Chapter 13
Emissions Data Base for GTAP

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A CO_2 *Emissions from Fossil Fuels Combustion*

A.1 Overview

Since GTAP 5 Data Base, a special satellite account that estimates CO_2 emissions from fossil fuel combustion has been developed (Lee 2008). A corresponding approach to the estimation of emissions has remained unchanged since then and relies on the Tier 1 method of the 1996 IPCC Guidelines (IPCC/OECD/IEA 1997). However, a number of concerns regarding discrepancies between GTAP CO_2 emissions data and other international data sources, such as EDGAR and IEA, have been raised (Chepeliev 2022). To address the identified issues, a revised approach based on the Tier 1 method of the 2006 IPCC Guidelines has been developed and implemented in the GTAP 11 Data Base (Chepeliev 2022). The revised approach includes estimation of emission factors at a more granular commodity level than in the original implementation. Two additional refinements include an updated accounting of emissions from blast furnaces and other recovered gases, as well as a more transparent treatment of CO_2 emissions from flaring. Following Chepeliev 2022, we implement an updated emissions accounting framework for the case of GTAP 12 energy database and show that emissions derived using this approach are well-aligned with other international data sources.

A.2 Introduction

Since the Global Trade Analysis Project (GTAP) 5 Data Base, a special satellite account that estimates CO_2 emissions from fossil fuel combustion has been developed and provided to the users together with the core accounts of the GTAP Data Base (Lee 2008). An originally developed methodology calculates the combustion-based CO_2 emissions from the GTAP energy volume data using the Tier 1 method of the International Panel on Climate Change IPCC/OECD/IEA 1997 Guidelines (IPCC/OECD/IEA 1997). A key motivation behind such an approach (compared to an alternative of externally-sourced CO_2 emissions data) was to ensure an internal consistency between the underlying GTAP energy volumes data and associated CO_2 emissions (Lee 2008).

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While delivering a consistent set of CO_2 emission estimates across countries and sectors, it has been revealed that the applied approach results in relatively substantial discrepancies between GTAP-based fossil fuel combustion CO_2 emissions and corresponding data from other international data sources (Chepeliev 2022). Starting from GTAP 11, a new approach to estimating CO_2 emissions from fossils fuel combustion has been implemented, as discussed in Chepeliev 2022.

The developed approach addresses the identified differences by introducing a revised emissions accounting framework based on the Tier 1 method of the 2006 IPCC Guidelines. The revised approach also includes estimation of emission factors at a more granular commodity level than implemented in Lee 2008. Two additional modifications include an updated accounting of emissions from blast furnaces and other recovered gases, as well as a more transparent treatment of CO_2 emissions from flaring. Following GTAP 11, we implement an updated emissions accounting framework for the case of GTAP 12 energy database and show that the resulting estimates of the CO_2 emissions from fossils fuel are consistent with available international data sources.

A.3 Overview of the fossil fuels combustion CO_2 emissions' accounting framework

A.3.1 Overall approach to estimating fossil fuels combustion CO_2 emissions in GTAP

CO_2 emissions from the use of energy commodity i by agent j in region r($CO_2^{i,j,r}$) are estimated as follows:

$$CO_2^{i,j,r} = \left(FC_{i,j,r} * CC_i * (1 - CST_{i,j,r}) * EF_i * FOC_i * \frac{44}{12} \right) / 1000, \qquad (13.1)$$

where $FC_{i,j,r}$ stands for the fuel consumption of energy commodity i by agent j in region r (measured in 1000 tonnes of oil equivalent (toe));
CC_i corresponds to the conversion coefficient for energy commodity i (TJ per 1000 toe);
$CST_{i,j,r}$ is a ratio of carbon stored of energy commodity i by agent j in region r;
EF_i is an emission factor of energy commodity i (tons of carbon (tC) per TJ); and
FOC_i is a fraction of carbon oxidized for energy commodity i.

Fuel consumption volumes ($FC_{i,j,r}$) from equation (13.1) are based on the estimates from GTAP 12 energy database. Conversion coefficient (CC) is equals 41.868 (TJ per 1000 toe). Following 2006 IPCC Guidelines, the default value of 1 is assumed for the fraction of carbon oxidized (FOC) for all fuels. Tables 13.1 and 13.2 provide values of the CST and EF coefficients from equation (13.1) as implemented for the CO_2 emissions accounting in the GTAP 12 Data Base.

Table 13.2: Carbon content values (emission factors) from IPCC 2006 Guidelines

Fuel Type	2006 Guidelines, kg/GJ
Anthracite	26.8
Coking Coal	25.8

Table 13.2 (continued): Carbon content values (emission factors) from IPCC 2006 Guidelines

Fuel Type	2006 Guidelines, kg/GJ
Other Bituminous Coal	25.8
Sub-Bituminous Coal	26.2
Lignite	27.6
Patent Fuel	26.6
Coke oven coke	29.2
Gas Coke	29.2
Coal Tar	22
BKB	26.6
Gas Works Gas	12.1
Coke Oven Gas	12.1
Blast Furnace Gas	70.8
Other recovered gases	49.6
Peat	28.9
Oil shale	29.1
Natural Gas	15.3
Crude Oil	20
Natural Gas Liquids	17.5
Refinery Feedstocks	20
Orimulsion	21
Refinery Gas	15.7
Ethane	16.8
Liquefied petroleum gases (LPG)	17.2
Motor Gasoline excl. biofuels	18.9
Aviation Gasoline	19.1
Gasoline type jet fuel	19.1
Kerosene type jet fuel excl. bio	19.5
Other Kerosene	19.6
Gas/Diesel Oil excl. biofuels	20.2
Fuel Oil	21.1
Naphtha	20.0
Lubricants	20.0
Bitumen	22.0
Petroleum Coke	26.6
Non-specified oil products	20.0
Other hydrocarbons	20.0
White Spirit & SBP	20.0
Paraffin Waxes	20.0

Notes: In addition to central values (reported in the table), 2006 IPCC guidelines also report the lower and upper limits of 95 percent confidence intervals, assuming lognormal distribution.
Source: Developed by the author based on IEA 2019.

Table 13.1: Value for the ratio of carbon stored coefficient from equation (13.1) used for estimating CO_2 emissions

Mode of use	CST value
Energy consumption	0.0
Transformation	1.0
Own use	0.0
Non-energy consumption	1.0

Notes: In the original implementation (Lee 2008), CST coefficient included country-specific shares of energy commodities used as a feedstock in the petrochemical industry. Currently used IEA's extended energy balances (IEA 2025b) report volumes of non-energy use across sectors as a separate category, thus this aspect (feedstock use) is explicitly captured in the used energy balances.

A.3.2 Accounting for emissions from blast furnace gas and other recovered gases

In the process of the GTAP energy database construction, a special treatment is applied to selected commodities. In particular, to avoid recognizing energy production by industries that predominantly produce non-energy goods (e.g., blast furnace gas production by ferrous metals industry), some energy commodity flows are re-classified or discarded (Chepeliev 2026). Two particular examples of such commodities include blast furnace gas and other recovered gases – both to a large extent being by-products of the metals industry and also being self-consumed (though a substantial share of blast furnace gas is also used in the electricity and heat generation). In the GTAP energy database construction process, to avoid the conversion of iron and steel sector into an energy supplying industry, corresponding energy volume flows (of blast furnace gas and other recovered gases) are discarded.

At the aggregate level, these flows represent a relatively small share of energy supply – global average share is under 1 percent. At the same time, combustion of the corresponding energy commodities is largely concentrated in two sectors – ferrous metals and electricity generation – thus the impacts of discarding these energy flows are very sector-concentrated. In addition, compared to other energy sources, blast furnace gas and other recovered gases have much higher carbon content values – around 2-3 times higher than coking coal (Chepeliev 2022). Thus, discarding corresponding energy flows reduces global CO_2 emission in a range of 2 percent. To take into account corresponding emissions, we revise the treatment of energy flows within the GTAP energy database (Chapter 12) and introduce corresponding emission factors for blast furnace gas and other recovered gases based on values reported in Table 13.2.

A.3.3 CO_2 emissions from flaring

Flaring emissions in the IPCC accounting framework are included to the fugitive emissions category and thus are separated from the fuel combustion activities (IPCC 2008). In the IEA's extended energy balances, energy flows that are flared are also not reported (IEA 2025b). In the GTAP energy database construction process, however, additional energy flows that correspond to flaring are

introduced. As a result, previous versions of the GTAP CO_2 emissions data accounts for flaring emissions as part of the fossil fuel combustion emissions. At the same time, flaring-related energy flows introduced in GTAP are based on historical estimates and are different from country-specific flaring data reported by other international data sources (e.g., CEC 2021).

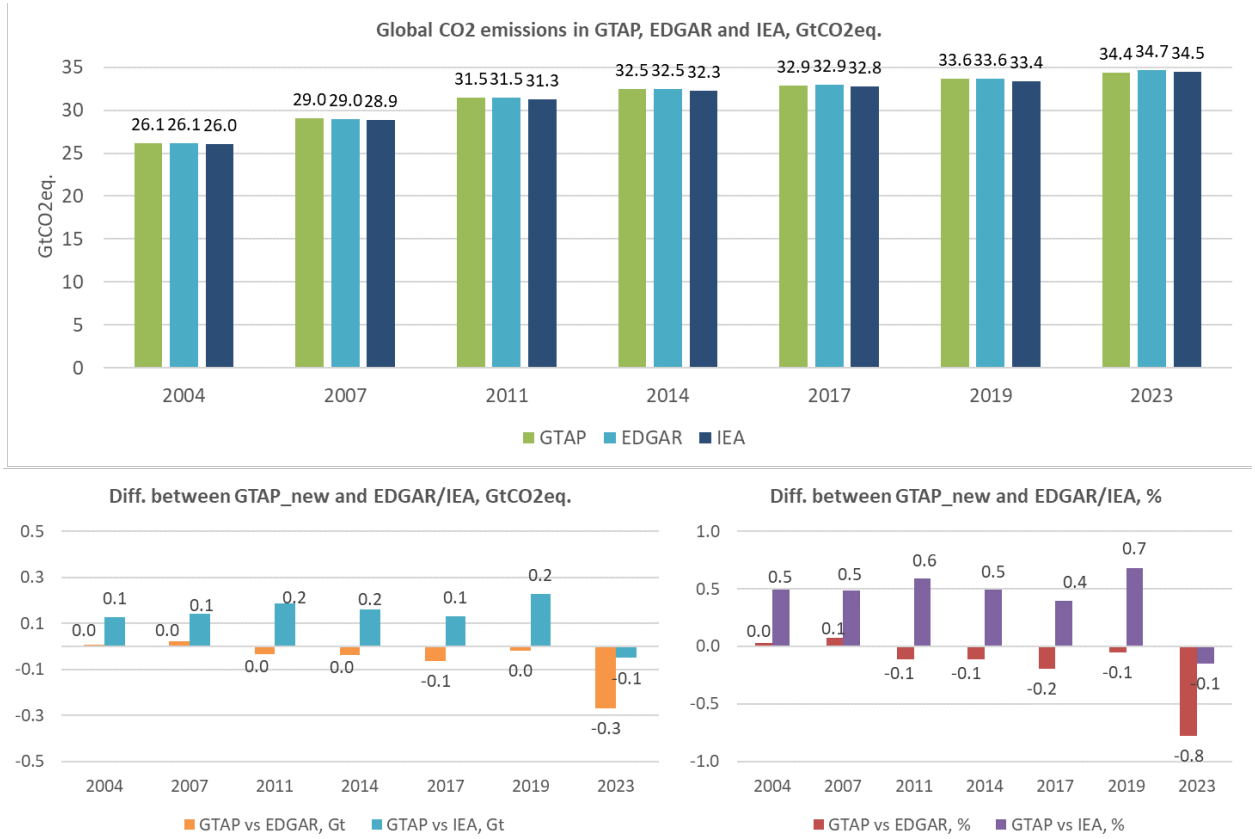
Following the approach used in GTAP 11, we discard the energy flows associated with flaring from the GTAP energy database to be consistent with the IEA energy balance accounting as well as the IPCC definition of the fossil fuel combustion emissions. For the consistency of greenhouse gas (GHG) emissions accounting within the overall GTAP emissions framework, corresponding flaring emissions are included to the complementary GHG emissions database together with fugitive and process emissions (Chapter 13B). Such treatment assures that flaring-related energy and emission flows are aligned with the corresponding estimates from international data sources. This also provides an explicit separation between fuel combustion and non-combustion emissions in consistency with an IPCC reporting framework (IPCC 2008).

A.4 Overview of the fossil fuels combustion CO_2 emission estimates

The CO_2 emissions accounting framework is applied to the GTAP 12 energy database, which covers seven reference years – 2004, 2007, 2011, 2014, 2017, 2019 and 2023. Within the GTAP energy database construction process, IEA's extended energy balances are gap-filled and preprocessed first, then they are mapped to more aggregate GTAP categories, followed by additional reconciliations and adjustments (Chapter 12). For the emissions estimation process implemented in this paper, we rely on the energy balances obtained after the first step described above, i.e., preprocessed and gap-filled, but not yet aggregated. This allows for a more transparent comparison between obtained emission estimates from GTAP and other international data sources at a sectoral and country level. For instance, within an aggregation process in GTAP, energy flows and emissions from international aviation and navigation activities are distributed across countries, while in the EDGAR and IEA databases, these emission categories are treated separately.

Figure 13.1 below provides a comparison of global CO_2 emissions between IEA, EDGAR and GTAP. Overall, the observed discrepancies between GTAP, IEA and EDGAR databases are relatively small. At the global level, differences do not exceed 0.2-0.3 $GtCO_2$ eq. or 0.7-0.8 percent across all analyzed years (Figure 13.1), which is comparable to the level of differences observed between IEA and EDGAR. On average, GTAP emission estimates are better aligned with the EDGAR database across all years except for 2023. In the latter case, GTAP emission estimates are closer to the IEA data (Figure 13.1).

Figure 13.1: Comparison of the global fossil fuel combustion CO_2 emissions from different data sources and emission estimation approaches



Notes: Only fossil fuel combustion CO_2 emissions are reported on the figure. For the case of IPPC 2006 classifications from the EDGAR database, these correspond to the "1.A" code. For the case of IEA reporting, emissions from non-fossil fuel sources (industrial waste and non-renewable municipal waste) are excluded from reporting. Figures from all data sources include emissions from international aviation and navigation. "$GtCO_2$ eq" stands for Gigatons (billion metric tons) of CO_2 equivalent. For the case of GTAP, emission estimates are based on the GTAP 12 energy database. Source: Developed by the author based on the GTAP energy database, Crippa et al. 2025, and IEA 2025a.

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