EXIOBASE Hybrid – Green steel version | Documentation

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EXIOBASE adjustment and extension

This section reports the rationale followed to adjust and extend the Exiobase database adopted for this study, available on Zenodo at https://doi.org/10.5281/zenodo.10843374.

Database choice

The underlying database in our analysis is EXIOBASE Hybrid v.3.3.18 [1], based on 2011 economic and physical accounts. As also reported in Rinaldi et al. [2], the reasons for this choice are mainly two:

- It is the only global multi-regional supply-use (MRSUT) database expressed in physical units known to the authors. This feature strongly reduces the assumptions on data collection for database extension, since inventory data are usually not provided in monetary units, ensuring physical consistency.
- The carbon footprints yielded by this database, after the update of the electricity mix of each region to 2024, are perfectly aligned to other literature's as mentioned in our Model Validation section. Moreover, we show a comparison of electricity production technologies' carbon footprints – analysed being electricity one of the main contributors of environmental impact for many industrial activities - comparing Exiobase Hybrid with other authoritative sources. While the chart shows how these values are significantly uncertain (this topic will be addressed in a future work by the authors) it is also evident how the chosen database well compares with the ranges. Since MRSUT and input-output models in general, overcome the cut-off problem of process-based life-cycle assessment (LCA) analyses, they generally yield higher values when comes to carbon footprinting, so the tendency shown in the chart is reasonable.

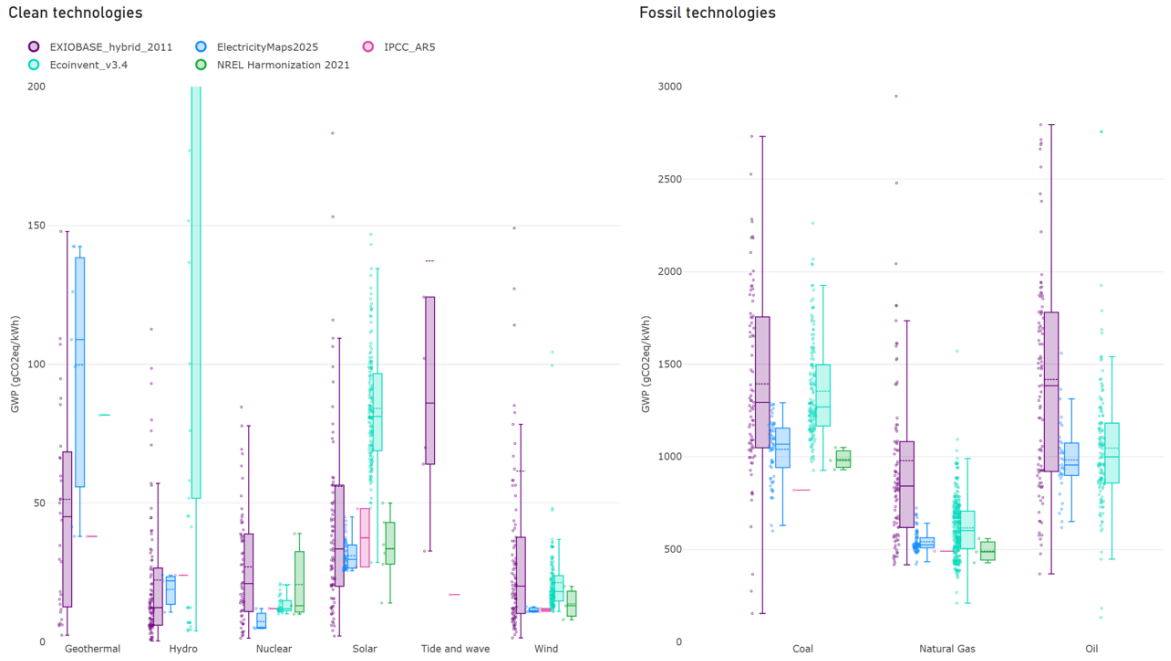

Figure 1. Comparison between power production technologies' carbon footprints across multiple sources, namely: EXIOBASE Hybrid 2011 [1], Electricity Maps [3], IPCC AR5 [4], NREL [4] and Ecoinvent v3.4 [5].

Database adjustments

Multiple adjustments have been performed to the database:

- to better resemble the 2024 baseline situation, such by updating the electricity and steel production mix of each country
- to change emissions allocation logic for the steel sector
- to fix what the authors interpreted as numerical issues

Electricity and steel production mixes update

The electricity production mix of 2011 was updated in each country or region according to EMBER data [6], available for 2024. This implies a slight aggregation of electricity production activities and their respective commodities from 12 to 9, to match EMBER granularity. Specifically, “Production of electricity by petroleum and other oil derivatives” and “Production of electricity nec” were mapped to “Other Fossil” category, “Production of electricity by solar thermal” and “Production of electricity by solar photovoltaic” to the “Solar” category and “Production of electricity by tide, wave, ocean” and “Production of electricity by Geothermal” to “Other Renewables”. The update of electricity mixes was performed on matrices **u** (intermediate consumption coefficients) and **Y** (final demand) of the EXIOBASE database, therefore the electricity consumption (coefficients in **u** or absolute values in **Y**) of each industrial activity (or final demand category in **Y**) in each region have been updated proportionally to the 2024 supply mix, keeping their total constant (e.g. the same electricity amount is consumed per unit of activity’s output) but redistributing the origin of such electricity among the different production technologies. This was necessary since changing the electricity mix on the supply side, therefore considering all technologies in competition to produce one single “Electricity” commodity, would have hindered the possibility of some technologies to consume just one type of electricity (it is the case for the “Hydrogen production from electrolysis”: in our model this hydrogen is always green).

Regarding the update of steel supply mixes, instead, Exiobase does not distinguish two different commodities for primary or secondary steel, while it does distinguish two primary (“Manufacture of basic iron and steel and of ferro-alloys and first products thereof”) and secondary (“Re-processing of secondary steel into new steel”) technologies supplying the single “Basic iron and steel and of ferro-alloys and first products thereof” commodity. In this case, the update of steel production mix was performed on the supply side, by changing the market share of these two technologies according to the latest data available from World Steel Association [7].

Steel sector’s emissions allocation logic

In the original EXIOBASE database, the primary steel industry (“Manufacture of basic iron and steel and of ferro-alloys and first products thereof”) produces not only the steel commodity itself (“Basic iron and steel and of ferro-alloys and first products thereof”) but also two by-products: “Blast Furnace Gas” and “Oxygen Steel Furnace Gas.” These gases are typically reused within steel plants to generate electricity for internal consumption, which is however attributed to the electricity production activities (i.e. these gases are consumed by the “Production of electricity by gas” activity). Therefore, the presence of these by-products leads to an underestimation of the inputs and emissions per unit of steel produced, as the recorded values are effectively “diluted” by the inclusion of these by-products in the industry’s total output.

To fix this logic, and correctly account for the emissions of the steel sector, we followed this procedure:

- We removed by-products production from the primary steel industry in EXIOBASE and created two fictious activities responsible for their production (one for blast furnace and one for oxygen steel furnace gas respectively). These activities just supply their respective output gas without consuming any input or emitting any greenhouse gas (it is the steel sectors’ responsibility to consume inputs to emit them).
- We recalculated the inputs consumption and emissions coefficients of the primary steel industry by dividing its total use of commodities and total emissions by the total supply of steel only (decreased by the by-products production). This led to the

Minor issues fixed

When checking the steel supply chains modelled in the EXIOBASE database we also encountered what we interpreted as minor numerical issue. In Australia, the “Re-processing of secondary steel into new steel“ industrial activity provides 4951 tonnes (service) of “Secondary steel for treatment; Re-processing of secondary steel into new steel” commodity per unit of its activity output against an average of 101 in other regions. This lead to a strong overestimation of Australian secondary process’s impacts, therefore we fixed the value setting it equal to the other regions’ average.

Database extension

The database extension procedure followed the same procedure described in Rinaldi et al. [2] but was applied to many additional steel technologies. The extension was performed originally in the context of a study developed in a European Horizon EU project deliverable (IAM COMPACT). For collecting the data, we referred to the inventories prepared in the EU-CHINA BRIDGE Horizon Project [8] and here we report all inventories data inserted in EXIOBASE adopting MARIO [9]. Those steel technologies reporting a “parent” activity, are initialized (in terms of data inventory) identical to the mentioned parent activity in the database, and the values showed in the table are the only ones changed with respect to the parent’s inventory.

While the table reports the total coefficient values adopted per functional unit of output of each new activity, the regionalization (e.g. how much of this total coefficient is domestic or imported and from where) resembles:

- In case the activity has a parent activity, the same import patterns of the parent activity regarding each commodity input.
- Otherwise, the same import pattern for each commodity input of the region where the technology operates.

The technologies have been added following this logic in all the database regions.

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