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INTEGRATING GREENHOUSE GAS EMISSIONS INVENTORIES AND ACCOUNTS

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Abstract

Greenhouse gas (GHG) emissions inventories and accounts complement each other offering policy makers and users at large two different quantitative assessments of emissions generated by economies. The inventories, based on the Intergovernmental Panel on Climate Change guidelines and compiled according to the territory principle, allow tracking emissions under the framework of the Paris Agreement. On the other hand, the accounts based on the System of Environmental-Economic Accounting following the residence principle are aligned with the System of National Accounts and useful for linking with economic statistics. Despite the different accounting principles, emissions scopes, and classifications used, the two information sets not only can be reconciled, but fully integrated. Such an integration would be particularly helpful to bridge climate and economic policy. Furthermore, additional benefits may include, among others, enhanced quality of the data and availability of more granular information. The integration can be represented with the help of a matrix that cross-classifies emissions by inventory source categories on the one hand and economic activities on the other. Such an integrated approach represents an innovative contribution towards the development of a single, comprehensive, and consistent dataset on GHG emissions.

This note presents some preliminary results on a feasibility study conducted by the OECD to implement the integration of the two accounting frameworks using a regression-based balancing algorithm.

I. INTRODUCTION

A. Inventories and accounts

1. Granular data on greenhouse gas (GHG) emissions are an essential input for policy analysis and projections to support climate change mitigation actions. Two official production-based datasets on GHG emissions for the whole economy are national GHG inventories and Air Emission Accounts (AEAs). GHG emissions inventories are based on the Intergovernmental Panel on Climate Change (IPCC) guidelines, while AEAs are based on the System of Environmental-Economic Accounting (SEEA). AEAs cover a range of emissions to air including GHGs.

2. Inventories and account differ in their accounting principles, source classification systems, and scope of emissions. First, inventories are compiled based on the territory principle and cover GHG emissions generated by entities within a specific geographical area regardless of the resident status of the entity generating the emissions. On the other hand, accounts are based on the residence principle and cover GHG emissions from the activities of resident units whether the emissions take place in the territory of the jurisdiction or outside it. Second, inventories are classified according to the IPCC source categories based on physical sources and emissions processes, whereas accounts are classified according to International Standard Industrial Classification of All Economic Activities (ISIC) or its national/regional equivalent and consumption activities by households. Third, inventories do not include emissions from international transport or CO2 emissions from biomass used as

a fuel in the national totals, whereas accounts currently do not include emissions and removals from Land Use, Land Use Change and Forestry (LULUCF) (Sakata, Aklilu, & Pizarro, 2024).

B. Objectives of integrating inventories and accounts

3. Inventories and accounts serve different user needs and complement each other. The former is mainly used for climate policy making (e.g. tracking emissions under the framework of the Paris Agreement) while the latter primarily supports data needs for economic policy making. This is facilitated as the structure of AEAs is aligned with the System of National Accounts. Discrepancies in total emissions between inventories and accounts are the result of the use of different accounting principles and a different scope of emissions. These differences can be reconciled by means of bridging items that account for GHG emissions by residents abroad (e.g. due to international air and maritime transport or fuelling by households) and non-residents on the territory (e.g. fuelling for land transport as well as domestic air and maritime transport) (Eurostat, 2015), (Eurostat, 2021). At present, however, inventories and accounts remain two standalone entities.

4. To ensure consistency between the two datasets and provide more granularity, this paper proposes integrating inventories and accounts by a matrix structure. Both compilers and users/policy makers will benefit from improved consistency, accuracy, granularity, accessibility, and visualisation through integrating inventories and accounts data.

II. CONCEPT

A. Structure of the matrix

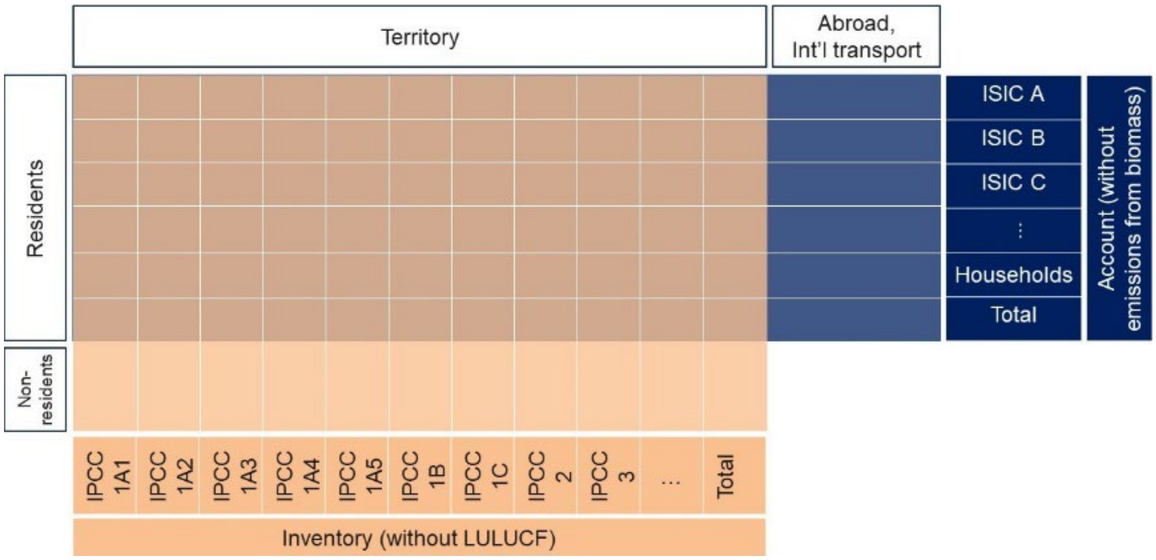
5. A contingency table can be used to simultaneously present emissions as reported in the inventories and the accounts. The structure of such a matrix is sketched in Figure 1. The matrix consists of two overlapping layers. The blue layer for GHG accounts without CO_2 emissions from biomass covers emissions by residents and is classified horizontally according to the ISIC Rev.4 economic activities and the household activities. The orange layer for GHG inventories excluding LULUCF covers emissions generated on the territory and is classified vertically according to the IPCC source categories.

6. This matrix can be divided into three parts: a. emissions from residents on the territory (i.e. the area where the blue and the orange layers overlap), b. emissions by resident units fuelling or bunkering outside of the country and all international air and maritime transport by residents (i.e. the area of the blue layer that does not overlap with the orange layer), and c. emissions by non-resident units fuelling or bunkering on the territory (i.e. the area of the orange layer that does not overlap with the blue layer).

7. The two overlapping layers, each classified horizontally and vertically, cross-classify emissions by the ISIC economic activities or household activities and the IPCC source categories.[1]

[1] For example, a cell cross-classified by the ISIC Section C Manufacturing and the IPCC category 1.A.3.b Road Transportation represents emissions from road transport (fuelled on the territory) by the resident manufacturing industry.

Figure 1. Structure of the matrix integrating inventories and accounts



B. Key features

8. The presented matrix can be a basis for developing a single, comprehensive, and consistent GHG emissions database. The database based on the matrix would be considered "single" as it can present both inventories and accounts emissions data from a single underlying dataset.

9. The database would be "comprehensive" because it captures all GHG emissions under the scope of inventories and accounts, except emissions from biomass which are out of scope of national total in the inventories and emissions and removals from LULUCF which are currently not included in the AEA.[2]

10. The database would be "internally consistent" in the sense that it will be possible to reconcile different estimates of emissions levels by adjusting for known differences between the datasets, such as the territory principle versus the residence principle. Noteworthy is that currently available bridging items only reconcile differences between total inventories and total accounts emissions whereas the proposed matrix can ensure consistency in in each row (ISIC economic activity and household activity) and each column (IPCC source category) thereby enhancing analytical relevance.

III. FEASIBILITY STUDY

A. Scope and data sources

11. The OECD conducted a feasibility study to assess to what extent it would be possible to fill in the proposed matrix using existing emissions data and what estimation techniques would be needed to fill in remaining gaps. The Netherlands was selected as a pilot country due to the high granularity of its publicly available emissions data. The study focused on carbon dioxide (CO_2) emissions for the year 2019.

12. To complete the exercise, various data sources were used. For the inventories, data submitted to the UNFCCC was used [3] while AEA, emissions related to road transport by NACE Rev. 2 activity, and related bridging

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[2] GHG without LULUCF is one of the common definitions of totals in the national inventories at the UNFCCC (https://di.unfccc.int/detailed_data_by_party) and GHG without CO_2 emissions from biomass used as a fuel is a common definition of national totals in the global data collection of AEA by Eurostat (https://ec.europa.eu/eurostat/data/database), the OECD (https://data-explorer.oecd.org), and the UNSD (https://data.un.org/SdmxBrowser/start)

[3] https://di.unfccc.int/flex_annex1

items were sourced from Eurostat [4]. In addition, the national emission registry was used as a complementary data source[5] The emission registry reports both national emission source codes, which correspond to IPCC source categories, and the Dutch Standard Industrial Classifications (SBI), which are national equivalents to the ISIC, for emissions from stationary sources. Finally, the OECD experimental estimates on CO_2 from air transport[6] were used.

B. Methodology

13. CO_2 emissions are either assigned to relevant cells in the matrix or estimated following the steps below.

1) Specify row and column totals and bridging items based on official statistics:
    i. Check that total inventory and account emissions are reconciled through bridging items.
    ii. Fill the bottom row of the matrix (total per IPCC emission source and total inventory) with the national inventory data and the last column (total per ISIC economic activity and households' activity and total AEA with the AEA data.
    iii. Fill the bridging items with officially reported bridging item data.
2) Fill inner cells of the matrix:
    i. Fill in the emissions from stationary sources using data from the national emission registry by checking the combination of national emission source code and SBI code.
    ii. Fill in the emissions from mobile sources:
        1. Split emissions from 1.A.3.a domestic aviation into residents and non-residents by the ratio derived from the OECD estimates on CO2 emissions from air transport. Allocate all emissions from domestic aviation by resident airlines to ISIC H51 Air Transport.
        2. Fill the column for 1.A.3.b road transportation and the column for land transport by resident units fuelling outside of the reporting country using data from AEA related to road transport. The ratio of road-related emissions across economic activities is assumed to be same for the fuel purchased on the territory and abroad.
        3. Fill the emissions from 1.A.3.d domestic navigation by households using the national emission registry. Split the rest of the emissions from 1.A.3.d into residents and non-residents by the estimated ratio derived from reports of the Central Commission for the Navigation of the Rhine. [7] Allocate emissions from domestic navigation by resident industries to ISIC H50 Water transport.
    iii. Identify other relevant ISIC economic activities using the Eurostat correspondence table between the UNFCCC CRF and the NACE. [8] Allocate emissions for 1-to-1 correspondence from IPCC categories to ISIC economic activities. Fill in the rest of missing cells in service industries (1-to-many correspondence from IPCC to ISIC (e.g. IPCC 1.A.4.a.ii Off-road Vehicles and Other Machinery to different ISIC activities)). If no other emissions data were available, the proportion

[4] https://data-explorer.oecd.org/?tm=DF_AEA, https://ec.europa.eu/eurostat/data/database, NACE (Statistical Classification of Economic Activities in the European Community) Rev.2 is equivalent to the ISIC Rev.4 at the 2-digit division level.
[5] https://www.emissieregistratie.nl/ (in Dutch)
[6] https://data-explorer.oecd.org/?tm=DF_AIR_TRANSPORT
[7] https://inland-navigation-market.org/?lang=en
[8] https://ec.europa.eu/eurostat/documents/1798247/6191529/Annex-I-%28Correspondence-between-CRF-NFR-NACE-Rev.-2%29-to-Manual-for-Air-Emissions-Accounts-%282015-edition%29/

of relevant ISIC activities in the total AEA emissions was applied to allocate emissions from an IPCC category to ISIC activities.

3) Based on the robustness of initial estimates, assign reliability coefficients (ranging from 1 to 100%) to each entry in the table, to avoid a pure proportional adjustment. 100% of reliability is assigned to the emissions from official inventories and accounts as well as to the inner cells which were filled with values directly from the national emission registry. Inner cells which could be estimated by simple calculation based on official data (e.g. two ISIC activities are relevant for an IPCC category and one of these two inner cells was known from the official emissions data) were assigned a higher reliability compared to the estimates with the proportional allocation in the step 2)iii or other cells involving assumptions such as domestic navigation.

4) Balance the matrix using a regression-based balancing algorithm (Stanger, 2018). The official and estimated emissions values and the reliability per each emissions value are used as the inputs. Official emissions values with 100% reliability are fixed. Estimated emissions values with less than 100% reliability are adjusted by the algorithm so that both the horizontal and vertical consistencies are met. 100% reliability for the inner cells was slightly loosened when sub-matrix was not reconcilable. The balancing algorithm is run in a top-down manner, i.e. the values are adjusted to meet the horizontal and vertical consistencies first on the aggregated IPCC and ISIC categories and then the values in the sub-sections of the table are subsequently adjusted to meet the consistencies on more disaggregated levels.

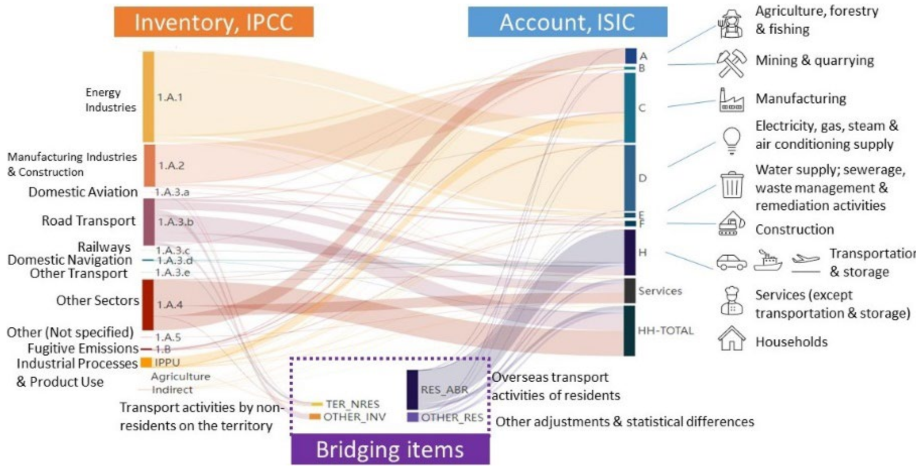
C. Preliminary results

14. Our pilot study for the Netherlands suggests that it is feasible to fully integrate inventories and accounts data on air emissions and that a double-entry table is convenient way to display the integrated data. Most of the inner cells of the table could be filled using the existing national data for stationary emissions classified by IPCC categories and economic activities, while estimates were needed mostly for mobile emission sources and service industries.

15. The regression–based balancing methodology seems promising although improvements are still required to limit the manual imputation of initial values and to avoid negative values. Moreover, sub-sections of the table with too few entries could not be balanced. Finally, the identification of accounting constraints and reliability coefficients remains a time demanding part of the exercise and requires extensive compilers' knowledge.

16. Figure 2 shows a Sankey diagram, based on aggregated values from the preliminary results, summarising how inventory emissions and account emissions relate to each other on aggregated level. For example, most of emissions of transport and storage industry (ISIC H) are not included in the national total of inventories but rather derive from the bridging item on emissions by resident units fuelling or bunkering outside of the country and international air and maritime transport by residents.

Figure 2. Inventory and account CO2 emissions, Netherlands, 2019



17. At the same time, the methodology to fill in the matrix should be further improved. First, the filled matrix after running the algorithm should be fully balanced by some fine tunings. Second, while the importance of national detailed emissions data is confirmed, very few countries disseminate detailed emissions data such as the national emission registry of the Netherlands. Hence, the methodology applied to the Netherlands is not directly applicable to other countries and additional data sources should be explored. Third, the methodology for reliability inputs should be refined. Fourth, the correspondence table between IPCC categories and ISIC economic activities could be further detailed. For example, while the Eurostat correspondence table allocate all emissions from 1.A.3.a domestic aviation to H51 air transport, civil aviation activities include not only commercial air transport but also general aviation. Fifth, there are no international estimates splitting emissions from maritime transport into residents and non-residents. Development of the OECD experimental database on CO2 emissions from air transport and from maritime transport[9] may address these last two topics.

IV. CONCLUSIONS AND NEXT STEPS

18. Our study suggests not only that the full integration of inventory emissions and account emissions is feasible despite the conceptual differences of the two frameworks in terms of accounting principle, the classifications, and the emission scope, but also that the benefits are manifold for many different users, including policy makers, modellers, forecasters, as well as national and international compilers.

19. For policy makers and analysts, the full integration of inventory and account will improve the accessibility to data as they will be stored in a single database. Moreover, cross-classified emissions by IPCC emission categories and ISIC economic industries will provide more granular information, allowing more detailed analysis.

20. Modellers and forecasters will be able to switch between inventory and account emissions. This will be particularly useful when projected emissions based on accounts will need to be linked to inventory data to track the gap with the Nationally Determined Contributions under the Paris Agreement. In this respect, the use of a single, comprehensive, and consistent conceptual framework could facilitate the dialogue between climate change experts and economists that currently tend to refer to either the inventories or accounts respectively.

21. For national compilers, the integration will help ensuring the consistency and the accuracy of the data. The matrix will extend the possibilities of visualisation revealing how inventories emissions and accounts emissions relate to each other. Ratios derived from the matrix (i.e. allocation key from IPCC source category to ISIC economic activities) will be helpful for estimating accounts from inventories for other countries.

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[9] https://data-explorer.oecd.org/?tm=DF_MARITIME_TRANSPORT

22. Also, international compilers will benefit from the integrated approach as it may allow expanding the geographical coverage to estimate GHG emissions for countries that are currently not reporting either the accounts, or gases other than CO_2, or to extend the timeseries.

23. Continued international collaboration is important for further advancing the study on the matrix. The existing collaboration with Eurostat and the IMF in the context of the Data Gaps Initiative seems to be a natural option.

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