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Draft Guidance Note

Issue D.3: "Inclusion of accounts for physical produced assets"

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GUIDANCE NOTE Issue D.3 "Inclusion of accounts for physical produced assets"

1 Introduction

1. The United Nations Statistical Commission has endorsed the update of the SEEA 2012 Central Framework and work in underway on the update process. An initial task is establishing a clear scope for the issues that have been identified to be the focus for the update. This guidance note provides a description of **Issue D3 – Inclusion of accounts for physical produced assets** to support a common understanding of the work that will be needed to fully investigate and articulate the alternative approaches and recommendations for change or addition to the SEEA Central Framework.

1.1 Motivation for the proposed change

2. The short description of issue D3 "Inclusion of accounts for physical produced assets (in the SEEA Central Framework)" from October 2024 is:

> *A key characteristic of the SEEA is that it looks at physical stocks and flows. Yet, physical asset accounts for produced assets are not part of SEEA CF. There in an increasing interest is these kinds of stocks in view of the circular economy and analysis of waste flows (e-waste, recycling potentials, etc.). Other types of accumulations could also be examined (e.g. accumulation of durable household goods).*

3. Ensuring the sustainability of economic development requires making the most efficient use possible of scarce natural capital. Both traditional natural resources – like minerals, timber, water and fossil fuels – and ecosystems must be used carefully so that they and the goods and services they provide are available not just to the economy and society today, but also in the future. One means of reducing the demands on natural resources and ecosystems is to ensure that the materials already found within the economy are maintained in use as long as possible, thus reducing the demands on natural resource stocks for new raw materials and the associated degradation of ecosystems associated with raw material extraction and waste emissions. This idea of maximising the efficiency of material use has been around for many years and known under various names: eco-efficiency, dematerialization, circular economy and industrial ecology.

4. The current version of the SEEA-CF has considerable potential to inform ideas and policy around material efficiency. In particular, the physical flow accounts of Chapter 3 can provide detailed information on the extraction and of raw materials (what the SEEA-CF calls "natural resource inputs") as well as on the flows of associated waste products (what are called "residuals"). These flow-based measures offer the potential to estimate several indicators of material intensity (for example, material use per unit of value added) and to do so in a way that allows industries to be compared with one another but also to regard a given industry's performance over time.

5. The SEEA-CF does not, however, measure the size of material stocks in use in the economy at a given point in the form of tangible fixed assets (including consumer durables), valuables and inventories of capital goods (referred to collectively as "produced assets[1]" in what follows). Nor does it measure the size

[1] Strictly speaking, we are not using the term "produced assets" here exactly as it is used in either the SEEA-CF or SNA. The official definition of produced assets includes several categories that are considered out of scope for this guidance note, either because they are not suitable for materials recovery (weapons systems and cultivated biological resources) or because they are not tangible (intellectual property products).

of these stocks found in waste repositories (mine tailings and landfills). Information on the size of these stocks is of interest to those focused on material efficiency, as it provides an indication of how much of the economy's requirement for new raw materials might be met by "mining" the materials already available to it. Just as geologists, foresters and hydrologists explore for stocks of minerals, timber and water in nature so they know what the nature's potential to provide raw materials is, so too – the argument goes – we should "explore" the economy to determine the amounts of materials it already holds and that could, in principle, be recycled or re-used to supplant raw materials as the source of the economy's material needs.

6. The idea of mining the stock of materials already available to the economy is not fanciful. Such mining already occurs, both in the literal and figurative senses. It occurs literally in instances where extraction from landfills or mine tailings takes place for the purpose of capturing the valuable materials they contain. It occurs more figuratively when materials that would otherwise end up in landfills are diverted from disposal to be processed for material (and sometimes energy) recovery. Thus, data on the size of the stock of materials held in produced assets, mine tailings and landfills, were it available, would be of relevance to activity that is already happening in the economy and, if sustainable development is to be achieved, will need to increase in the future.

1.2 Process for developing the Guidance Note

7. To come.

1.3 Structure

8. The remainder of this Guidance Note proceeds as follows. The case for measuring physical stocks of materials in the economy is presented in more detail in Section 2, followed by descriptions of the relevant parts of the current SEEA-CF and other relevant statistical frameworks. Section 3 presents various options for inclusion of a physical stock account for materials in the revised SEEA-CF. Section 4 offers recommendations regarding the proposed treatment options, finishing with a list of questions to reviewers regarding the recommended options. Section 5 details proposed indicators, key terms and definitions, existing compilation guidance, testing options and a future research agenda.

2 Review of existing measurement and research

9. The idea of treating the economy as an ecosystem with its own "metabolism" (Frosch and Gallopoulos, 1989) has existed for decades. A key concept within industrial ecology is that of the "urban mine" (Brunner, 2011). The urban mine – or what is also called "anthropogenic resources" – comprises the stock of materials bound up in:

- produced assets (buildings, machinery, infrastructure, equipment, etc.)
- waste products residing in landfill sites or in mine tailings, and
- so-called "hibernating" products (that is, products no longer in active use by their owners use but also not formally disposed of).[2]

10. The urban mine represents a source of valuable materials that can, in principle, be captured and re-used in further economic production. The materials bound up in produced assets and hibernating stocks may

[2] An example of a hibernating waste is an obsolete cellphone residing in a drawer of its owner, unused but also not formally discarded. Other examples include unused automobiles sitting in garages, unused farm equipment sitting in fields and unused municipal water pipes sitting underground.

be captured when the items in question reach the end of life by diverting some or all the associated waste flow away from landfilling and into a material recovery process. Additionally, materials can be recovered by, literally, mining materials from the wastes previously discarded in landfill sites or mine tailings.

11. Measuring the size of the urban mine is complex and existing efforts by academic researchers have generally focused on estimating the quantities of specific products (for example, electric and electronic goods) with high economic value and potential for recycling. This research almost always focuses on metals; for example, copper (Kapur and Graedel, 2006; Spatari et al., 2005) or precious metals (Avarmaa et al., 2019).

12. Researchers typically apply one of two approaches in measuring the size of the urban mine (Koutamansis et al., 2018). The first, known as the "top-down approach" or "dynamic material flow analysis", measures the stock of a material (for example, copper) in the urban mine by considering the inflows of it to the economy as a raw material, its transformation into products of various types within the economy and the disposal of those products at the end of their lives. The accumulation of the material within the economy is simply the difference between the inflows and the outflows. Long (multiple decade) timeseries of input, transformation and disposal data are required to arrive at estimations of the current stock. The method is relatively simple to apply but is data intensive and does not yield much information about where the material physically exists within the economy (either in terms of what products it exists within or in terms of where those products are physically located).

13. In the other approach, known as the "bottom-up approach", the stock of a material residing in the economy at any point in time is derived by multiplying the quantity of the material found in different types of products (for example, the weight of copper wiring in a typical automobile or the weight of copper plumbing pipes in a typical building) by the number of such products in use in the economy at that time. This obviously requires detailed data on both the quantities of specific materials found in myriad products and on the number and characteristics (e.g., age, location, size[3]) of those products in use, making the approach particularly data and labour intensive. For this reason, it is usually applied for a limited geographic region (for example, a city). Applying it more broadly than this requires "massive" amounts of data (Aldebie and Dombi, 2021). Its benefit comes in the form of generally more accurate results that the top-down approach, as well as more detailed information on the "location" of the material in terms of the products in which it resides (e.g., the share of copper found in automobiles versus in buildings). When done for a specific geographic location (for example, a city), the approach also yields information about where those products are physically located (Van Beers and Graedel, 2007).

2.1 Existing guidance in the SNA

14. Unsurprisingly, the SNA – as a handbook devoted entirely to accounting in monetary units - offers no explicit guidance on the measurement of the urban mine, though it does provide a classification for one element of the urban mine (produced assets; see Table 13.2, p. 260) that could serve as a useful starting point for thinking about its measurement in physical terms. At the highest level, this classification includes several entries relevant to the urban mine: dwellings; other buildings and structures; transport equipment; ICT equipment; other machinery and equipment; inventories; and valuables. Each of these categories can be further disaggregated using the products defined in the *Central Product Classification*.

[3] For example, if the "product" in question was a high-rise apartment building, information regarding its date of construction, its size (number of stories or floor area) and its physical location would all be useful in determining its contribution to the materials found in the urban mine.

15. Regarding the other elements of the urban mine (landfills, mine tailings and hibernating wastes), the SNA is entirely silent. Landfills and mine tailings as such are not recognized in SNA – certainly not as potential "assets" that might be "mined" for materials. The waste management industry that manages landfills is, of course, captured by the SNA in principle, though, again, it is not explicitly discussed in the handbook. As for hibernating wastes, again there is no discussion.

2.2 Existing guidance in the SEEA-CF

16. Section 2.5.3 of the SEEA-CF, which discusses the measurement of stocks in physical terms, makes clear that the current handbook's focus is on the measurement of physical stocks of *environmental* assets only (e.g., physical stocks of timber or minerals). No mention is made of the measurement of stocks of *produced* assets in physical terms. Nor does the handbook discuss measurement of the stocks of materials stored in landfill sites, mine tailings or hibernating stocks. Thus, the current version of the SEEA-CF has nothing direct to offer in terms of measuring the stocks associated with the urban mine. However, this does not mean the current handbook is irrelevant in this regard. Indeed, it has – in principle – much to offer, all of which comes in its guidance related to physical flow accounts (Chapter 3).

17. The general framework of the SEEA-CF physical flow accounts (see Table 3.1, p. 41) lays out an accounting system that tracks all flows necessary to compile physical measures of produced assets, though it stops short of cumulating those flows into stock estimates. The framework tracks the entry of raw materials into the economy in the form of natural inputs (like minerals, water, timber, fossil fuels, etc) and in the form of products (including wastes) imported from abroad. It also tracks the use of these materials in the economy, including their accumulation through gross fixed capital formation and inventory formation (Cell G of the use portion of Table 3.1) and through household final consumption[4] (Cell H of the use portion of Table 3.1). In principle, all that is required to create a physical account of produced assets would be to cumulate these flows (net of their deaccumulation, which is measured in cell K1 of the supply portion of Table 3.1 for fixed assets and in cell J of the supply portion for household goods) over time starting from a base year.

18. While the physical flow accounting framework of the existing SEEA-CF lends itself well, in principle, to the compilation of physical accounts for produced assets, in practice, three issues must be addressed. First, it is clear from the discussion above that researchers in industrial ecology are mainly interested, for now, at least, in the urban mine as a source of metals and metallic materials, as these are readily recyclable and valuable. (It is worth noting, though, that a recent study for the Netherlands [van der Voet et al., 2025] has expanded this focus to include textiles, glass, plastics, wood, concrete and others). Meeting the need for data just for metals, like copper, iron or aluminum, makes the statistical challenge easier, as there is no need to compile comprehensive, data-intensive physical flow accounts of all materials. The SEEA-CF already addresses the compilation of material-specific physical flow accounts in Section 3.6.2. The handbook uses toxic materials (mercury) and plant nutrients (phosphorous, nitrogen and potassium) as illustrative examples of the accounting for specific materials, but the accounts could be compiled for any kind of product, including the metals that appear to be of particular interest from an urban mining perspective.

19. The second issue to be addressed is that the cumulation of a given material flow (say copper metal) into a physical stock requires, of course, an estimate of the physical stock of copper metal bound up in produced assets in some base year. The SEEA-CF has nothing to offer in this regard since it is focussed purely on

[4] Recall that consumer durables and valuables, the purchase of both of which is considered household final consumption in the SNA and SEEA-CF, are part of what we are defining here as produced assets.

flows in relation to such materials. However, such an estimate, while not trivial, could be complied using the kinds of methods industrial ecologists use to measure the urban mine described above. This is discussed further below in the section on conceptual options and treatments.

20. The third issue is that data on the urban mine are most useful when they are spatially explicit (Rauch, 2009; Zhu, 2014). Knowing simply how much metallic copper, for example, exists in the total urban mine of a country is not especially useful, since companies involved in recovering and reusing copper need to know where to set up their operations (Van Beers and Graedel, 2007). This implies the need for data at the sub-sub-regional level (ideally, for specific cities). Whether data would be needed for all sub-sub-regions in a given country is an open question. Urban mines must be large enough to serve as reliable and significant sources of materials for companies to take advantage of economies of scale. Brunner (2011) suggests that cities must have "several million" inhabitants for such economies of scale to emerge. This would mean that compiling data on the urban mine for smaller cities may be a waste of statistical resources.

21. The SEEA-CF does not address the issue of compiling physical flow accounts for sub-national regions, but there is nothing conceptually to stop this. (Note that the question of the spatial scope of the revised SEEA-CF is taken up in Guidance Note A4). However, questions of data available and data confidentiality come into play, as national statistical systems are often challenged to provide statistics at this level of spatial disaggregation. The emergence of city-level estimates of GDP (for example, those from Statistics Canada) demonstrates that producing such spatially detailed data as part of official statistics is possible. But it is still far from common or simple.

22. Though the motivation for this Guidance Note was the possibility of adding physical stock accounts specifically for *produced assets* to the upcoming SEEA, we have already noted that the demand for data on the urban mine goes beyond this to also include wastes in landfills, mine tailings and hibernating goods. Indeed, data on the quantities of materials bound up in produced assets may be of *least interest* to potential users. Produced assets are a relatively inaccessible element of the urban mine for the simple reason that, until they are discarded, they are in use by households or businesses to conduct their affairs. A residential building may well be a valuable source of metallic copper, iron, lead, or zinc (not to mention other materials) but getting to these materials must wait until the building is demolished or until significant renovations take place (Koutamanis et al., 2018). Thus, industrial ecologists emphasize wastes (what the SEEA-CF calls "residuals") as being the more accessible source of materials in the urban mine. Of course, the size of waste stocks and flows is a function in part of the size of the stock of produced assets from which they are, in large part[5], derived. So, even if waste flows are of most direct interest to those focused on the urban mine, it may also be relevant to them to know how large the stock is that is their source. For all these reasons, the Guidance Note goes beyond the original motivation and discusses options for including physical stock accounts for the entire urban mine (produced assets, landfills, mine tailings and hibernating wastes) in the revised SEEA-CF.

23. Wastes are seen to be of three types by industrial ecologists. One is the wastes discarded in the current period that can be diverted from disposal and go directly to material recovery processes. The second is the wastes discarded in previous periods and now stored in landfill sites or mine tailings. The third is the so-called hibernating wastes mentioned earlier. The SEEA-CF has much to offer in regard to the first, potentially something to offer for the second, and nothing to offer for the third.

[5] We say "in large part" because, of course, not all waste stocks or flows have their origin in produced asset stocks. A great deal of waste flows originate simply from the consumption of non-durable goods like food and fuel.

24. Regarding the first of the three waste types (wastes diverted from disposal), the SEEA-CF is directly relevant. Section 3.6.5 of the handbook (more specifically, Table 3.9 on p. 90) deals with the physical flow account for solid wastes. The solid waste account comprises a physical supply table for solid wastes and a corresponding physical use table. It includes entries that are directly related to measuring flows of current wastes and their diversion to material recovery. These entries measure the generation of solid wastes by households and businesses and the subsequent use of these wastes for recycling or as recycled inputs into other industries (as well as the amounts that end up in landfill sites, incineration and export for international processing). The solid waste accounts distinguish between "solid waste residuals" and "solid waste products". The former are solid wastes that are discarded by their owner without any kind of remuneration; for example, a household putting waste beverage bottles into a recycling bin. The latter are wastes for which there is remuneration to the owner as the result of a financial transaction with a third party that sees economic value in the waste materials and is, therefore, willing to pay to purchase them (for example, scrap metal sold to a metal recycler). Such wastes are called "products" rather than "residuals" because they are said to remain within the economy. Both types of solid wastes are relevant to measuring the urban mine. Note that the SEEA-CF solid waste account and its possible revisions in the updated manual are the topic of more detailed discussions in Guidance Note B7.

25. Noting that no standard international classification of solid waste exists, the solid waste account uses an indicative list of solid wastes that includes entries for "metallic waste", "non-metallic recyclables", "discarded equipment and vehicles" and "mixed residential and commercial wastes", all of which would include materials of interest for urban mining. Further disaggregation of the list would be necessary for data from a SEEA-CF solid waste account to be of direct value to those interested in urban mining; for example, metallic waste would have to be detailed in terms of specific metals.

26. Regarding the second waste type of interest to industrial ecologists (waste stored in landfills or mine tailings), the solid waste account has the potential to provide useful information, though changes would be required to make this possible. First, the solid waste account does not include an explicit entry for the accumulation of waste in either landfills or mine tailings despite the fact that the SEEA's general conceptual presentation of physical flow accounts in Table 3.1 (p. 41) does so (see cell O in Table 3.1).[6] This inconsistency would have to be addressed in the revised SEEA-CF. Second, the annual flows of wastes into landfill sites and mine tailings would have to be cumulated over time to measure the stock of materials stored in those reservoirs. Similar to the observation above regarding physical estimates of produced assets, this would require an initial estimate of the materials held in landfill sites and mine tailings in some base year. These points are addressed further below in the section on conceptual options and treatments.

27. Regarding hibernating wastes, the SEEA-CF currently has nothing to offer. Any such wastes would be assumed to either remain part of the accumulated materials bound up in produced assets or in household goods. There is no reason why they could not be disaggregated in the entries on wastes generated by industries and households, however. This point is also addressed below in the section on conceptual options and treatments.

[6] Whether the SEEA-CF currently includes mine tailings is debatable. Cell O in Table 3.1 refers only to "accumulation of waste in controlled landfill sites". A strict interpretation of this could mean that mine tailings are excluded, since the term "landfill" is most commonly used in reference to sites where household and light industrial/commercial wastes are deposited. A broader interpretation could be used however that would refer to any area where wastes or any sort are deposited for long-term management by any economic sector. This would include mine tailings so long as they are controlled in the long term through active management of the materials they contain and any leakage from them.

28. In addition to the solid waste account, the SEEA-CF includes an economy-wide material flow account (Section 3.6.6) that is of potential relevance to urban mine data. As the name implies, economy-wide material flow accounts do not focus on the details of individual material flows but on aggregate flows of all materials combined. As such, their relevance to the urban mine is limited. At best, they would provide an upper limit on the weight of materials that might plausibly be available to be mined.

29. Given the above, the physical flow accounts of the current SEEA-CF have considerable potential to provide data relevant to the urban mine. The extent to which they do is a function of the detail with which they are compiled. At one end of this spectrum lies the economy-wide material flow accounts, which are of limited relevance due to their highly aggregated nature. At the other end would be the kind of product-specific flow accounts the SEEA-CF mentions for mercury and nutrients. These have the potential to be directly relevant to informing the urban mine. In between, there lies quite a wide scope of potential accounts that might be of greater or lesser relevance depending on their contents.

30. It is not known how many countries compile the sort of product-specific physical flow accounts that are directly relevant to the urban mine. What is known, however, is that material flow accounts of some kind (not including economy-wide material flow accounts) were compiled by just 26 of 94 countries that reported compiling SEEA-CF-based accounts of any kind in 2024 (UN, 2024). Another 41 reported compiling economy-wide material flow accounts[7] and 20 reported compiling solid waste accounts.

31. As a final word on existing guidance in the SEEA-CF, it should be noted that the possibility of including a physical stock account for materials in the revised SEEA-CF raises a broader set of issues around the need for conceptual and methodological integration between material stock and flow accounting in the revised handbook. The existing handbook does not address this issue (for the simple reason that it does not deal with stock accounts for materials but only flow accounts) and there are obvious areas where additional material would be required in the revised handbook; as just one example, in the sequence of accounts, it would be necessary to show how the stock and flow accounts relate to one another such as that opening and closing stocks of materials in an accounting period could be derived by accounting for intra-period flows.

2.3 Links to other statistical frameworks

32. The United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC; UNECE, 2019) is the official statistical classification of fossil fuel and mineral reserves. It is used in the SEEA-CF as the basis for the identification of the reserves that are measured in the environmental asset accounts for mineral and energy resources (Section 5.5). In 2025, the UNFC was expanded to include additional specifications for the classification of resources coming from anthropogenic sources. Though the UNFC anthropogenic resource specifications are new and, therefore, have not likely been tested in many applications, their development involved carrying out of several case studies that provide evidence of their utility (for example, Winterstetter et al. [2018] and Huber & Fellner [2018]). The UN Economic Commission for Europe (UNECE, 2022) has also published guidance on the application of the (then still draft) anthropogenic resource specifications in Europe. If the decision is made to include accounts for anthropogenic resources (i.e., the urban mine) in the revised SEEA-CF, these new UNFC specifications would seem to be the appropriate choice for the classification of resources.

[7] The relatively large number of countries compiling economy-wide material flow accounts is explained, in part, by the requirement from Eurostat that all EU member states compile such accounts. Of the 41 countries reporting them, the vast majority were EU members.

3 Conceptual options and treatments

33. Below we discuss options for adding a physical stock account for materials (produced assets, landfills, mine tailings and hibernating wastes) to the revised SEEA-CF. Such an account could be added in the chapter on asset accounts but also in the chapter on physical flow accounts. We discuss options for this account along three dimensions: 1) the scope of materials to be included in the accounts; 2) the reservoirs (that is, the "places" where materials are bound up) to be included in the accounts; and 3) the geographic scope of the accounts.

3.1 Scope of materials to be included

34. As already noted, the majority of research related to the urban mine focuses on metals and related materials (Pauliuk et al.,2013; Song et al., 2020; Ciacci et al., 2017; Dong et al.,2020; Lifset et al., 2002; Kapur and Graedel, 2006) This is likely because metals are valuable, readily recycled, limited in number and relatively easily tracked through the economy. Some studies (for example, van der Voet, 2025) consider broader ranges of materials, including glass, plastics, ceramics, wood, concrete, asphalt, bricks, gypsum and insulation materials, but these are in the minority. This leads to proposals for three options regarding the scope of materials:

    - **Option 1a** – Include physical stock accounts only for metals and metallic products in the revised SEEA-CF.
    - **Option 1b** – Include physical accounts for a broad suite of materials, including metals and metallic products, glass, plastics, ceramics, wood, concrete, asphalt, bricks, gypsum and insulation materials and so on.
    - **Option 1c** – Include physical accounts for all materials.

3.2 Scope of material reservoirs to be included

35. In the context of the urban mine, a "reservoir" is physical feature (a product, an asset, a site) where materials accumulate and are bound up for some period of time, perhaps forever. Two broad reservoir categories are considered by urban ecologists: produced assets (buildings, infrastructure, machinery, equipment, etc.) and waste stockpiles (mine tailings, landfills and hibernating goods). Again, this leads to two options.

3.2.1 Option 2a – Add a physical stock account for produced assets only

36. Option 1 would be to add an account to the revised SEEA, probably in the chapter on asset accounts but possibly in the chapter on physical flow accounts, measuring the stock (weight) of materials bound up in produced assets, which we have earlier defined to include dwellings and other buildings/structures, machinery and equipment, inventories and valuables, whether they be owned by businesses or households. Such an account would provide those interested in the urban mine with an indication of how large the stock of materials is in currently in-use produced assets, how much that stock is increasing by each year and how much it is decreasing by. But it would not inform them on the amounts of materials available in stocks of already-discarded materials found in landfills and mine tailings and in hibernating wastes.

37. As discussed in the previous section, conceptually, a physical stock account for produced assets could be constructed by cumulating the flows of materials recorded in cells F and G of the general SEEA supply and

use table (Table 3.1, p. 41). In practice, the first issue would be to decide on the scope of materials measured (that is, to choose among Options 1a, 1b and 1c above). Industrial ecologists researching the urban mine appear to have no interest in an account that, literally, attempts to measure the weight of every produced asset in the economy (Option 1c). Such an account would be all but impossible to compile in any case (it in included here as an option mainly because it does, in theory, represent the logical starting point for compiling physical stock accounts for materials). In practice, however, users are likely most interested in an account that would measure the weights of specific materials bound up in specific assets; for example, the account measuring the weight of all copper metal contained in transportation equipment. A crude example of what such an account might look like (focused on metals only) is shown in Table 1; this would correspond to Option 1a above. A similar table could be constructed using a broader range of materials that would correspond to Option 1b.

Table 1 - Crude physical stock account for metals in fixed assets, as of December 31, 20XX

Material	Reservoir				
	Buildings and dwellings	Other structures	Transport equipment	ICT equipment	Other machinery and equipment
Copper and alloys					
Iron and alloys					
Aluminum and alloys					
Zinc and alloys					
Nickel and alloys					
Precious metals					
Rare earths					
Etc.					

38. As noted in the previous section, compilation of an account such as that in Table 1 first requires an estimate of each of the stocks for some base year. In years following the base year, the account would simply be kept up to date by tracking additions to the stock from new produced asset acquisitions and deduction due to the retirement of assets. Two approaches to measuring the base-year stock and the annual flows used by industrial ecologists were mentioned previously: a bottom-up and a top-down approach. The former was noted to be very data intensive when applied at broad geographic scale such as a nation, which leaves the top-down approach – or dynamic material flow analysis – as the most likely possibility for use in the revised SEEA-CF.

39. As noted, material flow analysis (MFA) already features in the SEEA-CF, where it is applied in a specialized form to compile the economy-wide material flow accounts (EW-MFA). The EW-MFA were noted to be of limited relevance to measuring the urban mine because they yield estimates that aggregate all materials together. But this limitation is not inherent to the method itself, just to the specific way in which it is used

in the handbook. The method can, in fact, be used to track stocks and flows of individual materials (like copper). When it is used in that way, it is often referred to as substance flow analysis (SFA).

40. There is a large existing literature on SFA and the approach has been used successfully by researchers to measure the urban mine. Spatari et al. (2005) used it, for example, to measure copper stocks and flows in North America. The approach is data intensive (but not so much as the bottom-up approach), requiring long timeseries on raw material use, production, imports, exports and waste flows. Such timeseries are, of course, just the kind of data that reside within the national statistical system (sometimes in the form of confidential statistics that only those working within the system have access to). Thus, the approach would seem well suited to use by those compiling SEEA-CF accounts.

3.2.2 Option 2b – Add a physical stock account for the entire urban mine

41. Option 2 builds on Option 1 by including in the physical stock account the materials bound up in discarded materials laying in landfills, mine tailings and in so-called hibernating wastes. A crude example is shown in Table 2, again with a focus on metals only (corresponding to Option 1a). As above, a version of Table 2 could be constructed using a broader range of materials that would correspond to Option 1b.

42. As with the accounting for the materials bound up in produced assets, the flows related to mine tailings and landfills are already detailed in the SEEA-CF general physical supply and use tables. Flows to landfills are explicitly recorded in cell O of the table and flows to mine tailings are part of the broader set of flows of wastes recorded in cell N (wastes collected and treated by industries). There is not, however, anywhere in the existing SEEA where flows of hibernating wastes are recorded, so this would have to be added.

43. As in the case of materials bound up in produced assets, accounting for the materials bound up in mine tailings, landfills and hibernating wastes requires a base-year estimate of the related stocks. The prospects of preparing such an estimate for mine tailings and landfills seem reasonably good, as the same approach discussed above for produced assets (SFA) can also be to prepare base-year estimates for mine tailings and landfills (Spatari et al, 2005). The approach does not lend itself, however, to preparing an estimate of hibernating wastes, which are challenging to measure (Kapur & Graedel, 2006). A recent study for the Netherlands (van der Voet et al., 2025) yielded estimates only some hibernating wastes (underground pipes and cables, monopiles, sewage pipes, and abandoned railways). The authors were unable to measure hibernating stocks in households and businesses, where valuable metals reside in hibernating electric and electronic products. Estimation of these quantities requires detail surveys and research and can only be done for small areas (Chan, 2004). The quantities in question appear to be small in comparison with other reservoirs however (Aldebei & Dombi, 2021; van der Voet et al, 2025), so it may not be worth the statistical resources to measure them.

Table 2 - Crude physical stock account for metals in fixed assets, as of December 31, 20XX

Material	Reservoir							
	Fixed assets					Discarded wastes		
	Buildings and dwellings	Other structures	Transport equipment	ICT equipment	Other machinery and equipment	Landfills	Mine tailings	Hibernating
Copper and alloys								
Iron and alloys								

Aluminum and alloys								
Zinc and alloys								
Nickel and alloys								
Precious metals								
Rare earths								
Etc.								

3.3 Geographic scope to be included

44. Though many urban mine studies are conducted at the level of countries – mainly due to the difficulty of compiling estimates for smaller geographic areas – researchers note that sub-national estimates make the data more useful to companies interested in exploiting the materials. This is simply because, as with conventional natural resources, materials in the urban mine cannot be exploited if their physical location is not known first. This leads to two options regarding geographic scope.

3.3.1 Option 3a – Compile the physical stock account only at the national or broad regional (province, state, etc.) level

45. The first option is to prepare the physical stock account for materials for the nation as a whole or, at most, the first sub-national level (province, state, etc.). This approach would align well with the use of SFA to compile the account, as SFA requires data (e.g., production, imports, exports) that are general available only at high levels of geographic aggregation. The approach may not yield data of interest to specific companies engaged in exploiting the urban mine (as they would require data at finer geographic resolution), but would – at least – inform the industry as a whole of the potential size of the mine.

3.3.2 Option 3b - Compile the physical stock account only for large cities

46. The second option is to prepare the physical stock account for materials only for large cities, on the grounds that the urban mine is only of practical value where materials are geographically concentrated in large enough quantities to justify their exploitation. As Brunner (2011) notes, economies-of-scale are needed to make urban mining practical and cities are where such economies emerge. This would mean that compiling data on the urban mine for areas other than large cities may be a waste of statistical resources.

47. Compilation of urban mine data for large cities does not align well with the SFA approach (as many of the required data will not be available for cities). This means that this option would require use of the so-called bottom-up approach in which detailed data on material reservoirs and their concentrations of materials are used (for example, number of buildings of type X in a city multiplied by the typical copper content of such buildings). As noted, this would make the approach extremely data intensive and, moreover, not particularly well suited to use with a statistical office where such data are rarely found.

48. Option 3b would not align with the general principle of the SNA and the SEEA-CF that the nation-state is the basic geographic starting point for the compilation of both economic and environmental-economic accounts.

4 Recommendations on conceptual treatments

49. To come following discussion with Technical Committee members

- Propose recommendations to address the issue (based on the options described under section 3). As appropriate, note connections and potential implications for other issues being considered in the update process.
- Note that final recommendations on conceptual treatments will not be determined until after the Global Consultation process so the development of content in this section is likely to be more in the form of proposals for consideration, but this will vary from issue to issue.
- List the sections/paragraphs of the SEEA CF that need to change or where additional content is required
- Where possible and appropriate provide proposed text for inclusion in the revised SEEA CF (This content is not required for the initial drafts and, depending on the issue, it may not be possible to propose text ahead of Global Consultation, i.e. until there is more clarity on the option to be incorporated.)

5 Other considerations in advancing the issue

50. To come following discussion with Technical Committee members

- If relevant, propose **indicators** (and their derivation methods) that could be derived for this issue to support reporting and analysis
- Document **key terms and definitions** for inclusion in the SEEA CF Glossary
- Describe the existing **compilation guidance** and document what additional compilation guidance might need to be updated or developed (do **not** provide the guidance itself, that is not for inclusion in the SEEA CF)
- If relevant, describe **options for testing** the possible approaches. For some issues – e.g. for pressure accounts and sustainable finance, where the development of data and methods is less advanced, it may be useful for some countries to investigate and test the options proposed in section 3 to support determining the appropriate recommendations.
- Document any issues that remain unresolved as a result of the investigation or issues that have emerged as a result of the work that should be placed on the **research agenda** of the SEEA and potentially in relation to other statistical standards (e.g. SNA, BPM, etc.)
- For issues that are also being considered in the **GFS and COFOG revision processes**, describe the connections and potential differences in proposed treatments

6 References

51. To come