Chapter 3: Physical flow accounts

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3.1 Introduction

1. An economy cannot function without drawing in natural resources and other inputs from the environment and using the environment to absorb the unwanted by-products of economic production. Measuring the physical flows of particular natural inputs into the economy and releases of residuals from the economy can therefore provide instructive information.
2. The usefulness of this information is considerably strengthened when organised using the same framework as used to assess economic flows in monetary terms. The use of the same framework, as outlined in this chapter, allows consistent analysis of the relationships between the flows of natural inputs and economic activity, the relationships between economic activity and the releases from the economy, and significantly, the relationships between the flows in physical and monetary terms.
3. The use of a common framework allows robust indicators to be established concerning the consumption of resources relative to economic indicators such as output and value added, since there is a parallel in the underlying accounting principles. Indicators on energy use, water consumption and air emissions by industry are further examples of the potential uses of data organised in a coherent and consistent manner.
4. The framework for measuring physical and monetary flows is also aligned with the framework for the measurement of environmental assets as presented in Chapter 5. This is a particularly important connection for natural resource flows and for the assessment of production processes in extracting industries. Relevant flows are recorded both in the asset accounts and in physical supply and use tables.

3.1.1The physical flow accounting framework and sub-systems

5. The framework for the measurement of physical flows is based on the structure of the monetary supply and use tables used to measure economic activity. In broad terms these tables show monetary transactions in products between industries, households, government and the rest of the world. These tables are based on the principles outlined in the 2008 SNA and are introduced in Chapter 2.
6. The same structure can be used to record the underlying physical flows relating to the monetary transactions between the different economic units. Further, flows to and from the environment can be linked in by adding relevant columns and rows to the basic supply and use table. These additions allow all physical flows: (i) from the environment, (ii) within the economy and (iii) back to the environment, to be recorded within one framework – the physical supply and use table (PSUT).

7. However, unlike monetary transactions it is not immediately obvious that all physical flows can simply be aggregated or that all physical flows should be recorded in a similar way. Consequently, three different sub-systems have developed within the broad supply and use framework – material flow accounting, water accounts and energy accounts.

8. Key features of the three sub-systems are:

    - In all three sub-systems physical flow accounting involves recording flows from the environment to the economy, flows within the economy, and flows back to the environment.
    - In material flow accounting flows are generally measured in terms of mass (egtonnes). In water accounts the unit of measurement is volume (egcubic metres) and in energy accounts the unit of measurement is energy content (eg joules).
    - While in concept material flow accounting can include the measurement of water, generally water is excluded because the mass of water tends to dominate the resulting statistics and overshadow the mass of all other materials.
    - In energy accounts there is consideration of flows of energy such as from geothermal sources, solar radiation, etc and these flows are not considered flows of materials in a material flow accounting context. At the same time a significant part of energy input is carried by physical substances, referred to as fuels, and these items are within scope of both energy accounts and material flow accounts – noting that they are measured in different units in the different accounts.

9. Within each of these sub-systems of physical flow accounting finer levels of focus can be undertaken consistent with the general principles of PSUTs. This is especially the case with regard to material flow accounts. At a national level, ie. covering all industries, Economy Wide Material Flow Accounts (EW-MFA) can be compiled. At the same time,considerable effort is placed on the construction of accounts relating to individual products, or on the flows of different types of residuals such as emissions to air or solid waste.

10. There may also be interest in looking at only one part of the physical flows, for example energy use by industries and households, rather than considering these flows in conjunction with energy supply. Nonetheless, even in this narrower case, the same concepts, definitions and standards are applied such that the organisation of data and the development of broader information systems can be supported.

11. Measuring physical flows requires large amounts of basic data, consistent classifications and units of measure and an agreed framework within which data can be structured at different levels of disaggregation. It also requires an understanding of the purposes for which the resulting tables can be applied.

12. Therefore, while this chapter aims to provide a comprehensive overview of the systems of physical flows in common use, it should be recognized that a complete implementation of the accounts

presented here is very ambitious and by no means always necessary since useful analysis can be done with any of the individual components of a full set of physical flow accounts.

3.1.2 Chapter structure

13. This chapter explains the physical supply and use approach in section 3.2 including definition of natural inputs, products and residuals. These definitions are fundamental in defining the boundaries between the environment and the economy and hence in constructing meaningful supply and use tables.

14. In section 3.3 a range of general accounting matters are discussed including gross and net recording of flows, the treatment of flows between countries and the treatment of losses.

15. The final three sections of the chapter discuss the measurement of individual physical flow accounts. Energy accounts are discussed in Section 3.4, Water accounts are discussed in Section 3.5 and a number of material flow accounts, including air emission accounts, are discussed in Section 3.6.

3.2 The physical flow accounting framework

16. This section introduces the physical supply and use approach to physical flow accounting through the introduction of the broad framework and its underlying accounting principles and then the definitions of the three key flows – natural inputs, products and residuals.

3.2.1 The physical supply and use table approach

17. The underlying framework for the recording of physical flows is the monetary supply and use tables for products as defined in the 2008 SNA and summarised in SEEA Chapter 2. The monetary supply and use table covers all flows of goods and services within the production boundary of the 2008 SNA.

18. The intent in physical flow accounting is to record the physical flows underpinning the monetary transactions, primarily with respect to goods, and then to extend the supply and use table to record physical flows from the environment to the economy (such as natural resources) and physical flows from the economy to the environment (such as emissions to air and water).

19. Broadly speaking, natural inputs represent the flows from the environment into the economy, flows within the economy consist of either products or residuals, and flows from the economy to the environment are residuals. Conceptually, flows solely within the environment are out of scope of physical supply and use tables although there may be instances where the recording of such flows is useful for analytical purposes. It is also noted that the asset accounts presented in Chapter 5 include flows within the environment to the extent that the flows reflect changes in the stock of environmental assets.

20. This general framework of flows may be applied in the case of individual commodities or groups of commodities. For example, flows of the hazardous element mercury might be tracked from the point it is extracted from the environment, circulated within the economy and released to the environment. Alternatively, there may be interest in only analysing physical flows into the economy or out of the economy without necessarily linking the two. For example the analysis of waste will focus on flows within the economy (for examples flows to waste treatment plants) and from the economy to the environment.

21. A full articulation of all flows is generally most relevant for energy and water where all flows can be meaningfully expressed in a single unit – eg joules or cubic metres. Indeed for water the accounts are tracking the flow of the same “thing” – i.e. water – from the point of abstraction, through units of the economy, and back to the environment. The general framework for the full articulation of physical flows is shown in Table 3.2.1 in the form of a physical supply table and a physical use table. The table shows the main types of flows that are recorded.

22. In reference to the discussion on supply and use tables in Chapter 2 it can be seen that the general PSUT involves the addition of a column for the environment and the addition of rows concerning natural inputs and residuals.

Table 3.2.1 General physical supply and use table

SUPPLY							
	Industries (including household production on own account)	**Households**			**Rest of the World**	**Environment**	**Total**
Natural inputs						A. Flows from environment	TSNI
Products	C. Domestic production (inclsale of recycled and reusedproducts)				D. Imports of products		TSP
Residuals	J1. Residuals generated by industry (incl. natural resource residuals& emissions from controlled landfill sites) J2. Residuals generated following treatment	K. Residuals generated by households			L. Residuals received from rest of the world	M. Residuals recovered from the environment	TSR
TOTAL SUPPLY							
USE							
	Industries	**Households**	**Government**	**Accumulation**	**Rest of the World**	**Environment**	**Total**
Natural inputs	B. Extraction of natural inputs						TUNI
	B1. Extraction incorporated into products B2. Natural resource residuals						
Products	E. Intermediate consumption (inclpurchase of recycled and reused products)	F. Household Consumption (incl purchase of recycled and reused products)	G. Government consumption	H. Gross Capital Formation	I. Exports of products		TUP
Residuals	N. Residuals received by waste mgt and other industries (excl accumulation in controlled landfill sites)			O. Accumulation in controlled landfill sites	P. Residuals sent to the rest of the world	Q. Residual flows direct to environment Q1. Direct from industry and households (incl. natural resource residuals) Q2. Following treatment	TUR
TOTAL USE							

Accounting and balancing identities

23. Of particular relevance in the construction of Table 3.2.1 is that the total supply of natural inputs (TSNI) in the first row of the supply table must equal the total use of natural inputs (TUNI) in the first row of the use table. The same is true for the rows for products and residuals – i.e. TSP = TUP and TSR = TUR.

24. These equalities relate to the fundamental physical identities underpinning the physical supply and use tables concerning the conservation of mass and the conservation of energy. These physical identities imply the existence of material and energy balances for all individual materials within the system.

25. The general material balance principle is applied in two ways within the general PSUT. First, it can be shown that, over an accounting period, flows of materials into an economy must equal the flows of materials out of an economy plus any net additions to stock in the economy. The net additions to the stock comprise additions and deductions over an accounting period in (i) gross capital formation in investment goods and inventories of products;(ii) physical flows of residuals to and from the rest of the world; (iii) residuals recovered from the environment (e.g. oil collected following an oil spill) and (iv) the accumulation of solid waste in controlled landfill sites.

26. Thus we have the input-output identity describing the physical flows between an economy and the environment (with cell references to Table 3.2.1)

Natural inputs (A) + Imports (D) =
Flows of residuals to the environment (Q) + Exports (I)
+ Net additions to stock in the economy (H + L – P + M + O)

27. This identity may be applied both at the level of an entire economy and also at the level of an individual industry or household where notions of imports and exports relate to flows to the rest of the economy as well as to the rest of the world. At the same time, since natural inputs are transformed and combined in a wide variety of ways and multiple times, recording a full balance is difficult to achieve in practice. It is also noted that the input-output identity is applied to materials, water and energy in the PSUT framework.

28. The second identity, the supply-use identity, recognises that, within the economy, the amount of a product supplied must also used within the economy, most likely by a range of different economic units, or exported. Thus we have (with cell references to Table 3.2.1)

Domestic production (C) + Imports (D) = Intermediate consumption (E) + Household and Government Consumption (F + G) + Gross capital formation (H)+ Exports (I)

29. These two identities shape the construction of PSUT by defining accounting relationships between natural inputs, products and residuals.

30. Particular note is made regarding the flows of residuals. For these flows a number of stages need to be recognised. In the first stage residuals are generated or come into the economy as reflected in cells (J1 and K to M) in Table 3.2.1. These residuals must be received by other units in the economy (N &O), in particular waste and water treatment facilities,sent to other countries (P) or returned to the environment (Q1). The residuals received by other units may be treated or processed and then either sold as recycled or reused products (for example reused water) or returned to the environment. If sold as recycled or reused products the output is recorded in (C) and the purchase in (E) or (F). The supply of the treated residual is recorded in (J2) and the use in (Q2).

31. In practice, a complete PSUT is rarely completed for materials other than energy and water. Nonetheless, these accounting identities and a common set of accounting principles can be applied even where only individual commodities or small groups of similar commodities are being recorded. In particular clear boundaries about the point of transition between the environment and the economy and back to the environment must be defined.

32. The following parts explain the general definitions and boundary issues relating to natural inputs, products and residuals.

3.2.2 Definition and classification of natural inputs

33. Natural inputs are all physical inputs that are directly incorporated into economic production processes or that are moved from their location in the environment as a part of economic production processes.

34. The three broad classes of natural inputs are natural resource inputs, ecosystem inputs and non-fuel energy inputs as presented in Table 3.2.2. This section discusses each of these classes and notes some specific measurement issues for natural resource inputs concerning the flows of resources affected by extraction processes but not used by the economy – natural resource residuals, and the treatment of cultivated biological resources.

Table 3.2.2 Classes of Natural Inputs

Code	Level 1	Level 2
	Natural resource inputs	
		Mineral and energy resources
		Soil resources
		Timber resources
		Fish resources
		Other biological resources
		Water resources
	Ecosystem inputs	
		Nitrogen
		Oxygen
		Carbon dioxide
		Other atmospheric inputs
		Soil nutrients
	Non-fuel energy inputs	
		Solar energy
		Hydro energy
		Wind energy
		Wave and tidal energy
		Geothermal energy
		Other heat energy

Natural resource inputs

35. Natural resource inputs cover mineral and energy resources, soil resources, timber resources, fish resources, other biological resources and water resources. The point at which they are recognised as entering the economy needs to be defined for each type of resource. It is recognised that some amount of economic activity must be undertaken before the natural resource can actually be considered extracted and hence it is a matter of determining the point at which the natural resource is best meaningfully described as extracted, and hence “enters the economy” as part of a longer production process.

36. Table 3.2.3 presents the treatment for different natural resource inputs using terms relevant to the extraction processes of each resource. It separates the quantities of resource extracted into those amounts that are intended and available for use in the economy – extraction incorporated into products, and those amounts that do not enter the economy – natural resource residuals. In general terms the point of entry to the economy, the extraction point - is the point at which the resource is available for further processing. The notion of processing includes the transportation of the resource, i.e. the extraction point should be as close to the physical location of the resource as possible.

Table 3.2.3Examples of the treatment of natural resource inputs

Natural resource input	Extraction incorporated into products	Natural resource residuals
Mineral and energy resources	Gross ore Crude oil Raw natural gas	Mining overburden Flaring, venting at well head Reinjection of raw gas
Soil resources	Excavated soil for agricultural, construction and landscaping purposes	
Timber resources	Removals of timber	Felling residues
Fish resources	Landings	By-catch
Other biological resources	Harvest/capture	Unextracted harvest
Water resources	Abstracted water	Return flows from hydropower plants Mine dewatering

37. Quantities of extraction incorporated into products are recorded as flowing from the environment into the economy. Quantities of natural resource residuals are recorded as flowing immediately back to the environment as residuals. Natural resource residuals are comprised of (i)losses during extraction which cover resources that the extractor would prefer to retain (for example losses of gas through flaring and venting), (ii) unused extraction which covers resources in which the extractor has no ongoing interest (for example mining overburden and by-catch) and (iii) return flows of water. Return flows of water are separately identified as often they represent a very large proportion of the total amount of abstraction. For example, water abstracted for the generation of hydropower is almost completely returned to the inland water system. Quantities of natural resource residuals may be of particular interest in the assessment of sustainable resource management.

38. These recording points for natural resource inputs are consistent with the recording of physical flows in the asset accounts for these resources as described in Chapter 5.

<u>Biological resources</u>

39. Biological resources require special consideration in the determination of the boundary between the environment and the economy as there is no simply defined boundary between situations where they should be considered to be extracted from the environment (natural biological resources) or they should be considered to be cultivated as part of a process of production (cultivated biological resources).

40. The distinction between natural and cultivated biological resources is based on the 2008 SNA production boundary. The criteria used include the extent of direct control, responsibility and management over the growth and regeneration of the biological resource and are discussed in greater detail in Chapter 5 with regard to timber resources (Section 5.8) and fish resources (Section

5.9). A consistent application of the criteria should be maintained for the purposes of both asset accounts and physical flow accounts.

41. Applying the distinction is important because the accounting treatment varies depending on whether the resource is natural or cultivated. For natural biological resources the resources are considered inputs to the economy at the time they are extracted – following the logic presented in Table 3.2.3. However, cultivated biological resources are not considered natural resource inputs and are instead treated as being within the economy throughout their life cycle.

42. This difference in treatment has implications for the recording of other flows. For natural biological resources the use of oxygen and nitrogen, etc and the uptake of soil nutrients and water are treated as flows within the environment and only the actual harvest of resources is considered to flow into theeconomy.

43. For cultivated biological resources since the resource itself is already "in" the economy, then, if a complete accounting is required, it is necessary to record the exchanges with the environment as part of natural inputs. Thus the uptake of soil nutrients and inputs of oxygen, nitrogen and other gases are recorded as ecosystem inputs and the flows resulting from metabolism, photosynthesis and transpiration are either embodied in products or return to the environment as residuals.

44. These inputs to the production of cultivated biological resources become embodied in the product itself, i.e. the growth of livestock or growth of the crop. Generally, an ongoing exchange will take place between the environment and the cultivated biological resource however it is not the intent of physical supply and use tables to record all of the detailed physiological changes.

Ecosystem inputs

45. Ecosystem inputs are comprised of substances taken in by the economy from the environment for purposes of production and consumption such as the compounds and elements (including nitrogen, oxygen and carbon dioxide) used by cultivated biological resources. Unlike natural resource inputs, ecosystem inputs are not easily identifiable in any of the products to which they contribute.

46. The uptake of water by cultivated plants is not considered an ecosystem input. Rather, this amount of water is part of the abstraction of water resources and hence is considered a natural resource input.

47. Generally, ecosystem inputs are not directly observed and recorded but are part of the structure of PSUT as they enable a complete input-output balance of all materials to be recorded in the system.

Non-fuel energy inputs

48. Non-fuel energy inputs are increasingly important sources of energy for economies in many countries. Non-fuel energy inputs are classified by different energy sources such as solar energy,

hydropower, wind energy, wave energy and geothermal energy. Inclusion of these inputs provides a basis for a complete balance of the flows of energy between the environment and the economy when measured in terms of energy content (joules).

49. Non-fuel energy inputs represent the energy captured by the capture technology. They should not be based on the potential energy that might be harnessed. In practice, estimates of non-fuel energy inputs will generally reflect the amount of energy actually produced, commonly but not exclusively, in the form of electricity.

50. Special consideration is required with regard to hydropower since, depending on the physical flow accounting involved it may be reflected in entries for non-fuel energy inputs or entries concerning water resources. For energy accounts, the entries concerning the flows from the environment should be considerednon-fuel energy inputs equal to the electricity produced by the hydro power plant, measured in joules. For water accounts, the flows from the environment should be recorded as natural resource inputs of water resources equal to the volume of water that passes through a hydropower plant.

3.2.3 Definition and classification of products

51. Following the 2008 SNA products are goods and services that result from a process of production. The scope of products included in physical flow accounts is limited to only those with positive monetary value.

52. The supply of products in the physical flow accounts is recorded as output. For an individual firm different types of output may be recorded. Output that is sold to other economic units is considered either the primary or secondary output of the firm depending the relative significance of the product. In principle, those firms that produce the same primary products are grouped to the same industry class.

53. In some cases, products are produced on own-account in that although they are not sold to other economic units they are used either directly for the final consumption of the producer, eg production of agricultural output consumed by farmers, or they are a form of capital formation, eg own-account construction of a house. In both cases the physical flows should be recorded to ensure consistency with the output and production boundaries of the monetary supply and use tables.

54. Consistent with the discussion on natural resource inputs, cultivated biological resources such as livestock, orchards and crops, are considered to be products and hence growth in these resources (equal to the amount harvested) is recorded as an increase in output of products.

55. A firm may also undertake ancillary production. This generally involves the production of supporting services (such as accounting, employment, cleaning, transport services) that might be purchased from other firms but are produced in-house to support the production of primary and secondary products. The 2008 SNA recommends that only in cases where ancillary production is

significant should distinct measures of output for the production of these different services be recorded. To do this, separate establishments should be created as the producers of the ancillary production. However, in most cases the production of these services is not recorded as a separate set of outputs and rather the inputs are recorded as comprising part of the overall inputs to the production of the firm's primary and secondary outputs.

56. Finally, there are some products that are used as part of production processes within an enterprise, intra-enterprise flows, that are not recognized by monetary transactions in the SNA. For example, flows of processed iron ore within a steel making enterprise would not be recorded in monetary terms. For physical flow accounting these intra-enterprise flows should be recorded where possible since there are physical flows that take place but the extent of recording should be consistent with the analytical purpose at hand.

57. In general the product component of physical flow accounts will focus on goods that are sold but in some cases, for example the provision of waste treatment services, there will be an interest in comparing the flow of waste into a waste treatment plant with any associated payment for the services.

Classification of products

58. Generally, physical flows of products are classified using the Central Product Classification (CPC). For some specific accounts, for example energy and solid waste accounts, specialised product classifications may be appropriate. These are discussed in relevant sections.

3.2.4 Definition and classification of residuals

59. Residuals are the incidental and undesired flows that are discarded, discharged or emitted by businesses and households through processes of production, consumption or accumulation. They are comprised of solid, liquid and gaseous materials and energy.

60. Residuals may be discarded, discharged or emitted directly to the environment or be captured, collected, treated, recycled or reused by economic units. These various transformation processes may lead to the generation of new products that are of economic value to the unit undertaking the transformation even if the residual, when first discarded or emitted may have no economic value to the person or business discarding or emitting the residual.

61. In situations where the intent is to discard a product but the discarder receives money or other benefits in exchange for the discarded product, this is treated as a transaction in a product and not as a residual. These flows may be of particular interest in the compilation of waste accounts.

62. A distinction must be made between payments made by a generator of residuals to businesses that collect, treat or otherwise transform residuals and the flows of the residuals themselves. The payments made are treated as payments for services and are treated as transactions in products

while the flows of residuals are recorded separately. A specific case of this distinction is in the case of flows of waste between countries. The payments for the services provided for the transport and treatment of waste by other countries are recorded as imports and exports of services while the physical flows of waste are separately recorded as flows of residuals.

63. Residuals should be recorded at the time the emission or discard event takes place. The timing of the emission or discard event may be quite distinct from the time of the acquisition of a good which is the appropriate time to record the flow from the perspective of the monetary accounts.

64. Controlled and managed landfill sites, emission capture and storage facilities, treatment plants and other waste disposal sites are considered to be within the economy. Therefore, flows of residuals into these facilities are regarded as flows within the economy rather than flows to the environment. Subsequent flows from these facilities may either be direct to the environment as residuals or lead to the creation of other products or residuals.

65. Residuals may be measured on a gross or a net basis depending on the purpose of analysis. Measurement on a gross basis records the amount of residuals generated by an economic unit. Measurement on a net basis records the amount of residuals released to the environment.The topic of gross and net recording of residuals is discussed in more detail in section 3.3.

66. Household or industrial waste may be dumped (possibly illegally) in open country or by the roadside. As well, tankers at sea may wash their tanks (also possibly illegally) or lose their cargo through being wrecked. These flows should be recorded as residuals flowing from the economy to the environment.

67. Efforts might be made to recover residuals from the environment and bring them back into the economy either for treatment or for consignment to a landfill site. This is the only case where flows of residuals from the environment to the economy should be recorded. In numerical terms, the amount may be small but, in respect of particular incidents (the wreck of an oil tanker near a protected coast, say) or particular locations, may arouse a sufficient degree of concern to merit identifying these flows explicitly.

68. Residuals that are emitted or discarded direct to the environment may be released into either the national environment or into other countries' environments. In these cases the attribution of the residuals is recorded following the residence principle such that it is the residence of the emitting household or business that determines which country has emitted the residuals.(For details see Section 3.3)

69. In principle, flows of residuals between the national environment and another environment are not generally recorded in PSUTas there are no flows out of or into an economy. Nonetheless, depending on the nature of the relationship between the different national environments there may be interest in recording these flows. For example, countries at the downstream end of a river system may be interested in the flows of residuals generated by other countries transported by a

river or the deposition of acidification ("acid rain") originating from acidifying emissions in other countries.

Groups of residuals

70. If the focus of accounting for residuals is purely on the physical characteristics of the materials and energy discarded and emitted then a classification of residuals by type of substance discarded or emitted would be appropriate. Often, analysis of residuals is undertaken through a focus on particular groups of emissions either in terms of the purpose behind the discard (e.g. waste), the destination (eg emissions to air), or the processes leading to the emission (e.g. dissipative losses). Consequently, there is no complete and mutually exclusive classification that is applied and commonly accepted covering all residual flows.

71. An example of the potential overlap is the treatment of flaring and venting of natural gas at the wellhead. These flows of gas are considered natural resource residuals, losses during extraction and a component of air emissions.

72. The following are the widely accepted groupings of residuals and their definitions. In practice, application of these definitions usually involves the creation of a list of relevant products deemed to be within scope. Sometimes such a list may be based on legislation and other requirements.

Solid waste

73. Solid waste covers discarded materials no longer desired by the owner or user. This grouping includes materials that are in a solid or liquid state but excludes wastewater and small particulate matter released into the atmosphere.

74. Solid waste includes all materials sent to or collected by waste collection or treatment schemes including landfill establishments. The majority of these establishments are coded to industry ISIC 38: Waste collection, treatment and disposal activities. Solid waste also includes those samematerialsif they are discarded directly to the environment – whether legally or illegally.

75. Solid waste may also include products exchanged between economic units but in practice a precise delineation of the products that are included as part of solid waste is difficult to define. The primary considerations are (i) whether benefits are received by the discarding unit from the receiving or collecting unit, and (ii) the extent to which processing or treatment is required by the receiving unit to use the product in its own production processes.

76. Table 3.2.4 outlines the potential treatments in broad terms. In general, the criteria of whether a benefits have been received enables a distinction to be made between a residual and a product and the criteria concerning the extent of reprocessing can be used to determine whether a product is within scope of the definition of solid waste. It is recommended that compilers consider carefully

the analytical questions under examination in determining the appropriate scope of materials for the measurement of solid waste.

Table 3.2.4 Treatment of solid waste as residuals and products

		Discarding unit receives benefits from receiving unit	
		Yes	No
Processing/treatment required by receiving unit	Yes	Product - Solid waste	Residual – Solid waste
	No	Product – not Solid waste	Residual – Solid waste

Wastewater

77. Wastewater is water that is of no further use.Water discharged into drains or sewers, water received by water treatment plants or water discharged direct to the environment is all considered wastewater. Wastewater includes return flows of water which are flows of water direct to the environment, with or without treatment. All water is included regardless of the quality of the water.

78. Wastewater also includes reused water which is wastewater supplied to a user for further use with or without treatment. Wastewater that is recycled within the same firm is not recorded.

Emissions

79. Emissions are releases of pollutants as a result of production or consumption processes. Often emissions are analysed by type of receiving medium – emissions to air, emissions to water, emissions to soil – but they may also be analysed from the perspective of the processes that led to their release – such as from the dissipative use of products or dissipative losses. Each of these different categories is defined below.

80. Generally, focus in the accounting for emissions is on the impact on the environment and hence the releases of emissions from the economy to the environment are of particular interest. However, in some cases emissions may be captured and transferred between economic units thus lessening the potential impact on the environment even while the total quantity of emissions released may remain at the same level. An example of this concerns the capture and storage of carbon dioxide emissions. The total generation of emissions are referred to as gross emissions and the emissions released to the environment are referred to as net emissions.

81. Emissions to air are gaseous or particulate pollutants released into the atmosphere as a direct result of production, accumulation or consumption processes. By convention, emissions to air exclude the release of steam or water via evaporation. Further details on accounting for emissions to air are presented in Section 3.6.

82. Emissions to water refer to pollutants added to water as a result of production and consumption processes in the economy. For any individual economic unit emissions to water are measured in terms of the additional pollutants that the unit has added to water rather than the total pollutants in

the water discharged by the same unit. In this way, pollutants that were already in the water received by the economic unit are not attributed to that unit.

83. Emissions to water exclude those materials that are not carried by normal flows of water such as large items of solid waste. These are included in measures of waste.

84. Emissions to soil are releases of pollutants to the soil as a result of production and consumption processes in the economy. Some emissions to soil may continue to enter the water system. In principle, flows of pollutants having been recorded once should not be recorded a second time as being attributable to an individual firm.

85. Residuals from dissipative use of products occur as a result of production processes in which products are distributed for specific economic purposes but end up in the environment. For example, pesticides are spread on crops, fertilizers (including manure) are spread on soil and salt is spread on roads. The proportion of the distributed product that is subsequently absorbed in the production of a product – for example nutrients from fertilizer that are absorbed by crops, are considered to be flows of products within the economy. The proportion of the product that is added to the environment (generally added to soil) should be recorded as a residual.

86. Dissipative losses refer to flows of materials to the environment such as abrasion residues from car brakes and tyres, particulate abrasion from roadsurfaces, and zinc from rain collection systems of roofs as a result of production and consumption activity.

Residual heat

87. Residual heat losses need to be recorded as part of residuals to ensure the maintenance of the energy balance principle in the physical flow accounts. These flows are relevant in the construction of energy accounts measured in joules.

Natural resource residuals

88. Flows of natural resource residualsare defined in the context of the extraction of natural resources. They are recorded as natural resource inputs to reflect that there are physical flows associated with production, that do not necessarily lead to the creation of products. Subsequently natural resource residualsare recorded as a residual both as the supply of residuals by extracting industries and as a flow of residuals direct to the environment. Table 3.2.3 explains the relationship between the definition of products and residuals in the recording of natural resource inputs.

89. Another way in which residuals are considered is in terms of losses. This is of particular interest in the analysis of physical flows of energy and water. Losses may occur at different stage of the

production process – during extraction, during distribution, during transformation or during storage. A definition and description of losses in provided in section 3.3.

Group of residuals

90. Although no strict classification of residuals can be defined the descriptions in Table 3.2.5 give an indication of the types of materials included in analysis of the different groupings of residuals.

Table 3.2.5Typical components for groups of residuals

Group	Typical components
Solid waste (includes recovered materials)	Compound waste, Chemical preparation waste, Health care and biological waste, Metallicwastes, Non-metallic wastes, Discarded equipment, Animal and vegetable wastes, Common sludges, Mineral waste, Solidified, stabilized and vitrified waste, Radioactive waste
Wastewater	Water for treatment and disposal, Return flows, Reused water,
Emissions to air	Carbon Dioxide, Methane, Dinotrogen oxide, Nitrous oxides, Hydrofluorocarbons, Perfluorocarbons, Sulphur Hexaflouride, Carbon monoxide, Non-methane volatile organic compounds, Sulphur dioxide, Ammonia, Heavy metals, Persistent organic pollutants, Particles (eg PM10, dust)
Emissions to water	Nitrogen compounds, Phosphorous compounds, Heavy metals, Other substances and (organic) compounds
Residuals from dissipative use of products	Organic fertilizer (manure), Mineral fertilizer, Sewerage sludge, Compost, Pesticides, Seeds, Other products for dissipative use (eg salt on roads, solvents)
Dissipative losses	
Residual heat	
Natural resource residuals	Mineral and energy resources, Timber resources, Fish resources, Other biological resources, Water resources

Accumulation of residual flows

91. The environmental impacts caused by residuals relate to residual flows from the current period and also flows in the past periods because of the ability of residuals to accumulate. The effect of the same level of current flow of a residual may be quite different depending on the level already accumulated at the beginning of the period. The question of measurement of stocks as well as

flows of residuals concerns the state and quality of the associated ecosystems that receive residuals. This matter is addressed in SEEA experimental ecosystem accounts

92. It is noted here that the damage inflicted by the ambient concentrations of a residual often increases non-linearly with the amount of residual generated. However, the supply and use tables described in this section detail only the quantity of residuals generated in a single period and do not reveal the consequences of cumulating this amount with past or future amounts of the same (or other) residuals. It is also noted in this regard that the impact on the environment will vary depending on the type of residual.

3.3Principles of physical flow accounting

3.3.1 Introduction

93. The application of the broad framework for physical flow accounting outlined in section 3.2 requires the adoption of a range of accounting principles and conventions. A number of these are explained in Chapter 2 including the principle of double entry accounting, the units of measurement, and the definitions of economic units and industries.

94. This section describes in detail some specific recording principles relevant to physical flow accounting namely, gross and net recording of physical flows, the treatment of international flows in goods, the treatment of goods for processing and the treatment of losses.

3.3.2 Gross and net recording of physical flows

95. The PSUT framework presented in section 3.2 records all flows between different economic units and, where applicable, records flows within economic units where own-account production and consumption of products is significant. This recording of flows is referred to in the SEEA as gross recording. The key advantage of a gross recording approach is that a full reconciliation of all flows at all levels of the supply and use table, for example by industry and product, can be found.

96. However, recording all of these flows may hide some key relationships and hence for analytical purposes, alternative consolidations and aggregations of flows have been developed. These alternative views are often referred to as net although the nature of the consolidations and aggregations does vary and hence there is no single definition of net recording. This section mentions some of the main types of net recording of relevance to the SEEA.

97. It is noted that the terms gross and net are used in a wide range of accounting situations. In the 2008 SNA and in the SEEA the terms gross and net are used to indicate whether an accounting aggregate has been adjusted for consumption of fixed capital. In other situations the term net is used simply as the different between two accounting items. The terms gross and net are also used to describe different aggregates that have different measurement scopes.

98. <u>Gross and net recording of energy flows</u>. One of the common areas in which gross and net recording is applied is in energy accounts. Energy accounts compiled on a gross basis show all flows of energy between economic units. Some of these flows represent flows of energy products to energy producers, e.g. flows of coal to electricity producers, and other flows are to an end user, e.g. flows of electricity to households. Net energy accounts remove the flows concerning the transformation of energy products and hence allow a focus on the total amount of energy in end uses. Thus net energy focuses on the consumption or dissipation of energy to the point where it is no longer available for use.

99. Gross and net recording of residuals. The recording of residual flows requires reflection of a number of different potential stages of treatment or return to the environment. In this situation the exact quantity of residuals generated through economic activity and the quantity of residuals released to the environment and potentially causing environmental pressures may not be immediately apparent. In this context gross residuals represent the total residuals generated through economic activity while net residuals represents the total residuals released to the environment. The difference between gross and net is equal to the quantity of residuals retained in the economy through storage or otherwise treated in the economy such that no potential environmental impact remains. This approach to gross and net recording may be applied in the derivation of estimates of gross and net flows of solid waste and gross and net emissions to air.[1]

100. Gross and net emissions to water. In this situation gross emissions to water represent the total quantity of pollutants in the water discharged by an economic unit into the water system. Net emissions to water represent the total addition of pollutants to water by an economic unit. Net emissions to water are derived by determining the difference between the gross emissions to water and the quantity of pollutants in the water received or abstracted by the economic units.

101. Generally, care should be taken in the use and interpretation of the terms gross and net and clear definitions of inclusions and exclusions should be provided and sought wherever possible.

3.3.3 Treatment of international flows

102. The treatment of physical flows to and from the rest of the world needs careful articulation. The underlying principle to be applied is one of residence whereby relevant flows are attributed to the country of residence of the producing or consuming unit. This differs from the territory principle of recording that is applied in a number of statistical collections. The concept of territory attributes the relevant flows to the country in which the producing or consuming unit is operating at the time of the flow.

103. In the vast majority of situations the concepts of territory and residence are closely aligned but there are important activities, in particular international transport, that need to be considered directly so as the appropriate treatment can be defined. This part examines the key areas of international transport, tourist activity and natural resource inputs, in turn.

International transport

104. The appropriate recording of international transport activity is important particularly for information concerning the use of energy and the associated release of emissions, the appropriate

[1] In relation to carbon emissions the term “net” is also used to refer to estimates of emissions measured after deducting carbon captured in managed forests.

and consistent attribution of physical flows relating to international transport to individual countries is an important component of the SEEA.

105. To ensure consistency with other parts of the accounts the treatment is centred on the residence of the operator of the transport equipment. Residence is determined on the basis of the economic territorywith which the transport operator has its strongest connection, ie. its centre of predominant economic interest. This will usually be the location of the headquarters of the transport operator. Therefore, irrespective of the distances travelled, the number of places of operation, whether the transport service is supplied to non-residents or whether the transport service is between two locations not within the resident country; all revenues, inputs (including fuel wherever purchased) and emissions are attributed to the country of residence of the operator.

106. By way of example the following scenarios are highlighted

i. A ship, resident in Country A, transports goods from Country B to Country C, and refuels in Country C before returning home. In this case purchases of fuel are attributed to Country A (being exports from Country C/imports of Country A).[2] Payments for transport service by Country C are exports of services by Country A. All emissions by the ship are attributed to Country A.

ii. A passenger aircraft, resident in Country X, transports people from Country X to Country Y and returns to Country X. The passengers are from various countries, X, Y and Z. In this case any purchases of fuel are attributed to Country X and are recorded as imports if purchased in Country Y.[3]Payments by the passengers are recorded as exports of services by Country X if the passengers are resident in Country Y or Z. All emissions by the aircraft are attributed to Country X.

107. Special note is required in relation to the bunkering of fuel, primarily for ships and aircraft. Although special arrangements may be entered into such that a unit resident in a country stores fuel in another country while still retaining ownership of the fuel itself. Following the principles of the 2008 SNA and the 6th edition of the Balance of Payments Manual (BPM6) the location of the fuel is not the primary consideration. Rather focus must be on the ownership of the fuel. Thus if Country A established a bunker in Country B and transports fuel to Country B in order to refuel a ship that it operates then the fuel it considered to have remained in the ownership of country A and no export of fuel to Country B is recorded. Thus the fuel stored in Country B is not necessarily all attributable to Country B. This treatment is likely to differ from the recording in international trade statistics and adjustments may be needed to source data to align to this treatment.

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[2] Note that this treatment is not consistent with the recording required in the compilation of international trade statistics.

[3] Note that this treatment is not consistent with the recording recommended for energy statistics in the International Recommendations on Energy Statistics.

Tourist activity

108. The recording of tourist activity is consistent with the recording of international transport activity in that the concept of residence is central. Tourists include all those travelling outside their usual environment including short term students, people travelling for medical reasons and those travelling for business or pleasure. The consumption activity of a tourist travelling abroad is attributed to the tourist’s country of residence and not to the location of the tourist when the consumption is undertaken. Thus purchases by the tourist in other countries are recorded as an export by the country visited and as an import of the country of residence of the tourist.

109. Waste generated by the tourist should be attributed to the country of residence and should be deducted from the total emissions and waste generated within the visited country. Concerning emissions from transport equipment, the emissions from local transport used by tourist in a foreign country are attributed to the local transport company and, as noted in regard to international transport, emissions from aircraft and other long distance transport equipment are attributed to the country of residence of the operator. In neither case is the emission attributed to the tourist.

110. Emissions from cars are also attributed to the country of residence of the operator (in this case the driver of the car), whether the car is owned by the driver or the car is being hired from a rental car company. Emissions from taxis, local minibuses and the like are also attributed to the driver or relevant business rather than the passenger.

Natural resource inputs

111. Natural resource inputs are comprised of mineral and energy resources, soil resources, timber resources, fish resources, other biological resources and water resources. Other than fish resources all of these resources are considered to be owned by residentsof the country in which the resources are located. By convention, natural resources that are legally owned by non-residents are considered to be ownedby a notional resident unit and the non-resident legal owner is shown as the financial owner of the notional resident unit. Consequently, in general, the extraction of natural resource inputs cannot cross national boundaries.

112. The major exception to this treatment concerns fish resources. Following accounting conventions, the harvest of fish is allocated to the residence of the operator of the vessel undertaking the fishing rather than to the location of the fish. Thus the amount of natural resource input that should be recorded is equal to the amount of fish caught by resident vessels irrespective of where the fish are caught. Natural resource inputs are not recorded for the harvest of fish by non-resident vessels in national waters and neither are exports recorded in this situation.

113. Where illegal extraction takes place, for example when non-residents illegally log timber resources, the reduction in the country’s resource should be recorded in the asset account (see Chapter 5) and the extraction and natural resource input should be shown in the accounts of the non-resident country. No exports should be recorded.

3.3.4 Treatment of goods for processing

114. It is increasingly common for goods from one country to be sent to another country for further processing before being either returned to the original country, sold in the processing country or sent to other countries. In situations where the original goods are sold to the processor in the second country there are no particular recording issues but in situations where the processing is undertaken on a fee for service basis and the ownership of the goods remains with the first country the financial flows are unlikely to relate directly to the physical flows of goods being traded.

115. From a monetary accounts perspective, the unit processing the goods assumes no risk associated with the eventual marketing of the products and the value of the output of the processor is the fee agreed for the processing which is recorded as an export of a service to the first country. A consequence of this treatment is that the recorded pattern of inputs for an establishment processing goods on behalf of another unit is quite different from the pattern of inputs when the establishment is manufacturing similar goods on their own account.

116. A simple illustration may be given by referring to the production of petroleum products. A producing unit that refines crude oil on own account has intermediate consumption of crude oil and output of refined petroleum products. A producing unit that is processing crude oil on behalf of another unit has all the other similar inputs and uses the same sort of produced assets but shows neither the intermediate consumption of crude oil nor the output of refined petroleum products. In their place only an output equal to the processing fee is recorded.

117. For similar amounts of crude oil processed, the value added and other inputs are likely to be comparable. However, the result of recording only the processing fee rather than the full value of the goods processed does change the nature of supply and use coefficients. They no longer represent the technological structures of an industrial process but an economic process.

118. Although this treatment provides the most appropriate recording of the monetary flows it does not correspond to the physical flows of goods. Consequently, a different treatment of goods for processing is recommended for physical supply and use tables. The treatment is to record the physical flows of goods, both as they enter into the country of the processing unit and as they leave that country. Tracking the physical flows in this way enables a clearer reconciliation of all physical flows in the economy and also provides a physical link to the recording of the environmental impact of the processing activity in the country in which the processing in being undertaken.

119. Thus emissions of an oil refinery are attributed to the country in which the processing plant is located. The recommended treatment for physical flow accounting also allows better understanding of production relationships within industries in cases where some firms undertake work on a fee for service basis and some do not. All else being equal the physical inputs and outputs from firms undertaking the same work should be recorded in the same way but this is not possible following the treatment applied in the monetary supply and use tables.

120. Depending on the products and industries that are of interest this may require additional entries to be estimated if accounts combining physical and monetary data are to be compiled. This issue is discussed in Chapter 6.

3.3.5 Treatment of losses

121. There is a range of potential stages in the production and distribution process during which losses need to be considered. In general losses should be recorded if there is a preference on the part of the economic unit to retain the physical quantities that are lost. Particularly in situations where resources are being extracted, some physical quantities of resources may be "lost" as part of the extraction process but if these quantities are of no interest to the extractor then they should not be considered losses. These paragraphs outline a general definition of losses in physical terms and then present a typology of losses with associated definitions.

122. Losses in physical terms are comprised of (i) flows of natural resources from the environment to the economy that are not available for further use within the economy because they have remained in or been returned to the environment but ideally would have been retained by the extractor; and (ii) materials that do not reach their intended destination or have disappeared from storage.

123. Within this definition four types of losses are identified according to the stage at which they occur through the production process. It is noted that some types of losses may be necessary for maintaining safe operating conditions as is the case of flaring and venting in the extraction of natural gas, while others may be unwanted losses as is the case for water evaporation from distribution channels.

124. The four types of losses are:

i. Lossesduring extraction/abstraction
ii. Lossesduring distribution/transport
iii. Lossesduringstorage
iv. Lossesduring transformation

125. <u>Losses during extraction</u> are losses that occur during extraction (e.g. flaring and venting of natural gas at the wellhead) of a natural resource before there is any further processing, treatment or transportation of the extracted natural resource. During the extraction process, some of the natural resource may be re-injected into the deposit from which it was extracted. This may be the case for example for natural gas re-injected into the reservoir or water abstracted from groundwater and re-injected into an aquifer. These flows are also considered as losses during extraction. In the case of water they are also considered return flows.

126. Losses during extraction differ from unused extraction in that quantities of unused extraction refer to quantities that the extractor does not wish to retain – for example mining overburden and by-catch in fishing.

127. Losses during distributionare losses that occur between a point of abstraction/extraction/supply and a point of use. In addition, when losses during distribution are computed as a difference between the amount supplied and that received, they may also include errors in meter readings, malfunctioning meters, etc. These are commonly referred to as apparent losses.

128. Losses during storage are losses of energy products and materials held in inventories. They include evaporation, leakages of fuels (measured in mass or volume units), wastage and accidental damage. Excluded from the scope of inventories are non-produced assets, even though they might be considered as being stored. Thus, for example, the evaporation of water from artificial reservoirs is excluded from losses during storage. These reductions in the volume of water are shown in asset accounts (Chapter 5).

129. Losses during transformationrefer to the energy lost, for example heat, during the transformation of one energy product into another energy product. It is essentially an energy balance concept reflecting the difference in calorific value between the input and output commodities. Losses during transformationonly apply to energy flows.

130. In addition, from the perspective of suppliers of products, the amounts of water, electricity, other energy products and other materials that are illegally diverted from distribution networks or from storage may be considered losses due to theft.Since, in physical terms the water, energy or other material is not lost to the economy they are not considered losses in the SEEA. However, there may be interest in compiling data concerning theft as a subset of overall consumption of water, energy and other products. It should be noted that losses due to theft may be difficult to measure in practice and may often be included in losses in distribution.

131. All losses can be recorded in the physical supply and use tables. In the derivation of measures of output in physical terms, losses during extraction should be netted off total amounts extracted. For losses during distribution, losses during transformation 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.

3.4 Physical flow accounts for energy

3.4.1 Introduction

132. Energy flow accounts describe energy flows, in physical units, from the initial extraction or capture of energy resources from the environment into the economy (natural inputs), to the flows within the economy in the form of supply and use by industries and households and finally, the flows of energy back to the environment (energy losses).

133. The compilation of energy flow accounts allows for a consistent monitoring of the supply and use of energy by energy type and, in combination with monetary information, indicators of energy intensity, efficiency and productivity can be derived.

134. Energy flow accounts are a sub-system within the general physical flow framework. Energy accounts data are compiled by converting physical measures of mass and volume such as tonnes, litres and cubic metres into a common unit representing energy content. The use of the joule as a common unit is recommended by the International Recommendations for Energy Statistics (IRES).[4]

3.4.2 Scope and definitions of energy flows

135. Energy flows consist of flows of (i) energy resources,(ii) flows of energy products and (iii) energy losses. Flows of air emissions and solid waste generated by energy production and use are not included although all types of waste used as inputs for production of energy are included.

136. Flows of energy resourcesinvolve the removal and capture of energy from the environment by economic units in the national territory. Energy resources may come in the form of natural resource inputs – primarily mineral and energy resources and timber resources in the form of fuelwood. Energy resources may also come in the form of non-fuel energy inputs such as solar, wind and hydropower.

137. Energy products are products that are exclusively or mainly used as a source of energy. They include energy in forms suitable for direct use (eg electricity and heat) and energy products that release energy while undergoing some chemical process (for example combustion). By convention, energy products include biomass and waste that are combusted for the production of electricity and/or heat[5]. Some energy products may be used for non-energy purposes.

138. A distinction can also be made between primary and secondary energy products. Primary energy products are the result of extraction or capture of energy resources from the environment. Secondary energy products are the result of transformation of primary, or other secondary, energy

[4] International Recommendations on Energy Statistics (IRES) 2011, 4.29

[5] International Recommendations on Energy Statistics (IRES) 2011, 2.B

products into other types of energy products. Examples include petroleum from crude oil, charcoal from wood fuel and electricity from fuel oil.

139. Heat and electricity may be either primary or secondary products depending on their production process. For example, if heat is captured directly from the environment through solar panels it is a primary energy product. It is a secondary energy product if produced from other energy products such as coal or oil.

140. Physical flows of energy products are classified using the Standard International Energy Product Classification (SIEC) presented in the IRES. Monetary flows will normally be classified using the CPC. Hence, in the development of accounts and indicators that combine physical and monetary data a reconciliation between these classifications will be needed.

141. Energy losses in physical terms are defined consistently with the general definition of losses outlined in Section 3.3. Particular cases of energy losses include flaring and venting of natural gas (also recorded as part of natural resource residuals) and losses during transformation from energy resources to energy products and in the production of secondary energy products.Losses during distribution may arise from the evaporation and leakages of liquid fuels, loss of heat during transport of steam, and losses during gas distribution, electricity transmission and pipeline transport. Energy losses are recorded in the SEEA consistently with the general recording of residuals as outlined in Section 3.2.

3.4.3 Physical supply and use tables for energy

142. Physical supply and use tables for energy record the flows of energy resources, energy products and energy losses in quantitative terms. They are based on the principle that the total supply of each energy resource, energy product or energy loss is equal to the total use of the same energy resource, product or loss.

143. Table 3.4.1 shows the SEEA physical supply and use tables for energy. The table includesflows of all energy resources and products including those energy products that are transformed into other energy products. Therefore, the energy content of some products is counted more than once. Coal, for example, is used as input into a transformation process to obtain electricity and heat, and the accounts record the energy content of the coal as well as the energy content of the resulting electricity and heat.

144. For analytical purposes it is possible to remove the flows of energy products that are used for transformation into other energy products and used for non-energy purposes. This information is regarded as recording energy products on a net basis rather than the gross basis of recording that underlies the general PSUT for energy.

Table 3.4.1 Physical supply and use table for energy

Physical supply table

		Industries						**Households**	**Rest of the world**	**Environment**	**TOTAL SUPPLY**
		Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries (incl own-account production)		Imports		
		ISIC 01	ISIC 02	ISIC 03	ISIC 04	ISIC 08					
Natural inputs											
	Natural resource inputs										
	Mineral and energy reosurces										
	Fuelwood										
	Non-fuel energy inputs										
	Solar energy										
	Hydro energy										
	Wind energy										
	Wave and tidal energy										
	Geothermal energy										
	Other heat energy										
Products											
Output of energy products by SIEC class											
	Coal										
	Peat and peat products										
	Oil shale/ oil sands										
	Natural gas										
	Oil										
	Biofuels										
	Waste										
	Electricity										
	Heat										
	Nuclear fuels and other fuels nec										
	Total										
Residuals											
	Losses during extraction										
	of which Reinjection of natural gas										
	of which Flaring and venting at well head										
	Losses during distribution										
	Losses during storage										
	Losses during conversion										
	Total losses										

Physical use table

		Industries						**Households**	**Rest of the world**	**Environment**	**TOTAL USE**
		Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries (incl own-account production)	Final consumption	Exports		
Natural inputs											
	Natural resource inputs										
	Mineral and energy reosurces										
	Fuelwood										
	Non-fuel energy inputs										
	Solar energy										
	Hydro energy										
	Wind energy										
	Wave and tidal energy										
	Geothermal energy										
	Other heat energy										
Products											
Transformation use of energy products by SIEC class											
	Coal										
	Peat and peat products										
	Oil shale/ oil sands										
	Natural gas										
	Oil										
	Biofuels										
	Waste										
	Electricity										
	Heat										
	Nuclear fuels and other fuels nec										
	Total										
End-use of energy products by SIEC class											
	Coal										
	Peat and peat products										
	Oil shale/ oil sands										
	Natural gas										
	Oil										
	Biofuels										
	Waste										
	Electricity										
	Heat										
	Nuclear fuels and other fuels nec										
	Total										
Residuals											
	Losses during extraction										
	Losses during distribution										
	Losses during storage										
	Losses during conversion										
	Total losses										
Total use											

Key components of the PSUT for energy

145. The key components of the PSUT for energy concern (i) the supply of energy products, including energy products produced on own account; (ii) imports and exports of energy products; (iii) intermediate consumption of energy products; and (iv) final consumption of energy products.

Supply of energy products

146. All energy products supplied from one unit to another, including between units within a single enterprise, are included in the flow accounts no matter if the energy product is sold or exchanged as part of a barter or provided free of charge.

147. Energy products are primarily produced by establishments classified to ISIC section B, *Mining and quarrying*, ISIC Section C, *Manufacturing* and ISIC section D, *Electricity, gas, steam and air conditioning supply.*For many countries, the primary source of supply may be imported energy products.

148. Energy products are also produced as secondary outputs by many industries and for use within an establishment – own account production. Where it is possible to quantify the own account supply and use of energy products, these flows should be recorded separately in the accounts as flows of energy for own use.

149. A special case in the supply of energy products concerns the energy production of households. Households may purchase and install equipment for the generation of energy products (such as solar panels) and also may collect and use energy resources such as fuelwood to generate energy products.It may be the case that the energy produced by households is sold, for example by selling electricity produced to an electricity grid or, alternatively the energy produced is consumed on own account. In either situation, if the activity is significant or of particular interest, the activity should be considered to be a productive activity and associated entries for output and consumption should be recorded in the accounts. The activity should be allocated to the relevant industry. A distinction between those amounts of energy produced by households for sale as compared to own-use may also be compiled.

Import and exports of energy products

150. Imports and exports of energy products should be recorded when change of ownership between a resident and a non-resident unit occur. In the absence of sources specifying the date on which ownership changes, there is a strong presumption that the goods will cross the frontiers of the countries concerned either shortly before or soon after the change of ownership takes place.

151. Energy products in transit through the economic territory should generally not be included in imports and exports. However, for electricity and heat it may be difficult to distinguish between

transit flows and other flows, and all flows of electricity and heat into a country may therefore in practice be recorded as imports, and all outgoing flows may be recorded as exports.

152. According to the 2008 SNA goods sent abroad for processing are not treated as exports or imports of goods since no change of ownership normally takes place. If for example crude oil is sent to another country to be refined, the crude oil is excluded from the exports and the returned refined products are excluded from imports of the country. Instead, an import of a service corresponding to the processing abroad is recorded as imports. Thus the processing corresponds to a similar processing within the country except that it is carried out with the use of an imported processing service.

153. However, in the SEEA it is considered appropriate to record the actual physical flows of goods sent abroad for processing. It is noted that foreign trade statistics normally record the flows of goods sent abroad for processing and the return flows together with other flows of products crossing the borders.

154. Energy use by resident units abroad, essentially covering tourists driving abroad and companies engaged in international transport activities, should be recorded in the accounts either as the use of the industries earning the value added from these activities or as a use of the households operating the transport equipment. Conversely, all energy use by non-resident entities within the national boundary (foreign ships, planes, trucks and tourists) should be excluded.

Consumption of energy products

155. Intermediate consumption includesthe use of all energy products by industries as inputs in a production process, regardless of the nature of the production process, i.e. whether it is a process converting an energy product into another energy product for further use in the economy (transformation), or whether it is a process which ultimately uses the energy content in the product so that no further use of the energy is possible (end-use).

156. The distinction between the amount of energy used for transformation and end-use by industries is presented in Table 3.4.1. It is noted that some end-use will relate to non-energy uses of energy products, for example the use of oil based products as lubricants or in the production of plastics. The distinction between energy and non-energy end-use is not shown in Table 3.4.1.

157. Re-injection of natural gas, as well as flaring and venting of crude oil and natural gas by the mining and extraction industries are not recorded as part of the intermediate consumption of energy products, but instead as flows of natural resource residuals (see Section 3.2). These flows are also treated as losses of energy during extraction.

158. Losses of energy products are also not recorded as intermediate consumption when the losses are related to products before a change of ownership from the producer to the user has taken place. However, if there are losses of an energy product after it has been delivered from the producer to the user of the product, the losses will be recorded as part of intermediate or final consumption of the user.

159. Final consumption refers to the consumption of households of energy products purchased or otherwise obtained from energy suppliers. All final consumption reflects the end use of energy. Final consumption includes the energy products produced by the households themselves, e.g.energy produced from fuelwood gathered by households and electricity generated by windmills for own-use by households.

160. The concepts of intermediate and final consumption of energy used in the SEEA differ from conceptof "final consumption" as defined in the IRES. In IRES final consumption relates to the total end-use of energy by industries and households. It is therefore a broader measure than final consumption in the SEEA to the extent of end-use of energy by industries.

3.4.4 Energy statistics, energy balances and energy accounts

161. Energy statistics, energy balances and energy accounts all provide information on energy supply and energy use. Energy statistics deal with collecting and compiling information on production, imports, exports and domestic use of energy products on the basis of specific surveys and by using e.g. business statistics and foreign trade statistics. Energy balances re-organise the basic statistics by confronting and consolidating the supply and use side, and by highlighting the transformation of energy within the economy. Similarly, energy accounts, can be seen as a re-organization and supplement to the energy statistics and balances, which consistently uses national accounts classifications and definitions. Both energy balances and energy accounts apply the principle that supply equals use, but the supply and use are defined in different ways in these two systems.

162. One main difference between the energy balances and the energy accounts concerns how activities are classified and the scope with respect to which activities are included (boundary). The energy accounts use the residence principle to determine whether a specific energy flow should be included, for instance, as imports and whether it is included as part of the energy use or not. The boundary of the energy balances follows the national territory.

163. Energy statistics and balances, in contrast to the energy accounts, normally include only physical data on energy. Since one of main purposes of energy accounts is to link physical and monetary data in a consistent way this leads to a different organisation of data that can be aligned with the monetary data in the national accounts.

3.4.5Energy indicators

164. Accounting for energy flows provides a useful framework for the assessment of energy production and consumption and related issues of resource use and air emissions. Many indicators can be derived from PSUT and, using the structured framework, these data can be linked to data from the economic accounts in physical and monetary terms, to derive measures of intensity and productivity in energy use. A description of these indicators is presented in Chapter 6.

3.5 Physical flow accounts for water

3.5.1 Introduction

165. Water is needed in all aspects of life. It is essential for basic human needs, for socio-economic development and for the integrity and survival of ecosystems. Water is absorbed by plants and animals, it is extracted for use in the economy, it is embodied in products and water is returned to the environment. Water can therefore figure in the physical flow accounting framework as a natural input, a product flow and as a residual.

166. This section focuses on description of a PSUT for water noting that individual components of the PSUT could be compiled separately. A PSUT for water provides information on the volumes of water exchanged between the environment and the economy – both abstraction and returns - and flows within the economy. Related accounting for emissions to water (Section 3.6) and asset accounts for water (Section 5.11) are also relevant.

167. For the purposes of water resource management the compilation of data for a river basin or other hydrologically relevant area may be appropriate. It is noted however, that while physical data may be available for such geographic areas, corresponding economic data may not be readily available.

3.5.2 Scope and definition of water flows

168. Water is in continuous movement. Solar radiation and gravity keep water moving from land and oceans to the atmosphere in the form of water vapour (evaporation and transpiration) and falling back through precipitation. The focus of the SEEA is the inland water resource system with provision for the inclusion of sea or ocean water abstracted for production and consumption (e.g. saline water for desalinization or cooling). The inland water system is composed of: (a) all inland water resources from which water is, or can be, abstracted; (b) water exchanges between water resources within the territory of reference (e.g. infiltration, runoff, percolation); and (c) water exchanges with water resources of other territories (i.e. inflows, outflows). Exchanges of water between the water resources are also referred to as natural transfers.

169. The water resources considered in the inland water resource system are rivers, lakes, artificial reservoirs, snow, ice, glaciers, groundwater and soilwater within the territory of reference and accessible seas and oceans. The main natural inputs of water for these resources are precipitation and inflows from other territories and from other resources within the territory. The main natural flows that decrease the stocks of water are evaporation, outflows to other water resources within the territory and outflows to other territories. The economic activities of production and consumption impact on the available stock of water resources through abstraction and return flows.

3.5.3 Physical supply and use table for water

170. Physical supply and use tables can be compiled at various levels of detail, depending on the required policy and analytical focus and data availability. A basic PSUT for water contains information on the supply and use of water and provides an overview of water flows. The PSUT is divided into four key sections that organize information on (a) the abstraction of water from the environment, (b) the distribution of abstracted water across industries and households, (c) the flows of wastewater and reused water and (d) water consumption and return flows of water to the environment.

171. The treatment and reuse of wastewater is separately identified showing that while these flows do not increase the overall supply of water they do redistribute water between using industries and households.

172. Table 3.5.1 shows the SEEA physical supply and use table for water. The breakdown of the economic activities, classified according to ISIC distinguishes the following groups:

- ISIC 01-03 which includes *Agriculture*, *Forestry* and *Fishing*;
- ISIC 05-33, 41-43 which includes: *Mining and quarrying*, *Manufacturing* and *Construction*;
- ISIC 35 - *Electricity, gas, steam and air conditioning supply*;
- ISIC 36 - *Water collection, treatment and supply*;
- ISIC 37 - *Sewerage*;
- ISIC 38, 39, 45-99, *Other industries*.

173. Industry classes ISIC 35, 36 and 37 are specifically identified because of their importance in the supply and use of water and provision of water-related services. ISIC 35 is a major user of water for hydroelectric power generation and cooling purposes: it abstracts and returns into the environment enormous quantities of water. ISIC 36 and 37 are the key industries for the distribution and treatment of water and wastewater.

174. The following are the relevant flows and aggregates portrayed in the PSUT.

<u>Abstraction</u>

175. Abstraction is defined as the amount of water that is removed from any source, either permanently or temporarily, in a given period of time for consumption and production activities. Water used for hydroelectric power generation, is considered as abstraction. Water abstraction is disaggregated by source and by industry.

176. Abstraction from soil waterincludes water used in rainfed agriculture. This is computed as the amount of uptake of water by plants which is either embodied in the harvested product or lost through transpiration as the crop grows.

Table 3.5.1 Physical supply and use table for water

Physical supply account for water resources

			Industry							Households	Rest of the world	Environment	Total supply
			Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Other industries (incl own account production)	Total		Imports		
Water abstraction													
	Inland water resources	Surface water											
		Groundwater											
		Soil water											
		Total											
	Other water resources	Precipitation											
		Sea water											
		Total											
	Total abstracted water												
Flows of water and wastewater within the economy													
	Water supplied to other economic units												
		By Water collection, treatment and supply											
		By Other industries											
	Retained for own use												
	Total allocation of abstracted water												
	Wastewater produced and sent for treatment												
	Reused water produced	For distribution											
		For own use											
		Total supply of wasterwater											
Return flows and water consumption													
	To inland water resources	Surface water											
		Ground water											
		Soil water											
		Total											
	To other sources												
	Total Return flows												
	Water consumption												
Total supply													

Physical use account for water resources

			Industry							Households	Rest of the world	Environment	Total use
			Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Other industries (incl own account production)	Total		Exports		
Water abstraction by industry													
	Inland water resources	Surface water											
		Groundwater											
		Soil water											
		Total											
	Other water sources	Precipitation											
		Sea water											
		Total											
	Total abstracted water												
Use of water and wastewater within the economy													
	Water received from other economic units												
		From Water collection, treatment and supply											
		From other sources											
	Retained for own use (incl undistributed water)												
	Wastewater received from other units												
	Reused water used												
	Total												
Return flows and water consumption													
	Returns of water to the environment												
		To inland water resources											
		To other sources											
	Total return flows												
	Water consumption												
Total Use													

177.

Abstraction from other sourcesincludes the abstraction of sea water and the direct collection of precipitation for production and consumption activities. Water is generally abstracted from the sea either for cooling purposes - the corresponding wastewater flow is generally returned to the original source of water (i.e. the sea or ocean) – or for desalination processes. In the latter case, desalinated water could be returned to the inland water resource and constitute a resource. A typical example of collection of precipitation is roof rain harvesting by households.

178. Water is abstracted either to be used by the same economic unit which abstracts it, (referred to as abstraction for own use), or to be supplied, possibly after some treatment, to other economic units, abstraction for distribution. Flows of water abstracted for own use are shown as being circulated in the economy. As mentioned earlier, most of the water that is abstracted for distribution is removed by ISIC 36, *Water collection, treatment and supply*; however, there may be other industries which abstract and supply water as a secondary activity.

Distribution and allocation of water

179. Within the economy, the water received from other economic units refers to the amount of water that is delivered to an industry, households or the rest of the world by another economic unit. This water is usually delivered through systems of pipes (mains), but other means of transportation are not excluded (such as artificial open channels, trucks, etc.). The use of water received from resident economic units by the rest of the world corresponds to the export of water.

180. To fully allocate the amount of abstracted water it is necessary to account for losses of water during distribution or storage. In practice, there may also be statistical differences due to poor or no metering of water flows or inconsistencies in data sources. Generally these are regarded as losses in distribution.

181. Within the economy, water can be exchanged between water producers and distributors before being effectively delivered to users. These water exchanges are referred to as intra-sectoral sales. These are the cases, for example, when the distribution network of one distributor/producer does not reach the water user and hence water must be sold to another distributor in order for the water to be delivered. These exchanges are not recorded in the PSUT as they are exchanges between units in the same industry and do not influence the total supply or use of water reflected in the accounts. Depending on the volumes of water involved it may be useful to present these intra-industry flows in a supplementary table.

182. Water can be temporarily stored in the economy, e.g. in water towers, in closed cooling or heating circuits, etc. Therefore, when comparing the situation at the beginning and end of the period, some changes in inventories may occur. However, these changes in inventories are generally assumed to be insignificant compared to the total volume of water that flowsinto and out of the economy in a period and thus they are not reported in the physical supply and use tables.

The flows of wastewater

183. The flows of water within the economy include flows of wastewater to treatment and sewerage plants, some return of that water to economic units and return flows to the environment.

184. Wastewater is water that is no longer of use. Wastewater can be discharged directly into the environment (in which case it is recorded as a return flow), supplied to a treatment facility (ISIC 37) (recorded as wastewater to Sewerage) or supplied to another industry for further use (reused water).

185. Reused water is wastewater supplied to a user for further use with or without prior treatment, excluding recycling of water within economic units. It is also commonly referred to as reclaimed wastewater.

186. Reused water excludes the recycling of water within the same establishment (on site). Information on recycled water, although potentially useful for analysis of water use efficiency, is not generally available. However, a reduction in the total volume of water used, while maintaining the same level of output, can provide an indication of an increase in water use efficiency which, in turn, may be due to the use of recycled water within an industry.

187. Once wastewater is discharged into the environment (e.g. into a river), its abstraction downstream is not considered as a reuse of water in the accounting tables, but as a new abstraction from the environment.

188. Flows of wastewater are shown as a series of flows from industries and households to sewerage facilities and the production and distribution of reused water. The net flows of wastewater for each industry and households is derived as the difference between total flows to sewerage facilities and flows of reused water to industries and households.

189. The addition of the net flows of wastewater to the allocation of abstracted water provides an estimate of the total water available for use by each industry and household.

Water use and returns to the environment

190. There are several ways to consider the use of water. In aggregate all water supplied must be returned to the environment as liquid water, evaporate, transpire, become embodied in products or consumed as drinking water by households and livestock.

191. The water that returns to the environment is measured by the concept of water returns or return flows. Total return flows can be classified according to the receiving media (i.e. water resources - as specified in the asset classification - and sea water) or by the type of water (e.g. treated water, cooling water, etc.). Return flows are shown both as outflows from industries and households and as inflows to the environment. Return flows also arise as part of natural resource residuals when water is abstracted for own use. Examples include the return flows of water following abstraction for hydropower generation and following the use of water for industrial cooling purposes.

192. In economic terms the consumption of water relates to the volume of water purchased from water suppliers and water abstracted for own use. It can be derived as the sum, for each industry and households, of water received from other economic units (including reused water) and water retained for own use.

193. In hydrological terms a different concept of consumption is applied. For water statistics, the concept of water consumption provides an estimate of the amount of water that is "lost" due to the use of water in the sense that water has entered the economy but has not returned to the inland water system or seas. This happens because during use part of the water is incorporated into products, evaporates, is transpired by plants or is consumed by households or livestock. It can be computed for each economic unit and for the whole economy as the difference between the total water abstracted for use and total return flows to the environment. For analytical purposes it may be useful to separate water consumption into those amounts due to evaporation and transpiration, those amounts incorporated into products and those amounts "lost" for other reasons.

Treatment of Losses

194. Consistent with the general treatment of losses outlined in Section 3.3 losses of water are comprised of flows of water that do not reach their intended destination or have disappeared from storage. The primary types of losses of water are losses during distribution and losses during storage.

195. Losses during distribution occur between a point of abstraction and a point of use or between points of use and reuse of water. These losses may be caused by a number of factors such as evaporation when, for example, water is distributed through open channels, and leakages when, for example, water leaks from pipes or distribution channels (including rivers in some cases) into the ground. In addition, when losses during distribution are computed as a difference between the amount of water supplied and received, they may also include errors in the meter's readings, malfunctioning meters, and the like.

196. For the derivation of aggregates in the PSUT tables losses should be recorded both by type of loss and by whether the lost water is returned to the environment. If the lost water is due to evaporation then these amounts are not considered returns to the environment and instead are considered part of water consumption (as defined in water statistics).

3.5.4 Water indicators

197. Water accounting provides a useful tool for improved water management. Many indicators can be derived from PSUT and, using the structured framework, these data can be linked to data from the economic accounts in physical and monetary terms, to derive measures of intensity and productivity of water use.

198. One of the key water indicators is water consumption as defined in this section following hydrological principles. Descriptions of other indicators that relate measure of the use of water to the stock of water resources are presented in Chapter 6.

3.6 Physical flow accounts for materials

3.6.1 Introduction

199. A third sub-system of physical flow accounting concerns materials. In contrast to energy and water materials are a far more diverse set of natural inputs, products and residuals. Consequently, although in principle a complete accounting for materials on the basis of the mass of each type of material may be accomplished, in practice accounting for materials tends to focus either on particular materials or on specific types of purposes or flows.

200. This section discusses the main areas in which development of physical flow accounting for materials has taken place – (i) product flow accounting, (ii) accounting for emissions, in particular air emissions, (iii) accounting for waste and (iv) economy wide material flow accounting (EW-MFA). In all cases the accounting systems work within the principles and structures outlined in Sections 3.2 and 3.3

3.6.2Product flow accounting

201. For the management of specific products it may be useful to trace the physical flows of an individual material from the environment, through the economy and back into the environment. At a very detailed level it is possible to trace elements such as mercury that may be of interest due to their hazardous nature. Using similar methods, nutrient balances in the soil might be traced in terms of the uptake of nutrients by crops and the embodiment of these nutrients in other products.

202. The embodiment of a specific material or product in other more complex products may make tracing the flow of an individual product difficult. Nonetheless using the framework of the PSUT showing the inputs of different products in the production of other products, it is possible to relate the flows of a specific, simpler product, to the output of products in which it is embodied. Further through the use of these input-output relationships modelled estimates of the final consumption of individual simpler products can be derived.

203. While product flow accounting may be undertaken following different accounting rules suited or tailored to an individual product, it is recommended that accounting be undertaken consistently with the boundaries and definitions outlined in section 3.2 and 3.3. If this is done it permits a much broader range of linkages and analysis.

3.6.3 Accounting for emissions

204. Section 3.2 defined emissions as a particular form of residual that are releases of materials into the air, water or soil as a result of production or consumption processes. The focus on accounting for emissions is therefore not on the complete cycle of the particular elements that comprise

emissions but rather on the flow from the economy to the environment of particular elements and substances.

205. While all emissions may be accounted for in a similar manner, the most developed accounts are those relating to air emissions. The relevant considerations in the compilation of air emission accounts are outlined here.

Air emission accounts

206. Air emissions are unwanted gaseous or particulate materials released to the atmosphereas a direct result of production, accumulation or consumption activities in the economy. The SEEA air emission account aims to record the generation of air emissions by resident economic units by type of substance.

207. Since the focus is only on the generation of residuals there is no requirement to construct a complete PSUT. Rather, emphasis is on determining an appropriate scope for the measurement of air emissions that aligns with the scope and boundaries used in the compilation of the economic accounts.

208. The SEEA air emission account is presented in Table 3.6.1. It shows the emissions to air by type of substance and by type of economic unit. Emissions from landfill sites are recorded separately as coming from landfill establishments. Emissions by households are broken down by purpose (transport, heating, other). A distinction is made between those emissions released direct to the environment and those that are captured and transferred to other economic units or stored.

Table 3.6.1 Air emissions account										
Air emissions account										
		Industry					**Household activity**			**Total**
		Waste management industries		Other industries			Transport	Heating	Other	
		Incineration	Landfill	ISIC01	ISIC 02	...				
Generation of air emissions										
Type of pollutant										
	Carbon dioxide									
	Methane									
	Dinitrogen oxide									
	Nitrous oxides									
	Hydroflourocarbons									
	Perflourocarbons									
	Sulphur hexaflouride									
	Carbon monoxide									
	Non-methane volatile organic compounds									
	Sulphur dioxide									
	Ammonia									
	Heavy metals									
	Persistent organic pollutants									
	Particles (incl PM10, dust)									
Capture, transfer and storage of air emissions by industry										
Type of pollutant										
	Carbon dioxide									
	Methane									
	Dinitrogen oxide									
	Nitrous oxides									
	Hydroflourocarbons									
	Perflourocarbons									
	Sulphur hexaflouride									
	Carbon monoxide									
	Non-methane volatile organic compounds									
	Sulphur dioxide									
	Ammonia									
	Heavy metals									
	Persistent organic pollutants									
	Particles (incl PM10, dust)									
Net air emissions to the environment										
Type of pollutant										
	Carbon dioxide									
	Methane									
	Dinitrogen oxide									
	Nitrous oxides									
	Hydroflourocarbons									
	Perflourocarbons									
	Sulphur hexaflouride									
	Carbon monoxide									
	Non-methane volatile organic compounds									
	Sulphur dioxide									
	Ammonia									
	Heavy metals									
	Persistent organic pollutants									
	Particles (incl PM10, dust)									

Economic boundary with respect to air emissions

209. Consistent with the general definition of the economic boundary using the principle of residence some air emissions will occur when economic units undertake activity in other countries. Consequently, while the majority of air emissions will be released into the national environment, some air emissions from resident economic units will be released into the environment of the rest of the world.The use of the residence principle means that air emission accounts for a nation will exclude emissions released within a national territory by non-residents such as tourists and foreign

transportation operations, whereas the emissions abroad of resident economic units will be included.

Environmental boundary with respect to air emissions

210. The nature of air emissions means that it is quite possible for air emissions released in one country to be carried through the atmosphere into the territory of another country. While these flows may be of considerable interest in understanding the state and quality of the atmosphere of a national environment, these flows are out of scope from air emission accounts as they are flows that take place within the environment.

211. Air emission accounts also do not cover the capture or embodiment of gases, particularly carbon dioxide, by the environment, for example in forests and soil.

Other scope and boundary issues

212. Included within the scope of air emissions in the air emission account are the emissions from cultivated livestock due to digestion (primarily methane). Emissions from natural processes such as unintended forest and grassland fires and human metabolic processes are excluded.

213. Secondary emissions occur when emissions from various economic processes combine in the atmosphere to create new substances. These new combinations should be considered as changes occurring in the environment and excluded from air emission accounts.

214. Flaring and venting of residual gaseous and particulate materials into the atmosphere is part of the process of extracting natural gas and crude oil. These releases are included in the air emission accounts although it is noted that they are also recorded as natural resource residuals since the relevant quantities of gas and oil are not considered to have entered the economy as products following the treatments outlined in section 3.2.

215. Emissions from manure collected and spread on agricultural land are within scope of the air emission accounts. The use of manure is considered the dissipative use of a product and following the general guidelines in section 3.2 the emissions from the manure are considered flows from the economy to the environment rather than flows within the environment.

Attribution of air emissions

216. Air emissions are released due to economic activity by industries and households. In order to permit effective linking of physical flow data to monetary data the physical flows of emissions should be classified using the same activity classifications used by the national accounts – namely ISIC for industries and COICOP for household activities.

217. This attribution is of particular relevance in the consideration of air emissions from durable goods such as cars. Air emission accounts should attribute the emissions to the nature of the activity for which the durable goods are being used rather than by the characteristics of the durable good. Thus emissions from a car used for private household transport should be classified to households while emissions from a car used for the delivery of goods by a retailer should be classified to the retail industry.

218. In addition to air emissions that are released through operation of durable goods there may also be emissions that are leaked into the atmosphere both during the operating life and after the good has been discarded. These leakages should be recorded as they occur and attributed to the owner of the good at the time of the leakage. It may be that the "ownership" of the discarded good is a landfill site in which case the leakages should be reflected as part of the overall air emissions from the landfill site.

219. Landfill sites may generate primary air emissions but may also capture these emissions to produce other outputs – for example methane captured to produce energy– thereby releasing other air emissions direct to the atmosphere that should also be recorded. All of these emissions should be attributed to the waste management industry of which the management of landfills is one activity.[6]

220. At the same time, usually emissions from solid waste in landfill sites will not relate directly to inflows of solid waste and other materials to the site during the current accounting period but instead are emissions due to the accumulation of solid waste over time. For this reason there may be analytical interest in only counting operational emissions from landfill operation and excluding emissions from solid waste in landfill sites as the emissions from solid waste cannot be directly related to broader measures of economic activity in the current period.

[6] Emissions from landfill sites will include both emissions from accumulated solid waste and emissions from equipment used to operate the site.

3.6.4Solid waste accounts

221. Solid waste accounts are useful in organising information on the generation of waste and the management of flows of solid waste to recycling facilities, to controlled landfills or directly to the environment. Measures of the volume of waste in aggregate or of quantities of specific waste materials may be important indicators of environmental pressure. The construction of solid waste accounts allows these indicators to be placed in a broader context with economic data in both physical and monetary terms.

222. The structure of a solid waste account following the logic of the broad PSUT for materials is presented in Table 3.6.2. The listing of types of solid waste in the table is based on a European classification of solid waste – EWC Stat.

223. The account highlights two key areas. First, the generation of waste of specific substances by industries and households. This solid waste must either flow directly to the environment or be collected or taken for treatment, storage or use within the economy. The account assumes that the activity of treating, storing and using solid waste is undertaken by establishments within ISIC 38 “Waste collection, treatment and disposal activities” but it is noted that this activity may be undertaken by establishments for whom this activity is undertaken as a secondary activity or as own-account production.To aid interpretation the activities within ISIC 38 may be broken down into Landfill, Incineration to generate energy, Other incineration activity and Recycling and reuse. It is noted that the activity within ISIC 38 may often be undertaken by general government units.

224. Second, the account considers flows of solid waste that are products rather than residuals following the distinction described in Section 3.2. These flows of products may be recorded in two cases. In the first case the product is identified at the time of disposal of the solid waste by the generating unit. It is a product because even though it is no longer of use to the generator, it is of value to another economic unit who is willing to both pay for the solid waste and also treat or reprocess the waste to use it in their production process. In the second case the product may be generated by the waste treatment industry through the recycling and reuse of solid waste collected from industries and households. These flows therefore do not permanently accumulate in landfill or return to the environment but re-enter the supply of products. In both cases the supply of products from solid waste is shown as being used as either intermediate consumption of businesses or final consumption of households. These flows are referred to in Table 3.6.2 as transactions in solid waste.

225. To fully account for the supply of solid waste,exports and imports of solid waste to and from the rest of the world are recorded. The total supply of solid waste also includes recovered residuals and the removal and treatment of contaminated soil or polluted water. These are residuals in the environment that are collected and captured by economic units (usually government). Examples may include removal of oil following an oil spill, the collection of debris following a natural disaster and the excavation and treatment of soil from locations at which hazardous chemicals were used.

Table 3.6.2 Solid waste account

Physical supply table for solid waste

		Industry					**Households**	**Rest of the world**	**Environment**	**Total supply**
		Waste collection, treatment and disposal industry				Other industries				
		Landfill	Incineration	Incineration to generate energy	Recycling and reuse			Imports	Recovered residuals	
Generation of solid waste										
	Chemical and healthcare waste									
	Radioactive waste									
	Metallic waste									
	Non-metallic waste									
	Discarded equipment									
	Animal and vegetable wastes									
	Mixed ordinary waste									
	Common sludge									
	Mineral waste									
	Total									
Transactions in solid waste										
Supply of products - solid waste										
	Chemical and healthcare waste									
	Radioactive waste									
	Metallic waste									
	Non-metallic waste									
	Discarded equipment									
	Animal and vegetable wastes									
	Mixed ordinary waste									
	Common sludge									
	Mineral waste									
	Total									

Physical use table for solid waste

		Industry					**Households**	**Rest of the world**	**Environment**	**Total use**
		Waste collection, treatment and disposal industry				Other industries				
		Landfill	Incineration	Incineration to generate energy	Recycling and reuse			Exports		
Collection and disposal of solid waste										
	Chemical and healthcare waste									
	Radioactive waste									
	Metallic waste									
	Non-metallic waste									
	Discarded equipment									
	Animal and vegetable wastes									
	Mixed ordinary waste									
	Common sludge									
	Mineral waste									
	Total									
Transactions in solid waste										
Use of products - solid waste										
	Chemical and healthcare waste									
	Radioactive waste									
	Metallic waste									
	Non-metallic waste									
	Discarded equipment									
	Animal and vegetable wastes									
	Mixed ordinary waste									
	Common sludge									
	Mineral waste									
	Total									

3.4.5 Economy wide Material Flow Accounts (EW-MFA)

226. The purpose of economy-wide material flow accounts (EW-MFA) is to provide an aggregate overview, in tonnes, of material inputs and outputs of an economy including inputs from the environment and output to the environment and the physical amounts of imports and exports. EW-MFA and associated balances constitute the basis from which a variety of material flow based indicators can be derived.

227. In general, EW-MFA arewell aligned with PSUTs as described in this chapter but they do not attempt to focus on the detail of physical flows, particularly as concerns flows within the economy. They generally focus on the mass of material entering the economy from the environment – natural resources and other natural inputs. With a macro-purpose in mind some practical choices on treatment have been made such that flows within the EW-MFA system can be reliably estimated. These choices are outlined below.

228. A full description of EW-MFA accounting and the associated indicators can be found in the OECD publication “Measuring Material Flows and Resource Productivity, Volume II: The Accounting Framework” (OECD, 2008)

Differences in treatment between EW-MFA and PSUT

229. International trade. EW-MFA estimates of physical flows of imports and exports are typically based on international trade data. While some adjustments are made to account for significant items such as fuel purchases abroad by resident economic units, a full adjustment of the trade data to a residence basis of recording is not attempted in EW-MFA accounts.

230. Recording of flows associated with biological resources. In EW-MFA cultivated biological resources are split into two groups – plants and animals. For cultivated crops, trees and other harvested plants, the flow from the environment to the economy is recognised at the point of harvest rather than as growth occurs. Consistent with drawing the boundary in this way, the uptake of soil nutrients and water and the inputs associated with photosynthesis are considered flows within the environment whereas in the PSUTs these flows are considered inputs from the environment to the economy (natural inputs). In effect, by recording the amount harvested rather than the individual flows the EW-MFA assumes that the harvested amounts embody all of the different natural inputs. Since the harvested amounts can be more reliably measured at an aggregate level this different boundary is appropriate for EW-MFA analysis.

231. One consequence of applying a “harvest” boundary in the EW-MFA is that flows of water for irrigation and fertiliser etc, are treated as flows from the economy to the environment whereas in the PSUTs only the amount not absorbed by cultivated plants is considered to flow to the environment. Another consequence is that an amount of natural resource residual will be recorded in EW-MFA in relation to cultivated biological resources that is not recorded in the PSUTs.

232. For cultivated livestock and fish the flows from the environment to the economy are treated in the same way in both the EW-MFA and the PSUTs. The treatment of natural biological resources, both plants and animals is also the same in both approaches in which all plants and animals are recorded as entering the economy at the point of harvest.

233. Although many ecosystem inputs are not directly recorded in the EW-MFA some ecosystem inputs are recorded concerning the respiration of livestock and the inputs consumed in combustion. They are referred to as input balancing items in EW-MFA.

234. These differences in treatment, particularly with regard to the use of the “harvest”production boundary in the EW-MFA means that the EW-MFA boundary and the SEEA boundaries are not aligned.