CREA CO2 Tracker Methodology

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Overview

The CREA CO2 Tracker is an online tool estimating CO2 emissions from fossil fuels within the EU27 region.

Approach - In its simplest form, the tracker derives fossil fuel consumption from EUROSTAT's Supply, Transformation, and Consumption data[1] and then applies IPCC emission factors[2] to estimate associated CO2 emissions.

Missing data imputation - Missing data, either because of data gaps or latency, is filled in by using proxy datasets and/or ad-hoc heuristics (read more below).

Scope - CREA CO2 Tracker covers CO2 emissions resulting from the combustion of fossil fuels. It does not include industrial process emissions that are not stemming from fossil fuels, nor does it include agricultural emissions or emissions related to Land use, land-use change, and forestry (LULUCF).

1. Fossil fuel consumption

The fossil fuel consumption within the CREA CO2 Tracker is derived from EUROSTAT's Supply, Transformation, and Consumption data.[1] We separate fossil fuels into three broad categories: solid, liquid and gas.

1.1 Solid Fossil Fuels

We included the following solid fossil fuels:

- Hard coal
- Brown coal
- Coke oven coke
- Brown coal briquettes
- Coke oven gas (see below)
- 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 analyzed 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.

1.2 Liquid fossil fuels

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

We also track **biofuels** (biogasoline and biodiesel) to subtract them from fossil fuel totals and assume no associated emissions for those.

1.3 Gas fossil fuels

The tracker accounts for the following gaseous fuels:

- Fossil gas
- Coke oven gas.

2. Missing-data imputation

CREA CO2 Tracker employs a series of data imputation and projection methods to provide up-to-date emissions estimates despite reporting delays, missing values, and varying levels of detail across different timeframes.

Our approach to missing data follows a hierarchical structure, applying imputation method in the following order:

2.1 Sectorial attribution in monthly data

Monthly energy statistics lack the sectoral detail available in annual data. We apply validated assumptions to allocate consumption to appropriate sectors. These assumptions were validated through statistical analysis of historical data, showing strong correlations and minimal year-to-year variation in the relevant proportions. They only apply to the most recent monthly data in the absence of more detailed yearly figures, which typically become available with a delay of 1-2 years.

2.1.1 Oil products and transport

- **Motor gasoline and diesel allocation**: A constant proportion of a country's gasoline and diesel supply (after excluding petrochemical use) is used for road transportation (a distinct proportion per fuel and country is applied).
- **Aviation fuel distribution**: The split between domestic and international aviation for kerosene-type jet fuel is assumed to be constant year-on-year for each country. Similarly, aviation gasoline is almost exclusively used for domestic flights, with this pattern holding steady over time.
- **Transport fuel composition**: Motor gasoline, road diesel, and kerosene together account for the vast majority (typically >95%) of transport sector oil consumption. This consistency allows us to estimate total transport emission trends from these major components.
- **Non-energy use**: The proportion of oil products used for non-energy purposes (like chemical feedstocks) relative to total deliveries is constant for each country.

2.1.2 Fossil gas

- **Non-energy use of gas**: For petrochemical feedstock use, we apply the historical ratio between non-energy use and total gas consumption from annual data.

2.2 Filling data gaps

2.2.1 Zero-Value Imputation

When a country reports consecutive small values (below the 5th percentile for that fuel x country) followed by missing data, we impute zeros. This approach is particularly useful for countries phasing out certain fuels (e.g., Slovenia's hard coal use for electricity) which stop publishing figures.

2.2.2 Interpolation for Stable Consumption Patterns

For countries with stable consumption patterns (coefficient of variation < 10%), we use interpolation to fill small gaps (up to 3 months). This method is applied for instance with coking coal in Finland.

2.2.3 Manual Fixes for Reporting Issues

Country-specific fixes are applied for manually detected reporting anomalies (e.g., France's intermittent reporting of hard coal for electricity, Greece wrongly declaring that none of its brown coal is used for electricity). These fixes are based on cross-validation with other data sources (e.g., ENTSOE power generation data).

2.3 EU Aggregation for the latest months

When EU-level data is missing but sufficient country-level data is available, we build a linear model without an intercept (i.e., a simple ratio) using the available country-level data for the most recent months to project the missing data. The model is only used if it reaches sufficient predictive capacity ($R^2 > 0.95$). This method is important for the most recent months, where a single missing country can result in the EU figure not being published, even if the missing country represents only a tiny fraction of that fuel and sector's consumption.

2.4 Proxy-Based Projections

For the most recent months with incomplete reporting, we use various proxy indicators:

2.4.1 Power Generation from ENTSOE

Electricity sector emissions are projected using daily power generation data by fuel type from ENTSOE.

Country-specific conversion factors translate electricity generation into fuel consumption.

This provides near-real-time estimates for a sector representing approximately 30% of fossil CO2 emissions.

2.4.2 Gas Consumption from ENTSOG

Natural gas consumption is projected using daily gas flow data from ENTSOG.

Country-specific models account for seasonal patterns and temperature effects.

This approach provides timely estimates for one of the most volatile components of emissions.

2.4.3 Industrial Production Indices

Industrial coal and oil use is projected using monthly industrial production indices.

Sector-specific indices (e.g., iron and steel, chemicals) are used for relevant fuel types.

This method captures economic activity impacts on emissions beyond the power sector.

2.5 Time Series Forecasting with Uncertainty

For sectors without reliable proxies:

Statistical time series models incorporate seasonal patterns, trends, and recent observations.

Confidence intervals reflect increasing uncertainty for longer projection periods.

Models are regularly recalibrated as new data becomes available.

These comprehensive imputation methods ensure that the CREA CO2 Tracker provides timely and accurate emissions estimates while maintaining methodological consistency. All imputation techniques have been validated against historical data (see the Validation section below).

3. CO2 Emissions

Emission factors are taken from the Intergovernmental Panel on Climate Change (IPCC) Emission Factor Database.[2] Table 4 below indicates the emission factors considered, expressed in tonne CO2 emitted per Terajoule (expressed in Net Calorific Value).

Table 1 - CO2 emission factors considered from the IPCC.

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	72.3
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

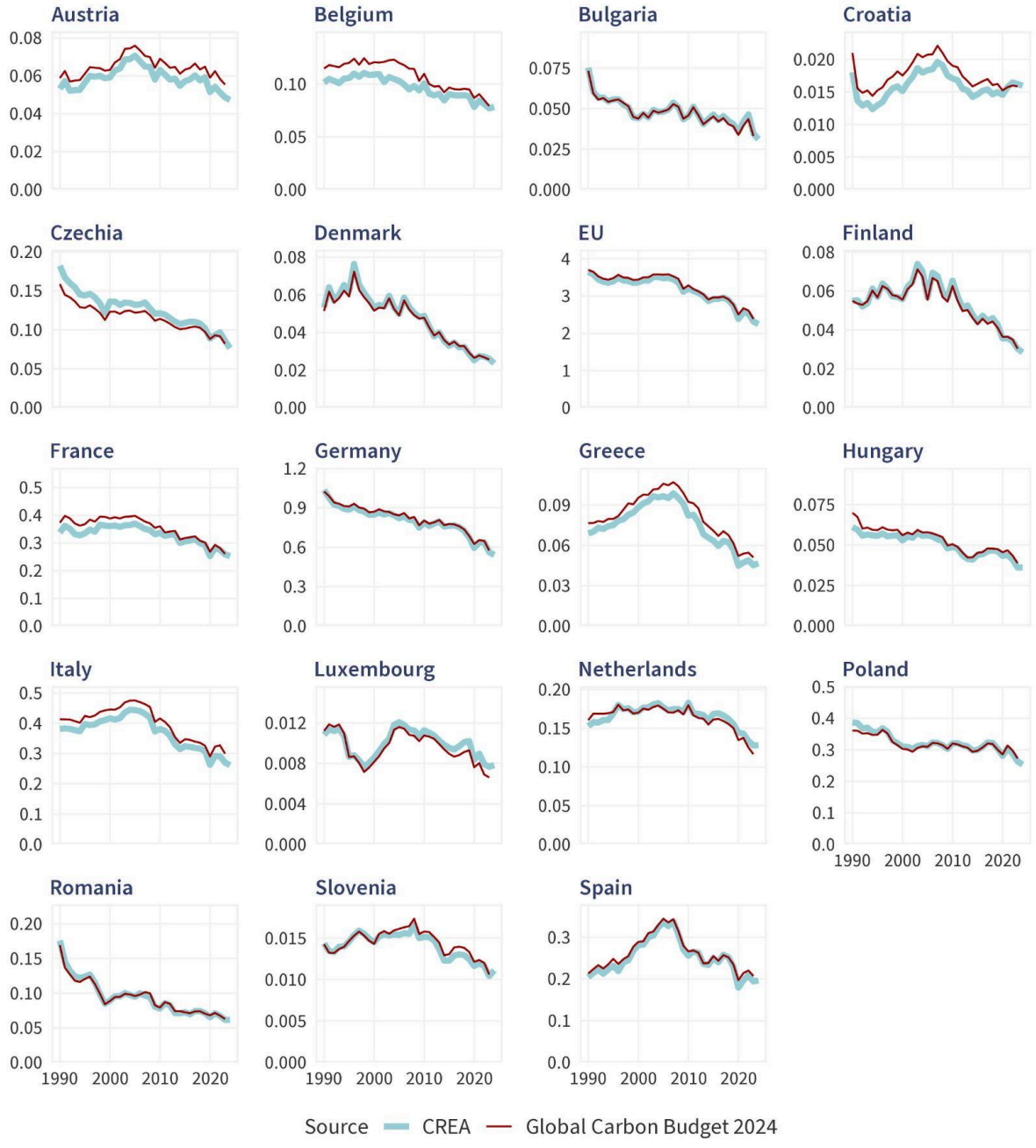
4. Validation

4.1 Comparison with Global Carbon Budget 2024

We validate national estimates values and trends against Global Carbon Budget 2024 datasets.[3] We only consider fossil emissions from coal, oil and gas and ignored emissions from the cement, flaring, and others categories.

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

Billion tonne CO2 per year



Source: CREA analysis and Global Carbon Budget 2024 (Friedlingstein et al., 2024b, ESSD).

Remaining limitations

Monthly data limitaitons

The main application of the CO2 Tracker is to assess recent trends. To do so, we largely rely on Eurostat monthly data which comes with the previously mentioned limitations: monthly data offers fewer energy balance and fuel categories than yearly data.

To provide recent estimates, we have assumed that certain characteristics remains constant since the latest available data point (see section 2. Missing-data imputation), namely:

- The share of motor gasoline, road diesel and aviation gasoline used by the transport sector is assumed constant in the last year.
- The non-energy use of liquid fossil fuels is directly proportional to the amount used by the petrochemical industry and the ratio remains constant.

These assumptions have been softly validated using historical data. Changes in industrial mix may therefore lead to overestimating or underestimating most recent trends in emissions.

Sectorial granularity

The CO2 Tracker offers partial sectoral granularity: CO2 emissions are attributed to either of the following “sectors”:

- Power generation
- Transport:
    - Domestic
    - International aviation
- “Others”, encompassing industry and buildings.

In the current version, the CO2 Tracker does not differentiate between industry and building emissions.

References

1. Statistics | Eurostat | Supply, transformation and consumption - commodity balances. https://ec.europa.eu/eurostat/databrowser/explore/all/envir?lang=en&subtheme=nrg.nrg_quant.nrg_quantm.nrg_cb_m&display=list&sort=category.
2. IPCC. IPCC Emission Factor Database. https://www.ipcc-nggip.iges.or.jp/EFDB/find_ef.php.
3. Friedlingstein, P. *et al.* Global Carbon Budget 2024. *Earth Syst. Sci. Data Discuss.* 1–133 (2024) doi:10.5194/essd-2024-519.