BRIEFING NOTE ON POSSIBLE GLOBAL SEEA DATABASES FOR MATERIALS, ENERGY, AND AIR EMISSIONS ACCOUNTS

This document was prepared by Stephan Moll (leader of the physical environmental accounts team at Eurostat) in summer 2015 during a short-term secondment to UNSD, with inputs from UNSD. It was then used for informal consultations with selected partners around the joint UNECE/OECD seminar and task force meeting on 'Implementation of SEEA' Geneva, 14-16 October 2015. Since the note was distributed in October 2015, there have been some developments, in particular concerning SDG indicators. These developments are not reflected in this version of the note (which is a slight update of the October 2015 version). However the arguments and the main conclusions of the note remain valid.

Introduction

1. The United Nations Committee of Experts on Environmental Economic Accounting (UNCEEA) was established by the United Nations Statistical Commission with mandates to mainstream environmental-economic accounting and related statistics and to advance the implementation of the SEEA in countries.

2. At its 10th Meeting in June 2015, the UNCEEA discussed the proposal to establish an SEEA database for selected accounts in support of the monitoring of the 2030 Agenda for Sustainable Development and the Sustainable Development Goals (SDGs) and Targets.

3. The Committee welcomed the proposal to consider SEEA based data dissemination at the international level as an important step in implementation of the SEEA. The Committee:

   - Recognized the possibility of compiling SEEA compliant data and the international level using existing economic and environmentally related data from existing international and regional data as an important first step in disseminating modular SEEA compliant accounts and tables;
   - Recommended setting priorities for a small set of accounts for data compilation, and requested an analysis of possible domains to cover taking into consideration policy priorities of both developed and developing countries as well as data availability.
   - Urged international organizations to adopt data sharing and exchange mechanisms on the basis of common data templates and where needed to make an in depth assessment of data being already collected and determine possible additional data collection/compilation for SEEA purposes.

4. The exercise of developing global databases on selected SEEA accounts is in line with the Committee's reiteration of the importance of the SEEA as an important framework to monitor the Sustainable Development Goals. The SDGs represent a shift towards an integrated approach to sustainable development policy, incorporating a range of goals and targets into an integrated agenda. Monitoring and reporting in support of this agenda should be based on statistical frameworks which integrate environmental, economic and social information into one coherent information system for sustainable development.

5. In line with the decisions taken by the UNCEEA, this strategic note provides a preliminary analysis of the possible areas in which physical environmental accounts global databases can be developed based on existing experience in particular in Eurostat and the availability of global data sets. It reflects on the usefulness and feasibility of establishing global SEEA datasets in the domain of SEEA physical flow accounting, namely:

   - Economy-wide material flow accounts (EW-MFA).
   - Energy accounts, more precisely physical energy flow accounts (PEFA).
   - Air emissions accounts (AEA).

6. Establishing global datasets or databases for SEEA physical flow accounting calls for reinforced co-operation between international bodies such as UNSD, OECD, Eurostat and others.

Rationale

7. The usefulness of establishing global SEEA databases is assessed along the question *'For what purpose?*' There are three generic possible purposes for global SEEA-physical databases:

   i. Serving the monitoring of *Sustainable Development Goals* (SDGs).

   ii. Linking the *global database of UNSD national accounts* (or other global databases for national accounts) with SEEA-physical data, enabling integrated environmental-economic analyses at global level (environmental-economic structural changes; productivity analyses at level of industries, decomposition analyses).

   iii. Linking *global multiregional input-output datasets* with global SEEA-physical data enabling e.g. consumption based/ 'footprint-type' calculations.

8. It has to be noted that the benefit of SEEA goes beyond the derivation of aggregated indicators; the benefit of SEEA lies in the integration of environmental data with national accounts into a consistent analytical framework providing multipurpose applications.

9. The feasibility of implementing SEEA-physical databases is particularly determined by and hence assessed along the following criteria:

   i. Availability of robust and mature, internationally standardised methodologies for SEEA-physical data sets;

   ii. Availability of [primary] data at national and international level enabling compilation of SEEA-physical data sets; or availability of ready-to-use physical accounts data at national and regional level which could be gathered;

iii. Availability of sufficient auxiliary information to make adjustments for the residence principle at national and global level.

10. This paper focuses on the feasibility of production of accounts globally, in terms of policy relevance, maturity of methodology, availability of data sources and complexity of the compilation process. The paper does not address the needs for SEEA related capacity building for national statistical authorities (methodological guidelines, trainings, video tutorials, IT tools, task forces, seminars) which will remain core activities of the UNCEEA and in particular UNSD and Eurostat. A separate paper addressing capacity building needs in support of the compilation of global databases would need to be developed as part of a plan of implementation of different SEEA database modules. The paper does not address either other aspects of setting up global databases that would require solutions. Governance of global databases is not addressed at all. The required standards for data transmissions (SDMX and data structure definitions) are only touched in passing. Those are important aspects which will need to be addressed at some stage.

11. **The conclusions of this note can be summarised as follows:**

- EW-MFA is the physical accounting area that could be the starting point for a global database. Getting progress in the short term with comparably little efforts could be low hanging fruit.
- A global database with some sort simplified energy accounts could be established in the short to mid-term, though requiring significant efforts and associated with computational and methodological challenges. Some basic choices need to be taken.
- A crude global AEA database could be compiled in the short to mid-term, for those countries providing UNFCCC and CLRTAP emission inventories.
- Efforts should be undertaken in overcoming the computational problems related to the residence adjustments due to international transport (relevant for energy and air emissions).

I) Economy-wide material flow accounts (EW-MFA)

Usefulness of a global EW-MFA database

12. Domestic material consumption (DMC) – an indicator derived from EW-MFA – will most likely be proposed and accepted to monitor Sustainable Development Goals (SDGs):

- SDG indicator 8.4: resource productivity GDP/DMC [1]
- DG indicator 12.2: DMC per capita and 'material footprint' per capita[2]

[1] Feasible at the economy-wide level using UNSD national accounts and global EW-MFA database provided by research consortia (e.g. http://materialflows.net, see below paragraph 19).
[2] Feasible using UN population statistics and global EW-MFA database provided by research consortia (UNEP study 'assessment of global material flows', see below paragraph 19).

13. The resource productivity indicator is a combination of physical accounts with national accounts. The 'material footprint' indicator is derivable from input-output models extended by EW-MFA data sets.

14. Another useful purpose of a global EW-MFA database is to link it to the global data sets on multiregional input-output tables. In EW-MFA the domestic extraction of materials is recorded in a detailed breakdown which can be assigned to industries as delineated in supply, use, and input-output tables.

Methodological maturity of EW-MFA

15. EW-MFA is the methodological framework developed and implemented by the European Statistical System (ESS) under the lead of Eurostat. The EW-MFA methodology is aligned to and mentioned in SEEA-CF. It is mature, internationally harmonised, and sufficiently documented in guidelines which can be found on the Eurostat website. The methodology can easily be extended at the global level, beyond EU countries.

16. Unlike other accounts, EW-MFA is a pure 'SEEA product' in so far that there are no competing 'schools of thoughts', methodological approaches or international bodies that provide similar metrics for material flows (as is the case for energy and air emissions).

Availability of EW-MFA data

17. EW-MFA are fully established in the *European Statistical System*[3]. Regular data collections and a routine schedule for early estimates have been installed to meet increasing EU policy makers' demand. Eurostat provides official statistics for EW-MFA for ca. 30 European countries via its website[4].

18. Material flow accounts are also established in Japan (Ministry of Economy, Trade and Industry) in the context of circular economy policies.

19. OECD maintains a database on material flows[5] covering 34 OECD countries and BRIICS countries (see recent report, in particular pages 14-15). The database has been compiled by contractors according to the Eurostat method. Notably the OECD database also includes so-called unused domestic extraction[6] which are not included in Eurostat's EW-MFA.

20. Furthermore, two international EW-MFA databases – following Eurostat methodology – have been established by research consortia:

[3] Annex III of consolidated/amended Regulation (EU) 691/2011
[4] The database structures (SDMX) still need to be harmonized across European national statistical authorities.
[5] Apparently there are two online databases at OECD: (1) OECD data on material flows (includes experimental data on unused flows): 'Material Resources' OECD Environment Statistics (database); (2) Selected OECD environmental data and indicators: OECD Environment Statistics (database)
[6] In SEEA-CF terminology: natural resource residuals

- UNEP/ International Resource Panel has commissioned a study in the context of which a global material flows database has been compiled[7]. The report will be published soon. The dataset is published on UNEP*Live*[8]. This database also includes 'material footprints' derived from global multi-regional input-output modelling (EORA).

- materialflows.net a global EW-MFA database provided online by a consortium of academia and consultants. Note that the concerned research groups are also involved in the former UNEP/International Resource Panel study.

Availability of primary data enabling compilation of EW-MFA

21. In general, EW-MFA are compiled from a range of widely available statistics, such as agriculture, mining, trade, production or energy statistics. At national level the availability and in particular the details of these primary statistics vary.

22. At international level these 'primary' statistics needed for compiling EW-MFA are widely harmonised in form of global databases. As exemplified by the two research consortia (see paragraph 19) a global EW-MFA database can be compiled from existing international data sources, e.g.:

    - Agriculture, fishery and forestry statistics (e.g. FAOSTAT);
    - Production statistics (e.g. UN Industrial Commodity Statistics);
    - geological surveys (e.g. USGS and BGS);
    - energy balances;
    - foreign trade statistics (e.g. UN Comtrade).

23. Nevertheless some data limitations need to be mentioned as well: (1) Official industrial production statistics on sand, gravel and other non-metallic minerals are often too low. Eurostat recommends alternative estimation procedures which may be less accurate as official statistics. Note that the category of non-metallic minerals represents half of the DMC. (2) Grazed biomass – which represents another significant share of DMC – needs to be estimated due to the lack of official statistics. Eurostat recommends respective estimation procedures.

Adjustments for the residence principle in EW-MFA

24. Adjustments for the residence principle are of minor quantitative importance in EW-MFA. The imports of petroleum products need to be adjusted because trade statistics – the data source usually used to compile EW-MFA – do not include as imports petroleum products purchased and used by resident units abroad. Also trade statistics do not declare as exports road transport fuels

[7] Eurostat was involved in formulating the *terms of reference* for this study project.
[8] It is a bit hidden though. You need to select a country. Then go to the bottom of the map displayed on next page. Underneath the map, click o 'UNEP Resources' and chose 'Natural Resources'.

sold to non-resident units on the territory. Quantitatively these adjustments are small in comparison to the overall material flow indicator DMC.

Conclusions and way towards a global EW-MFA database

25. Global EW-MFA databases are feasible and already exist, notably in the research community. It would be good to institutionalise the existing database deriving from the UNEP study. A more 'official' EW-MFA database could be used to monitor SDGs 8.4 and 12.2.

26. The institutional setup of an 'official' global EW-MFA database should build upon the existing UNEP study. It requires some coordination efforts among the involved international bodies, namely UNSD, UNEP, FAO, OECD, Eurostat, and possibly other partners.

27. UNSD could be the host for an 'official' global database on EW-MFA. This global database should make use of the Eurostat official statistics and employ their established database structures (in view of SDMX compatibility). Non-European EW-MFA could be compiled based on existing international data sources (see paragraph 21) by UNSD staff and/or contractors.

28. Next step:

    - UNSD to start talks with OECD, UNEP, FAO, Eurostat and others to find out most suitable institutional arrangement and partnership for a global EW-MFA database.

    - Develop a SEEA Technical Note on EW-MFA including a core accounts and table.

    - Study in detail the UNEP global material flow database, in particular the compilation methods and data sources.

    - First sketch of data flow procedures (from international 'primary' sources towards EW-MFA core table.

    - UNSD to anticipate human resource needs for setting up and maintenance: At UNSD an administrator (partly) is required for the steering/supervision of the project. One assistant for the database work should be calculated. The setting up phase requires external contractors.

II) Energy accounts with focus on physical energy flow accounts (PEFA)

Usefulness of a global energy accounts database

29. It is thinkable that a global database of some sort of simplified energy accounts[9] could be established in the short to mid term to monitor SDG indicators (see also Annex 1 for an analysis of energy related SDG indicators). In particular 'energy intensities in a break down by economic activity' require a global dataset of kind of simplified energy accounts.

30. Simplified energy accounts refers here to some integration/combination of existing global energy databases (e.g. energy balances) and the UNSD National Accounts Main Aggregates Database. Note that the latter provides a very broad industry breakdown based on ISIC Rev. 3[10]. The classification of energy use sectors can be matched with broad groupings of ISIC divisions except for the energy use by the transport sector (see Annex 2).

Methodological maturity of energy accounts

PEFA

31. Out of the wider scope of SEEA energy accounts[11] it is the European module on PEFA[12] which is expected to be implemented by statistical authorities soon[13]. There are a few European countries who have been compiling the one or the other sort of energy accounts for some years. So far, these have not been comparable as the concepts and formats vary. With PEFA, a standardised methodology will be established.

32. The methodological concepts for the European PEFA are documented in a draft Manual for PEFA (2014). Major conceptual revisions are not expected but could possibly reveal from the ongoing test data collections in Europe running until 2017.

33. The European PEFA questionnaire has five tables in total. At its core it has a pair of physical supply and use tables (Tables A and B) fully in line with the SEEA-CF generic accounting framework for physical flow accounts (see SEEA-CF Table 3.1). The European physical use table (Table B) does not have the breakdown into transformation use and end use (see SEEA-CF Table 3.5) but could easily be derived. Table C is a physical use table only for emission relevant energy use. Table D derives 7 key indicators from Tables A and B. Finally, Table E bridges from the residence to the territory principle.

A simplified energy account

[9] Starting from the core table for energy as described in SEEA Technical Note on Energy
[10] Switch to ISIC Rev. 4 is expected soon.
[11] Notably only few European countries – endowed with respective energy resources – are interested in compiling energy asset accounts.
[12] Full-fledged physical supply and use tables for energy, measured in Terajoule
[13] Annex VI of consolidated/amended Regulation (EU) 691/2011 with first mandatory data collection in September 2017.

34. The draft SEEA Technical Note on Energy presents a core table some elements of which (i.e. rows) may serve as a starting point for developing a simplified energy accounts (in the sense of paragraph 29). The exact format of such a simplified energy account requires some more investigations. Annex 2 presents some first thoughts.

Availability of energy accounts

35. International databases of standardised and comparable energy accounts are not available yet.

36. The European Statistical System (ESS) has started to establish PEFA. Currently Eurostat is developing database structures (SDMX), validation procedures, and gap-filling procedures. Those are expected to mature during two voluntary data collection cycles (2015/16 and 2016/17) before mandatory data collection will start in September 2017. Data obtained so far from test data collections are not publishable.

37. Eurostat has developed an IT-tool (PEFA-builder) that populates PEFA questionnaire (Tables A, B, and E) mainly from the five IEA/Eurostat annual questionnaires. The user must provide additional input data necessary for residence adjustments related to transport and detailing of industry columns. Using the PEFA-Builder requires considerable expertise in energy statistics and accounts.

38. A similar approach to PEFA could be used to established global simplified energy accounts.

Availability of energy statistics and national accounts main aggregates enabling a simplified energy account

Energy statistics

39. Eurostat publishes energy balances for some 30 ESS countries through their website. The Eurostat energy balances and derived key indicators are used for European energy policy making and target setting (e.g. so-called 20-20-20 targets).

40. The IEA provides global databases for energy balances, though associated with a considerable license fee. Basis for this is a nearly worldwide data collection using five IEA/Eurostat annual questionnaires[14]. The IEA energy balances and derived key indicators, such as e.g. primary energy consumption (PES), are currently used to monitor energy policies at global level.

41. UNSD holds a global database on energy balances as well as energy statistics database.

42. Although most definitions and concepts for energy balances have been harmonised (see IRES) they vary slightly between IEA and Eurostat. In particular national energy balances still have slightly different concepts and formats.

National accounts main aggregates

[14] Note that in EU collection of energy statistics is also legally based, see Regulation (EC) No 1099/2008

43. UNSD publishes two global datasets including gross value added by economic activity: The National Accounts Main Aggregates Database is a gap-filled and complete data set which however has a quite aggregated industry breakdown; it includes value added generated by 7 seven broad groupings of industries. Value added and output for a more disaggregated industry breakdown is provided through the UNdata portal. This data set – entitled National Accounts Official Country Data – is however incomplete and hence maybe less suited.

Adjustments for the residence principle in energy accounts

44. Energy accounts as well as national accounts main aggregates follow the residence principle whereas energy statistics/balances are based on a 'fuels-sold-on-the-territory' principle. When compiling energy accounts, e.g. PEFA or a more simplified account, from energy balances/statistics the compiler needs to deduct energy purchased by non-residents on the territory and add energy purchased by resident units abroad. These residence adjustments are in particular significant for international water and air transport activities.

45. Auxiliary information is hardly available and varies across countries, at least in Europe. So far no standard approach for residence adjustments could be found that employs global databases of adequate auxiliary information. It still needs to be researched whether a database of the International Civil Aviation Organisation (ICAO) could potentially bear some information for a global standard residence-adjustment-approach in the case of air transport. A similar 'big data' source still needs to be found and explored for water transport.

Conclusions and strategic outlook – choices and next steps

46. More analysis on the data sources as well as the amount of work needed to set up a global database for simplified PEFA needs to be undertaken. The European PEFAs are not available yet. Compiling PEFAs for the rest of the world with the help of the PEFA-Builder seems a too huge effort.

47. SDG indicator 7.3.1 'Change rate of energy intensity[15]' may be needed with a breakdown by industries. This could justify setting up a global database for a kind of simplified energy account inspired by the core table for energy. It could combine UNSD national accounts main aggregates with existing global energy statistics databases (e.g. IEA). The energy statistics data would have to be transformed towards SEEA-conform indicators (see Annex 2 for more details). Yet the exact compilation procedure still needs to be developed and feasibility should be verified.

48. Possible next steps:
    - Define a simplified energy account, starting from the core table for energy[16]. Basically it should include the following rows:
        - 3. Gross value added

[15] 'end use of energy products' or 'net domestic energy use' per unit value added
[16] See SEEA Technical Note on Energy.

- (5. Total extraction of natural energy inputs)?
- 7. End use of energy products
- 8. Net domestic energy use

- Clarify access conditions and chose a global data source for energy statistics from which the compilation procedure for a simplified energy accounts should start. There are the following options:
  - IEA/Eurostat annual energy questionnaires;
  - IEA energy balances;
  - UNSD energy balances.
- Develop/define an algorithm (compilation procedure) for the transfer from energy statistics data towards SEEA conform energy aggregates (5.), 7. and 8.
- Map the ISIC breakdown used in UNSD national accounts main aggregates to the classification used in energy statistics.
- Explore possible auxiliary data sources that might help to develop a standard-residence-adjustment-approach for international air and water transport. E.g. explore 'big data' such as databases provided by ICAO (International Civil Aviation Organisation).
- UNSD may programme PEFA capacity building activities addressed to national statistical authorities. The existing knowledge base at Eurostat (trainings, video-tutorial for PEFA-builder etc.) would be a good point of departure.
- Talk with OECD about their plans in the domain of energy accounts.
- Anticipate human resource requirements in-house UNSD and external experts).

III) Air Emissions Accounts (AEA)

Usefulness of a global AEA database

49. SDGs refer to greenhouse gas (GHG) emissions, emissions of air pollutants are not considered (see Annex 3 for an analysis of air emission related SDGs). SDG indicator 9.4 Carbon emission per unit value added ideally requires global AEA data.

Methodological maturity of AEA

50. AEA are established in the European Statistical System[17]. The European AEA are in accordance with SEEA-CF Table 3.7 and cover 13 substances (6 greenhouse gases and 7 air pollutants, namely SO_x, NO_x, NH_3, CO, NMVOC, PM2.5, PM10).

[17] Annex I of consolidated/amended Regulation (EU) 691/2011.

51. The AEA methodology is sufficiently documented. Methodological guidance for AEA next to the AEA questionnaire can be found on the Eurostat website. The methodology could be applied at the global level.

Availability of AEA

52. There are currently two international databases available for AEA:

    - Eurostat's online database provides AEA for EU Member States, Norway and Switzerland.
    - OECD's online database provides AEA for Australia and Canada, next to those produced by Eurostat.

Availability of global air emission data that can be used for AEA compilation

53. So-called national emission inventories are established for a wide range of countries through international conventions: UNFCCC[18] for greenhouse gas emission inventories and CLRTAP[19] for emission inventories for air pollutants. Concepts and compilation methods are in place for UNFCCC inventories[20] as well as for CLRTAP inventories[21]. Clearly scheduled data production cycles are established at least for European countries coordinated by the European Environment Agency (EEA).

54. National emission inventories most often form the primary data source for the AEA compilation.

55. Notably, Eurostat has developed a correspondence matrix which links the CRF/NFR classification of emission sources (used in UNFCCC and CLRTAP inventories) to the European classification of economic activities (NACE). Eurostat uses this correspondence matrix to generate' artificial' AEA-questionnaires for plausibility checking. It could be used to generate AEA for USA, Canada and other European non-EU countries for which CLRTAP inventories are available.

56. In addition, FAO has established a global data set on GHG emissions in agriculture, forestry and other land use.

57. At national level so-called Pollutant Release and Transfer Registers (PRTR) may constitute a data source for compiling AEA. A global PRTR is not available.

Availability of greenhouse gas emission inventories

58. Worldwide GHG data are provided through multiple channels, the most important ones are:

    - The UNFCCC website provides various data on GHG emissions. The most detailed data sources are GHG inventories for more than 40 Annex I parties as well as GHG inventories for

[18] UN Framework Convention on Climate Change.
[19] UNECE Convention on Long-range Transboundary Air Pollution. Note limited coverage of European countries, Canada and USA.
[20] See IPPC Guidelines for National Greenhouse Gas Inventories and UNFCCC reporting guidelines on annual inventories
[21] See EMEP/EEA air pollutant emission inventory guidebook

some non-Annex I parties. Note, At UNFCCC the inventories are available in form of EXCEL workbooks per country. The European Environment Agency (EEA) provides a database including the GHG inventory data for more than 30 European countries.

- A global database for GHG aggregates (detailed data by Annex I parties and non-Annex I parties) is also provided through the UNFCCC GHG data interface.
- A UNFCCC website provides a good overview of 'external' global GHG databases hosted by various organisations such as UNSD, FAO, World Bank, IEA etc.

Availability of emissions inventories for air pollutants

59. A worldwide database including detailed CLRTAP inventory data does not exist as CLRTAP is limited to European countries, the USA and Canada. The CLRTAP emission inventories of air pollutants are available through the following sources:

    - Detailed data from CLRTAP inventories (39 European and North American parties[22]) are available on the website of the Centre on Emission Inventories and Projections (CEIP).
    - The European Environment Agency (EEA) provides a detailed database of CLRTAP inventory date for more 30 EEA member countries and cooperating countries.

60. OECD provides aggregates, i.e. national totals, for 6 air pollutants (SOX, NOX, PM10, PM2.5, CO, NMVOC) for 34 OECD member countries.

Conclusions and strategic outlook – choices and next steps

61. It would be feasible to create an AEA database for GHG (estimates) by applying Eurostat's correspondence matrix for those countries for which detailed UNFCCC inventories are available (Annex I parties and a number of non Annex I parties). Many out of those countries report already AEA data to Eurostat and OECD. Hence, AEA would need to be compiled for a few remaining countries. Notably, such an AEA database would not have global geographic coverage.

Next steps:

- Explore which countries are missing (see paragraph 60) for which AEA could be compiled using the Eurostat correspondence matrices; basically those countries not included in OECD database but for which UNFCCC GHG inventories are available.
- Talk with OECD about their planned activities in the domain of AEA.
- Talk to UNFCCC and FAO to better understand their initiatives and how to establish close collaboration.

[22] Austria, Azerbaijan, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, EU, Estonia, Finland, France, Georgia, Germany, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The former Yugoslav Republic of Macedonia, Turkey, United Kingdom, United States

Annex 1: Brief analysis of SDG indicators related to energy

- Sustainable Development Goals (SDGs) in the domain of energy are monitorable using existing global database for energy (e.g. IEA energy balances) and the UNSD National Accounts Main Aggregates Database. Note that the latter provides a very broad industry breakdown based on ISIC Rev. 3:

  - SDG indicator 7.2.1 Renewable share in total final energy consumption (%):

    - Definition for this indicator needs to be specified as there are several possible at economy-wide level.

    - In Europe several indicators of 'renewable shares' are legally defined[23]. All are derived from the five IEA/Eurostat annual questionnaires using a standardised IT tool.

    - IEA provides two indicators of 'renewable shares' based on their energy balances: renewable sources in total primary energy supply and renewable share in total electricity generation.

  - SDG indicator 7.3.1 Change rate of energy intensity (primary energy over GDP):

    - At economy-wide level: feasible to derive from IEA energy balances and UNSD National Accounts Main Aggregates Database. Unclear how 'primary energy' is defined here? Assumingly the IEA key indicator 'primary energy supply' is meant?

    - At disaggregated industry level: Feasible, if final energy use is taken instead of 'primary energy'. Note that the UNSD National Accounts Main Aggregates Database provides gross value added for 7 broad groupings of ISIC industries. These can be matched by the more detailed industry breakdown for which global energy data (e.g. IEA energy balances) provide final energy use. See Annex 2 for a crude correspondence between the industry groupings employed in UNSD National Accounts Main Aggregates Database and IEA energy balances.

  - SDG indicator 7.3.2 Composite energy efficiency improvement index built up of sub-indicators measuring:

    - *Transport energy efficiency:* IEA energy balances provide transport energy use broken down by road, air, water, and railways. Whereas the latter three can be assigned to transport industry as delineated in national accounts, the first includes road transport operated by all industries and private households. Unclear what metric could be used for 'transport output'?
      In case PEFA data would be used, road transport energy use undertaken by

[23] Directive 2009/28/EC on the promotion of the use of energy from renewable sources

private households and non-transport industries would not be taken into account.

- *Industrial energy efficiency:* Feasible, using UNSD National Accounts Main Aggregates Database and IEA energy balances.
- Power generation energy efficiency: Feasible, solely using IEA energy balances relating electricity output to primary energy input of power plants. Needs technical clarifications concerning CHP plants.
- Buildings energy efficiency: Needs to be specified. Neither IEA energy balances nor national accounts provide this data.
- Agriculture energy efficiency: Feasible, using UNSD National Accounts Main Aggregates Database and IEA energy balances.

- SDG indicator 7.a.1 Change rate of net carbon intensity of the energy sector (GHG/TFC[24]):
  - Feasible on the basis of IEA energy balances and UNFCCC inventories as both use the same definition and delineation of energy sector. Note that UNFCCC inventories are not available for all countries.
- *SDG indicator 7.b.1 Change rate of energy productivity (production output per energy input):*
  - see above SDG indicator 7.3.1

[24] Total final energy consumption; derivable from energy balances and defined in IRES.

Annex 2: How to integrate IEA energy balances and UNSD national accounts main aggregates?

In the following some ideas are presented on how the SEEA Core Table for Energy [Accounting] could be populated from existing international databases. Also, some conceptual issues related to the Core Table are addressed which seem not fully though through (e.g. renewable share, missing accumulation column). Thirdly, the ideas are channelled towards the possibility to use the Core Table as reference for SDG indicators.

Energy intensities (productivities) by industry

The idea is to compile SDG indicator 7.3.1 '[change rate of] energy intensity' in a breakdown by industry. Energy intensity is a ratio: some energy use parameter is related to an economic output parameter. In a first step one has to precisely specify and define the two parameters.

For the energy numerator one has to make a choice out of two IEA indicators and five SEEA aggregates:

a) IEA indicator *total primary energy supply (TPES)*: In IEA energy balances this key indicator is provided for each energy product and for the total of all products. It is defined as the aggregate of *primary production + imports – exports – marine bunkers ± stock changes*[25]. It represents the amount of energy in form of energy products made available for the country. Notably this key indicator makes only sense for the aggregated economy, i.e. it is not feasible to break down TPES by industries. Only a breakdown by products is given, the latter can be distinguished into non-renewables and renewables.

b) IEA indicator *total final consumption (TFC)*[26]: In IEA balances this key indicator is defined as the sum of final use – for energy and non-energy purposes – of energy products in the following so-called sectors: industry, transport, and others (incl. residential, agriculture, services etc.).
- TFC notably excludes own use in the so-called energy sector.
- TFC excludes distribution losses.
- TFC also excludes international marine and aviation bunkers.
- TFC includes non-energy purposes.

The breakdown by sectors and sub-sectors is fairly detailed in IEA energy balances; they are even more detailed than the published UN national accounts in the case of manufacturing (see embedded EXCEL below).

c) SEEA Core Table row item 5 *Total extraction of natural energy inputs (incl. 'of which from renewable sources')*: This vector of natural inputs shows extraction of energy from the environment by the extracting industries (e.g. coal mining, crude oil and natural gas

[25] Additions to stock are deducted, withdrawals are added to PES for each product.
[26] Final consumption of energy products represents the last stage in which the energy products are utilised and disappear from the statistical observation (IRES para. 2.19).

extraction, extraction of renewable energy sources such as hydro, wind, solar etc.). This indicator has decomposable into non-renewables and renewables.

d) SEEA Core Table row item 6 *Supply of energy products*: This vector shows the total of energy products supplied by domestic production activities – broken down by industries – private households and the rest of the world (imports). Note that this includes kind of double counting of energy amounts.

e) SEEA Core Table row item 7 *End-use of energy products*: This vector shows the total of energy products that are finally used by industries, households and the rest of the world (exports). The SEEA *end-use of energy products* is the closest equivalent to the IEA *total final consumption (TFC)* indicator.
- It notably includes the end-use of energy products by the so-called energy sector (own use), which is different to TFC (see b) above).
- It includes distribution losses, which is different to TFC (see b) above).
- It notably includes end-use of fuels by resident units operating international transport, but ditto for non-resident transport units that purchased on the territory.
- It notably includes[27] end-uses for non-energy purposes.

f) SEEA Core Table row item 8 *Net domestic energy use*: SEEA defines this vector as the end-use by industries and households of energy products (including changes in inventories of energy products) less exports[28] of energy products plus all[29] losses of energy (losses during extraction, losses during transformation, losses during storage and losses during distribution).
Basically net domestic energy use equals end-use of energy products plus losses in a breakdown by industries, households, and stocks.
The SEEA *net domestic use* is the equivalent to the IEA *total primary energy supply (PES)* indicator – but from an end-user perspective and in a breakdown by industries and households?

g) SEEA Core Table row item 8 *Total energy requirement*: This aggregate is not defined in SEEA Technical Note on Energy Accounting or in the SEEA-CF.

For the economic denominator one has to make a choice between two national accounts aggregates:

1) UNSD National Accounts questionnaire – Table 2.5 *Value added by industries at constant prices (ISIC Rev. 4)*:

2) UNSD National Accounts questionnaire – Tables 2.6 *Output by industries at current prices (ISIC Rev. 4)*:

[27] See SEEA-CF para. 3.168
[28] Only relevant for the national total (economy-wide level), i.e. the column rest of the world is blank.
[29] Note, that end-use losses, i.e. dissipative heat resulting from end-use, are excluded.

It is suggested to compile energy intensity by relating f) to 1) by deriving f) from the IEA data base and 1) from UNSD database. The following EXCEL file presents a mapping/correspondence of industry classifications used in the two data sources:

Correspondence ISIC4 to IEA sectors.

Annex 3: Brief analysis of SDG indicators related to air emissions

- There are a number of SDG indicators in the domain of air emissions, more specifically GHG emissions[30]. They can widely be monitored using UNFCCC inventories for greenhouse gases:
  - SDG indicator 2.4.1 GHG emissions in agriculture (per hectare of land and per unit output, separately for crop and livestock sector):
    - This indicator would be informed by the FAO database
  - SDG indicator 2.4.2 Absolute levels of emissions in relevant sectors and sub-sectors [of agriculture]:
    - Indicator is not further specified yet. As far as GHG are concerned, it would be informed by FAO database
  - SDG indicator 7.3.2 Composite energy efficiency improvement index:
    - Not further specified; seems to address carbon intensity of transport which could be easily derived from combining UNFCCC inventory and IEA energy balances which employ same breakdown of transport by mode. Linking to transport statistics seems not feasible.
  - SDG indicator 7.a.1 Carbon intensity of the energy sector:
    - Relates CO_2 emissions to energy use in energy sector. This can be derived easily by combining UNFCCC GHG inventory data with IEA energy balances which employ the same sector breakdown. The energy sector is defined in e.g. IRES, p. 73-81 in particular Table 5.1 nicely shows correspondence to ISIC.
  - SDG indicator 9.4 Carbon emission per unit value added :
    - Relates CO_2 to gross value added of not further specified industries or sectors. This data would ideally come from AEA combined with national accounts data. However, the industry breakdown of UN national accounts (which would assumingly be the resolution of AEA compiled by UNSD) is rather aggregated and can hence be mapped with UNFCCC classification of emission sources. Hence combining UN national accounts with UNFCCC could do the job.

[30] Note that emissions of other air pollutants are not mentioned in the SDG indicator list.