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Issue #2: Classification of physical flows[1]

Carl Obst
SEEA Editor

[1] This outcome paper has been prepared by the SEEA Editor. It is based on papers presented to the London Group of Experts on Environmental Accounting and discussions among those experts. Investigation and research for this outcome paper was led by Odd Andersen and Alessandra Alfieri of the UN Statistics Division.

A. Introduction

1. At the core of most environmental analysis is the study of the extraction of natural resources and other ecosystem inputs from the environment, their use and conversion within the economy and society generally and the ultimate release of materials back into the environment.

2. Because the System of Environmental and Economic Accounts (SEEA) is bringing together both environmental analysis which is generally in physical terms and economic analysis which is most commonly in monetary terms there is a need to consider very precisely the boundaries around the flows just described. If this is not done then it is likely that the recognized boundaries between the economy and the environment will differ in physical and monetary terms thus limiting the usefulness of joint analysis.

3. As well, since analysis in physical terms may be undertaken across a number of fields, for example, energy and water, comparison across these fields of research would be enhanced through the adoption of common boundaries for the physical flows.

4. Defining the boundaries around these physical flows and the associated classifications of the materials that are "flowing" has been an important part of the revision of the SEEA. This outcome paper presents the outcomes from investigations and discussions undertaken within the London Group. It is structured to present the general framework and definitions in Section B and the three relevant classifications in Sections C, D and E. Recommendations are included throughout the paper where relevant and annexes provide the detail behind the classifications that are explained in the paper.

5. It is recognized that the central nature of physical flows within the SEEA means that there are a number of dependencies between outcomes and proposals presented in this paper and the proposals made under other issues investigated during the SEEA revision process. Some of these consistency issues have been addressed but a number will need to be considered through the course of drafting the revised SEEA.

B. A framework for defining physical flows

Broad context for the discussion

6. Discussion of physical flows has been challenging due to the development over time of a range of terms which relate to very similar concepts but which may also be used in other contexts within environmental or national accounts. This section aims to provide some clear recommendations on terminology and concepts such that discussion on these issues can be well understood and to give a firm basis to the development of the relevant classifications.

7. To begin, physical flows must be considered in a broad sense to include not only tangible items and entities but also flows of energy (for example as captured in the form of useable heat). This broad context allows definition of three sub-systems of physical flow accounts, material flow accounts, water accounts and energy accounts. It is intended that the framework, definitions and classifications presented in this paper be applied consistently across these three sub-systems.

8. Some comments on the connections between these various systems are needed to provide a better context for the framework discussion.

i. 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.
ii. In material flow accounts these flows are generally measured in terms of mass (e.g. kilograms). In water accounts the unit of measurement is volume (e.g. m^3) and in energy accounts the unit of measurement is energy content, usually measured in joules.
iii. While in concept material flow accounts can include the measurement of water, generally it is excluded as the weight of water tends to dominate the resulting statistics and overshadow the weight of all other materials. Thus, while water can be considered a material it is generally considered only in the context of water accounts.

iv. In energy accounts there is consideration of flows of energy from the environment. These include energy inputs carried by physical substances, referred to as fuels and other flows such as heat from geothermal sources, solar radiation, etc., referred to as non-fuels. The first type of flows are within the scope of material flow accounts and energy, measured in kilograms and joules, the second types of flows is only within the scope of energy accounts, measured in joules.[2]

9. This context is presented in Figure 1.

Figure 1: Context for types of physical flow accounting

	Types of physical flow accounting		
	Material flow accounts (MFA)	**Water accounts**	**Energy accounts**
Materials (excl. water and fuels)	Yes (kg.)	No	No
Water	No	Yes (m^3)	No
Fuels	Yes (kg)	No	Yes (joules)
Non-fuels	No	No	Yes (joules)

A framework for recording physical flows

10. With this context in mind, and recalling that the intent is that the accounting of the flows in all of the three sub-systems be aligned, the remainder of this section develops a single framework for the consideration of the relevant flows.

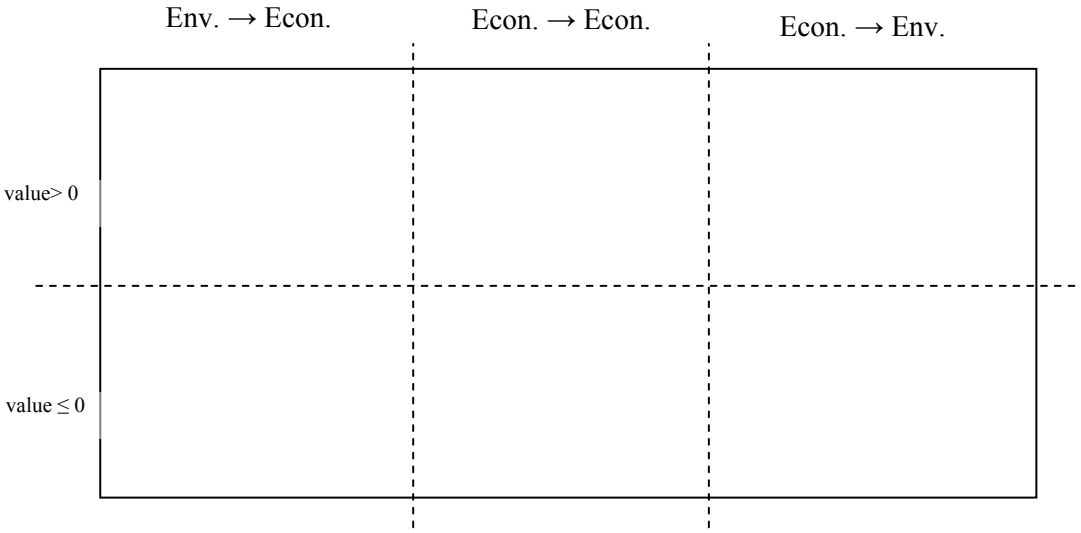
11. Since the SEEA considers the flows of materials and energy from both a physical and a monetary perspective then it is useful to characterize each flow by:

- The *source and direction* of the flow (environment → economy; intra-economy; economy → environment) and
- The *economic value* of the flow

12. These flows of materials and energy can be presented schematically as in Figure 2.

[2] For the purpose of this paper, fuels include categories A.1.1 – A.1.3 of the classification of natural inputs in Annex 1. Category A.1.3 Uranium and thorium ores is included only with the understanding that these flows are inputs in the generation of fuels and the must undergo significant transformation before being considered fuels.

Figure 2: Types of flows of materials and energy (physical flows)



13. In this figure, the columns group flows according to the *source-direction* dimension. The leftmost column represents flows from the environment into the economy, the middle column represents intra-economy flows, and the rightmost column represents flows from the economy to the environment. The rows of the diagram divide flows into those with positive and negative/zero economic value. The universe of flows is thus divided into six boxes.

14. Using this structure, terms can be applied to refer to types of materials and energy that are flowing within the structure. It is proposed to use the term "natural inputs" to refer the materials and energy that flow from the environment to the economy whether of positive or negative value. Terminology for these flows has been the most problematic to determine. In the SEEA-2003 no single term was used. Rather there is reference to both "natural resources" and "ecosystem inputs". This second term was suggested for use in the revised SEEA but is considered to potentially create confusion with the developing notions around ecosystem services. The term "natural resources" has been commonly used to refer to the entire category but this term has specific meaning in the context of the SEEA asset accounts.

15. Natural inputs are defined to include (i) resources which are incorporated into products in the economy (such as timber, crops, livestock, fish, water, mineral and energy resources); (ii) other energy inputs such as geothermal energy and solar energy; (iii) unused extraction such as soil excavated during mining operations which are natural inputs that are impacted by economic activity but are never incorporated into products; and (iv) ecosystem inputs, such as oxygen, nutrients and CO2.

16. It is noted at this stage that the precise scope of resources that are included in the definition of natural inputs is dependent upon decisions made regarding the treatment of cultivated resources such as plantation timber and livestock on farms. This is discussed at length in the next sub-section.

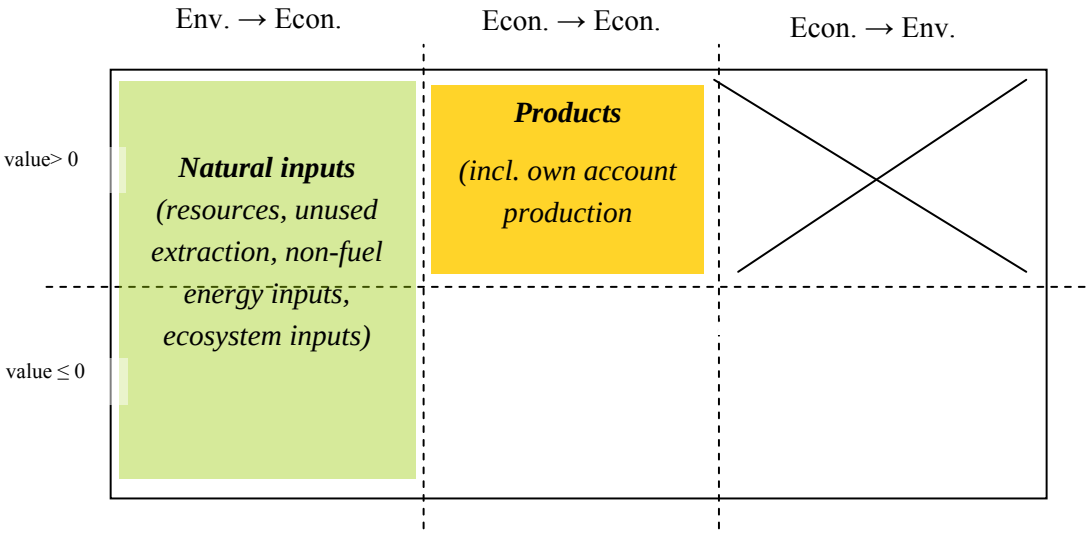
17. The term 'products' refers to all materials of positive economic value flowing inside the economy. The scope of products within the economy is generally limited to only those with positive monetary values in order to maintain a correspondence with the monetary accounts. However, it is recognized that there are some flows of materials that are used as part of own account production which are not recognized by monetary transactions in a national accounts context. For example, flows of processed iron ore within a steel making enterprise would not be recorded as monetary transactions but these should be regarded as flows of products since a meaningful price could be imputed in such situations and would be recorded in the national accounts if the processed iron ore was sold to a separate manufacturing business.

18. All materials of zero or negative value circulating within the economy or flowing from the economy to the environment are referred to as 'residuals'. The exact definition of residuals agreed upon by the London Group reads "discarded or emitted materials with no monetary value". This involves both intra-economy flows and flows from the economy to the environment. There are a number of different types of residuals including waste, wastewater, emissions, unused extraction and return flows. These different types of residuals are considered in more detail later in this section and in Section E.

19. It is noted that in the physical flow accounts of the SEEA-2003, the concept of 'residual' is somewhat different than how it is defined here. In the SEEA-2003, residuals are described as "*incidental and undesired outputs from the economy that have a value of zero (or a negative) to the generator.*[3]" It is further acknowledged that "*residuals may have a positive value for a unit other than the generator […]*[4]*".* Similar to the proposal of the present paper, residual flows in the SEEA-2003 can take place within the economy as well as from the economy to the environment. An important difference is however that in the SEEA-2003, residuals may have a positive economic value, as long as this value relates to someone else than the generator.

20. Using these terms and definitions the boxes from Figure 2 can be labelled as done in Figure 3.

Figure 3: Broad types of materials by type of flow.



21. The upper-right box (flows of positive value from the economy to the environment) is not covered by any of these three definitions. It is assumed that these flows do not exist for the purposes of this framework. If materials of positive value move from the economy to the environment, they would do so by first becoming residuals inside the economy and subsequently move to the environment in the form of residuals. One example of this would be *dissipative use of products*, such as fertilizers. Fertilizers would be recorded as flows within the economy and become residuals after they are spread into the field. They may subsequently flow into the environment.

22. Finally, it is noted that the overall framework presented in this paper only distinguishes between flows from the environment to the economy, flows within the economy and flows from the economy to the environment. Flows between the national economy and other economies (e.g. imports and

[3] SEEA 2003, p. 3.38

[4] Ibid.

exports) are considered to be intra-economy flows and are therefore classified according to the classification of products proposed later in this paper.

Recommendation 2.1: That in the revised SEEA natural inputs should be defined as comprising materials and energy inputs that flow from the environment to the economy comprising resources, unused extraction, energy inputs and ecosystem inputs.

Recommendation 2.2: That in the revised SEEA products should be defined as comprising materials and energy inputs that flow within the economy, including flows related to own account production, and which have positive economic value.

Recommendation 2.3: That in the revised SEEA residuals should be defined as comprising materials and energy (primarily in the form of residual heat) that flow either within the economy or from the economy to the environment and are discarded or emitted materials with no monetary value.

The harvest approach

23. A fundamental issue in applying and interpreting this framework concerns the description of the boundary between the environment and the economy. Where natural inputs are understood as being purely extracted from the environment (such as the mining of coal) this boundary seems quite clear. However, where there is a reasonable degree of economic intervention in the growth and condition of the natural inputs (for example in the cultivation of plantation forests) it is less clear where the environment stops and the economy starts. It is certainly the case that forests grow through natural processes but to varying degrees this process can be managed such that the growth in the forest might also be regarded as an economic production process.

24. There are two basic approaches for drawing the line between the environment and the economy. Under the first approach, known generally as the harvest approach, resources are shown as entering the economy (becoming products) at the time the resources are harvested and the natural growth is stopped. The corollary of this is that flows of products that are part of the cultivation process (such as fertilizers and pesticides) are recorded as used within the economy by agriculture and then returned in full to the environment. The benefit of the use of these products is subsequently reflected in the growth in the natural input noting that the amount absorbed is likely to be less than the initial flows to the environment.

25. The second approach, referred to here as the ecosystem approach, considers that in cases where there is active cultivation of resources, then the resources should be considered products within the economy even as they are growing – i.e. the growth is internal to the economy. Thus inputs such as fertilizer are shown as flows within the economy and only the residual amounts left in the environment are shown as flowing to the environment. The growth in the cultivated resources under the ecosystem approach is not considered part of natural inputs. The only natural inputs that are recorded are the ecosystem inputs (oxygen, soil nutrients, etc) that are absorbed by the resources during the cultivation process.

26. Making a single choice between these two approaches for all aspects of physical flow accounting is not straightforward as cultivation processes for the same type of resource vary greatly across countries and the information of interest tends to vary by type of resource and by extent of cultivation. For example, for livestock, if intensive agricultural practices are common in a country then the ecosystem approach which regards the cultivation process as quite mechanistic might well be the most appropriate. But where raising livestock involves large scale ranching and infrequent contact with the animals, then precise recording of other natural inputs such as oxygen and soil nutrients seems irrelevant.

27. One implication of the harvest approach is that certain flows that may be of interest in environmental accounting may be treated as flows within the environment and hence out of scope of the accounts. For example, natural emissions from livestock (e.g. methane, excreta) would not be

recorded while under the ecosystem approach these flows would be recorded as flows from the economy to the environment.

28. It is also noted that under the harvest approach it is necessary to record as natural inputs both the resource that becomes a product (for example wood from cultivated forests) and the unused material that subsequently remains in the environment (forest residue which is also recorded as a residual). Under the ecosystem approach, since all of the growth is regarded as a flow within the economy there are no natural inputs of wood or unused material and there is simply a residual flow to the environment of the forest residue.

29. In considering the two approaches an important boundary issue concerns the distinction between cultivated and non-cultivated resources. This is a distinction defined in the System of National Account (SNA) and concerns the extent to which the growth of the resources are controlled and managed by economic units. In situations where there is little control or management the resources are defined as non-cultivated. In the SNA the same logic applies to mineral and energy resources and water resources which are regarded as non-produced. In all of these cases the treatment within the physical flows is the harvest approach since by construction there is no productive activity within the economy that is leading to the growth in the resource.

30. Within the scope of cultivated resources different distinctions are applied in different physical flow accounting situations. It is possible to apply the harvest approach to all cultivated resources – trees, crops, livestock and fish – an approach commonly referred to as the extended harvest approach. It is also possible to apply different approaches to different resources – the common boundary drawn is to treat trees and crops using the harvest approach and livestock and fish using the ecosystem approach.

31. An alternative is to apply different approaches to different types of cultivation. Thus for situations where the cultivation process is relatively natural (e.g. broad acre cattle farming) the harvest approach would be applied and in situations where the cultivation process is intensive (e.g. market gardening) the ecosystem approach would be applied. One benefit of this approach is that it takes into consideration that the same type of resource may be cultivated in different ways in different countries.

32. The choice has been discussed as well in the context of the relationship between the SEEA concepts and the definitions underlying a separate body of work on material flow accounts titled Economy Wide – Material Flow Accounts (EW-MFA). SEEA Revision #1: Harmonization of MFA with SEEA concepts examines this issue in more depth. In short the EW-MFA applies two treatments and it seems unlikely that the SEEA can align fully with the EW-MFA. Nonetheless, the paper explains in more detail the harvest approach and suggests a way forward for SEEA that requires making a distinction in terms of the extent of cultivation as just discussed. However, while this conclusion may work well for material flow accounts purposes it may not be appropriate for all physical flow accounting purposes such as water accounting or emission accounting.

33. On balance no recommendation regarding the use of the harvest approach or the ecosystem approach is made at this stage in the context of overall physical flow accounting. A specific recommendation is made in relation to material flow accounts in SEEA Revision Issue #1: Harmonization of MFA with SEEA concepts. A question is posed in this paper seeking feedback from countries on this issue.

34. It is noted that since the harvest approach must be used when the resources are non-cultivated and since it is likely that some forms of cultivation are so intensive that the ecosystem approach is the only meaningful choice (e.g. greenhouse cultivation), the classification of natural inputs will need to be flexible to deal with both potential treatments. At an individual country level country specific choices might be made however, since the choice of boundary can significantly affect the size of recorded flows. International comparability requirements mean that a clear decision needs to be reflected in the revised SEEA.

Question 2.4: Do you have comments on the choice of either the harvest approach or the ecosystem approach to the recording of flows associated with cultivated resources for the general purposes of physical flow accounting in the SEEA?

Waste, wastewater, emissions and return flows

35. There are other flows of materials not made explicit by the framework outlined above that are commonly discussed and measured in the context of physical flow accounting. These flows are grouped based on more specific criteria than used in the framework above but are still within its scope. Generally, but not exclusively, they concern the definition of flows of materials from the economy to the environment.

36. Waste, by which is meant solid waste as distinct from wastewater, is an important environmental indicator and needs a clear definition in the revised SEEA. The following definition is proposed

> ***Waste*** *consists of products and residuals that meet one or more of the following conditions:*
>
> *It is collected by, or delivered to, a waste collection scheme*
>
> *It is discarded and not reused, and requires treatment before return to the environment*
>
> *It is to be reused, but in need of treatment before re-use*

37. According to this definition, waste may circulate within the economy, or be directed from the economy to the environment. Also, waste may have positive, zero or negative value. The definition of waste spans over products and residuals as defined earlier.

38. The most difficult issue in the definition of waste concerns the application of the term "require treatment" under the second condition in the definition above. The phrasing is such that the material may be defined as waste whether or not treatment actually takes place. However, whether the material requires treatment may be a function of legal, social or ecological opinion and may not be easily determined. The intended sense is that if the direct disposal of the material into the environment is considered to have no adverse environmental effect then it should not be considered waste.

39. This intended sense has two other implications. First, the definition includes within scope illegal dumping of rubbish and unwanted materials since it is assumed that their disposal in the environment would have an adverse environmental effect. Second, the definition also implicitly includes *emissions to soil* (e.g. spill of chemical on land) since these are solid wastes emitted to the soil that have an adverse effect on the environment. Thus in the development of the classification there is no separate specification of emissions to soil distinct from waste in general, since drawing the boundary line between these flows and waste by type of material was not considered possible.

40. The direct flows to the environment that are not considered harmful are considered *return flows*. The most common return flows refer to water since there are few products that can be easily absorbed without adverse environmental effect.

41. The present paper proposes a definition of 'wastewater' as follows:

> ***Wastewater*** *consists of water that meets one or several of the following conditions:*
>
> *It has been discharged into drains or sewers, regardless of quality*
>
> *It is destined to be returned to the environment after required treatment*
>
> *It has been supplied from one economic unit to another, and requires treatment before being used by the receiving unit.*

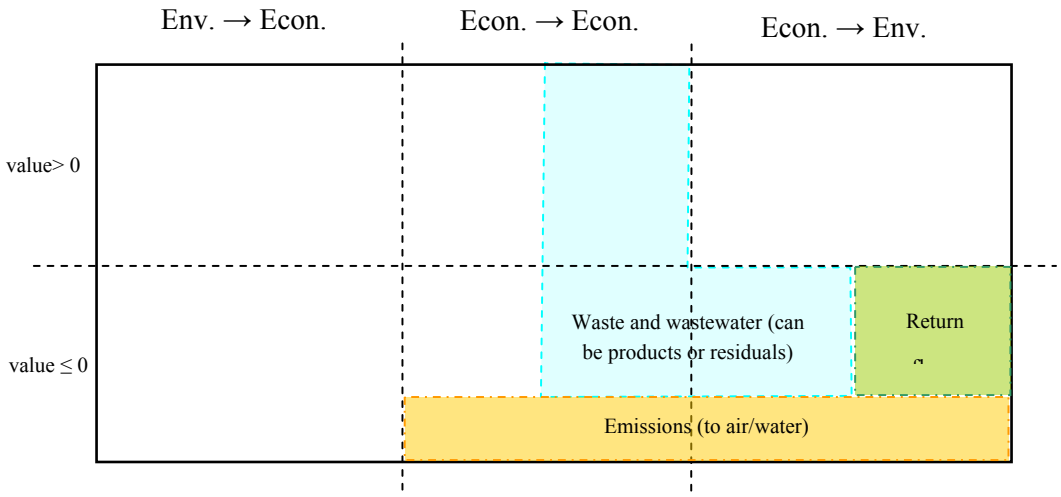
42. The definition of wastewater is intended to align directly with the definition of waste given above. The matter of "requires treatment" again arises and may well be considered more significant in this case since the volumes of water that are released to the environment necessitate careful delineation between wastewater and return flows of water.

43. *Emissions to air* are gaseous or particulate materials released into the atmosphere from production or consumption processes in the economy. An exception is made for water vapour which is not considered to be an emission.

44. E*missions to water* refer to pollutants added to and carried by water as a result of production and consumption processes in the economy.

45. In the diagram below (Figure 4), the relationships between *waste and wastewater*, *emissions* and *return flows* have been placed within the general framework and color-coded with light-blue, orange and green, respectively. It is noted that the bottom right hand box in this figure also includes, from a conceptual perspective, residuals resulting from dissipative use of products (e.g. fertilizers), dissipative losses (e.g. abrasion from tires), and unused extraction of materials.

Figure 4: Waste, wastewater, emissions and return flows



Recommendation 2.5: That the revised SEEA should apply the definitions of waste, wastewater, emissions and return flows as presented in the outcome paper in paragraphs 36 – 44.

C. Classification of natural inputs

The proposed classification

46. The proposed classification of natural inputs, presented in Annex 1, is intended to cover all materials and non-fuel energy inputs that cross the boundary between the environment and the economy.

47. The proposed classification has been developed using Central Product Classification (CPC) categories as building blocks (with some additional distinctions and exclusions). The compatibility with CPC has largely been preserved. The primary areas of difference from CPC concern further disaggregations of water and crude oil and additions of some items not covered by CPC such as non-fuel energy inputs. These issues are discussed separately below.

Disaggregation for water

48. The proposed classification disaggregates the category water abstraction into sub-categories that are aligned with the SEEA-Water asset classification, and thus differentiates between type of surface

water (artificial reservoirs, lakes, rivers and glaciers), groundwater and soil water. Sea water has also been added as a separate category.

Disaggregation for crude oil

49. The categories for crude oil have been slightly modified. The CPC class 1201 crude petroleum oils covers both conventional crude oil and non-conventional crude oils (e.g. oil produced from the processing of oil shale). In the proposed classification this class has been restricted to cover only conventional crude oil. It is straightforward to regard conventional crude oil as an inflow from the environment to the economy[5].

50. The case is more ambiguous for non-conventional crude oils, as they may be extracted directly from the mining site[6] (in-situ processing), but are also frequently produced off-site by the processing of already excavated materials[7] (ex-situ). Therefore, non-conventional crude oils may sometimes be best interpreted as flowing from the environment to the economy, whereas in other cases they are better understood as being involved in intra-economy flows: processed products obtained from raw materials already accounted for as having entered the economy.

51. For the present proposal, it was decided to separate non-conventional crude oils in the classification. Thus for in-situ extraction situations the natural input that should be recorded is non-conventional crude oil but for ex-situ extraction the natural input that should be recorded is the resource from which the oil is typically extracted (e.g. oil shale, tar sands) which are also separately identified in the classification.

52. An important classification with regard to energy products is the Standard International Energy Classification (SIEC) that is being developed as part of the International Recommendations on Energy Statistics (IRES). A preliminary draft of SIEC is presented in Annex 3. To assist in understanding the links between SIEC and the proposed classification of natural inputs it is noted that the draft SIEC does differentiate between conventional and non-conventional crude oil and hence the proposed change to CPC class 1201 does not hinder correspondence with the SIEC. It is also noted that all categories of fossil fuel in the proposed classification of natural inputs can be directly linked with SIEC.

Non-fuel energy inputs

53. A full range of non-fuel energy input categories have been incorporated into the classification of natural inputs such that full energy accounting can be accommodated. The categories are intended to align with work recently undertaken by InterEnerStat[8] in the context of developing harmonized definitions for use in energy statistics.

Unused extraction

[5] This oil exists in the liquid phase under normal surface temperature and pressure, and usually flows to the surface under the pressure of the reservoir. ("conventional" extraction).

[6] Examples include oils extracted from reservoirs containing extra heavy oils or oil sands, and which need on-site heating or treatment before extraction.

[7] Examples include non-conventional oil produced from ex-situ processing of oil shale or oils produced by the transformation of natural gas.

[8] Initiative undertaken by 24 major regional and international organizations collecting or using energy statistics. See: http://www.iea.org/interenerstat_v2/index.asp

54. Unused extraction is generated when extracting natural resources, and have in common that they are not fit or intended for economic use, they do not enter the waste collection system and they are usually left behind at the site of production.

55. Some important examples of unused extraction are:

- Mining overburden
- Unused materials generated by construction works
- Residues from cultivation of crops and trees
- Residues from extraction of non-cultivated biological resources (e.g. by-catch of fishing)

56. It is proposed that flows of unused extraction be considered flows that enter and then immediately exit the economy. As such, unused extraction needs to be included both in the classification of natural inputs as well as in the classification of residuals.

57. One defining characteristic of unused extraction is that it does not pass through a waste collection scheme. If this were the case, it would be considered *waste*. Category B.6 and B.7 (which are expected to be treated or collected by a waste collection scheme) are therefore different from categories D.3 and D.4, although the headings of the categories are similar.

Biological resources

58. For biological resources, the proposed classification does not make a distinction between cultivated and non-cultivated resources. It may be that this distinction would be useful depending on the outcomes of discussion on the adoption of the harvest approach or the ecosystem approach to recording cultivated resources as mentioned earlier in the paper.

59. It is also noted that the CPC classes do not always make a sufficiently explicit distinction in the classification regarding the degree of processing that occurs at the time of extracting biological resources. Thus, notes have been added to the proposed classification to recognize that the scope of natural inputs excludes any degree of processing, for example the freezing of fish caught at sea.

Metal ores

60. For metal ores, the categories in the proposed classification have a narrower scope than the CPC categories to which they are linked. The CPC categories not only includes *ore* (in the state extracted from the mine), but also *concentrates* (ores which have had part or all of the foreign matter removed by special treatment). Concentrates are the result of a production process (the treatment to remove foreign matter from the ore) and as such they are considered flows within the economy. Concentrates have therefore been excluded from the categories in the proposed classification[9].

Other issues of scope and classification

61. Some parts of the proposed classification are not included in CPC at all. This is the case for

A.0.1.10 – Grazed biomass
B (all subcategories) – Ecosystem inputs
C (all subcategories) – Non-fuel energy inputs
D (all subcategories) – Unused extraction

62. Finally, it is mentioned that since all the categories of the proposed classification are intended to represent materials flowing from the environment to the economy (not inside the economy), one should expect that the corresponding CPC categories would be linked with ISIC Rev.4 industries that

[9] A similar situation happens for coal and lignite, where the proposed classification excludes agglomerated coal/lignite, although the corresponding CPC classes include them. In this case, however, the lowest-level categories of both classifications remain fully compatible.

are either within ISIC Section A – "Agriculture, forestry and fishing" or Section B – "Mining and quarrying". Generally, this is the case, but there are a few exceptions:

> Category A.0.2.2 – "*Raw milk, eggs and other animal resources (excluding meat)*" of the proposed classification contain several items that would be output of manufacturing industries, according to the linking table between CPC and ISIC Rev.4[10].
>
> Water is considered to be output of ISIC Rev.4 industry 3600 – "Water collection, treatment and supply".

Recommendation 2.6: That, in the revised SEEA natural inputs should be classified following the classification described in Section C of the outcome paper and presented in Annex 1.

D. Classification of products

63. With a view of having one single product classification to be used both for material flow accounts and energy accounting, consideration was given to combining two classifications, CPC and SIEC, into a new hybrid one, based on SIEC for energy products and CPC for all other products. However this did not prove to be possible.

64. One question relates to how the aggregations of the new classification would be defined. The hierarchies of CPC and SIEC are obviously different. If the CPC hierarchy had been defined in such a way that the whole scope of SIEC neatly fit below one of its higher-level categories, one could simply replace the lower-level categories with those of SIEC. However, this is not possible; the hierarchies of the two classifications are not compatible. For example, CPC Division 17[11] is partially covered by three different SIEC sections[12], and with one of its Groups not covered by SIEC at all[13].

65. Thus, any proposed combination of CPC and SIEC would have to abandon the hierarchy of one of the classifications. The hierarchy to abandon would naturally be that of SIEC, since energy products are only a small part of the whole range of products covered by CPC. However, this is not practical either, for the following reasons.

66. The key issue is the large number of multiple and partial links between the two classifications. Many CPC subclasses are partially, but not completely covered by SIEC categories. Such subclasses would therefore have to be further split up if the relevant parts were to be replaced, leading to a more complicated classification. Although this problem occurs in most areas of SIEC, the situation is particularly serious for biofuels and waste. On the other hand, some SIEC subclasses would have to be further subdivided as well, in order to create categories that lie neatly within the higher-order aggregations of CPC[14].

67. As well, SIEC only covers products that are used or intended to be used for energy purposes. Thus, waste, agricultural crops and other biomass is covered by SIEC when used for energy production[15], but not otherwise. CPC, on the other hand, generally makes no distinction according to end use. In a combined classification, the CPC categories for these products could not be removed,

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[10] Examples of such products: *raw hides and skins, insect waxes* and *spermaceti*.

[11] CPC Division 17 – "Electricity, town gas, steam and hot water"

[12] SIEC Section 1 – "Solid fossil fuels and derived products", SIEC Section 5 – "Electricity" and SIEC Section 6 – "Heat".

[13] Group 173 – "Ice and Snow".

[14] Examples of SIEC categories with scopes that cut across CPC Divisions include:

- 1.1.3.8.0 – "Other coal products n.e.s." (links with CPC Division 33 *and* 34)
- 1.2.2.2.0 – "Peat products n.e.s." (links with CPC Division 11 *and* 33)
- 2.2.5.0.0 – "Other hydrocarbons" (links with CPC Division 12 *and* 34)
- 2.2.6.12.0 – "Petroleum coke" (links with CPC Division 33 *and* 34)
-

[15] E.g. combustion at a waste incineration facility with associated generation of electricity and/or heat.

but their scope would have to be redefined based on an end-use criteria that is used nowhere else in the classification.

68. Finally on the issue of classification of products in the SEEA, as recognized in the discussion defining waste, some waste flows circulating within the economy are associated with a positive value. In line with the framework proposed here, such flows should therefore be classified using CPC and SIEC rather than by using the classification of residuals presented in Section E and Annex 2.

69. However, it is important to be aware that this leads to a very different treatment in the classification of waste depending on whether it has positive value or not. The classification of residuals (used for waste with negative value) has solid waste categories based on EWC-STAT. CPC, on the other hand, treats waste differently. Whereas CPC does have a division for wastes and scraps (Division 39), its structure is not comparable to EWC-STAT. Moreover, many types of specific waste are found in classes outside Division 39, typically together with non-waste products with which they are associated[16].

70. The lack of a single classification is a significant issue for the construction of energy accounts. The difficulty is that SIEC would be the standard for classifying physical flows of energy but monetary data from the national accounts are not compiled following this classification, rather the CPC is used. Consequently, in this area a choice to have both classifications means that the key objective of SEEA of integrating physical and monetary data cannot be directly achieved. The views of countries are sought regarding this difficulty.

Recommendation 2.7: That in the revised SEEA products (defined as comprising material inputs which have positive economic value) should be classified according to CPC for material flow accounts.

Question 2.8: Do you have views and suggestions on the classification for use for energy modules in energy accounts considering that it is not possible to develop a correspondence between SIEC and CPC?

Recommendation 2.9: That CPC should be used to classify waste that has a positive value and EWC-Stat should be used to classify waste that has a negative value.

E. Classification of residuals

71. The proposed classification of residuals, presented in Annex 2, is intended to cover all flows of zero or negative value that either circulate within the economy or are directed from the economy to the environment (middle and right lower box in Figure 2). As can be seen in Figure 3, residuals cover a wide range of flows including all *emissions* and *return flows*, all *waste of zero or negative value*, as well as all *other flows of zero or negative value within the economy*. The proposed classification has eight top-level categories.

72. Category A covers solid waste. This category is intended for all materials that fit our proposed definition of waste[17] while also being of zero or negative value. Its sub-categories are identical to those found in EWC-Stat, with an additional category A.14 for radioactive waste (which is outside the scope of EWC-Stat). It should be noted that in general, emissions to soil would be covered within this category, whereas emissions to air and water are found in Category C and D (see below).

73. Category B covers wastewater. This is water that is of no further immediate use to the generator, and which needs to be treated before re-use or lawful release into the environment. This category should be limited to water defined as wastewater whereas all other returned water are considered return flows, and found under top-level category F.

[16] Some examples: waste of natural textile fibres classified together with the textile fibres themselves; waste and scrap of glass classified together with unworked glass.

[17] in our framework, waste of positive value is considered a product to be classified by CPC v2.

74. The next two categories, C and D concern emissions to air and water. To avoid double counting, it is important to be precise about the scope of these categories. The nitrogen and phosphorous compounds of category D.1 and D.2 explicitly exclude emissions from agriculture, as these would be considered as resulting from dissipative use of products and hence classified separately (in category E). On the other hand, some of the emission categories explicitly make reference to dissipative use (C.3.1, C.9.2). In these cases, the dissipative uses are not related to agriculture, but rather to the use of these substances as products outside of agriculture (e.g. solvents, narcosis).

75. Category C classifies emissions to air. It has 14 sub-categories representing different physical substances. These categories are aligned with the terminology used in IPCC[18] and CORINAIR[19]. Three of these categories (C.1 – carbon dioxide, C.3 – dinitrogen oxide, and C.9 – non-methane volatile organic compounds) are further broken down according to origin.

76. Category D classifies emissions to water. The categories are identical to those found in the Eurostat EW-MFA questionnaire, with the exclusion of *materials dumped at sea*, which in our framework are not considered emissions but waste.

77. Category E covers residuals resulting from the dissipative use of products, other than those already covered by category D.

78. Category F represents *dissipative losses*, i.e. unintentional outputs of materials to the environment resulting from abrasion, corrosion and erosion at mobile and stationary sources, and from leakages or from accidents during transportation of goods.

79. Category G covers water returned to the environment, other than waste water. This includes not only evaporated water and water losses, but *all* return flows of water other than wastewater.

80. Category H covers residual heat lost through energy transformation processes.

81. Category I covers unused materials. As discussed in Section C these are materials that can be considered as entering and then immediately exiting the economy. As such, they need to be accounted for both on the inflow and outflow side. Category I thus exactly mirrors Category C of the proposed classification of natural materials[20].

Recommendation 2.10: That in the revised SEEA residuals should be classified following the classification described in Section E of the outcome paper and presented in Annex 2.

[18] Intergovernmental Panel on Climate Change.

[19] Core inventory of air emissions, by the European Environment Agency. Inventory compiled under the UNECE convention on long range trans-boundary air pollutants (LRTAP).

[20] Useful clarification: *unpolluted dredging spoils* are in our framework considered to be unused materials and classified under G. On the other hand, *contaminated dredging spoils* are considered waste, and classified under A.

Annex 1: Classification of natural inputs

CODE	DESCRIPTION	CPC equiv.
A	**Natural resources and cultivated resources**	0 + 1
A.0	**Biological resources from agriculture, forestry and fishery**	0
A.0.1	**Resources from agriculture, horticulture and market gardening**	01
A.0.1.10	Grazed biomass	n.a.
A.0.2	**Live animals and animal resources (excluding meat)**	02
A.0.2.1	Live animals	021
A.0.2.2	Raw milk, eggs and other animal resources (excluding meat)	022-029
A.0.3	**Forestry resources**	03
A.0.3.1	Wood in the rough	031
A.0.3.2	Non-wood forest resources	032
A.0.4	**Fish and other fishing resources (excluding processed fish)**	04
A.1	**Ores and minerals, water**	1 (excl.17)
A.1.1	**Coal and lignite, peat (excl. agglomerated coal and lignite)**	11 (excl. 1102, 1104)
A.1.1.1	Coal, not agglomerated	1101
A.1.1.3	Lignite, not agglomerated	1103
A.1.1.5	Peat	1105
A.1.2	**Crude oil, natural gas, oil shale and tar sands**	12
A.1.2.1	Conventional crude oil and natural gas	120 ex
A.1.2.1.1	Conventional crude oil (incl. natural gas liquids)	1201ex
A.1.2.1.2	Natural gas	1202
A.1.2.2	Non-conventional crude oil and gas	
A.1.2.3	Bituminous or oil shale and tar sands	1203
A.1.3	**Uranium and thorium ores (excl. concentrates)**	13ex
A.1.4	**Metal ores (excl. concentrates)**	14 ex
A.1.4.1	Iron ores, other than roasted iron pyrites (excl. concentrates)	141 ex
A.1.4.2	Non-ferrous metal ores (other than uranium or thorium ores), excl. concentrates	142 ex
A.1.4.2.1	Copper ores (excl. concentrates)	1421 ex
A.1.4.2.2	Nickel ores (excl. concentrates)	1422 ex
A.1.4.2.3	Aluminium ores (excl. concentrates)	1423 ex
A.1.4.2.4	Precious metal ores (excl. concentrates)	1424 ex
A.1.4.2.9	Other non-ferreous metal ores (other than uranium or thorium ores), excl. concentrates	1429 ex
A.1.5	**Stone, sand and clay**	15
A.1.5.1	Monumental or building stone	151
A.1.5.2	Gypsium; andrythe; limestone flux; limestone and other calareousstomne, of kind used for the manufacture of lime or cement	152
A.1.5.3	Sands, pebbles, gravel, broken or crushed stone, natural bitumen and asphalt	153
A.1.5.4	Clays	154
A.1.6	**Other minerals**	16
A.1.6.1	Chemical and fertilizer minerals	161
A.1.6.2	Salt and pure soduim chloride~~;~~	162
A.1.6.3	Precious and semi precious stones; pumice stone; emery; natural abrasives; other minerals	163
A.1.8	**Water resources**	18, 174
A.1.8.1	Surface water	18
A.1.8.1.1	Water from artificial reservoirs	18
A.1.8.1.2	Water from lakes	18
A.1.8.1.3	Water from rivers and streams	18
A.1.8.1.4	Water from glaciers, snow and ice	18

A.1.8.2	Groundwater	18
A.1.8.3	Soil water	18
A.1.8.4	Sea water	162 ex
B	**Ecosystem inputs**	n.a.
B.1	Oxygen	n.a.
B.1.1	Oxygen for combustion processes	n.a.
B.1.2	Oxygen for respiration	n.a.
B.1.2.1	Oxygen for respiration of cultivated animals and aquatic resources	n.a.
B.1.2.2	Oxygen for human respiration	n.a.
B.2	Nitrogen	
B.2.1	Nitrogen for Haber-Boschprocess	n.a.
B.2.2	Nitrogen for emissions from combustion	n.a.
B.3	Air for other industrial processes (liquefied tehcnical gases, polymerization, etc.)	n.a.
B.4	Carbon dioxide for respiration of cultivated crops, plants, and trees	n.a.
B.5	Soil minerals	n.a.
B.6	Unused biomass from parks and gardening for waste collection	n.a.
B.7	Contaminated soils and polluted dredging spoils	n.a.
C	**Non-fuel energy inputs**	n.a.
C.1	Solar energy	n.a.
C.1.1	Photovoltaic solar energy	n.a.
C.1.2	Thermal solar energy	n.a.
C.2	Hydro energy	n.a.
C.3	Marine energy	n.a.
C.3.1	Wave energy	n.a.
C.3.2	Tidal energy	n.a.
C.3.3	Other marine energy	n.a.
C.4	Geothermal energy	n.a.
C.5	Other heat (including energy from heat pumps)	n.a.
D	**Unused extraction**	n.a.
D.1	Unused extraction from mining and quarrying of fossil fuels	n.a.
D.2	Unused extraction from mining and quarrying of minerals	n.a.
D.3	Unused biomass from harvest	n.a.
D.3.1	Wood harvesting losses	n.a.
D.3.2	Agricultural harvesting losses	n.a.
D.3.3	Other unused biomass from harvest (including by-catch, etc.)	n.a.
D.4	Soil excavation and dredging	n.a.
D.4.1	Excavation for construction activities	n.a.
D4.2	Dredging materials	n.a.

Annex 2 – Proposed classification of residuals

MFA Code	EWC-Stat code	CPC Ver.2	Description
A		**39**	**Solid waste**
A.1	01	3994, 3999ex	Compound waste
A.2	02	3995ex	Chemical preparation waste
A.3	03	3995ex	Other chemical waste
A.5	05	3993	Health care and biological waste
A.6	06	3931-3936	Metallic wastes
A.7	07	392	Non-metallic waste
A.8	08	3937, 3938	Discarded equipment
A.9	09	391, 3999ex	Animal and vegetable wastes
A.10	10	3991. 3999ex	Mixed ordinary waste
A.11	11	3992	Common sludges
A.12	12	3999ex	Mineral waste
A.13	13	3999ex	Solidified, stabilized and vitrified waste
A.14	n.a	3999ex	Radioactive waste
B.			**Waste water**
C			**Emissions to air**
C.1			**Carbon dioxide (CO2)**
C.1.1			Carbon dioxide (CO2) other than from biomass combustion and respiration of humans and livestock
C.1.2			Carbon dioxide (CO2) from biomass combustion
C.1.3			Carbon dioxide (CO2) from respiration of humans (balancing item input side)
C.1.4			Carbon dioxide (CO2) from respiration of livestock (balancing item input side)
C.2			**Methane (CH4)**
C.3			**Dinitrogen oxide (N2O)**
C.3.1			Dinitrogen oxide (N2O) other than from dissipative use as a product
C.3.2			Dinitrogen oxide (N2O) from dissipative use as a product
C.4			**Nitrous oxides (NOx)**
C.5			**Hydrofluorocarbons (HFCs)**
C.6			**Perfluorocarbons (PFCs)**
C.7			**Sulphur Hexafluoride**
C.8			**Carbon monoxide (CO)**
C.9			**Non-methane volatile organic compounds (NMVOC)**
C.9.1			Non-methane volatile organic compounds (NMVOC) other than from dissipative use as a product
C.9.2			Non-methane volatile organic compounds (NMVOC) from dissipative use as a product
C.10			**Sulfur dioxide (SO2)**
C.11			**Ammonia (NH3)**
C.12			**Heavy metals**
C.13			**Persistent organic pollutants (POPs)**
C.14			**Particles (e.g. PM10, dust)**
D			**Emissions to water**

D.1			Nitrogen compounds (N), excl. emissions from agriculture (dissipative use)
D.2			Phosphorous compounds (P), excl. emissions from agriculture..
D.3			Heavy metals
D.4			Other substances and (organic) compounds
E			**Residuals resulting from dissipative use of products, n.e.c.**
E.1	09.3	34654ex 3461 - 3465 (excl	Organic fertilizer (manure)
E.2		34654)	Mineral fertilizer
E.3	11.1 09.2	39920	Sewage sludge
E.4	ex		Compost
E.5		3466	Pesticides
E.6			Seeds
E.6,1		01111, 01121, 01131, 01141, 01151, 01161, 01171, 01181,	Seed of cereals
E.6.2		012 ex - 019 ex	Other seed
E.7			Other products for dissipative use (e.g. materials spread on roads, solvents)
F			Dissipative losses (e.g. abrasion from tires, friction products, buildings and infrastructure)
G			**Water returns and losses, other than wastewater**
G.1			Evaporation of water
G.1.1			Evaporation of water from fuel combustion
G.1.2			Other evaporation of water
G.2			Water losses
G.3			Other returns of liquid water
H			**Residual heat**
I			**Unused extraction**
I.1			Unused extraction from mining and quarrying of fossil fuels
I.2			Unused extraction from mining and quarrying of minerals
I.3			Unused biomass from harvest
I.3.1			Wood harvesting losses
I.3.2			Agricultural harvesting losses
I.3.3			Other unused biomass from harvest (including by-catch, etc.)
I.4			Soil excavation and dredging
I.4.1			Excavation for construction activities
I.4.2			Dredging materials

Annex 3: Standard International Energy Classification (draft) Structure

SIEC HEADINGS	CORRESPONDENCES	
SECTION, DIVISION, GROUP, CLASS	**CPC ver.2**	**HS 2007**
0 – Coal		
01 - Hard coal		
011 – Anthracite		
0110 - Anthracite	11010*	2701.11
012 - Bituminous coal		
0121 - Coking coal	11010*	2701.19
0129 - Other bituminous coal	11010*	2701.12
02 - Brown coal		
021 - Sub-bituminous coal		
0210 - Sub-bituminous coal	11030*	2702.10*
022 - Lignite		
0220 - Lignite	11030*	2702.10*
03 – Coal products		
031 - Coal coke		
0311 - Coke oven coke	33100*	2704*
0312 - Gas coke	33100*	2704*
0313 - Coke breeze	33100*	2704*
0314 - Semi cokes	33100*	2704*
032 - Patent fuel		
0320 - Patent fuel	11020	2701.20
033 - Brown coal briquettes (BKB)		
0330 - Brown coal briquettes (BKB)	11040	2702.20
034 - Coal tar		
0340 - Coal tar	33200	2706
035 - Coke oven gas		
0350 - Coke oven gas	17200*	2705.00*
036 - Gas works gas (and other manufactured gases for distribution)		
0360 - Gas works gas (and other manufactured gases for distribution)	17200*	2705.00*
037 - Recovered gases		
0371 - Blast furnace gas	17200*	2705.00*
0372 - Basic oxygen steel furnace gas	17200*	2705.00*
0379 - Other recovered gases	17200*	2705.00*
039 - Other coal products n.e.c.		
0390 - Other coal products n.e.c.	33500*, 34540*	2707, 2708.10*,.20*, 2712.90*
1 – Peat and peat products		
11 – Peat		

SIEC HEADINGS	CORRESPONDENCES	
SECTION, DIVISION, GROUP, CLASS	**CPC ver.2**	**HS 2007**
111 – Sod peat		
1110 – Sod peat	11050*	2703.00*
112 – Milled peat		
1120 – Milled peat	11050*	2703.00*
12 – Peat products		
121 – Peat briquettes		
1210 – Peat briquettes	11050*	2703.00*
129 – Peat products n.e.c.		
1290 – Peat products n.e.c.	11050*, 33500*	2703.00*, 2712.90*
2 - Oil shale		
20 - Oil shale		
200 - Oil shale		
2000 - Oil shale	12030*	2714.10*
3 - Natural gas		
30 - Natural gas		
300 - Natural gas		
3000 - Natural gas	12020	2711.11, .21
4 - Oil		
41 - Conventional crude oil		
410 - Conventional crude oil		
4100 - Conventional crude oil	12010*	2709.00*
42 - Natural gas liquids (NGL)		
420 - Natural gas liquids (NGL)		
4200 - Natural gas liquids (NGL)	33420*	2711.14, .19*, .29*
43 - Refinery feedstocks	?	?
430 - Refinery feedstocks	?	?
4300 - Refinery feedstocks	?	?
44 – Additives and oxygenates		
440 - Additives and oxygenates		
4400 - Additives and oxygenates	35430*	3811
45 - Other hydrocarbons		
450 - Other hydrocarbons		
4500 - Other hydrocarbons	12010*, 34210*	2709.00*, 2804.10
46 – Oil products		
461 - Refinery gas		
4610 - Refinery gas	?	?
462 - Ethane		
4620 - Ethane	33420*	2711.19*, 29*,
463 - Liquefied petroleum gas (LPG)		
4630 - Liquefied petroleum gas (LPG)	33410	2711.12, .13
464 - Naphtha		
4640 - Naphtha	33330*	2710.11*

SIEC HEADINGS	CORRESPONDENCES	
SECTION, DIVISION, GROUP, CLASS	**CPC ver.2**	**HS 2007**
465 – Gasolines		
4651- Aviation gasoline	33310*	2710.11*
4652 - Motor gasoline	33310*	2710.11*
4653 - Gasoline-type jet fuel	33320	2710.11*
466 - Kerosenes		
4661 - Kerosene-type jet fuel	33342	2710.19*
4669 - Other kerosene	33341	2710.19*
467 – Gas oil / diesel oil		
4671- Road diesel	33360*	2710.19*
4672 - Heavy gas oil	33360*	2710.19*
4679 - Heating and other gas oil	33360*	2710.19*
468 - Fuel oil		
4680 - Fuel oil	33370	2710.19*
469 – Other oil products		
4691 - White spirit and special boiling point industrial spirits	33350	2710.11*
4692 - Lubricants	33380*	2710.19*
4693 - Paraffin waxes	33500*	2712.20*
4694 - Petroleum coke	33500*, 34540*	2713.11, .12, 2708.20*
4695 - Bitumen	33500*	2713.20
4699 - Other oil products n.e.c.	33330*, 33500*, 34540*	2708.10*, 2710.11*, 2712.10*, .90*, 2713.90
5 – Biofuels		
51 - Solid biofuels		
511 - Fuelwood, wood residues and by-products		
5110 - Fuelwood, wood residues and by-products	03130, 31230, 39280	4401
512 - Charcoal		
5120 - Charcoal	34510	4402
513 – Bagasse		
5130 - Bagasse	39140*	2303.20*
514 – Animal waste		
5140 – Animal waste	34654*	
515 - Black liquor		
5150 -Black liquor	39230*	3804.00*
519 - Other vegetal material and residues		
5190 - Other vegetal material and residues	?	?
52 - Liquid biofuels		
521 - Biogasoline		
5210 - Biogasoline	34131*, 34139*	2207.20*, 2905.11
522 - Biodiesels		
5220 - Biodiesels	35490*	3824.90*
529 - Other liquid biofuels		
5290 - Other liquid biofuels	?	?

SIEC HEADINGS	CORRESPONDENCES	
SECTION, DIVISION, GROUP, CLASS	**CPC ver.2**	**HS 2007**
53 – Biogases		
531 – Natural biogases		
5311 - Landfill gas	?	?
5312 - Sewage sludge gas	?	?
5319 - Other primary biogases	?	?
532 - Manufactured biogases		
5320 – Manufactured biogases	?	?
6 – Waste		
61 - Industrial waste		
610 - Industrial waste		
6100 - Industrial waste	?	?
62 - Municipal waste		
620 - Municipal waste		
6200 - Municipal waste	39910	3825.10
7 – Electricity		
70 - Electricity		
700 – Electricity		
7000 - Electricity	11010*	2701.11
8 – Heat		
81 - Heat		
811 – Heat		
8110 - Heat	11010*	2701.11
9 – Nuclear fuels and other fuels n.e.c.		
91 - Uranium and plutonium		
910 - Uranium and plutonium		
9100 - Uranium and plutonium	33610*, 33620*, 33710	2844.10*, .20*, 8401.30
92 – Other nuclear fuels		
920 – Other nuclear fuels		
9200 – Other nuclear fuels	33630*, 33690*	2844.30*, .40*
99 – Other fuels n.e.c.		
990 – Other fuels n.e.c.		
9900 – Other fuels n.e.c.	?	?

CPC and HS codes are described in the annex to Chapter 3.