level, and the new 2.2 % LRF begins. The second is the United Kingdom’s exit from the EU ETS: the transitional period ended on 31 December 2020, after which UK installations are no longer in the system. The figure annotates both at year 2021; the Phase 4 anchor explains the drop in the cap line, while Brexit explains the drop in the bar (the UK’s free allocation and auctioned volume disappear from the country-rows total).

The visual effect is that 2021 looks like a particularly sharp year-on-year drop, with two distinct mechanisms layered on top of each other. Untangling them is part of the reason a componentised model is useful. Note that Brexit does not alter the EU-27 Phase 4 cap-setting formula itself: the 1,571.6 Mt anchor and the 2.2 % LRF were determined independently of UK membership. The UK exit affects the registry-side total (free allocation and auctions in UK installations cease) but not the regulatory cap budget.

5.2 Phase 4 fund pools

A meaningful share of the Phase 4 cap is set aside into multi-year pools that auction allowances on their own schedules rather than evenly across the phase. The full list is:

- **Innovation Fund (Article 10a(8)):** 450 million allowances over 2020–2030, raised to 575 million by Directive (EU) 2023/959. Funds innovation in low-carbon technologies, building on the NER 300 precedent.

- **Modernisation Fund (Article 10d):** approximately 700 million allowances over Phase 4, including the Article 10c carryover from Phase 3, funding modernisation of energy systems in lower-income Member States.
- **Phase 4 New Entrants Reserve (Article 10a(7)):** 331.3 million allowances pooled for new entrants and capacity expansions, of which 200 million was contributed by the MSR and 131.3 million carried forward from unallocated Phase 3 allowances.
- **RRF / REPowerEU programme (Decision (EU) 2023/435):** 250 million allowances auctioned 2023–2026 to fund the EU's energy-security and decarbonisation response to the 2022 energy crisis (200 million from the MSR, 50 million from the Innovation Fund).
- **Social Climate Fund (Article 10a(8b) and Article 30d(3)):** 50 million ETS-1 allowances plus 150 million ETS-2 allowances, frontloaded from 2026 to capitalise the Fund before ETS-2 begins.
- **Aviation Sustainable Aviation Fuel reserve:** 20 million allowances over 2024–2030, supporting the transition to SAF in aviation (a separate scope from the figure here).

These pools each receive allowances from the cap budget and auction them over multi-year schedules determined by Commission decisions and (for the Modernisation Fund) Investment Committee approvals. The fund auctions visible in the orange segments of Figure 1 from 2020 onwards are this activity.

The year-by-year intake leg of these flows — how many allowances each pool received from the cap in each calendar year — is not published in any Commission document we have located. Only the auction leg (volumes actually sold to market) is reported, and it appears in the fund-row aggregates of EEA's data. This is the main reason the residual gap in Figure 1 is materially larger in 2021–2023 than in other Phase 4 years; see §7.

5.3 The 2024 rebase, maritime inclusion, and the new LRF

Directive (EU) 2023/959 (the Fit for 55 ETS revision) introduced three simultaneous changes effective from 2024:

- A rebase of the cap downward by 90 million allowances as a one-off step-down to align the cap with the EU's new –62 % emissions reduction target by 2030 (versus 2005). Decision (EU) 2023/1575 sets the amount.
- **Maritime transport inclusion:** the cap is expanded by 78.4 million allowances to accommodate the inclusion of shipping emissions for vessels of $\geq 5,000$ gross tonnage on intra-EEA routes. The 78.4 Mt is the cap adjustment — the additional allowance budget made available to cover the new sector — and should not be read as 2024 maritime emissions, which are a separate (and lower) figure. The maritime inclusion phases in at 40 % of emissions in 2024, 70 % in 2025, and 100 % in 2026.
- A new LRF of 4.3 %, replacing the Phase 4 2.2 % factor from 2024 onward, with a further increase to 4.4 % programmed from 2028.

The combined effect in 2024 is a step-down in the cap line (rebase plus new LRF) that is partially offset by the maritime expansion. The figure annotates the cluster at year 2024.

Primary sources for Phase 4: Directive (EU) 2018/410 (Phase 4 anchor, 2.2 % LRF, MSR amendments); Decision (EU) 2020/1722 (cap-setting decision for 2021); Directive (EU) 2023/959 (Fit for 55 ETS revision, 4.3 % LRF, fund pool top-ups, ETS-2 establishment); Decision (EU) 2023/1575

(cap revision for 2024, including rebase and maritime addition); Decision (EU) 2023/435 (RRF / REPowerEU); COM(2024) 538 and SWD(2024) 264 (carbon-market report for 2023); SWD(2025) 388 (technical SWD for 2024).

6. AVIATION (2012–2026): THE PARALLEL CAP

Aviation entered the EU ETS in 2012 with its own cap, its own allowance type — the EUAA — and its own allocation machinery. For twelve years it ran as a parallel system inside the same market: reported separately by the EEA, auctioned under separate contracts, and capped by arithmetic anchored in a different base period than the stationary cap. That separation ended in December 2024. This section walks the aviation cap from its anchor to its consolidation, in the same componentised terms as the stationary walk-through above — and shows that for most of its life, the aviation cap that mattered was not the one written in the Directive.

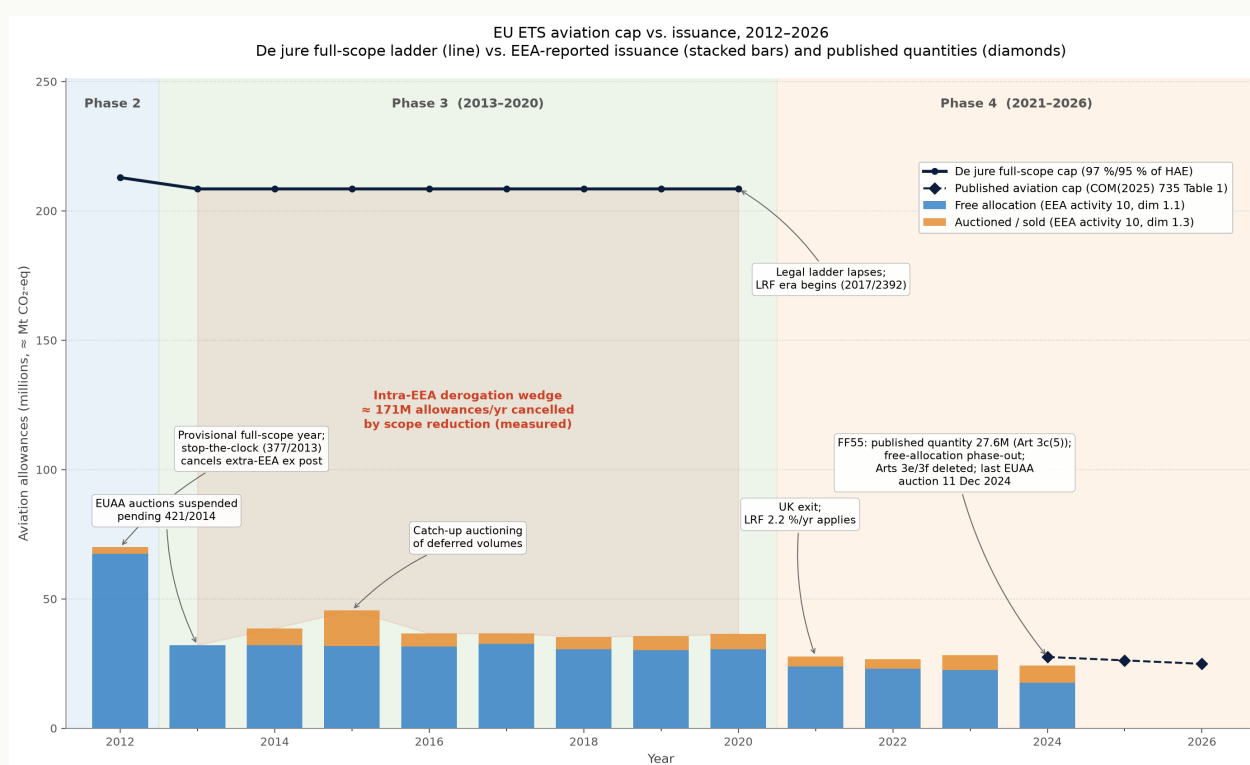


Figure 2 — Aviation cap vs. issuance, 2012–2026. De jure full-scope cap ladder (line), EEA-reported issuance (stacked bars), Commission-published quantities 2024–2026 (diamonds), with regime markers.

6.1 The anchor: historical aviation emissions

Where the stationary cap was assembled from 27 national allocation plans and a 2010 Commission Decision, the aviation cap rests on a single measured quantity. Commission Decision 2011/149/EU determined the “historical aviation emissions”: the mean of modelled emissions from EU ETS-scope flights in 2004, 2005 and 2006 — 209,123,585 t, 220,703,342 t and 228,602,103 t respectively — giving an anchor of 219,476,343 tonnes of CO₂. Article 3c of the amended Directive set the cap as a percentage of that anchor: 97 % for the provisional year 2012 (212,892,053 allowances) and 95 % per year for 2013–2020 (208,502,526).

The allocation split was fixed alongside: 82 % free by tonne-kilometre benchmark (0.6422 allowances per 1,000 tkm, Decision 2011/638/EU), 15 % auctioned, 3 % held in a special reserve for new entrants and fast-growing operators. Unlike the stationary cap, the aviation cap had no LRF — it was flat by construction until 2021.

6.2 2012: provisional inclusion, retrospective retreat

The 2012 cap applied to the full international scope — every flight arriving at or departing from an EEA aerodrome. The international reaction to that scope produced the “stop-the-clock” Decision (No 377/2013/EU) within the compliance year: obligations for extra-EEA flights were waived, allowances not issued for such flights were cancelled, and auction volumes were cut “proportional to the lower number of total aviation allowances in circulation”.

The registry data measures what that meant, in two layers. The EEA’s free-allocation dimension records roughly 174 million allowances as originally issued to operators at full scope; a correction dimension then removes some 106 million returned or cancelled under the derogation, leaving — with the small 2.5 million auctioned — a net supply of 70.0 million aviation allowances entering circulation in 2012, 33 % of the 212.9 million *de jure* cap. From its first year, the aviation cap on paper and the aviation supply in the market were different objects.

6.3 2013–2020: the intra-EEA wedge

Regulation (EU) No 421/2014 made the retreat structural for 2013–2016, and Regulation (EU) 2017/2392 extended it through 2023: obligations applied to intra-EEA flights only, free allocation was reduced “in proportion to the reduction of the surrender obligation”, unallocated allowances were cancelled, and auction volumes were reduced in proportion to the reduction in total issuance.

Neither regulation states a number. The effective cap of the derogation era is knowable only from the registry: issuance ran between 32 and 46 million per year (mean $\approx$ 37 million) against the constant legal cap of 208.5 million — a wedge of roughly 171 million allowances per year, or 82 % of the *de jure* cap, cancelled by scope reduction. Two details in the annual pattern corroborate the mechanism: EUAA auctions were suspended entirely in 2013 pending the 421/2014 settlement (zero on both the exchange and registry sides), and the 2015 spike to 45.6 million reflects the catch-up auctioning of deferred volumes.

In our data model this era carries two scenarios: `full_scope_legal` (the 97 %/95 % ladder, constant to 2020) and `baseline` (the issuance-basis series from EEA activity-10 data). The gap between them is the derogation, measured annually.

6.4 2021–2023: Brexit and the first decline

Two changes arrived together in 2021. The United Kingdom left the system — visible as the step from 36.4 million (2020) to 27.7 million (2021) — and Regulation (EU) 2017/2392’s other provision activated: from 1 January 2021 the number of allowances allocated to aircraft operators became subject to the Article 9 linear reduction factor (2.2 %), the aviation cap’s first structural decline.

Unlike the stationary quantity (fixed for 2021 by Decision (EU) 2020/1722), no consolidated aviation quantity was published for these years; the operative number remained issuance-driven.

Our reconciliation of the registry series against the LRF rule finds 2022 within tolerance (–1.4 %) and 2023 running +7.8 % above the mechanical expectation — a residual consistent with special-reserve distributions and auction catch-up, and a reminder that even in the LRF era the aviation supply was administratively textured.

6.5 2024–2026: Fit-for-55 and the end of the parallel system

Directive (EU) 2023/958 rebuilt the aviation pillar in one act. The 2024 quantity was re-anchored by formula — the 2023 total allocation reduced by the new 4.3 % LRF (Article 3c(5)) — and extended in scope to flights departing the EEA for Switzerland and the United Kingdom (Article 3c(7)). The Commission published the results in its carbon market report (COM(2025) 735, Table 1): 27,563,529 for 2024, 26,233,302 for 2025, 24,903,076 for 2026, declining by a stated aviation LRF step of 1,330,226 per year.

Free allocation is being phased out on the same schedule: in 2024, 15 % of the quantity was auctioned plus 25 % of the remaining 85 %; in 2025 the 25 % becomes 50 %; from 2026 the entire quantity is auctioned. Within the cap — not additional to it — a reserve of up to 20 million allowances (2024–2030) covers part of the price differential between fossil kerosene and eligible sustainable aviation fuels, at coverage rates from 50 % to 100 % depending on fuel and route category. This SAF reserve is the regulatory bridge between the cap decomposition in this paper and the SAF supply modelling of WP03/WP04.

The same act dismantled the parallel machinery: Articles 3e and 3f — the tonne-kilometre benchmark allocation and the 3 % special reserve — were deleted with effect from 2024, and allowances issued for aviation became, in the Commission's words, “general allowances and no longer a separate allowance category”. The last EUAA auction settled on 11 December 2024; from 2025 aviation volumes are auctioned as ordinary EUAs. For forward modelling this is the decisive fact: from 2024 there is one fungible supply, and the aviation quantities above are simply components of it.

One measurement caveat belongs on the record. The registry-derived issuance for 2024 (24.2 million in the EEA's September-2025 data vintage) sits 3.3 million below the published quantity — a gap our reconciliation tracks explicitly and attributes provisionally to issuance timing against the registry extraction date, with the SAF reserve's within-cap accounting a contributing candidate. The published Table 1 figures are the cap; the registry series is the issuance; the two converge as vintages mature.

Two dates frame what comes next. From 1 January 2026, with free allocation fully phased out, aircraft operators pay the market carbon price on every in-scope tonne — the SAF reserve's support allocations (through 2030) being the only remaining non-auctioned channel. And the intra-EEA scope limitation itself runs only to the end of 2026: under Article 28b, the Commission's review of CORSIA — whether the states applying it represent at least 70 % of international aviation emissions — determines whether the EU ETS returns to full international scope from 2027. Fourteen years after stop-the-clock, the question that created the derogation wedge is scheduled to be asked again.

6.6 Aviation and the Market Stability Reserve

The TNAC — the quantity that drives MSR intake — ignored aviation entirely until 2024. Under Article 1(4a) of the amended MSR Decision, the calculation now includes the cumulative

aviation allowances issued and cumulative verified aviation emissions, but counting only from 1 January 2024 (excluding flights on routes covered by CORSIA offsetting under Article 12(6)). The asymmetry is deliberate and permanent: the pre-2024 EUAA stock — twelve years of issuance against twelve years of surrender — never enters the TNAC. Aviation affects the MSR only at the margin of its post-2024 net position, while the historical aviation bank sits outside the reserve’s trigger arithmetic altogether.

6.7 Sources and reconciliation, aviation addendum

The aviation components carry the same (year, kind, value, source document) structure as the stationary set, and two checks run against them. The first verifies the Directive’s year-on-year rules (the 2.2 % and 4.3 % LRF eras) against registry actuals. The second reconciles exchange-reported EUAA auction volumes against the EEA’s auctioned-or-sold dimension — and finds them identical to the unit in every year, which is itself a finding: both series descend from the same common-platform auction reports, and the United Kingdom’s aviation auctions, which ran on ICE rather than EEX, are invisible to both. The Commission’s own TNAC communication footnotes its auction sources as “EEX and ICE”; a complete pre-Brexit auction-supply series would require the ICE reports and remains on the source shopping list.

7. READING THE GAP

Reading the residuals teaches us what the cap model can and cannot close from public data. The visible gap between the cap line and the top of each stacked bar is the residual — the portion of the cap budget not yet accounted for in the EEA’s registry data for that year. The pattern of residuals across the 18 years is therefore not a chart imperfection but the analytical result of the reconciliation exercise: it tells us where the public record is complete and where it is not.

For 2008–2012, the gap is essentially zero. Phase 2 is bounded by the same EEA aggregate that produces the cap line, so the two are tautologically close. The substitution of per-MS NAP Commission Decisions as the cap source (roadmap item 11) will create a proper residual for Phase 2 that exposes NER drawdown timing.

For 2013–2018, the gap is small and negative: the bar tops are 1–3 % below the cap line. This is the Cross-Sectoral Correction Factor (CSCF) — a uniform haircut applied by the Commission under Article 10a(5) of the ETS Directive when verified historical activity levels exceeded the industrial free-allocation ceiling. CSCF rounding noise is the dominant explanation for the small Phase 3 residuals.

For 2019, the gap is small and positive (about +1 %): the residue after the MSR calendar-year attribution fix has been applied.

For 2020, the gap closes to zero once the registry cut-off effect from COM(2021) 962 footnote 29 is added as an inflow.

For 2021–2023, the gap is materially negative (–8 % to –10 %). This is the cap-to-pool timing opacity: allowances allocated from the cap to the Phase 4 fund pools (Innovation Fund, Modernisation Fund, Phase 4 NER, RRF/REPowerEU, Social Climate Fund) in year T but auctioned

by the pools in year T+1 or later. The pool intakes are not published in any Commission document we have located, only the pool auctions. The residuals reflect a specific opacity about when allowances move between cap, pools, and market — not about what the pools do with the proceeds, which is well-disclosed.

For 2024, the gap closes via the closures-corrections series from COM(2024) 538 Table 3, which records partial cessations, surrenders, and late-issuance adjustments.

For 2025, the gap is small and positive (about +2 %), consistent with slow-pool auctioning catching up on holdback from 2021–2023.

In summary: 15 of 18 years reconcile to within $\pm 3\%$; the three remaining material years (2021–2023) sit at the limit of what public Commission data allows us to close. Closing further would require Registry-internal cap-to-pool stock-and-flow accounting that we have not been able to source from any Commission publication.

8. WHY THIS MATTERS FOR FORWARD MODELLING

A back-of-the-envelope projection that takes “cap $\times$ (1 – LRF)” forward misses the 80 Mt that the Innovation Fund draws from the cap in any given year, the further fund-pool draws, the maritime ramp-up, the new LRF schedule from 2028, the MSR’s intake-or-release rule conditional on TNAC, the Phase 4 NER’s project-decision-driven drawdown rate, and the ETS-2 launch in 2027. Each of these is a non-LRF mechanism, and each is material at the 50–250 Mt/yr scale. Without them, a forward projection is wrong by hundreds of millions of allowances per year by 2030.

The componentised view in this paper is what the forward modelling builds on. Each component in the model has the structure (year, kind, value, source document) needed to extend into a counterfactual or projection scenario by editing or adding components without disturbing the rest.

Aviation, integrated in this version (§6), matters to that forward model less for its magnitude — 24–70 Mt/yr against ~1,500–2,000 Mt for stationary — than for its 2024 consolidation: EUAs and EUAAs are now fungible, so any supply-side projection from 2024 onward must carry the aviation quantities, the free-allocation phase-out, and the SAF reserve drawdown as components of a single pool.

One follow-up remains on the work programme: a separate methodology paper will document the forward-projection framework and the scenario-comparison logic that uses this componentised cap as its base.

9. SOURCES AND RECONCILIATION

Constructing the cap line in Figure 1 required reconciling data from five independent sources, each of which publishes a partial view:

- **The legal instruments:** the Directives, Regulations, and Decisions that authorise each mechanism — Directive 2003/87/EC and its amendments, Decision 2010/670/EU (NER 300), Decision 1359/2013/EU (back-loading), Decision (EU) 2015/1814 (MSR), Directive (EU) 2018/410 (Phase 4 + 2.2 % LRF), Decision (EU) 2020/1722 (Phase 4 anchor), Decision (EU) 2023/435 (RRF/REPowerEU), Directive (EU) 2023/959 (Fit for 55), Decision (EU) 2023/1575 (2024 cap revision). These provide the structural numbers (anchor, LRF, rebase amounts) but not the year-by-year operational figures.
- **Commission Communications and Reports (COM documents):** the annual carbon-market reports published each November, which set out the state of the system and disclose figures such as closure adjustments, free-allocation volumes, and the MSR's annual decision.
- **Staff Working Documents (SWD documents):** the technical appendices to the carbon-market reports, which carry per-Member-State breakdowns needed for the MSR calendar-year attribution and for the closures-corrections series.
- **Commission Communications on the Total Number of Allowances in Circulation (C(YYYY) NNN):** the annual TNAC communications, which govern the MSR's intake or release decision for the upcoming twelve months from 1 September.
- **The European Environment Agency's ETS data viewer:** the installation-level and country-level allocation and auction data, which is the source of truth for what was actually issued.

Each of these is necessary; none is sufficient. The annual COM and SWD reports describe what was done; the legal instruments describe what was authorised; the EEA data describes what showed up in the registry. The componentised cap reconciles all three. The reconciliation surface — the Check B residual visible as the gap on Figure 1 — is the test that the reconciliation has been done well; the remaining residuals are where the public data does not allow a clean close.

The reconciliation work itself uses a per-component, per-year, per-source- document attribution structure that we will describe in a separate methodology paper once we have a longer monitoring period to report on its behaviour over time.

APPENDIX A — SOURCES AND CITATION TAGS

Documents referenced in the text, in the order they appear:

Framework - Directive 2003/87/EC: ETS framework directive. - Directive 2009/29/EC: 2009 amendment establishing the harmonised Phase 3 cap, LRF, and free-allocation rules.

Phase 2 and EEA-EFTA - EEA Joint Committee Decisions extending the ETS to Norway, Iceland, and Liechtenstein from 2008. - Per-MS Commission Decisions on 2008–2012 NAPs (not individually cited; pending integration as roadmap item 11).

Phase 3 mechanisms - Decision 2010/670/EU: NER 300 demonstration-project funding scheme. - Decision 1359/2013/EU: back-loading legal basis. - Decision (EU) 2015/1814: Market Stability Reserve.

Phase 4 cap setting - Directive (EU) 2018/410: Phase 4 anchor, 2.2 % LRF, MSR amendments. - Decision (EU) 2020/1722: Phase 4 cap-setting for 2021. - Decision (EU) 2023/435: RRF / REPowerEU. - Directive (EU) 2023/959: Fit for 55 ETS revision (4.3 % LRF, fund pool top-ups, ETS-2 establishment, Social Climate Fund). - Decision (EU) 2023/1575: cap revision for 2024 (rebase + maritime).

Aviation (§6) - Directive 2008/101/EC: aviation inclusion; Article 3c cap percentages, Articles 3d–3f allocation machinery. - Commission Decision 2011/149/EU: historical aviation emissions (the 219,476,343 t anchor). - Commission Decision 2011/638/EU: tonne-kilometre benchmarks (0.6422 allowances per 1,000 tkm). - Decision No 377/2013/EU: “stop-the-clock” derogation for 2012. - Regulation (EU) No 421/2014: intra-EEA derogation 2013–2016. - Regulation (EU) 2017/2392: intra-EEA extension 2017–2023; aviation LRF from 2021. - Directive (EU) 2023/958: Fit for 55 aviation revision (3c(5) re-anchoring, 3c(6) SAF reserve, 3c(7) CH/UK scope extension, free-allocation phase-out, deletion of Articles 3e/3f). - COM(2025) 735 final, Table 1: published aviation quantities 2024–2026 and the 1,330,226/yr aviation LRF step. - C(2025) 3120: TNAC Communication for 2024; Article 1(4a) aviation treatment.

Carbon-market reports (COM) - COM(2021) 962 final: carbon-market report for 2020 (includes the Registry cut-off footnote that underlies the 2020 inflow). - COM(2024) 538 final: carbon-market report for 2023 (includes the closures-corrections table that underlies the 2024 inflow). - Earlier years’ COM reports (2012, 2015, 2017–2019, 2022–2025) used for cross-referencing.

Staff Working Documents (SWD) - SWD(2021) 308: technical SWD for 2020 (calendar-year MSR per-MS for 2019–2021). - SWD(2023) 346: technical SWD for 2022 (MSR per-MS for 2021–2023). - SWD(2024) 264: technical SWD for 2023. - SWD(2025) 388: technical SWD for 2024 (authoritative for 2025 MSR intake).

TNAC Communications (C/YYYY) - Annual Commission Communications on the Total Number of Allowances in Circulation, mid-May each year, governing the MSR intake/release decision for September(T)–August(T+1).

EEA data - European Environment Agency, EU Emissions Trading System (ETS) data viewer, eea.europa.eu.

APPENDIX B — COMPONENT SUMMARY

For reference, the components plotted as the regulatory cap line in Figure 1, grouped by phase. Each component has a `kind` (additive / subtractive / one-time / external adjustment) that determines its sign contribution to the year's expected total.

Component	Phase	Kind	Source
<code>eu25_nap_aggregate</code>	2 (2008–12)	<code>cap_additive</code>	EEA dim 1 (provisional – to be replaced by per-MS NAP Decisions)
<code>bg_nap</code> , <code>ro_nap</code>	2	<code>cap_additive</code>	EEA dim 1 (provisional)
<code>no_opt_in</code> , <code>is_opt_in</code> , <code>li_opt_in</code>	2	<code>cap_additive</code>	EEA dim 1 (provisional)
<code>phase3_anchor</code>	3 (2013–20)	<code>cap_additive</code>	Directive 2009/29/EC
<code>lrf_reduction</code>	3	<code>cap_subtractive</code>	Directive 2009/29/EC (1.74 %)
<code>ner300_monetised</code>	3 (2013, 2014)	<code>one_time_monetisation</code>	Decision 2010/670/EU; COM(2021) 962
<code>back_loading_withdrawal</code>	3 (2014–16)	<code>external_adjustment</code>	Decision 1359/2013/EU
<code>msr_intake</code>	3, 4	<code>external_adjustment</code>	Decision (EU) 2015/1814; SWD per-MS series
<code>phase3_ner_setaside</code>	3	<code>external_adjustment</code>	COM(2021) 962
<code>phase3_closures_unallocated</code>	3	<code>external_adjustment</code>	COM(2021) 962
<code>phase3_closures_recovered_2020</code>	3 (2020)	<code>reserve_drawdown</code>	COM(2021) 962 fn 29
<code>phase4_anchor</code>	4 (2021+)	<code>cap_additive</code>	Decision (EU) 2020/1722
<code>lrf_2018_410</code>	4 (2021–23)	<code>cap_subtractive</code>	Directive (EU) 2018/410 (2.2 %)
<code>lrf_2023_959</code>	4 (2024+)	<code>cap_subtractive</code>	Directive (EU) 2023/959 (4.3 %)
<code>rebase_2024</code>	4 (2024+)	<code>cap_subtractive</code>	Decision (EU) 2023/1575
<code>maritime_inclusion_2024</code>	4 (2024+)	<code>cap_additive</code>	Decision (EU) 2023/1575
<code>phase4_closures_corrections</code>	4 (2021+)	<code>external_adjustment</code>	COM(2024) 538 Table 3
<code>aviation_anchor_hae</code>	aviation (2012–20)	<code>cap_additive</code>	Decision 2011/149/EU

Component	Phase	Kind	Source
art3c1_3pct_reduction	aviation (2012)	cap_subtractive	Directive 2008/101/EC
art3c2_5pct_reduction	aviation (2013–20)	cap_subtractive	Directive 2008/101/EC
full_scope_legal_carry	aviation (2013–20)	cap_additive	derived (see §6.3)
intra_eea_scope_adjustment	aviation (2013–20)	cap_subtractive	EEA activity-10 (measured wedge)
ff55_published_quantity	aviation (2024)	cap_additive	COM(2025) 735 Table 1
ff55_2024_carry , ff55_2025_carry	aviation (2025, 2026)	cap_additive	COM(2025) 735 Table 1
lrf_step_aviation	aviation (2025–26)	cap_subtractive	COM(2025) 735 (1,330,226/yr)

End of v0.3 draft (aviation integrated). Comments and edits welcome.