# System of Environmental and Economic Accounting for Energy

## SEEA-E

## Chapter 2 The SEEA-E Framework

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### **Chapter 2 The SEEA-E framework**

#### A. Introduction

2.1. The System of Environmental-Economic Accounting for Energy, SEEA-E is a conceptual framework for organizing physical and monetary information on energy with a special emphasis on its role in the economy. It provides a set of tables and rules for the recording of information on stocks and flows of energy resources and energy products and the various economic activities involved in the supply and use of energy.

2.2. As a framework for environmental-economic accounting the SEEA-E builds on the System of Economic-Environmental Accounts, SEEA, and the System of National Accounts, SNA 2008.

2.3. This implies that the SEEA-E from SEEA has inherited a systems view in which the world consists of the environment and the economy as two overall components. In SEEA-E, the main role of the environment is to provide energy resources to the economy while the economy consists of various economic entities or units, of which domestic industries and households together with economies in the rest of the world, as the main economic actors, supply and use energy products. Further, following the SEEA approach, the interaction between the environment and the economy is described in both physical and monetary terms.

2.4. It is mainly from the SNA 2008 that SEEA and SEEA-E has inherited the accounting structure with respect to the way tables are set up, which items they include, and the book keeping identities on which they are based. It is also the SNA 2008 that provides, for instance, the principle of using market values and the convention to use the International Standard Industrial Classification of All Economic Activities, ISIC, for classifying activities carried out in relation to the extraction of energy resources and the production and use of energy.

2.5. While the SEEA and the SNA 2008 provides the main principles and building blocks for SEEA-E, also elements and concepts from other systems are included. This applies for instance to elements and concepts, which are specific for energy. These elements and concepts originate from the subject area of energy statistics and energy balances. Examples include the classification of energy products by the Standard International Energy Classification, SIEC, the use of specific measurement units for energy, and the tradition to set up accounts, which excludes energy used for transformation into other energy products in order to obtain measures, which avoids including the same energy content more than once. For many of these energy specific features, the International Recommendations for Energy Statistics, IRES, is used as a reference.

2.6. One important type of interaction between the environment and the economy is not included explicitly in the SEEA-E framework: Flows from the economy to the environment of air emissions and other residuals related to energy use are excluded. Accounts for all types of residuals including air emissions are described in the SEEA, but in SEEA-E reference to air emissions are only made in this chapter and in Chapter 7, where an example is presented concerning how the energy accounts can be used as basis for estimation of the air emissions.

2.7. A more elaborated presentation of the SEEA-E systems view and the interactions between the environment and the economy as far as energy concerns is given below in Section B. By means of a diagram the stocks and flows of energy resources and energy products is described in a non-technical way.

2.8. Section C presents some important boundary issues, which are important in order to understand how the scope of SEEA-E in some respects differs from the scope of energy statistics and balances as presented, for instance, in IRES.

2.9. Finally, section D gives an overview of all SEEA-E accounts and some of the basic accounting principles applied.

#### **B.** Energy and the interaction between the environment and the economy

2.10. With the focus on one specific economy the diagram in Figure 2.1 schematically outlines the exchange of energy resources, energy products and energy related air emissions and other residuals. The exchange is made between the environment, the economy in focus, and the rest of the world economies represented as one overall group.

2.11. A precise definition of what an *economy* constitutes in the SNA 2008 meaning of the word is given in Section C below. For the moment it is sufficient, although not entirely correct, to think of the economy as essentially the economic activities taking place at the geographical territory of a country. Similarly, the *rest of the world* can for the moment be considered to constitute all economic activities of other countries

2.12. There are two main channels through which energy enters the economy. One is through the extraction of fossil and nuclear energy resources from the stocks deposited in the environment or through the capture of energy from renewable resources. The other is through imports of energy products from the rest of the world. In the first case, once the energy resources have entered the economy they become energy products, which may be the subject of economic transactions, just like any other products are.

2.13. Having entered the economy, energy products may be used directly for fuels, they may be converted into other energy products (e.g. crude oil is converted into petrol or diesel) or they may be exported to the rest of the world.

2.14. In some cases, instead, energy products may be used to produce non-energy products, e.g. plastics or bitumen. In contrast, energy products is produced within the economy from products, which are normally not considered to be energy products. The latter is the case, for instance, when energy is produced from incineration of waste and when crops are being transformed into biofuels.

2.15. Some energy products may temporarily be accumulated in inventories for use in a subsequent period. Similarly, some energy products accumulated in a previous period may be taken out from inventories to be used in the economy or for exports.

2.16. Energy products, which are used for fuels, together with the air used for the combustion, are transformed into heat or electricity accompanied by an output of residuals in the form of solid waste like fly ash and slag, emissions of greenhouse gases and other gases, and evaporation of water, etc.

2.17. The solid waste from energy combustion is used either as inputs into the production of products (e.g. fly ash used for production of plasterboards) or it is accumulated in waste disposal sites. In some cases, part of the waste is exported to other countries, just as some may be imported into the economy in focus.

2.18. Another type of residuals, which flow from the economy to the environment are losses of energy. Typical examples are electricity and heat, which are lost from the distribution network into the environment.

2.19. Other more peripheral – but not necessarily unimportant – energy-related flows exist. For example, the production of certain types of energy requires use of huge amounts of water for cooling. This non-consumptive use of water might affect eco-systems because of the change of the temperature in the water.

2.20. With regard to the extraction of natural energy resources the extraction process involves extraction of large amounts of associated materials, which at some stage are relocated or removed from the "pure" energy product. The latter type of flows is the subject of economy wide material flow accounting (EW-MFA), and is not within the scope of SEEA-E. These flows are not shown in the diagram.



Figure 5.1 Energy related stocks and flows

2.21. All stocks and flows represented in Figure 5.1 fall within the scope of SEEA. However, as mentioned, flows of residuals such as air emissions and solid waste from energy production is not

described by the SEEA-E as such. The energy related air emissions are however to some extent covered in Chapter 7 on the applications of the SEEA-E accounts.

2.22. Losses of energy from the economy to the environment are included within the scope of the SEEA-E accounts.

#### C. Boundary issues in energy accounting

2.23. SEEA and SEEA-E are based on the definitions and classifications applied in the System of National Accounts (SNA). Concepts of resident units and centre of economic interest are used to define the boundaries and therefore to decide, which activities should be included in or excluded from the accounts.

2.24. An institutional unit is said to be resident within the economic territory of a country when it maintains the centre of economic interest in that territory – that is, when it engages, or intends to engage, in economic activities or transactions usually over at least one year.

2.25. In the SEEA-E, as in the SEEA and in the SNA 2008, all economic activities of resident institutional units are included in the accounts irrespectively of where they take place.

2.26. Using these concepts to define the boundary is different from the practice normally used in energy statistics and energy balances, where instead the national territory is used.

2.27. The activities of a resident institutional unit may take place inside or outside the geographical territory. Similarly, non-resident units may undertake activities within the geographical territory of the economy in focus. The difference is mainly related to the treatment of international transport.

2.28. Using the residence principle means, for instance, that energy bought and used by a resident unit outside the boundary of the national territory is included as energy in the SEEA-E, while energy bought and used by a non-resident inside the boundary is excluded. For countries with many international transport activities the use of the economic territory instead of the national territory may make a significant difference when the supply and use of energy is recorded.

2.29. Extraction of energy resources is always considered undertaken by residents. An enterprise that will undertake extraction is deemed to become resident when the requisite licences or leases are issued, if not before (SNA 2008, 4.15).

2.30. Figure 5.2 illustrates the principles for recording the fuel use according to the territory and residence principle, respectively. Energy statistics and balances are focusing on the national territory (row-wise) by adding energy, which is sold on the territory to resident units, with energy sold on the territory to non-residents. The latter part includes fuel sold on the territory for foreign cars, trucks, ships and planes. In contrast the SEEA-E is focusing on the residents (column-wise). The SEEA-E includes fuel use sold to residents on the territory and fuel sold to residents abroad. The latter part includes fuel bunkered abroad by cars, trucks, ships and planes operated by residents.



#### Figure 5.2 Residence vs. territory principle for fuel use

#### **D.** The SEEA-E Framework

2.31. The SEEA-E framework consists of the four main modules: 1) Physical asset accounts, 2) Monetary asset accounts, 3) Physical flow accounts, and 4) Monetary and hybrid flow accounts and related accounts.

#### 1. Physical asset accounts

2.32. Physical asset account shows the opening and closing stocks of energy resources such as coal, oil, natural gas and uranium ore and the change in them during the period in focus. Physical units like tonnes, cubic metres, joules are used as the measuring unit for the accounts.

2.33. Assets are in SEEA-E defined in a broader way than in SNA 2008. In SNA 2008 only natural resources, which have an economic value are recognised as assets. In contrast, SEEA-E includes all known deposits, even parts of the resources, which have no present economic value.

2.34. The SEEA-E does not include "infinite" renewable energy resources, such as wind, solar and hydro energy as assets. This does not in any way imply that renewable energy resources are considered to be unimportant, but it is a consequence of the fact that measurement of the stocks of these energy resources is a complicated issue, which is still the subject of research and discussion. It should also be observed that the supply and use of renewable energy are included in the flow accounts. In other words, the stocks of the "infinite" renewable energy resources like wind, solar and hydro energy are not recorded in SEEA-E, but the flows of the resources are.

2.35. Firewood in forests and other stocks of biomass in nature are not included as energy resources in the SEEA-E asset accounts because these assets are as an overall group not primarily energy

resources, and it is first in the use phase that it becomes evident that they are being used for energy purposes. They are, however, in the general SEEA asset accounts recorded as biological resources, and, as in the case of the "infinite" renewable energy resources, the supply and use of these cyclical renewable energy resources are presented in the flow accounts.

2.36. Estimates of the quantities of energy resources in known deposits can be associated with some level of confidence and they are therefore included in the asset accounts. In contrast, estimates of quantities of so-called potential resources are based on indirect evidence and limited technical data, and as they are of a hypothetical nature they are not included in the SEEA-E asset accounts.

2.37. In SEEA-E the energy resources are characterised by type based on the principles of the United Nations Framework Classification of Mineral and Petroleum Resources, UNFC-2009, which entails a characterisation based on an economic and social criteria, a project status and feasibility criteria and a geologic knowledge criteria. Based on these criteria the energy resources are divided into three main groups: A. Commercial Energy Resources, B. Potential Commercial Energy Resources, and C. Non Commercial and Other Quantities in Place

2.38. In line with the System of National Accounts, SEEA-E includes as assets also energy products held in inventories. Energy products in inventories include primary energy products (crude oil, natural gas, coal, and uranium ore, etc.), which are accumulated after extraction and before processing take place as well as secondary energy products (gasoline, diesel, fuel oil, town gas, etc.), which are the result of a further processing.

#### 2. Monetary asset accounts

2.39. The monetary asset accounts for energy resources provide a market based valuation of the physical stocks of energy resources and the changes in them. Setting up the monetary asset accounts corresponds to attributing market values to the physical opening and closing stock of the energy resources, and to identifying the causes of the changes in the market values that have taken place in the period.

2.40. The starting point is that all of the energy resources described by the physical asset accounts should be associated with a market value. In that sense, all of the known deposits are in principle within the scope of the monetary asset accounts. If market values for the stocks and changes in them can be observed and identified by statistical surveys, these observed values should be used for the accounts. In practice, however, it can be assumed that only energy resources, which we expect will be extracted have market values. In terms of the UNFC-2009 based classification of the energy resources this corresponds to Class A Commercial Energy Resources.

2.41. In practice, many deposits of energy resources are seldom or never exchanged on a market and therefore, even if, in principle, the energy resources have a market value, these can often not be observed. Thus, the market valuation of the energy resources must be based on assumptions of what the market price would have been, if the energy resources were traded in a hypothetical market. In order to determine that value the so-called net present value method, NPV, may be applied. The NPV method estimates the present value of all future income streams accruing from the extraction. These income streams are called resource rents, and the present value of these are estimated by discounting the values back to present time based on the assumption that an income in a future year has less present value than the same income in the present year. By using the NPV method it is not only possible to estimate the value of opening and closing stocks, but also to the changes in these values. A description of how the NPV method may be used for the valuation of energy resources is an integral part of SEEA-E.

2.42. One of the changes between opening and closing stocks of energy resources is caused by extraction of energy resources. The effect on the stock value of the physical removal of the energy resources is, by convention, calculated as the change in the total net present value of future extractions under the assumption that no other changes than those caused by the extraction take place. Hereby, the increase in value due to less discounting of all future resource rents because one period has passed, the so-called unwinding of the discounting, is per definition affecting the depletion downwards. The significance of this convention is that an income accruing to the extractor of the energy resources can be recorded in the so-called depletion adjusted accounts elsewhere in SEEA-E (see below).

2.43. Besides the monetary asset accounts for energy resources, also monetary asset accounts for inventories of energy products, and asset accounts for energy-related fixed assets, i.e. buildings, machineries and transport equipment, and the results of exploration and evaluation activities, etc. used by the energy extraction industries are described as part of the SEEA-E framework.

2.44. While the presentation of the monetary asset accounts generally refer to the energy resources as a whole and assumes that it is not necessary to make a distinction between the extractor of the energy resources and the owner of energy resources, SEEA-E recognizes that the owner and the extractor may not be the same unit, and SEEA-E includes therefore a presentation of separate monetary asset accounts for the owner and the extractor.

#### 3. *Physical flow accounts*

2.45. Physical flow accounts describe energy flows, in physical units, from its initial extraction or capture from the environment into the economy, and within the economy in the form of supply and use, all expressed in quantitative terms.

#### **Basic concepts used for the flow accounts**

2.46. SEEA-E distinguishes between whether energy flows are flows of natural resources, flows of products between different economic units, flows of energy for own use within the same establishment or losses of energy.

2.47. For energy products a distinction is made between primary energy products and secondary energy products. Primary energy products are the result of the extraction or capture of energy resources from the environment. Once the energy resources have been extracted they become energy products, which are delivered from the extracting industries to other units of the economy. Bio-fuels, heat and power produced by capturing renewable energy (e.g. hydropower) from the environment are included as primary energy products.

2.48. Secondary energy products are the result of transformation of primary or other secondary energy products into other types of energy products. Examples include petroleum produced from crude oil, electricity produced from fuel oil and charcoal produced from fuel wood.

2.49. Throughout SEEA-E the energy products are classified using the Standard International Energy Classification, SIEC, while the industries are classified using the International Standard Industrial Classification of All Economic Activities, ISIC, Rev. 4.

#### Physical supply and use tables

2.50. The physical flow accounts take the form of so-called supply and use tables, which are well-known buildings blocks included in the frameworks of the SNA 2008 and the SEEA.

2.51. The physical supply table shows the production and imports of energy products. The use table shows the total use of energy by industries and households, the exports, and the changes in inventories. Extraction of energy resources and losses of energy during extraction, distribution and storage are also presented in the use and the supply tables, respectively.

2.52. Physical supply and use tables (PSUT) have the same structure as the monetary supply and use tables compiled as part of the standard national accounts compilation, and generally the two sets of tables share the characteristic that the total use exactly equals the total supply. Organising physical information using the same framework as the monetary accounts is one of the basic features of the SEEA.

2.53. Physical energy flow accounts are a special case and subset of the physical flow accounts of SEEA. Like the general SEEA physical flow accounts, the energy supply and use tables are compiled first by using original mass and volume measures such as tonnes, litres and cubic metres or units specific for energy, such as Sm3 (standard cubic metres). However, because it is useful to measure energy resources and products also by its calorific content of energy, an additional set of accounts, which use the common unit joule, is introduced.

2.54. In addition to the general supply and use tables, which follow the format of supply and use tables in SEEA and the SNA 2008 closely, SEEA-E includes in its framework some additional tables which still follows the general format, but which at the same time introduces some additional features specific to energy accounts.

2.55. One specific SEEA-E table is a use table by purpose. In addition to the breakdown of uses by industries, households, exports, and inventory changes a breakdown by use for transport, heating, etc., other energy purposes and non-energy purposes is introduced.

2.56. Three other SEEA-E tables present a) the supply of primary energy and imports, b) the conversion of energy, and c) the so-called end use of energy. The latter presents the energy use without the double counting of energy, which is a general feature of the standard supply and use tables because they include both the primary energy (e.g. coal) and the converted energy (electricity), which is the result of the use of the primary energy by the energy supply industries. The specific presentation of the energy flows and the split between supply of primary energy, conversion and end use of energy is close to the way energy flows are presented in so-called energy balances according to, for instance, the International Recommendations of Energy Statistics, IRES.

#### 4. Monetary and hybrid flow accounts and related accounts

#### Monetary supply and use tables

2.57. SEEA-E includes monetary supply and use tables, which correspond on the one hand to the physical supply and use tables with respect to classifications and on the other hand to the principles described in the SNA 2008 with regard to the format of general supply and use tables and the valuation principles for economic transactions.

2.58. The SEEA-E monetary supply table for energy products shows the value of the domestic production of the different energy products and the value of imports valued at basic prices. However, the table presents also information on taxes, subsidies and trade and transport margins related to each energy product, and based on this information it is possible to show the value of the supply also at purchasers' prices.

2.59. The use table is first set up at purchasers' prices, and it shows how much the users actually pay for the various energy products they use. As in the physical use table, the use is divided into

intermediate consumption by industries and other uses i.e. private consumption, exports and inventory changes.

2.60. In order to "convert" the use table in purchasers' prices into basic prices a breakdown of the use at purchasers' prices into the elements of taxes less subsidies, trade and transport margins, and use at basic prices, are presented in the context of the use table in purchasers' prices.

2.61. Inherent in the accounts of SNA-2008, the SEEA and the SEEA-E is the book keeping identities. For the monetary supply and use tables the important identity is that for each energy product, the total use at purchasers' prices is equal to the total supply at purchasers' prices. This is reflected by the following expression:

Total supply at purchasers' prices = Domestic production at basic prices + Imports, c.i.f. + taxes less subsidies on products + trade and transport margins

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*Total use at purchasers 'prices = Intermediate consumption + Private consumption + Inventory changes + Exports* 

#### Hybrid supply and use tables

2.62. To highlight the consistency between the physical and monetary supply and use tables and to provide a basis for analysis of the links, SEEA-E present so-called hybrid supply and use tables in which the physical and monetary flows are combined.

2.63. One part of these tables presents the monetary supply or use of energy products, and another part presents the corresponding physical supply or use. In order to put the monetary flows into a broader context, also the supply and use of all other products than energy products are presented in an aggregated way in the tables.

#### **Production, generation and allocation of income**

2.64. The monetary transactions related to energy as presented by the monetary supply and use tables make up only a part of the overall economic activities involved in energy resource extraction and production of energy products. In order to present information on these activities, SEEA-E includes the so-called production and generation of income accounts for the relevant industries. These accounts are at the outset taken directly from the national accounts, although a subdivision of taxes and subsidies are introduced in order to make a link to the estimation of resource rent and depletion, which is the subject of other parts of SEEA-E. Overall, the accounts shows the value of the production and the costs incurred by the industries, which extracts energy resources and produces energy. The operating surplus created by the activities is estimated by subtracting the costs from the output. This output is then allocated between sectors of the economy by means of tax and rent payments.

#### **Depletion adjusted accounts**

2.65. When these standard accounts are set up according to the SNA 2008 no allowance is made for the fact that part of the surplus of the industries, which extract energy resources, is made possible because the energy resources are extracted and thereby are being used up.

2.66. Therefore SEEA-E goes one step further and introduces so-called depletion adjusted accounts, which goes beyond the standard national accounts principles. In these accounts a charge is made against the surplus corresponding exactly to the depletion of the energy resources. The adjusted measures are

obtained by deducting the depletion from the "conventional" surplus and income measures. They are typically lower than the conventional ones. These measures may generally be considered as being more appropriate for assessing whether the development is sustainable.

2.67. Closely related to these adjusted accounts is the conventions and procedures involved in the estimation of resource rent and depletion, and there is therefore a direct link between the depletion adjusted accounts and the monetary asset accounts. The estimations and the links are elaborated in detail in SEEA-E.

#### Transfers, etc. related to energy

2.68. Since taxes, subsidies and other transfers related to the production and use of energy is the subject of much interest and an important policy issue, SEEA-E includes tables, which summarise the information from other parts of SEEA-E and the national accounts on those energy related instruments.

#### Energy related expenditures for environmental protection and resource use and management

2.69. Within the SEEA-E framework are also accounts for activities aiming at protecting the environment from the harmful effects often associated with energy extraction, production, and use. Also activities related to the managing of energy resources are included.

2.70. SEEA-E presents shortly main concepts and accounts, which can be used to describe these activities. The description is based on the so-called SERIEE manual published by Eurostat (European Communities, 20021). More in-depth description of this type of accounts can be found in SEEA.

<sup>&</sup>lt;sup>1</sup> SERIEE European System for the collection of economic information on the environment — 1994 Version, European Communities, 2002