

CREA EU CO₂ Tracker Methodology

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Overview

The CREA EU CO₂ Tracker estimates the CO₂ released by burning fossil fuels in the EU, with results available sooner than complete official annual statistics. It combines reported energy data with other timely datasets to fill reporting gaps, then converts the estimated use of coal, oil and gas into emissions. Recent estimates rely more heavily on assumptions and projections and may therefore be revised as more complete data become available.

The tracker covers emissions from fossil-fuel combustion. It does not cover emissions from industrial processes that do not involve fuel combustion, agriculture, or land use, land-use change and forestry (LULUCF).

Weather correction - The tracker provides weather-corrected estimates that adjust for the influence of meteorological conditions (temperature, wind, solar irradiance) on energy demand and renewable generation, allowing users to isolate underlying emission trends.

The model code is publicly available on [GitHub](#), together with its [version history and release notes](#).

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1. Fossil fuel consumption

Energy statistics generally report how much fuel is supplied or used rather than the resulting CO₂ emissions. We therefore first estimate the consumption of coal, oil and gas, including which sectors use them. This section explains which fuel categories are included and how overlapping records are reconciled so that the same fuel is not counted twice.

Fossil fuel consumption is derived from EUROSTAT's Supply, Transformation, and Consumption data¹, separated into three categories: solid, liquid and gas.

1.1 Solid Fossil Fuels

Coal statistics include both raw fuels and products made from them. The method therefore follows fuels through transformation processes, such as the conversion of hard coal into coke, and adjusts overlapping records so that the same carbon is not counted more than once.

The tracker includes the following solid fossil fuels:

- Hard coal
- Brown coal
- Coke oven coke
- Brown coal briquettes
- Peat
- Oil shale

During the **coking process**, hard coal is transformed into coke oven coke, with coke oven gas generated as a byproduct. To avoid double counting while still accounting for all emissions, we analyse the relationship between hard coal inputs and resulting energy content. We estimate that coke oven gas emissions downstream represent approximately 8% of the equivalent hard coal emissions. Therefore, we retain 8% of the coal input to coking plants in our accounting to represent these coke oven gas emissions, while subtracting the remaining 92% to prevent double counting with the coke oven coke that is tracked separately in consumption statistics.

Required coal-balance components are taken from reported data or reconstructed using the methods in Appendix A. Where a required component remains unresolved after

reconstruction, the corresponding derived quantity is not calculated. The coking deduction is applied after establishing its input quantity.

1.2 Liquid fossil fuels

Oil is reported through both broad totals and specific products such as petrol, diesel, fuel oil and jet fuel. We use the detailed categories where available, reconcile them with aggregate totals, and remove biofuel quantities and other overlaps so that the estimate represents fossil oil consumption only.

The tracker accounts for these key oil products:

- Oil products (aggregate): The overall category encompassing all petroleum products
- Fuel oil: Heavy residual oil used in industry and shipping
- Heating gasoil: Oil used primarily for heating in buildings and industry
- Road diesel: Diesel fuel used in road transportation
- Motor gasoline: Gasoline used primarily in road transportation
- Jet fuel (kerosene): Fuel used in aviation
- Aviation gasoline: Specialized gasoline for small aircraft
- Oil used for electricity and CHP heat production is included; fuel oil and heating gasoil volumes used in these sectors are deducted from aggregate oil power rows to avoid double counting.

We also track **biofuels** (biogasoline and biodiesel) to exclude their quantities from fossil fuel totals before calculating fossil-combustion emissions.

1.3 Gas fossil fuels

Fossil gas is estimated as a separate fuel. Coke-oven-gas emissions are included in hard-coal accounting through the retained coking-input fraction described in Section 1.1. This treatment avoids double counting fuels produced through transformation processes.

2. Data preparation and estimation

The tracker combines reported fuel balances with activity indicators to estimate fuel consumption and emissions at different time resolutions. This involves selecting between sources, reconstructing missing quantities, allocating consumption to sectors, projecting recent periods and constructing aggregate estimates. Methods and conditions differ between components. Appendix A describes fuel-balance preparation and accounting, Appendix B describes activity inputs and emissions estimation, and Appendix C records documented source exceptions.

2.1 Combining monthly and annual fuel data

Monthly energy statistics are available sooner but contain fewer fuel and sector categories than annual balances. After the applicable source cutoffs, usable monthly values generally take precedence over annual-derived monthly estimates. Annual data are used to reconstruct missing quantities and estimate sector shares.

Annual quantities are distributed using seasonal shares derived from complete monthly years. For the covered coal series, a separate method preserves usable monthly quantities and allocates the remaining annual amount across missing months. Historical profiles and fallback rules differ between these methods, and specific accounting conflicts can require adjustments to reported quantities (Appendix A.1).

2.2 Reconstructing fuel use and allocating it to sectors

Fuel-specific methods use accounting relationships, interpolation, previous-year observations, annual totals and industrial indicators. Coking-input and coke-consumption reconstructions have separate candidate models and eligibility conditions. Some methods are selected using historical holdouts; others use specified fallbacks where comparative testing is limited. Depending on the method, missing quantities may remain unresolved or be estimated as zero under specified conditions.

Sector allocation is distinct from estimating the total. A known total with an unsupported split can be retained as an unknown sector; a residual is calculated only under the relevant accounting conditions. Oil transport shares are derived within each country and fuel. Oil non-energy use is estimated from petrochemical deliveries and annual relationships, while gas non-energy use uses annual consumption shares. Product overlaps and biofuel

quantities are deducted before fossil emissions are calculated. Detailed rules are in Appendix A; source-specific exceptions are in Appendix C.

2.3 Preparing activity indicators

Power-generation activity combines ENTSO-E daily generation with Ember monthly and annual data. The generation series is scaled to Ember monthly and annual data. Eurostat supplies the fuel-consumption data. Where ENTSO-E lacks meaningful coverage, Ember monthly quantities provide a uniformly distributed daily profile.

Daily gas-demand candidates use ENTSO-G consumption and distribution flows, apparent demand from supply and storage changes, and an alternative incorporating AGSI storage data. Historical comparison with Eurostat informs candidate selection. In the emissions workflow, the selected series is scaled to Eurostat monthly consumption where a valid factor is available. Appendix B.1–B.2 describes how the activity series are prepared. Their use in emissions projections is described in Appendix B.3.

2.4 Projecting recent emissions and representing uncertainty

For recent periods without suitable fuel observations, regressions relate emissions to activity indicators over alternative historical windows. Standard proxy projections require an adjusted R-squared of at least 0.7. Power activity informs power-sector estimates; gas demand informs gas estimates; the general industrial-production projection applies to coal outside power. Industrial indicators used to reconstruct coking inputs and coke consumption are separate methods.

Where suitable proxy projections are unavailable, the general emissions fallback uses Holt-Winters seasonal forecasting. Other specified seasonal fallbacks operate within the fuel-balance methods. Negative forecast values are set to zero. Forecast intervals describe uncertainty conditional on the fitted forecasting model. They provide a partial measure of overall uncertainty, which also includes uncertainty in input reconstruction, sector allocation and reporting. An estimate may have identical central, lower and upper values when no separate uncertainty interval has been calculated (Appendix B.3).

2.5 Producing daily estimates

Monthly emissions are distributed across days using an applicable daily activity profile, or uniformly where no usable profile is available. Missing proxy values can be carried forward

before allocation. For a complete returned month, allocation preserves the monthly quantity; a partial returned month contains only the allocation to its returned days. Day-to-day variation in these emissions estimates is determined by the activity profiles and allocation assumptions (Appendix B.4).

2.6 Constructing EU estimates and aggregate totals

EU estimation distinguishes direct member-state sums, projections using a country sum as a regression proxy, and replacement of recent EU estimates. Coverage and historical-acceptance conditions differ. Replacing recent coal or all-fuel EU estimates with country sums requires a unique finite contribution from every EU member state as well as historical agreement. Country-sum regression uses its own coverage and model-fit requirements (Appendix B.5).

Recent EU estimates can also receive seasonal year-on-year adjustments where historical tests support them. Accepted country-sum replacements take precedence over seasonal replacements. Component adjustments are applied before fuel totals are recomputed; a separately accepted EU total can subsequently replace that recomputed total. Gas total and power-sector emissions are estimated separately, with non-power gas recovered as a residual. Some final aggregates are calculated from the available components even when other inputs remain unresolved (Appendix B.5-B.6).

3. Weather Correction

Weather can cause emissions to rise or fall even when underlying behaviour, economic activity and technology have not changed. Cold weather can increase heating demand, while wind, sunshine and water conditions affect renewable generation and therefore the amount of fossil power required. Weather-corrected estimates remove the modelled effect of unusual weather so that changes between periods are more directly comparable.

3.1 Purpose and Approach

Weather-corrected CO₂ estimates start from the estimated emissions series and apply demand and generation-mix factors. In the direct demand correction, actual demand is adjusted by the difference between fitted demand under normal and actual weather, preserving the difference between observed and fitted demand. “Normal weather” uses historical conditions for the same time of year.

The methodology distinguishes between the direct CO₂ weather-correction workflow and the separate demand-components workflow, which uses Generalized Additive Models (GAMs) for decomposition. The direct demand correction uses linear models: electricity demand includes HDD/CDD, weekday and HDD/CDD-by-year terms; gas demand uses weekday, gas-fired power generation and separate member-state HDD predictors.

The direct demand correction is:

$$\text{corrected} = \text{actual} + (\text{fitted_normal_weather} - \text{fitted_actual_weather})$$

The fitted values come from the linear demand models described below. This adjustment is distinct from the fitted counterfactual components used in the separate GAM decomposition.

3.2 Demand Correction

Weather affects energy demand primarily through heating and cooling. Separate models estimate how electricity demand and non-power gas demand respond to temperature, while accounting for recurring patterns such as differences between weekdays. The difference between estimated demand under actual and typical weather provides the correction.

3.2.1 Electricity Demand

Electricity demand is represented by the total-generation series combining ENTSO-E daily data with Ember monthly and annual data (Appendix B.1). For the direct CO₂ weather correction, this series is corrected using a linear regression model:

$$\text{demand} \sim \text{HDD} + \text{CDD} + \text{weekday} + \text{HDD:year} + \text{CDD:year}$$

where:

- HDD (Heating Degree Days): captures increased demand during cold periods
- CDD (Cooling Degree Days): captures increased demand during hot periods
- weekday: controls for weekly consumption patterns

Daily correction factors are computed by comparing fitted demand at actual weather versus fitted demand at climatological average weather (mean HDD/CDD for each day-of-year over the historical period).

Separately, the corrected-demand / demand-components workflow decomposes electricity demand using a GAM:

$$\text{demand} \sim s(\text{date}) + s(\text{date}, \text{by} = \text{HDD}) + s(\text{date}, \text{by} = \text{CDD}) + \text{weekday} + \text{HDD:weekday} + \text{CDD:weekday}$$

Components are calculated using counterfactual predictions:

- Other demand is predicted with HDD and CDD set to zero.
- Heating demand is the additional fitted demand associated with HDD.
- Cooling demand is observed demand minus the prediction with CDD set to zero. Model residuals are therefore included in the cooling component.
- Weather-corrected heating and cooling are calculated from differences between fitted predictions with HDD and CDD set to their climatological day-of-year means. The difference between observed and corrected cooling demand includes both the fitted weather effect and the model residual assigned to the observed cooling component. Other demand is unchanged.

3.2.2 Gas Demand Correction and Decomposition

The direct gas-demand correction is calculated for the EU aggregate only. A linear model relates total gas demand to weekday, observed gas-fired power generation and separate HDD predictors for the member states. The resulting factor is applied to non-power gas emissions.

$$demand \sim weekday + gas_power_generation + HDD$$

Here, HDD represents separate member-state series. The model is fitted using rows on the first available date of each month, with observed gas-fired power generation included. For the weather correction, fitted demand under actual and climatologically normal weather is calculated with gas-fired power generation set to zero. The corrected demand is:

$$corrected = actual + (fitted_normal_weather - fitted_actual_weather)$$

Dividing corrected demand by actual total gas demand gives the daily factor applied to non-power gas emissions. The demand adjustment preserves differences between observed and fitted demand.

Separately, the corrected-demand / demand-components workflow decomposes gas demand using a GAM:

$$demand \sim s(date) + s(date, by = HDD) + weekday + HDD:weekday + gas_power_generation$$

Components are calculated using counterfactual predictions:

- Non-heating demand is predicted with HDD and gas-fired power generation set to zero.
- Power-sector gas demand is the difference between predictions using actual and zero gas-fired power generation, with HDD set to zero.
- Heating demand is observed demand minus predicted demand with HDD set to zero and actual gas-fired power generation retained. Model residuals are therefore included in the heating component.
- Weather-corrected heating demand is calculated as fitted demand at the climatological mean HDD for that day of the year minus fitted demand at zero HDD, using actual gas-fired power generation in both predictions. The difference between observed and corrected heating demand therefore includes both the

fitted weather effect and the model residual assigned to the observed heating component. The non-heating and power-sector components are unchanged.

3.3 Renewable Generation Correction

Weather affects the amount of electricity generated from wind, solar and hydropower. The method estimates what generation would have been under typical conditions, using an approach suited to each technology.

3.3.1 Wind

Wind generation is corrected using a Gradient Boosting Machine (GBM):

$$generation \sim year + ws + ws^2 + ws^3 \times inv_temp$$

where:

- **ws**: wind speed at 50m (from NASA POWER)
- **inv_temp**: inverse temperature (1/K), capturing air density effects on turbine output
- **year**: accounts for capacity additions over time

Weather variables are collected at turbine locations identified in the Global Energy Monitor wind tracker. For each target day, the model predicts generation using each historical set of weather conditions for that day of the year, then averages the predictions. Evaluating the model before averaging incorporates its non-linear response across the historical distribution of weather conditions.

3.3.2 Solar

Solar generation is corrected using a GBM:

$$generation \sim year + solar_radiation$$

where **solar_radiation** is surface solar irradiance from ERA5 (direct + diffuse). The same averaging approach as wind is applied to handle non-linearity.

3.3.3 Hydropower

Hydro generation is normalized using historical capacity factors rather than a weather model. Unlike wind and solar, hydro output depends on factors operating over longer timescales: seasonal precipitation, snowmelt timing, glacier melt, reservoir management, and competing water demands (irrigation, cooling). These factors make daily weather-based correction impractical.

Instead, we normalize each year's capacity factor to the mean annual capacity factor over the historical period used in the analysis:

$$corrected = actual \times (average_CF / actual_CF)$$

The result is a single annual adjustment for the combined influences on capacity factors, including hydrological conditions and reservoir management.

3.4 Power Sector CO2 Correction

A weather-related change in renewable generation affects emissions through the fossil-fuel generation that it replaces. We translate the estimated renewable correction into an equivalent change in thermal generation and use this to adjust power-sector CO2. Safeguards limit implausible corrections in countries where thermal generation is very low.

Actual and weather-corrected renewable generation are aggregated by country or region and calendar year. The correction assumes that 1 MWh of additional renewable generation displaces 1 MWh of thermal generation, with the thermal fuel mix held unchanged:

$$thermal_corrected = thermal_actual - (renewable_corrected - renewable_actual)$$

After corrected thermal generation is floored at zero and capped at the historical maximum, the annual correction factor is the ratio of corrected to actual thermal generation:

$$correction_factor = thermal_corrected / thermal_actual$$

The cap is the maximum annual thermal-generation quantity for the same country or region within the data supplied to the analysis. Each annual factor is applied to daily power-sector emissions in its corresponding year.

3.5 Combined CO₂ Correction

Different parts of the energy system require different weather adjustments. Daily power-sector emissions are multiplied by the daily electricity-demand factor and the power-mix factor for the corresponding year. Non-power gas emissions receive the daily gas-demand factor. These effects are combined as a first-order approximation, without attempting to model every possible interaction between demand and the electricity mix.

Weather corrections are applied to CO₂ emissions as follows:

Sector	Fuel	Correction Applied
Power	All	Daily electricity-demand factor × annual power-mix factor
Non-power	Gas	Daily gas-demand factor (EU aggregate)

4. CO₂ Emissions

Once fossil-fuel consumption has been estimated, it is converted into CO₂ emissions. Different fuels release different amounts of CO₂ for the same amount of energy produced. Reported fuel quantities are first converted into a common energy unit using net calorific values.

Most emission factors are taken from the Intergovernmental Panel on Climate Change (IPCC) Emission Factor Database.² Kerosene and aviation gasoline factors are taken from the European Environment Agency (EEA). Table 1 lists the factors used, expressed in tonnes of CO₂ per terajoule on a net-calorific-value basis. The net calorific values (NCVs) are taken from the IEA World Energy Statistics conversion factors.

Fuel	Value (t _{CO₂} / TJ)
Hard coal	92.8
Brown coal	113.1
Brown coal briquettes	99.0
Peat	117.8
Oil shale	108.0
Oil products	73.33
Fuel oil	77.7
Heating gasoil	73.33
Motor gasoline	72.1
Road diesel	72.1
Natural gas	55.7
Coke oven coke	113.0
Coke oven gas	41.2
Kerosene	72.7
Aviation gasoline	70.6

Table 1 - CO₂ emission factors (IPCC; kerosene and aviation gasoline: EEA)

4.1 Net calorific values

Net calorific values convert physical fuel quantities into energy units. In the country-specific IEA method, outlier screening is followed by filling across years and consumption-weighted or reference-average fallbacks where country factors are unavailable. Factors are then averaged over time for each country and fuel, so changes in annual conversion factors do not themselves create changes in the emissions series.

An alternative conversion method applies the latest available consumption-weighted IEA factor for each fuel across countries and years. Reported quantities already expressed in energy units are treated using their relevant unit conversion.

5. Validation

Comparison with an independent dataset assesses agreement in estimated emissions levels and trends and helps identify systematic differences or periods requiring further investigation. Differences in source data, coverage and methods also contribute to discrepancies between the datasets, limiting how directly those discrepancies can be attributed to errors in either estimate.

Historical reconstruction holdouts, accounting consistency checks and external dataset comparisons are assessed separately. Holdouts inform selection for the methods that use them; specified fallbacks can still be applied where comparable tests are insufficient. Accounting checks assess consistency between quantities. Historical holdouts assess reconstruction performance.

5.1 Revision analysis

CREA's [revision analysis](#) reconstructs EU27 annual and first-half (H1) estimates for 2020–2024 using typical publication delays and a fixed estimation method. At routine publication points (January for annual estimates and September for H1), median absolute revisions were 0.23% and 0.39% of the later reference estimate, with maxima of 0.55% and 0.54%, respectively. Revisions preserved the direction of year-on-year change in all five years tested. Reference estimates use data available at the end of January two years after the reporting year. The reconstruction uses source datasets that include later revisions, so its results describe stability under the assumed publication schedules and may differ from revisions observed in a fully archived real-time dataset.

5.2 Comparison with Global Carbon Budget 2025

Last updated: January 2026

We compare national coal, oil and gas emissions with the corresponding Global Carbon Budget series, excluding its separate cement, flaring and other categories. The results are not expected to match exactly because the datasets differ in their source data and scope. For example, the Global Carbon Budget includes some emissions from the oxidation of fuels used as chemical feedstocks, while the CREA tracker estimates emissions from fossil-fuel combustion.

The Global Carbon Budget data are from Friedlingstein et al. (2025).³

Country screening compares annual percentage changes using complete daily coverage and consecutive calendar years with positive totals. At least three comparable changes are required. The default mean absolute difference threshold is three percentage points. Correlation must be at least 0.9 when five or more comparable changes are available; with fewer observations, correlation is advisory. These criteria assess agreement in annual changes with the comparison dataset.

Figure 1 - CO₂ emissions from fossil fuels - Comparison with Global Carbon Budget

Billion tonne CO₂ per year



Source: CREA analysis and Global Carbon Budget 2025 (Friedlingstein et al., 2025).

Remaining limitations

Recent estimates are necessarily less certain than historical estimates because they rely more heavily on incomplete monthly data, assumptions and projections. The limitations below identify circumstances in which the method may not immediately capture rapid changes in fuel use, economic activity or reporting practices. Estimates are updated as more complete and detailed data become available.

Monthly data limitations

Monthly Eurostat data contain fewer fuel and sector categories than annual balances. Historical transport shares and other fuel-specific relationships are extended where recent detail is unavailable. These relationships may not capture sudden changes in industrial activity, production processes or transport patterns. Oil non-energy estimates use petrochemical deliveries and annual ratios, not a fixed fraction of total oil consumption across all years.

Some reconstructions use specified fallbacks where comparative historical testing is limited. A method's accounting consistency, historical predictive performance and agreement with an external dataset establish different things. None guarantees the accuracy of a recent estimate during reporting disruptions or structural changes.

Treatment of missing quantities depends on the method. Some components remain unresolved, some are estimated as zero under specific conditions, and some final aggregates sum available components. An aggregate calculated from available contributions can have incomplete country, fuel or sector coverage. Daily profiles can also include uniform allocation or carried-forward activity rather than observed daily variation. Forecast intervals do not quantify all uncertainty in source data, reconstruction, allocation or aggregation.

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Appendix A: Fuel-balance preparation and accounting

A.1 Monthly and annual fuel balances

Source selection

Usable monthly values generally take precedence over annual-derived monthly values after the source cutoffs. Monthly natural gas and most solid and liquid fuel series are used from 2020; coke oven coke and kerosene use a 2019 cutoff. Portugal's oil cutoff differs (Appendix C). Earlier periods and remaining gaps use annual-derived estimates where available. Consistency between monthly and annual quantities is also checked.

Annual allocation

The general method distributes annual quantities using seasonal shares calculated from complete monthly years for the same country, fuel and sector. These estimates are then combined with monthly observations.

For the covered coal series, usable monthly quantities are preserved and the remaining annual amount is allocated across missing months. The preferred seasonal profile is the preceding complete year, followed by an average of three complete years within the preceding five-year window. For historical periods before 2020, an observed climatology can provide a retrospective profile, including observations from later years. Equal-month allocation is used where the applicable profile is unavailable. An inconsistent negative annual remainder is not allocated. An explicitly zero annual energy balance can override a contradictory complete monthly series under the specified conflict rule.

A.2 Coal and coke balances

Short monthly gaps

For established hard-coal, brown-coal, brown-coal-briquette and oil-shale series, gaps of up to six months are assessed within the available reporting window. Consumption can be reconstructed as production plus imports minus exports plus stock change when all target-month supply components are present and three prior complete years reconcile with annual consumption within the 5% tolerance. Internal hard-coal consumption gaps can then be interpolated between reported observations. A usable non-negative

observation from the same month of the previous year is the next fallback. The requirement for reported values on both sides of the gap applies only to interpolation. Longer or otherwise unsupported gaps remain unresolved by this method.

Hard-coal inputs to coking

Candidates use previous-year inputs, coke production and the C241 iron-and-steel production index. Activity relationships are calibrated on original observations preceding the reconstruction period; annual observations can support calibration where monthly history is insufficient. Comparable historical six-month holdouts inform selection when at least three matched tests are available. Selection prioritises error in the period total, then monthly error. Where holdouts are insufficient, an available candidate is used as a specified fallback.

A usable reported annual total constrains the amount allocated to missing months while preserving usable observations. Allocation can use candidate estimates, activity profiles or uniform weights. An unresolved annual quantity can be reconstructed from a complete monthly sum or, under the applicable conditions, the preceding annual observation. Duplicate or unsupported components remain unresolved. The 92% coking deduction is applied after resolving inputs.

Coke consumption

The dedicated consumption method applies only to internal gaps of at most six months bounded by reported coke consumption. Candidates are previous-year values, historical seasonal averages, a ratio to C24 basic-metals production and activity-adjusted year-on-year values. Selection requires at least three matched historical holdouts and prioritises period-total error, then monthly error. Training precedes the gap, and adding later reporting years does not itself change an earlier gap's eligibility. Previous-year values are subject to the same selection requirements as the other candidates. Long, unbounded, duplicate or insufficiently supported gaps remain unresolved by this method.

Power-sector allocation

Total consumption and power-sector inputs are established separately. Supported current-year power inputs can be reconstructed month by month from consumption and a sufficiently stable historical power-to-consumption relationship. Missing consumption in

later months does not prevent estimates for earlier supported months. Reported power zeros are changed only under the relevant accounting-consistency conditions.

A separate rule estimates missing coke electricity and combined heat and power use as zero when three consecutive historical annual observations show zero or negligible use. Otherwise the sector allocation remains unresolved. Where a known coal total lacks a split, a prior complete split can provide shares within a bounded historical window, preferring the same calendar month. Unsupported sector allocations remain marked as unknown.

Conflicting quantities

Where a forecast total is below known sector consumption, it is raised to the known-sector sum. The calculated residual is then zero. In a different case, a conflicting split containing negative derived consumption is bounded to a valid non-negative existing total by rescaling the positive components. Invalid totals or unsupported negative components remain unresolved. Redundant annual coke totals are removed when the corresponding monthly sector allocation is complete.

A.3 Oil balances and sector allocation

Missing deliveries and non-energy use

General oil-series gap filling uses conditional zero-filling after runs of low values and interpolation subject to variability and gap-length conditions. A separate substitution uses calculated inland deliveries where observed deliveries are missing or zero. Recent trailing zeros can also be removed under specific source rules; a reported zero is not universally classified as a gap.

Annual petrochemical deliveries can substitute for an unavailable non-energy-use series under the source-selection rule. Monthly non-energy use is estimated by multiplying petrochemical deliveries by the historical ratio of annual non-energy use to annualised petrochemical deliveries. Ratios are filled across time within each country and fuel. If the ratio is unavailable, the fallback is one, equating non-energy use with petrochemical deliveries.

Transport and aviation

Annual country- and fuel-specific relationships allocate monthly motor gasoline and road diesel to transport. Domestic aviation quantities are reconstructed using annual

relationships with fuel deliveries or international aviation consumption, as applicable. Shares are derived and extended within each country and fuel. These relationships are not assumed constant across the entire reported historical series.

Product and biofuel deductions

Aggregate oil consumption and non-energy-use rows are reduced by separately accounted fuel oil, heating gasoil, biogasoline and biodiesel quantities. Biodiesel is also deducted from the road-diesel transport quantity. Aggregate oil power inputs exclude the separately accounted fuel-oil and heating-gasoil power quantities. Biofuel rows are then removed from fossil accounting. Known sector quantities are deducted from totals to avoid overlapping contributions; where detail is incomplete, the applicable residual treatment distinguishes other uses from unknown allocation. Some legacy deduction paths use zero for missing deductions, so missingness is not handled identically across all oil operations.

A.4 Gas fuel balances

Annual non-energy use is expressed as a share of consumption and applied to monthly gas quantities, with historical shares carried forward where applicable. The zero-share fallback applies to a missing calculated annual non-energy share. Power inputs and total gas consumption are treated separately. Some legacy sector-allocation calculations substitute zero for missing components before calculating a residual. Daily gas-demand activity data and the final emissions residual are described in Appendix B.

A.5 EU fuel balances

Rebuilding the covered EU coal balances from member states requires complete, unique and usable member-state contributions. Other source-level filling procedures have their own coverage and historical-agreement conditions. Oil country-sum filling requires at least 25 countries and a historical agreement check; a separate coverage check considers Germany, France, Italy and Spain.

For coking inputs, a missing EU value can be rebuilt from complete resolved member-state coverage. An existing EU value with a verified omitted French contribution is instead adjusted by adding that resolved contribution (Appendix C). Verified country power-allocation corrections can be carried into an EU sector aggregate where the original aggregate corresponds to the uncorrected country sum. Such power reallocations preserve

total coal emissions. Coking-input corrections can change total combustion emissions through the coking deduction.

Appendix B: Activity data and emissions estimation

B.1 Power-generation activity data

ENTSO-E daily generation is grouped into compatible fuel categories. Complete overlapping months establish Ember-to-ENTSO-E scaling ratios; daily values are scaled by the monthly ratio. A second, uniform annual factor reconciles Ember monthly quantities with Ember annual quantities. Consequently, annual adjustment can change the previously matched monthly amounts. Eurostat fuel consumption remains a separate input and does not replace the generation series.

Available observed ratios are retained when scaling the data. Median-absolute-deviation screening supports the interpolation and forecasting of missing ratios. Missing monthly ratios are interpolated or extended using exponential smoothing, with last-value fallback where history or fitting is insufficient. Annual-factor extension uses the last available value. Where no usable ratio exists, ENTSO-E values can pass through unscaled.

For country/source combinations with no meaningful ENTSO-E output but positive Ember generation, monthly Ember quantities are distributed uniformly across calendar days. The last monthly quantity is carried forward to later months where required, before annual scaling. The resulting daily profile assumes uniform generation within each month.

B.2 Gas-demand activity data

Candidate series use reported consumption and distribution flows, apparent demand from net imports plus production and storage drawdown, and an apparent-demand alternative using AGSI storage data. Missing internal dates can be interpolated. Some aggregation and coverage-completion steps substitute zero for missing values, including periods outside source reporting coverage.

Candidate methods and historical starting periods are compared with Eurostat monthly consumption. The emissions workflow requires at least 12 comparison points, squared correlation above 0.95 and relative root squared error below 0.3, alongside its coverage and recency selection rules. These criteria select the gas-demand series. Its use in emissions projections is assessed under Appendix B.3.

The selected daily demand is scaled by Eurostat monthly consumption divided by the corresponding monthly sum of daily demand where a valid factor exists. The last valid factor is carried forward to later months without a factor. Earlier missing factors are not automatically filled by this extension rule; daily values remain unscaled where a factor is unavailable. The resulting activity series is then available for emissions projection and daily allocation.

B.3 Emissions projections and forecasts

Regressions are fitted without an intercept by default. Calibration windows from two to ten years are compared, and the fit with the highest adjusted R-squared is selected. For standard power, gas and non-power coal projections, the selected fit must have an adjusted R-squared of at least 0.7. Power activity informs power emissions, gas demand informs total gas emissions, and industrial-production indices inform coal emissions outside power. The dedicated C241 coking-input and C24 coke-consumption methods operate on fuel quantities and are described in Appendix A.

Available daily power or gas activity is expressed as a full-month equivalent using the mean daily quantity and the number of calendar days. Eligible power series can continue at zero where the latest emissions observation and the relevant observed and future activity evidence support zero use.

The general emissions fallback is Holt-Winters seasonal forecasting using up to ten years of history. It is distinct from exponential-smoothing extension of power-scaling ratios. Forecasts fill unresolved projected periods. Negative forecast values are set to zero. Peat is accounted separately before recombination into coal.

Forecast bounds describe uncertainty conditional on the forecasting model. Historical and reconstructed quantities without a separately calculated interval can have identical central, lower and upper values. The bounds provide a partial measure of overall uncertainty. Reconstruction, source corrections, activity relationships and sector allocation introduce further uncertainty beyond that represented by these bounds.

B.4 Daily emissions allocation

Monthly emissions are first distributed uniformly across calendar days. Applicable daily power or total-gas proxies then shape that allocation from March 2021 onwards, normalised within each month to preserve the monthly quantity over the returned

calendar. Proxy values can be carried forward across missing dates before allocation. Where no usable proxy-based allocation is obtained, the uniform values remain.

The returned daily calendar is limited by activity coverage and excludes the latest three days by default. A complete returned month retains the full monthly quantity; an incomplete returned month contains only the allocation to its returned days. Where uniform allocation or carried-forward activity is used, the daily pattern reflects those assumptions. The resulting emissions series is an allocation of the monthly estimate.

B.5 EU emissions estimates

Internal-gap filling

Missing internal EU estimates can be filled using available-country sums where coverage and historical agreement satisfy the applicable checks. Eligible remaining internal gaps can be interpolated in procedures that allow it; protected groups have separate restrictions. These historical-gap operations are distinct from forecasting beyond the last available EU observation.

Country-sum regression

For recent months, the sum of an available set of countries can act as a regression proxy for the EU series. The method requires sufficient country coverage (at least 20 by default) and an adjusted R-squared of at least 0.95. Historical comparisons use a consistent set of contributing countries. Where several sets provide eligible estimates, larger sets are preferred. The method does not assign fixed historical weights to individual countries.

Recent-period replacements

In the latest four months, country-sum replacements are considered where the earlier EU series and country sum have at least six comparable points and a maximum relative difference no greater than 5%. At least 20 country contributions are required for eligible non-coal groups; coal and all-fuel replacements require all 27 member states with unique finite contributions.

Seasonal year-on-year replacements are considered where a recent ratio outperforms a one-step Holt-Winters forecast on the specified historical holdout and meets the history and ratio conditions. For daily data, the existing within-month profile is scaled to the

coverage-matched seasonal target. Accepted country-sum replacements take precedence over seasonal replacements.

B.6 Final emissions aggregation and uncertainty

Gas total and power-sector emissions are estimated separately; non-power gas is recovered as their residual. Overlapping all-sector totals are removed when represented by retained sector quantities. Where the allocation cannot be completed, the relevant unallocated contribution is retained as unknown. Peat is recombined with coal, and separately estimated coal and coke contributions are combined without treating an explicitly unresolved required coke contribution as zero.

Missingness rules differ between aggregation stages. Some final central totals sum available contributions and remain finite despite missing inputs. Bounds can remain unavailable where required central or upper components are missing. Where component uncertainty is combined, squared deviations of upper values from central estimates are added and the square root is used around the summed central estimate. This is a quadrature approximation, not a model of all correlations or methodological uncertainty.

Non-total EU adjustments are applied before fuel totals are recomputed. An independently accepted country-sum total can then replace that recomputed EU total. Independent replacement of the EU total can produce a difference between the published total and the sum of its published components for the same period.

Appendix C: Documented source exceptions

The following treatments apply to specific reporting issues. They are separate from the general reconstruction methods in Appendix A. Evidence of a reporting conflict does not by itself establish its cause.

Series and period	Treatment	Evidence and scope
French annual coking inputs, 2021-2024	Treat the affected annual zeros as reporting conflicts and reconstruct inputs using the general coking method (A.2). Positive observations take precedence.	SDES sources support continued coke-oven operation and the accounting rationale (C1).
French contribution to EU coking inputs	Add the resolved French contribution where omission checks are satisfied. Rebuild a missing EU value from a complete resolved member-state sum instead.	The omission check compares the reported EU value with original member-state coverage excluding France.
Estonian oil series	Use more permissive zero-filling and interpolation settings for the affected oil-series treatment.	A recorded reporting-gap example is October 2024; the implemented treatment is not restricted to that month.
Portuguese oil before January 2023	Exclude monthly oil data before the cutoff and use annual-derived estimates where available. The condition covers all oil fuels.	Recorded concern about oscillating fuel-oil data.

Evidence notes

C1. SDES, [Bilan énergétique de la France pour 2024](#) (March 2026), section 3.3, p. 76, describes the two active French coke ovens and activity in 2024 compared with 2023. SDES, [Méthodologie du bilan énergétique de la France](#) (March 2026), p. 67, describes coke-oven accounting. These references support continued operation and the accounting rationale; they do not independently establish a cause for every annual zero covered by the 2021-2024 exception.