The recording of losses in the SEEA Central Framework

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A. Background

1. Recording losses can provide important information to understand the efficiency of production processes since reducing losses at the various stages of production can significantly improve the overall output from a given process. The System of Environmental and Economic Accounting (SEEA) completed in 2003 (SEEA-2003) did not systematically address the recording of losses. Thus, in the revision of SEEA it was recommended that work focus on developing a consistent recording of losses in both physical and monetary terms.

2. The treatment and recording of losses in physical supply and use tables has been a particularly challenging issue for environmental-economic accountants. There have been many approaches to the recording of losses and the approaches have often varied depending on the perceived analytical requirements and the physical flow being measured – primarily water or energy.

3. This paper builds on the experiences in drafting and discussing the accounting treatment of losses through the revision of the SEEA that culminated in the adoption of the SEEA 2012 Central Framework. In particular, at the very end of the process of finalising the SEEA Central Framework for publication, it became apparent that the recording of losses that had been shown in the SEEA Central Framework white cover version for the physical supply and use table (PSUT) for energy was different from the recording of losses in the PSUT for water. The final decision was to amend the recording of losses in the PSUT for water but to leave the energy PSUT unchanged. In addition, the various sections of text were left unchanged because, while the text was perhaps less than fully explanatory, as a matter of fact, the text was not incorrect.

4. This outcome highlights the challenges in this space since different accountants can interpret the same text in quite different ways. With this context in mind, the paper hopes to bridge the gap in understanding of this issue which, from the perspective of the author, is largely due to a lack of full articulation of the relevant flows before derivation of indicators and varying use of terms.

B. Findings from the SEEA revision process

5. The recording of losses was Issue #17 of the SEEA revision list of issues. The summary of the outcome of that discussion is shown in Annex I. In all, four recommendations were accepted prior to drafting. There is no contention on the issues of the location of the production boundary, the different types of losses or the treatment in the SNA. Problems have arisen however in the interpretation and recording of the “netting” of losses from measures of output and intermediate consumption. This is the area of focus in this paper.

6. As noted in the issue description, the intention through the SEEA revision process was to determine a single generic treatment of losses applicable for all PSUT, particularly water and energy.

7. The difficulty in explaining the recording of losses lies in the framing of the various flows that are relevant in their calculation. The typical approach to the treatment of losses is to consider the four major types of losses being losses during extraction, losses during distribution, losses during storage, and losses during transformation. Since the PSUT framework encompasses all of the flows from the environment to the economy, within the economy and from the economy to the environment, there is not an issue as to whether the losses should be recorded within the PSUT. It is thus a question of where losses should be recorded in the PSUT.

8. In hindsight, a key driver of the varying recording of losses seems to have arisen from alternative structures of PSUT that have been developed. A number of PSUT designs did not incorporate strict definitions of total supply and total use or enforce a balance between these two entries. (For example in SEEA Water, the entry for water consumption represents the balancing entry between supply and use – see SEEA Water Table 3.1, p 47). Further, there was not necessarily a clear articulation or balancing of flows between the environment and the economy. In effect various PSUTs were designed with the particular characteristics of water, energy or other materials in mind.

9. A related issue was the lack of clarity on the definition of own-use and the production boundary such that consistent distinctions can be made between natural inputs, products and residuals. This in turn reflected a sometimes stylised view of the chain of flows that might be relevant in a PSUT and the appropriate treatment of losses was often discussed in the context of a common or assumed set of flows rather than using a principles based approach.

10. Since it is accepted that there are a number of different types of losses that occur at different stages of the extraction, production and consumption process, another risk has been that different recordings might be applied for different types of losses.

11. It is in this context that a generalised recording of losses needs to be considered. In the following it is accepted that there are five main types of losses, noting that losses due to theft are different since, in physical terms, these losses do not represent returns to the environment.

C. A generalised treatment of losses

12. To explain a consistent recording of losses (excluding theft) it is necessary to apply the general accounting principle that when a transaction between economic units takes place, the physical flow recorded as flowing from one economic unit must equal the physical flow recorded as being received by the other economic

unit. Thus, in physical terms the quantity supplied must equal the quantity received. Any loss of material or energy following its initial receipt by an economic unit should not change these entries recorded at the time of the transaction.

13. The general accounting identity that is in operation here is the supply-use identity. In general, quantities supplied will represent measures of output while quantities received will be measures of intermediate consumption or household consumption. There are a number of additional possibilities (for example flows of imports and exports) but output and consumption are the main entries and are sufficient to explain the basic recording.

14. Given that physical losses take place in the extraction, production and consumption process, it is generally not the case that the quantity received by an economic unit (for example of energy or water) will be equal to the amount that they subsequently transact or supply to other economic units. Thus, for example, the amount of energy received by an electricity producer in the form of coal will be greater than the amount of energy in the form of electricity subsequently supplied to final consumers. It is the recording and attribution of this difference between "what comes in" and "what goes out" that has been the area of contention.

D. Recording of losses by type of loss

15. To explain the recording in more depth it is useful to consider the entries by type of loss.

16. *Losses during extraction* are losses that occur at the time of extraction of mineral and energy resources prior to any further processing, treatment or transportation of the extracted mineral and energy resource. Such losses include, for example, flaring and venting of natural gas during extraction.[1] Losses during extraction are attributed to the economic unit undertaking the extraction. The gross amount extracted (i.e. including the losses) is shown as flowing from the environment to the extracting unit (as the supply and use of natural inputs). The losses during extraction are recorded as a part of natural resource residuals. They are part of the supply of residuals by the extracting industry and are "used" by the environment. Assuming no other losses (or natural resource residuals) are attributable to the extracting industry, the output of products supplied to other economic units by the extracting industry will be equal to the gross extraction less the losses during extraction.

17. *Losses during distribution or transmission* are losses that occur between a point of extraction or supply, and a point of use (for either intermediate consumption

[1] Some natural gas may also be re-injected into the deposit in order to increase the pressure and facilitate further extraction. However, reinjections are not treated as losses since the re-injected gas could be extracted in a later period.

or household consumption). These losses may be caused by a number of factors, including evaporation and leakage of liquid fuels, leaks of water from pipes and channels, loss of heat during transportation of steam, and losses during gas distribution, electricity transmission and pipeline transport.

18. Losses during distribution/transmission are attributed to the economic unit supplying the energy product on the assumption that the ownership of the energy product only changes at the point the energy is received by the user. Following the general recording principle, the output of the supplying unit should exclude losses during distribution/transmission and should equal the quantity recorded by the other economic unit (business or household) as consumption.

19. *Losses during transformation/conversion* are relevant in energy accounts and refer to the energy lost, for example, residual heat, during the transformation from one energy product to another. It occurs, for instance, when coal is transformed into electricity. Such losses are linked to the difference between intermediate consumption of one energy product (e.g. coal) and outputs of a different energy product (e.g. electricity) within a single economic unit. Losses during transformation/conversion are attributed to the economic unit undertaking the transformation or conversion. The estimate of the intermediate consumption of the energy product that is to be transformed is not affected. Rather, following the general recording principle, the output of the transformed energy products is reduced (equal to the amount distributed (assuming no other losses)) and a corresponding entry for the supply of energy residuals by the transforming unit is recorded.

20. *Losses during storage* are losses of products held as inventories. They may be caused by evaporation,[2] leakages, wastage or accidental damage. Losses during storage are attributed to the economic unit storing the products. The key to understanding the recording of these losses is to recognise that the output or consumption of products that are in storage has been recorded in a previous accounting period. Consequently, changes in inventories in the current accounting period do not directly affect the measures of output or consumption in the current period for the business or household that is holding the inventories.

21. To use a simple example. If a business produces 100 tons of steel in period one but does not sell the steel then output in period one is recorded as 100 tons and there is an increase in inventories in period one of 100 tons. If the steel is subsequently sold in period two there is no change in output for the business but a decrease in inventories. Similarly, if the steel were to be lost from storage in period two the measure of output from period one is unaffected.

[2] Note that water stored in man-made reservoirs is not considered a product and hence losses from reservoirs are not recorded as losses during storage. There may be analytical interest in attributing these changes in water resources to an economic unit but this requires melding information from the PSUT with information from the asset account and the flows should not be reconciled within one standard PSUT.

22. While not affecting past measures of output or consumption, losses during storage can still be attributed to businesses or households as required for analytical purposes. Note that, all else being equal, losses during storage of finished goods ready for distribution will mean that sales of products will be lower than would otherwise have been the case. However, for accounting purposes it is not appropriate to record the sales that may have occurred. It is sufficient to record the initial production and the subsequent changes in inventories.

23. Where a business is holding inventories for future use in production or a household holds products previously purchased, the recorded consumption is equal to the quantity of product initially purchased. Subsequent losses during storage of quantities already purchased do not reduce measures of consumption.

24. At times these treatments may appear counter-intuitive. For example, it seems inappropriate to record consumption of products which never get actually used because they are lost during storage. The challenge here is to distinguish the appropriate recording within accounting structures that observe the supply-use and input-output identities from the organisation of information to answer various analytical questions. For the accounting treatments to be generalised and consistently applied it is important that the organisation of data for analytical purposes be clearly separated from the recording of basic information. Commonly, it is the failure to distinguish these two steps that leads to inconsistent recording of losses.

25. *Losses due to theft.* From the perspective of suppliers of products, the amounts of electricity, other energy products, water and other products that are illegally diverted from distribution networks or from storage may be considered losses due to theft. However, since in physical terms, the energy, water and other products are not lost to the economy (i.e. the energy is still consumed by economic units) they are not considered losses in the SEEA. Nonetheless there may be interest in compiling data concerning theft as a subset of overall use of energy, water or other products. In practice, losses due to theft may be difficult to identify in and may often be included in losses in distribution. It should be recognised that this recording is conceptually incorrect as it has the effect of underestimating both the output and consumption of products in physical terms.

5. Examples of the recording of losses for water and energy

26. To reinforce the conceptual treatment outlined in the previous sections, this section steps through the recording of losses using selected (and altered) entries from the PSUTs for water and energy in the SEEA CF.[3]

Recording losses for water

27. In the example shown in Table 1 the water collection, treatment and supply industry (including own-account abstraction by households) abstracts 439.4m3 of water from the environment. 378.2m3 are distributed to other economic units (including households), 3.1m3 are used by the industry for its own purposes (e.g. cleaning pipes) and 10.8m3 reflect the own-use by households. Assuming all flows are abstracted from surface water and all return flows are direct to surface water, the following entries in a water PSUT are appropriate.

Table 1: Selected entries for a water PSUT (cubic metres)

Supply table	Water supply industry	Other economic units	Households	Environment	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)
(I) Sources of abstracted water				439.4	439.4
(II) Abstracted water					
Distributed water	378.2				378.2
Own-use	13.9				13.9
(IV) Return flows					
Losses during distribution	47.3				47.3
Other return flows	3.1	138.7	250.3		392.1
Use table	Water supply industry	Other economic units	Household final consumption	Environment	TOTAL
(I) Sources of abstracted water	439.4				439.4
(II) Abstracted water					
Distributed water	0	138.7	239.5		378.2
Own-use	3.1		10.8		13.9
(IV) Return flows				439.4	439.4

28. The recording shown in Table 1 permits the derivation of a range of indicators since it is clear how much water has been extracted by the water industry (in

[3] Note that for water the following entries are somewhat different from the entries that are presented in the SEEA Central Framework - White cover edition. Since the release of the white cover the recording of losses in the water PSUT has been aligned with the recording of losses in the energy PSUT.

column (2) of the use table) and the associated losses (in column (2) of the supply table).

29. In other PSUT structures the total quantity of water abstracted from the environment may not be clearly attributed to an industry and the two rows labelled "(I) Sources of abstracted water" may be removed. When this occurs one method of reflecting the total quantity of water abstracted is to increase the entry for own use of water by the water supply industry by an amount equal to the quantity of losses in distribution. While this approach allows the derivation of appropriate indicators it requires a recording of own-use that is not consistent with the underlying concept of own-use and ignores the general recording principle that the output of the industry should equal the amount received by other economic units.

30. While the recording in Table 1 may, at one level, seem to require too many entries, it does provide a clear and consistent conceptual treatment of all relevant flows and consequently allows the transparent derivation of relevant indicators.

Recording losses for energy

31. Table 2 shows entries for an energy PSUT and includes entries for various types of losses. The structure of the table follows the structure of the energy PSUT presented in Chapter 3 of the SEEA Central Framework.

32. In this example natural gas is extracted by the mining industry and converted to electricity. The electricity is then distributed to other economic units including other industries and households. Three types of losses are included in the example, losses during extraction, losses during transformation and losses during distribution.

33. In line with the discussion above the losses during extraction (45j) are attributed to the mining industry, derived as the difference between the amount extracted from the environment (1161j) and the amount sold to the electricity industry (1116j). Note that the 1116j is shown as both the output of the mining industry and the intermediate consumption of the electricity industry in line with the general recording principle described earlier.

Table 2: Selected entries for an energy PSUT (joules)

Supply table	Mining industry	Electricity industry	Other economic units	Households	Environment	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Energy from natural inputs						
Natural gas					1161	1161
Energy products						
Natural gas	1116					1116
Electricity		598				598
Energy residuals						
Losses during extraction	45					45
Losses during transformation		418				418
Losses during distribution		100				100
Other energy residuals			402	196		598
						1161
Use table	Mining industry	Electricity industry	Other economic units	Household final consumption	Environment	TOTAL
Energy from natural inputs						
Natural gas	1161					1161
Energy products						
Transformation of energy products						
Natural gas		1116				1116
End-use of energy products						
Electricity			402	196		598
Energy residuals						
Losses during extraction					45	45
Losses during transformation					418	418
Losses during distribution					100	100
Other energy residuals					598	598
					1161	1161

34. Losses in transformation and losses during distribution are both attributed to the electricity industry on the basis that the electricity remains in the "ownership" of the electricity industry until such time as it is actually used by an end-user (industry or household). The output of the electricity industry and hence, the consumption (intermediate and final) of other industries and households are equal to 598j.

35. To ensure a balance in the PSUT, other energy residuals, in this case residual heat from the use of electricity, are shown as supplied by other industries and households. In the final section of the use table all losses and the other energy residuals are recorded as returning to the environment. Thus, the total energy into the system during the accounting period (1161j) is equal to the total energy out of the system during the accounting period (1161j).

36. It is important to recognise that there are a number of stages in the production and distribution process and the recording of losses and the explanation of the recording needs to take each stage into consideration.

Recording losses during storage

37. The final type of loss is losses during storage. Its recording is somewhat more confusing as it involves entries associated with inventories which are traditionally less intuitive than standard entries for production and consumption. To explain the appropriate recording the energy PSUT example above has been augmented in Table 4 below to show a situation in which the mining industry uses inventories of natural gas held in reserve at the beginning of the accounting period. The information on the inventories of natural gas is shown in Table 3.

Table 3: Inventories of natural gas held by the mining industry (joules)

	Beginning of year	**Additions to inventories**	**Reductions in inventories**		**End of year**
			Sales to Electricity industry	Losses during storage	
Natural gas inventories	500	1116	1166	50	400

38. Table 3 shows that over the year there was a total change in inventories of -100j. The additions to inventories are equivalent to the gross extractions less losses during extraction as recorded in Table 2. The reductions are a combination of (i) losses during storage (50j) and (ii) sales to the electricity industry (1166j). Note that the sales to the electricity industry are higher in this situation due to the use, by the mining industry, of natural gas from its inventories in addition to production in the current year. The effect of using the natural gas from inventories is that energy from past extraction is effectively brought back into the system meaning that, in comparison to the example in Table 2, there is more energy to account for in the PSUT. Consequently, as shown in Table 4, while there is no change in the PSUT with regard to flows of energy from natural inputs (still 1161j), the flows relating to energy products and energy residuals are greater.

39. Aside from the introduction of new rows showing losses during storage, the only structural addition in Table 4 compared to Table 2 is the new column for changes in inventories. In the supply table the losses during storage are shown as supplied in the changes in inventories column (consistent with the information in Table 3). In principle, it is possible to show the changes in inventories column by industry. In this case the inventories and the losses should be attributed to the mining industry. Note that recording the losses during storage as supplied by the mining industry in column 2 would lead to the input-output identity for that industry being imbalanced.

40. In terms of flows of energy products the only increase shown relates to the increased sales of natural gas (1166j compared to 1116j). These extra sales are shown as higher intermediate consumption of natural gas by the electricity industry in the use table. Importantly however, the measure of output by the mining industry remains unchanged (1116j) since there has been no increase in the production of natural gas by the mining industry during the accounting period. Following national accounting conventions, the increased intermediate consumption is accounted for by showing a negative change in inventories (-50j) in the use table. This ensures that the total supply and total use of natural gas (as an energy product) are equal for the period (1116j).

41. The additional energy being brought back into the system from past extraction is reflected in additional output of electricity (618j compared to 598j); and also increased losses during transformation (448j compared to 418j). Overall, it can be seen that the total return of energy to the environment during the period of 1261j is 100j higher than the energy that entered the economy through the accounting period through extraction (1161j). This difference is the change in inventories as recorded in Table 3.

42. An important observation concerning this recording is that it is necessary to have a full understanding of the changes in inventories as shown in Table 3 in order to complete the supply and use table. This is an example of where the accounting system as a whole comes to the fore. While it may seem to introduce additional complexity by requiring additional tables to be compiled, in fact understanding the role of different tables and their relationships eases the burden on the compiler. Appropriate use of different table structures increases the likelihood of consistent recording of different transactions compared to the risks of trying to accommodate various treatments within single table structures.

Table 4: Selected entries for an energy PSUT incl. losses during storage (joules)

Supply table	Mining industry	Electricity industry	Other economic units	Households	Change in inventories	Environment	TOTAL
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Energy from natural inputs							
Natural gas						1161	1161
Energy products							
Natural gas	1116						1116
Electricity		618					598
Energy residuals							
Losses during extraction	45						45
Losses during transformation		448					448
Losses during distribution		100					100
Losses during storage					50		50
Other energy residuals			412	206			618
							1261
Use table	Mining industry	Electricity industry	Other economic units	Household final consumption	Change in inventories	Environment	TOTAL
Energy from natural inputs							
Natural gas	1161						1161
Energy products							
Transformation of energy products							
Natural gas		1166			-50		1116
End-use of energy products							
Electricity			412	206			618
Energy residuals							
Losses during extraction						45	45
Losses during transformation						448	448
Losses during distribution						100	100
Losses during storage						50	50
Other energy residuals						618	618
Total energy residuals							1261

6. Conclusion

43. In the experience of the author, a large proportion of the confusions in national accounting (both in practice and in theory) arise as a result of misunderstanding whether certain entries include or exclude various components – in effect whether treatments are net or gross. Most commonly, these confusions can be resolved through a full articulation of the relevant flows which, in turn, often reveals underlying assumptions. The discussions concerning the treatment of losses is one of these areas.

44. The discussion in this paper explains that a full recording of the physical flows associated with losses is possible within the structure of the PSUT defined in the SEEA Central Framework. Indeed, the conclusion of this paper is that without

the use of the full structure of the PSUT it is likely that a full and consistent recording of all types of losses will not be possible.

45. In addition, the recording described here requires careful consideration of the relevant entries to ensure that the supply-use identity and input-output identity are maintained. In many situations this process is reasonably straightforward but there are some particular challenges in working through the appropriate recording of losses during storage.

46. Once a full recording has been applied, relevant analytical indicators can be derived. This may well require re-organisation of entries from different parts of the PSUT that pertain to a single industry. However, distinguishing the full recording of physical flows from the derivation of indicators is an important conclusion from the paper.

47. This paper was intended to help improve the understanding of how losses should be recorded in the context of the SEEA Central Framework. In this regard, the paper complements the discussion and descriptions in the SEEA Central Framework and is not considered to be inconsistent with any parts of SEEA Central Framework.

Annex 1: SEEA Revision Issue #17: Recording of losses

Issue Description
Estimates of losses of energy and water (in extraction, storage, distribution and transformation) are important indicators of the efficiency of the relevant production processes and allow for a complete accounting of flows. To date however there have been differences in the way in which estimates of losses have been treated in water and energy accounts. The revised SEEA should consider the development of a general treatment of losses including consideration of the treatment of losses in physical and monetary terms.

The following recommendations were made in relation to the recording of losses in the revised SEEA:

(i) Within the context of the production boundary of the 2008 SNA, losses should be comprised of (a) flows of natural resources from the environment that are not available for further use in the economy because they are immediately returned to the environment and are not retained in the inventories of the extractor; and (b) products that do not reach their intended destination or have disappeared from storage.

(ii) Five types of losses should be defined: (a) losses during extraction/abstraction; (b) losses during distribution/transport; (c) losses during storage; (d) losses during conversion; and (e) losses due to theft. Losses due to theft should be recorded separately as they are not losses returned to the environment.

(iii) In the monetary flow accounts of the revised SEEA the treatment of losses should be consistent with the treatment of losses in the 2008 SNA.

(iv) In physical terms all losses should be recorded in the physical supply and use tables. In the derivation of measures of output in physical terms losses during extraction/abstraction should be netted off total amounts extracted. For losses during distribution, losses during conversion and losses due to theft, output should be derived net of these losses. Losses during storage may impact on measures of output or intermediate consumption. Losses of finished goods from storage should be deducted in the derivation of measures of output. Losses of materials or supplies from storage should be added in the derivation of measures of intermediate consumption.

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