Sustainable1

Sustainable1 Sovereign Bond Analysis

Methodology

S&P Global Sustainable1 – August 2022

S&P Global

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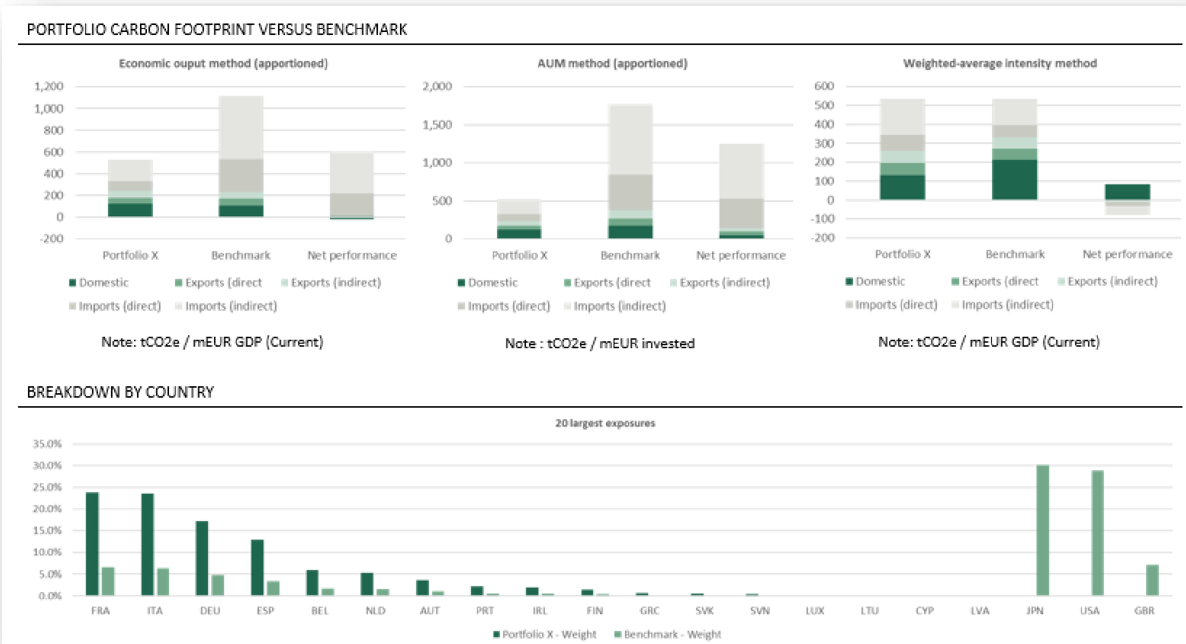
Introduction

Sustainable1 has developed a methodology to analyse the carbon footprint of investments in sovereign bonds. This document outlines Sustainable1's approach to analyzing sovereign bonds with respect to their carbon impact. The methodology allows investors to measure the carbon exposure directly or indirectly linked to their investments in sovereign bonds and helps them evaluate the exposure in comparison to a benchmark.

Sustainable1's sovereign greenhouse gas emissions database covers 170 countries covering all Greenhouse Gas Protocol gases and covers all sectoral emissions including those associated with land use change.



Sovereign Emissions

How are Sovereign Emissions calculated?

In order to calculate sovereign bond emissions, there are a number of key questions to consider:

- Should the allocated emissions be limited to just the public sector or the country as a whole, which would include the private sector and households? More philosophically, can these aspects of the economy be separated or not?
- Should emissions created domestically but then exported (e.g., the mining of coal for export and processing overseas) be considered, or those created internationally but imported and consumed domestically (e.g., the processing involved on creating our smart phones, which are then imported)?
- How should emissions be normalized to make comparisons between economies of different sizes and to assess emission intensity and efficiency? How should economies of different wealth and population size be compared? Which is more important for an assessment of carbon efficiency for a given purpose?

What is the appropriate scope of a sovereign emissions analysis?

Government as **an 'economic agent'**

Within the narrowest definition, the government is seen as separate from the private sector and households, and its emissions are simply those generated by the public sector. Under this approach, the emissions of a national government would principally result from its consumption of goods and services for provision of public services and defense. For example, it would include emissions from energy used in public buildings (Scopes 1 and 2) and embodied in the goods and services of the supply chain (Scope 3 upstream) or use of products (Scope 3 downstream). This is much like any other economic agent, such as corporations.

Government as a 'regulator'

An alternative approach is to quantify a country's emissions more broadly by considering all emissions generated within its territorial boundary. In this case, the entire economy becomes the unit of analysis, with its own emissions making up its direct emissions, and indirect emissions would include those of its imports from other nations. This is consistent with the scope of a government's regulatory oversight and impact, which is not limited to the central government and public services activities.

Exhibit 1: Sovereign emissions Scope

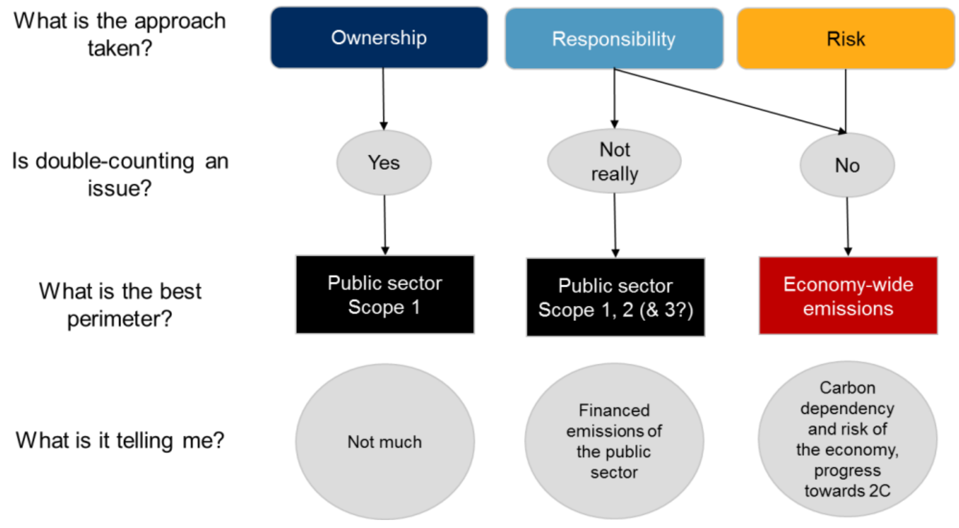
	Government as an economic agent	**Government as a regulator**
Unit of analysis	Public sector emissions	Emissions of the entire economy
Scope	Scope 1, 2 & 3	Territorial emissions
Pathway	Government spending and public sector activities	Climate policies, regulation and dependency on taxes and duties

Definition: *'Territorial emissions'* are the point source emissions deriving from direct emitting operations of agents within an economic territory.

Although considering economy-wide emissions potentially introduces some double-counting across asset classes, it is the best-available measure of an economy's dependency on carbon-intensive industries which in turn contribute to taxes and wages of this economy. For instance, it acknowledges the broader impact of a government on the private sector and households when investing in a sovereign bond. Private households' emissions are, at least partly, under the responsibility of governments, especially those that provide significant welfare services, which are financed through taxes and debt. Indeed, household emissions represent part of a government's Scope 3 emissions.

Moreover, while double counting might be an issue when assessing what institution is responsible for emissions, there may be cases that would need to consider double (or triple) counting when taking a risk-oriented view, as financial risks can also double up.

Exhibit 2: Different approaches lead to different scopes



Deriving Sovereign Emissions

Adjusting for trade

Country emissions can be split into several categories:

- Territorial emissions embedded in domestic consumption
- Territorial emissions embedded in exported goods and services
- Emissions embedded in imported goods and services

Depending on the approach taken, these emissions will be accounted for or not:

Production-based:

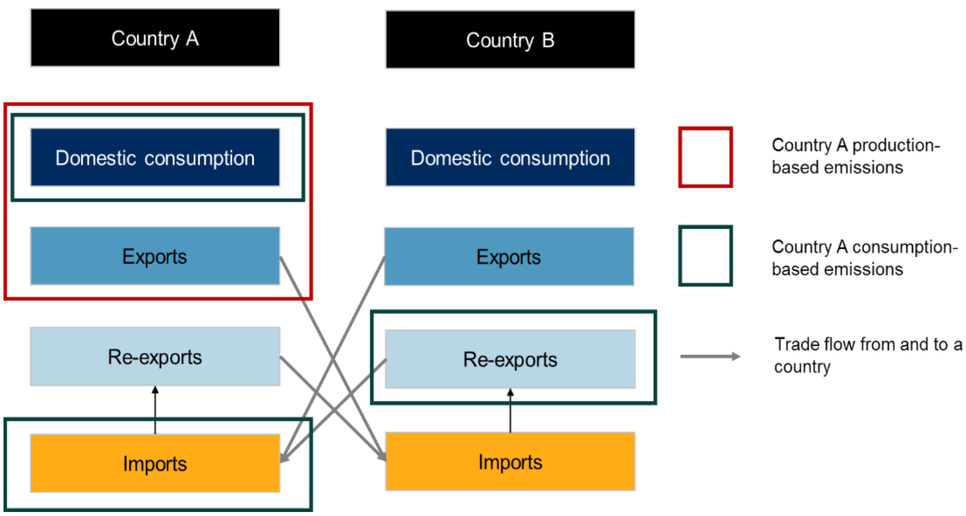
Governments generally report their GHG emissions in accordance with international standards set out for National Greenhouse Gas Inventories by the Intergovernmental Panel on Climate Change (IPCC). This means their carbon estimates and reporting are based on a territorial approach and measure emissions on a "production" basis. This accounts for all the point source emissions generated (or sequestrated) within their borders, regardless of the destination of the goods or services; so a country could, essentially, export its emissions by creating products with significant embedded carbon that need to be processed in a different country. In technical terms, this amounts to the sum of domestic consumption emissions (domestic emissions) and emissions embedded in goods and services that are exported (exported emissions). While this choice is understandable from a practical point of view, it introduces or encourages "carbon leakage" and can be criticized for failing to address the demand side of the emissions problem.

Definition: According to the IPCC, '*carbon leakage*' is defined as "the increase in CO2 emissions outside the countries taking domestic mitigation action divided by the reduction in the emissions of these countries." In layman's terms, it describes the transfer of emissions from high-emitting industries from highly regulated countries (e.g., members of the Organisation for Economic Cooperation and Development [OECD] since the 1990s) to countries with less stringent regulation—or no rules at all (e.g., developing and emerging economies, especially Brazil, Russia, India, China, and South Africa [BRICS] since the 1990s).

Consumption-based:

This method allocates to an economy all the emissions associated with the goods and services effectively "consumed" within its borders: Mathematically, this amounts to summing emissions embedded in domestic consumption and emissions embedded in imported goods and services (imported emissions). This will negatively bias net importers of carbon emissions embedded in goods and services, which are typically developed economies with higher GDPs.

Exhibit 3: Production versus Consumption emissions



The Third way:

This method allocates to an economy all the emissions upon which the economy has direct or indirect control: the sum of territorial emissions (domestic + exports) and emissions embedded in its imports. This reduces bias.

Exhibit 4: Sovereign emissions approaches

	Production-based	Consumption-based	Territorial emissions + Imported emissions
Scope	Emissions generated by an economy, within its national territory	Emissions associated with the consumption of a country's population or final demand	Emissions associated with any aspect of an economy's activity, i.e. the carbon intensity of an economy
Calculation	Territorial emissions = Domestic emissions + Exported emissions	Domestic emissions + Imported emissions	Domestic emissions + Exported emissions + Imported emissions

BIAS	Towards exporters or GHG producers	Towards importers or GHG consumers	No bias
COMPLEXITY	Low	High	High
PROS (+)	Consistent with international standards Reflects the carbon-intensity of an economy's output	Reflects demand-based emissions, wherever the emission is produced	Reflects the carbon dependency of an economy, whether it is demand-driven (domestic or imported) or offer-driven (exported) Equivalent of accounting for direct + indirect emissions already a standard in the corporate world.
CONS (-)	Unable to address carbon leakage May be seen as socially unfair as puts the responsibility on emerging economies (vs developed economies)	Does not capture the carbon intensity of an economy's output Political acceptability Difficult or complex mitigation effectiveness	Introduces double counting

While Sustainable1 offers all three approaches, the latter (production + imports) is considered to be the best proxy of an economy's dependency on carbon-intensive industries, despite the double counting at the global level. This is the equivalent of accounting for direct + indirect emissions already a standard in the corporate world.

Based on the territorial emissions reported by the Potsdam Institute[1] and the World Resources Institute[2], economic and trade data published by the International Monetary Fund and the World Bank, Sustainable1 uses a proprietary Environmentally Extended Multi-regional Input Output (EEMRIO) model uses to calculate emissions embodied in trade for each country in the dataset:

1. Domestic emissions: The emissions embodied in all goods and services produced and consumed within a given territory
2. Direct imports: The emissions embodied in goods and services directly imported by a country
3. Indirect imports: The emissions embodied in goods and services indirectly imported by a country, meaning that they originated in a different country that the country from which the goods and services are imported
4. Direct exports: The emissions embodied in goods and services produced in a country and exported to a foreign economy
5. Indirect exports: The emissions embodied in goods and services imported and re-exported by a country, after processing or not, meaning that they originated in a different country

[1] Gütschow, Johannes; Jeffery, Louise; Gieseke, Robert; Gebel, Ronja; Stevens, David; Krapp, Mario; Rocha, Marcia (2016): The PRIMAP-hist national historical emissions time series (1850-2014). GFZ Data Services. http://doi.org/10.5880/PIK.2016.003

[2] WRI, CAIT. 2014. Climate Analysis Indicators Tool: WRI's Climate Data Explorer. Washington, DC: World Resources Institute. Available at: http://cait2.wri.org.

Deriving emissions intensities

Once the scope of emissions accounting has been defined, the next question is what denominator to use. Using a denominator creates an emission intensity for each country that enables comparisons to be made between countries with economies of different size.

GDP is used as primary proxy for deriving territorial emissions intensities. Normalizing production-based emissions by GDP—the monetary value of goods and services produced within a country—is therefore a logical choice to express the carbon intensity of an economy, as it mirrors the scope of the emissions calculation.

Since territorial emissions are reported with a lag of one to two years, greenhouse gas intensities are used to estimate recent emissions based on the latest available GDP figure published. In order not to introduce currency rate or inflation bias, GDP figures are expressed in constant local currencies.

Data Sources

Sustainable1 has utilized the following public and proprietary socio-economic and environmental data sources to derive the sovereign greenhouse gas emissions and energy data:

Exhibit 5: Data Sources

Source	Coverage	Data points
World Input Output Database	43 countries + ROW*	Input output table – Domestic emissions + Imported emissions
EORA	187 countries	Input output table – Exported emissions
Postdam Institute	192 countries	GHG territorial emissions
S&P Market Intelligence – Economist Intelligence Unit	192 countries	GDP, government debt, population & other socio-economic data
International Monetary Fund	192 countries	GDP, government debt, population & other socio-economic data
Economist Intelligence Unit	192 countries	GDP, government debt, population & other socio-economic data
World Bank	192 countries	Exports/Imports & other socio-economic data
Global Data	101 countries	Power generation data
International Energy Agency	N.A.	2 degree reference scenario - Power generation energy mix
Sustainable1	56 Sectors (from 464)	GHG Emission factors

Data Handling and Gap Filing

Sustainable1 obtains overlapping country level economic data from three separate data sources (WB, IMF, EIU) to improve coverage. Sustainable1 uses a single source of economic data for the economic indicators of each country, with a process incorporated the chooses the source with the most complete recent (last three years) data. Where this is not possible then the data source with the most complete data overall will be used. In events where the data sources have the same coverage available then EIU data will be used. The data source used can be found in the column marked '…Data_Source_S1'.

When the chosen data source contains gaps in the data, Sustainable1 fills these gaps by incorporating a Compound Annual Growth Rate (CAGR) formula using four years of data. Typically this will be backwards looking however in cases where the missing data occurs at the beginning of the period then the formula is forwards looking. Instances where this occurs can be seen in the column marked '…Data_Source_S1' and are marked as being 'S1'.

To further aid clarity, Sustainable1 provides the specific economic figures used for modeling in the columns ending with '_S1'.

Portfolio Analysis: Aggregation

The analysis of a sovereign bond portfolio requires the aggregation of each bond's emissions impacts to the portfolio-level. Sovereign bond investments can be mapped to Sustainable1's sovereign greenhouse gas data set using mappings of bond ISINs to a sovereign issuer. There are several common ways to calculate the carbon footprint of an investment portfolio with each providing a different set of insights.

Portfolio emissions 'RESPONSIBILITY':

These approaches calculate the specific portion of sovereign emissions a holding of responsible for ('apportioned emissions') and can use a variety of denominators in deriving portfolio carbon intensity metrics.

Portfolio emissions 'EXPOSURE':

These approaches assess the portfolio's relative exposure to specific investments by investment weight (% of total value invested). The portfolio's overall footprint will be determined by the individual bond intensities.

All carbon footprint approaches discussed below use GDP as their denominator in intensity metrics, though intensities can be denominated by GDP, population or another parameter.

Apportioning to Portfolio Bonds

Once mapped, the level of financing of a country's government can be calculated using the value invested in each bond and knowledge of each country's Gross General Debt. In principle, this is equivalent to calculating the level of equity ownership of a corporate for listed equity investments (holdings value/market capitalization), or the level of financial of a corporate for corporate bond investments (holdings value/enterprise value). Once this ratio is calculated, it can be multiplied by a country's emissions to derive the emissions apportioned to an investment in a specific bond.

Equation 1: Apportioned sovereign emissions:

$$\frac{Sovereign\ Bond\ Investment\ (US\$)}{Gross\ General\ Debt\ (US\$)} * Country\ Emissions\ (tCO2e)$$

This calculation feeds into two sovereign bond carbon footprint methodologies adopted by Sustainable1 (economic output and assets under management methods).

i) Economic Output Method

This sovereign bond carbon footprint metric describes the relationship between the average amount of greenhouse gas (tCO_2e) emissions generated per million US$ of gross domestic product (GDP) generated. A lower level of emissions to benchmark represents a lower dependency on production and consumption of carbon intensive goods and services on average.

This metric is calculated by dividing the sum of all portfolio-apportioned emissions by the sum of all portfolio-apportioned GDP.

Equation 2.1: Economic Output Carbon Footprint

$$\frac{\boldsymbol{tCO2e}'}{\boldsymbol{GDP}'} = \frac{\sum_i^n \boldsymbol{tCO2e}'_{i,c}}{\sum_i^n \boldsymbol{GDP}'_{i,c}}$$

Where:

tCO_2**e ‘** = Total portfolio-apportioned territorial emissions (tCO_2e).
GDP ‘ = Total portfolio-apportioned GDP (US$ mn)
tCO2e ‘ $_i$ = Apportioned territorial emissions of sovereign bond ‘i’ mapped to country ‘c’.
GDP ‘ $_i$ = Apportioned Real GDP of sovereign bond ‘i’ mapped to country ‘c’.

Equation 2.2: Economic Output Carbon Footprint – Portfolio Apportionment

$$\frac{\sum_i^n \boldsymbol{tCO2e}'_{i,c}}{\sum_i^n \boldsymbol{GDP}'_{i,c}} = \frac{\sum_i^n \frac{Sovereign\ Bond\ Investment\ (US\$)_{i,c}}{Gross\ General\ Debt\ (US\$)_c} * Country\ Emissions\ (tCO2e)_c}{\sum_i^n \frac{Sovereign\ Bond\ Investment\ (US\$)_{i,c}}{Gross\ General\ Debt\ (US\$)_c} * Real\ GDP\ (contant\ US\$\ mn)_c}$$

Where:

Sovereign Bond Investment $(US\$)_i$ = The value invested in sovereign bond ‘i’ in US$ that is mapped to country, ‘c’.
Gross General Debt $(US\$)_c$ = The value of gross general debt of country ‘c’ in US$.
Country Emissions $(tCO_2e)_c$ = The sovereign greenhouse gas emissions (tCO_2e) of country ‘c’.
Real GDP (constant US$ mn)$_c$ = The real Gross Domestic Product (GDP) of country ‘c’ in millions of constant US$.
n = The number of sovereign bonds in the portfolio.

ii) Assets Under Management (AUM) Method

This sovereign bond carbon footprint metric describes the relationship between the average amount of greenhouse gas (tCO_2e) emissions generated per million US$ of investments made in the portfolio. A lower level of emissions relative to benchmark represents a lower greenhouse gas impact per unit of investment on average.

This metric is calculated by dividing the sum of all portfolio-apportioned emissions and the millions of US$ invested.

Equation 3: Assets Under Management (AUM) Carbon Footprint

$$\frac{\boldsymbol{tCO2e}'}{\boldsymbol{Inv}\ (\boldsymbol{US\$}\ \boldsymbol{mn})} = \frac{\sum_i^n \boldsymbol{tCO2e}'_i}{\sum_i^n \boldsymbol{Inv}\ (\boldsymbol{US\$}\ \boldsymbol{mn})_i}$$

Where:

tCO_2**e ‘** = Total portfolio-apportioned territorial emissions (tCO_2e).

Inv (US$ mn) ' = The total value invested in the sovereign bond portfolio in millions of US$.
tCO2e ' $_i$ = Apportioned territorial emissions of sovereign bond 'i' mapped to country 'c'.
Inv (US$ mn) $_i$ = The value invested in sovereign bond 'i' in millions of US$.
n = The number of sovereign bonds in the portfolio.

Portfolio Exposure Carbon Footprints

A third carbon footprint metric Sustainable1 can use to analyze sovereign bond portfolios is the weighted-average carbon intensity metric that describes a portfolio's average exposure to carbon the carbon intensities of different bond investments.

iii) Weighted-average Carbon Intensity Method

This sovereign bond carbon footprint metric describes the portfolio's exposure to specific countries' carbon intensities on a portfolio weight (%) basis. Portfolio weight is determined by value invested, so the portfolio's overall carbon intensity (carbon footprint) will be determined by individual country-level carbon intensities depending on how much is invested in each country's bonds.

This metric is calculated by performing a weighted-average of each bond's portfolio weight and the territorial carbon intensity of the bond's mapped country.

Equation 4: Weighted Average (WACI) Carbon Footprint

$$\sum_{i}^{n} W_i * \left(\frac{Country\ Emissions\ (tCO2e)_c}{Real\ GDP\ (contant\ US\$\ mn)_c}\right)$$

Where:

W_i = the value of holding portfolio weight (%) of sovereign bond 'i'.
Country Emissions (tCO_2e)$_c$ = The sovereign greenhouse gas emissions (tCO_2e) of country 'c'.
Real GDP (constant US$ mn)$_c$ = The real Gross Domestic Product (GDP) of country 'c' in millions of constant US$.
n = The number of sovereign bonds in the portfolio.

Glossary

Territorial emissions: Emissions generated discretely within a country's territory as defined by its geographic boundary. For the purpose of this report it covers all anthropogenic industrial and non-industrial processes as well as land use, land use change and forestry emissions.

Consumption emissions: Emissions generated by a country's consumption. It covers the share of territorial embedded in goods and services domestically consumed, as well as the emissions embedded in the goods and services imported and consumed in the country.

Exported emissions: Emissions generated by a country's economy embedded in goods and services that are exported to other countries.

Imported emissions: Emissions generated outside of a country's geographic boundary but embedded in goods and services that are imported by the country.

Intensity (GHG): GHG emissions of country per unit of GDP (unless specified otherwise). it is a measure of a country GHG efficiency expressed in economic terms.

Renewable share (% generation mix): Share of a country's electricity generated from renewable resources (hydropower, solar, wind, geothermal and biomass).

Fossil fuel share (% generation mix): Share of a country's electricity generated from fossil resources (coal, petroleum products and natural gas).

Global warming contribution score: Ratio of a country's share of global annual GHG emissions (%) and its share of global population (%). A ratio higher than 1 characterises a country that emits more per capita than the global average, while a ratio lower than 1 characterises a country that emits less than the global average, on a per capita basis.

Natural resources rents: The estimates of natural resources rents are calculated as the difference between the price of a commodity and the average cost of producing it. This is done by estimating the world price of units of specific commodities and subtracting estimates of average unit costs of extraction or harvesting costs (including a normal return on capital). These unit rents are then multiplied by the physical quantities countries extract or harvest to determine the rents for each commodity as a share of gross domestic product (GDP). Source: World Bank.

IEA 2C scenario: The 2DS lays out an energy system deployment pathway and an emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C. The 2DS limits the total remaining cumulative energy-related CO_2 emissions between 2015 and 2100 to 1 000 $GtCO_2$. The 2DS reduces CO_2 emissions (including emissions from fuel combustion and process and feedstock emissions in industry) by almost 60% by 2050 (compared with 2013), with carbon emissions being projected to decline after 2050 until carbon neutrality is reached. Source: IEA

Sources

Guidance: Describe the key analytical methods and fundamental factors used to standardize, analyse, and transform data to achieve the expected results, at a high level.

EORA: The Eora multi-region input-output table (MRIO) database provides a time series of high resolution IO tables with matching environmental and social satellite accounts for 187 countries (to 190 in some datasets).

Gütschow, Johannes; Jeffery, Louise; Gieseke, Robert; Gebel, Ronja; Stevens, David; Krapp, Mario; Rocha, Marcia (2016): The PRIMAP-hist national historical emissions time series (1850-2014). GFZ Data Services. http://doi.org/10.5880/PIK.2016.003:

International Monetary Fund (IMF): World Economic Outlook Database (http://www.imf.org)

Lenzen, M., Kanemoto, K., Moran, D., Geschke, A. Mapping the Structure of the World Economy (2012). Env. Sci. Tech. 46(15) pp 8374-8381. DOI:10.1021/es300171x

Lenzen, M., Moran, D., Kanemoto, K., Geschke, A. (2013) Building Eora: A Global Multi-regional Input-Output Database at High Country and Sector Reso lution, Economic Systems Research, 25:1, 20-49, DOI:10.1080/09535314.2013.769 938

PRIMAP: The PRIMAP-hist national historical emissions time series (1850-2014) developed by the Postdam Institute for Climate Impact Research.

Timmer, M. P., Dietzenbacher, E., Los, B., Stehrer, R. and de Vries, G. J. (2015), "An Illustrated User Guide to the World Input–Output Database: the Case of Global Automotive Production", Review of International Economics., 23: 575–605

World Bank (WB): World Development Indicators (https://datacatalog.worldbank.org/)
World Input Output Databse (WIOD): World Input-Output Tables and underlying data, covering 43 countries, and a model for the rest of the world for the period 2000-2014. Data for 56 sectors are classified according to the International Standard Industrial Classification revision 4 (ISIC Rev. 4).

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