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System of Environmental-Economic Accounting for Energy
SEEA-Energy

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DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
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SEEA-Energy

Consultation Draft

System of Environmental-Economic Accounting for Energy

SEEA-Energy

Draft Version for Global Consultation

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The following text has been drafted for consultation as part of the process of finalising the SEEA-Energy. The material should not be considered final and should not be quoted.

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Chapter 1: Introduction

1.1 What is the System of Environmental -Economic Accounting for Energy?

1.1 The *System of Environmental-Economic Accounting for Energy* (SEEA-Energy) is a multi-disciplinary, multi-purpose, conceptual framework for organising energy-related statistical information. It supports analyses of the role of energy within the economy and of the relationship between energy-related activities and the environment.

1.2 The concepts and definitions that comprise SEEA-Energy are designed to be applicable across all countries, irrespective of how their energy is produced and used, their relative state of economic development, or the composition and state of their energy from natural inputs, and physical environment.

1.3 At the heart of SEEA-Energy is an accounting approach that records, as completely as possible, the stocks and flows of energy within the economy as well as energy-related aspects of environmental issues. The accounting approach of SEEA-Energy is based on the System of Environmental-Economic Accounting (SEEA), a conceptual framework that has been developed over the past two decades to integrate measurement of environmental and economic phenomena. In particular SEEA-Energy is a subsystem of the SEEA Central Framework which was adopted by the United Nations Statistical Commission in 2012 as the international statistical standard for environmental-economic accounts. More broadly, SEEA-Energy and SEEA Central Framework are satellite accounts of the 2008 System of National Accounts (2008 SNA).

1.4 SEEA-Energy also draws on the work undertaken in the *International Recommendations for Energy Statistics* (IRES) and formalises and extends the possible range of accounts to inform policy makers of energy-related matters by presenting an integrated set of accounts for energy-related stocks and flows (in physical and monetary terms) and for combined presentations of these physical and monetary data. The *International Recommendations for Energy Statistics* (IRES) was adopted by United Nations Statistical Commission in 2011 and provides guidance on relevant concepts and definitions, classifications, data sources and data compilation for energy statistics and balances.

1.5 Energy information is typically presented in physical terms. A particular strength of SEEA-Energy is its capacity to apply monetary valuations to various energy-related stocks and flows. Monetary measures of flows of energy products are organized in monetary supply and use tables. For stocks, energy statistics record physical extraction of energy from natural inputs; SEEA-Energy adds to this picture with monetary values for resource depletion arising from this extraction. This monetary measure of depletion is directly relatable to physical measures of extraction of energy from natural inputs, and at the same time can be used as part of the calculation of such measures as depletion-adjusted national saving and depletion-adjusted gross domestic product (GDP).

1.6 SEEA-Energy is not designed to provide or replace the richness and depth provided by various existing types of energy information. Rather it is the linkages and connections developed in SEEA-Energy that provide an additional and broader perspective and hence add value to the detailed energy information already available.

1.7 It is these linkages that underline the power of SEEA-Energy. To formulate a policy response to an environmental issue such as climate change affected by energy-related carbon emissions to air, it is essential to understand human impacts on the physical environment (e.g. which industry generates the carbon emissions and what energy products are involved?); to understand energy needs and possible constraints and solutions (e.g. what are our ongoing energy requirements and what low-carbon energy from natural inputs could we utilise?). It is also essential to understand the effects on the economy and the environment of using economic instruments such as tradable carbon emission permits carbon to solve problems in certain areas(e.g. impacts on energy prices, household spending and business profitability and, crucially, on emissions of carbon by domestic producers and as embodied in imports). Data produced through SEEA-Energy has the capacity to inform these types of questions.

1.2 Policy relevance and uses of SEEA-Energy

1.8 Energy is integral to human existence and the way we use energy is an essential element to achieving sustainable development. The effect of human use of energy on the environment has emerged as a critical policy issue. There is a growing concern about the impact of each country's energy use and of related emissions upon global and local environments. On the other hand, there is a recognition that continuing human welfare and development are dependent upon the benefits obtained from the use of energy.

1.9 As a multi-purpose system, SEEA-Energy informs policy decisions related to the supply and use of energy. First, summary information in SEEA-Energy can provide broad guidance on issues and areas of concern that should be the focus of decision makers and provide indicators of progress towards policy objectives. Second, the detailed information in SEEA-Energy can support a richer understanding of the issues including potentially identifying the key drivers of change. Third, the SEEA-Energy framework supports the development of models and scenarios that can be used to assess the impact of possible policies both within a country and between countries.

1.10 SEEA-Energy and IRES provide the conceptual framework for monitoring progress towards energy policy objectives in countries and on an international scale. Energy policy involves a number of actors including civil society, enterprises, and political actors, each with different perspectives and interests. Each actor through its actions puts pressure on different areas of the energy sector and on the environment.

1.11 The use of energy by households and by industry creates a range of pressures on the physical environment. These pressures arise from decisions on energy production and use, and could reflect for example a national decision to adopt widespread use of coal-powered electricity. These choices give rise to pressures, including those related to depletion of non-renewable resources and of environmental degradation arising from energy-related emissions. These environmental pressures in turn impact the state of the environment affecting, among other things, stocks of mineral and energy resources and air and water quality.

1.12 Ultimately, environmental pressures will impact on the policy realm, where various political, enterprise and civil actors develop policy responses to these pressures. Given the range of actors involved in energy-related policymaking, fully informed decisions on energy policy require multi-disciplinary information systems to ensure effective alignment among the various competing socio-economic interests.

1.13 Policies directed towards achieving secure and sustainable production and use of energy will have varying emphases depending on the specific characteristics and needs of each country. However, the overarching policy objectives could typically be framed against three major categories: improving energy distribution and access to energy; managing energy supply and demand; and reducing pressures of energy production and consumption on the environment.

1.14 The first category, *Improving energy distribution and access to energy*, refers to policies that aim to ensure that all energy users (including rural and urban households) have access to appropriate, reliable and affordable energy. Energy production and distribution services are delivered by a range of providers, including networks operated by electricity and gas utilities. SEEA-Energy can provide a range of measures to guide policymakers in assessing and managing the performance of these providers in supplying energy including information on capital outlays.

1.15 SEEA-Energy accounts can monitor the various energy products supplied to households, government and enterprises (as well as energy products exported) and thereby assist policy-makers in their efforts to ensure ongoing provision of energy supply services. It is important to capture the cost and affordability of energy products being offered to energy users. Costs associated with providing these services, including both current and future capital costs, as well as the means of financing these operations need to be taken into account. SEEA-Energy can provide ongoing information to assess operational efficiency of the energy providers. This is important since providers must be able to deliver a reliable service to energy users, recover the costs of providing these services, and generate sufficient return to address ongoing capital needs (for example, to meet infrastructure repairs and upgrades) while remaining commercially viable.

1.16 The second category, *Managing energy supply and demand*, refers to policies that address issues related to energy supply and allocation. For these policies, energy accounts can be used to monitor the amounts of energy allocated for different uses (both by the *type of user* consuming the energy and by the *purpose* of this use) and the associated losses during extraction and distribution. It is also essential to measure trade-offs in the allocation of energy, since certain resources such as timber and mineral and energy resources are scarce and should be used efficiently – energy accounts can link information on enterprise use of energy products to the associated value added generated by these businesses. This information can be assessed alongside information on the relative prices paid by different consumers for energy products consumed.

1.17 The third category, *Reducing pressures on the environment*, recognizes the key role of managing energy-related emissions in order to avoid adverse environmental outcomes. In this respect, it is important to identify and measure those variables inherent in energy production and delivery which may have a negative environmental impact, for example, SO2 emissions related to coal combustion; and energy-related CO2 emissions. SEEA-Energy can inform on taxes and various instruments aimed at controlling these variables (such as tradable permits to emit carbon) and, through its links to the SNA framework, SEEA-Energy has the capacity to link these policies to the impacts on measures such as household expenditure and saving; government revenue; and gross domestic product.

1.18 Expenditure on environmental protection and resource management activities related to energy supply is also relevant to this category. SEEA-Energy captures both current expenditures and relevant investment expenditures, including, for example, those related to carbon capture and storage and those related to the infrastructure for capturing energy from renewable sources. Various categories of environmental clean-up, including costs of decommissioning of mines and energy-related equipment are recorded in SEEA-Energy.

1.19 This category also recognises the importance of sustainable management of energy from natural inputs. In this respect, SEEA-Energy provides a number of fundamental extensions to information presented in the SNA. For example, following the SEEA Central Framework, SEEA-Energy considers the depletion of mineral and energy resources such as coal, oil and natural gas to be a cost of energy extraction which allows for the calculation depletion adjusted measures.

1.20 The SEEA-Energy framework supports a number of applications that can inform across multiple categories of policy interest. For example, the framework supports the estimation of carbon embedded into various products. A country adopting a policy to deliver a low-carbon future may elect not to produce products with significant embedded carbon. This has implications for the policy areas of *Improving energy distribution and access to energy* and *Managing energy supply and demand* (as discussed above). But a full assessment of the carbon ‘footprint’ of the country would consider carbon embedded in imports and the information is also relevant for *Reducing impacts on the environment*.

1.21 The nature of energy issues requires that a wide variety of measures are needed to understand the implications of decisions taken. In order to measure progress towards the achievement of the goals set out in each of the policy categories described above, integrated information systems are therefore required. These systems will assist with collecting data and converting it into information for benchmarking, monitoring progress and identifying trends. But more importantly they provide the capacity to consider, within a single framework, various environmental and economic aspects of energy-related policy questions. It is therefore necessary to have a comprehensive conceptual framework to guide the process of data integration and its transformation into policy relevant information. SEEA-Energy is the framework able to meet this purpose.

1.3 SEEA-Energy as a system

1.22 SEEA-Energy consists of a coherent, consistent and integrated set of tables and accounts related to energy. It informs on the role of energy within the economy, the state of mineral and energy resources and various energy-related transactions. The tables and accounts of SEEA-Energy may be produced in both physical and monetary terms and are based on internationally agreed concepts, definitions, classifications and accounting rules.

1.3.1 Scope and coverage of SEEA-Energy

1.23 Generally, the accounts are compiled in respect of a national economy – defined in accordance with the SNA and the SEEA Central Framework. In geographic terms, the economy is defined by the economic territory of a country (which generally aligns closely in physical terms with its national boundaries as commonly recognised). The economic units of interest are those enterprises, households and governments with a centre of interest in the economic territory (a concept known as residence principle). The economy is defined by the production, consumption and accumulation activity undertaken within the economic territory by the relevant economic units. It should be noted that transactions related to international bunkering and international transport are accounted for based on the residence of the operator of the transport equipment.

1.24 The scope of the environment, from which energy is sourced and into which emissions are absorbed, is also bounded by these territorial considerations. Thus, all energy from natural inputs and the environment within a country's economic territory (including its exclusive economic zone) are within scope of the SEEA-Energy framework.

1.3.2 Types of SEEA-Energy accounts

1.25 There are three main types of accounts in the SEEA framework: (i) physical flow accounts, (ii) accounts for energy-related transactions and (iii) asset accounts in physical and monetary terms. Descriptions of these three types of accounts form the core of SEEA-Energy as described in Chapters 2 – 6.

Physical flow accounts

1.26 The first type of account is the physical flow account in which flows of energy are recorded in physical units. Physical flow accounts for energy aim to record flows of energy from natural inputs from the environment to the economy, within the economy (as energy products), and from the economy to the environment (as losses and returns of energy to the environment). Within SEEA-Energy, physical energy flows are expressed in energetic units, joules. This provides a common unit allowing physical energy flows to be directly compared and/or combined. In other types of accounts, physical flows of energy may be recorded in a variety of units, for example the use of mass units (e.g. tonnes) or volumetric units (e.g. cubic metres) is made in material flow accounts.

1.27 Accounting for these various physical flows involves the application of basic laws concerning the conservation of mass and energy as well as accounting rules concerning supply and use. Thus the supply of energy from natural inputs by the environment must be matched by the use of those inputs by the economy, including use for non-energy purposes, or the immediate return of those inputs to the environment (e.g. flaring of gas during natural gas extraction). Also, the supply of energy products (i.e. goods and services) within the economy must equal the use of these products within the economy (with relevant adjustments for the trade in goods and services between countries). Finally, the generation of residuals by the economy must be matched by either the collection of these residuals by other economic units (for example the use of fly ash to make building products[1]) or the release of the residuals to the environment. Incineration of solid waste to produce energy is recorded in the accounts as supplied from within the economy.

1.28 As a result of accounting for the various physical energy flows in this way, a framework, known as a physical supply and use table (PSUT), can be constructed in which the various types of energy-related physical flows are recorded. The PSUT in SEEA-Energy is based on supply and use tables of SEEA Central Framework that have been developed for environmental economic accounting and is extended to include consideration of energy-related flows between the environment and the economy. The PSUT includes only energy related flows. For example, even though all timber could potentially be used as a source of heat and energy, flows of timber are only included in the accounts when it is to be used for energy purposes.

Accounts for energy-related transactions

1.29 Many of the physical flows of energy have corresponding monetary flows reflecting various transactions between economic units (i.e. industries, households, governments). For example, the use of refined petroleum products by households can be physically measured in joules, but can also be recorded in terms of household spending on these products. All such transactions between economic units are recorded in the SNA.

1.30 Accordingly, flows related to the supply and use of energy products are recorded in monetary terms. These are the monetary supply and use tables for energy and are recorded in addition to the physical terms used in the PSUT framework as described above. Monetary supply and use tables for energy have a narrower scope than the

[1] In practice residuals collected by other economic units either have no energy content or such content is unknown.

corresponding PSUT in that they relate only to flows of energy products within the economy and not to energy-related flows between the environment and the economy.

1.31 Other transactions related to energy are of interest. Many of these will be environmentally-related transactions, including transactions relating to those activities that reduce or eliminate pressures on the environment and that aim at making more efficient use of energy from natural inputs. Examples include investing in technologies designed to prevent or reduce pollution; and technologies leading to more efficient use of energy.

1.32 There is likely to be policy interest in certain energy-related monetary flows to and from government for environmental purposes and in this context the measurement of energy-specific taxes and subsidies and similar flows (such as investment grants to capture renewable sources of energy) is appropriate.

1.33 There are a number of other economic aggregates of likely interest related to extraction and exploration activity. For example, measures of value added, and payments of rent to access these resources may be particularly relevant. There may also be a focus on the level of investment in extraction equipment and on the state of the associated produced assets (for example concerning the condition of a country's gas extraction infrastructure). All of this information can be organised into relevant accounts for energy-related transactions.

Asset accounts in physical and monetary terms

1.34 Measuring the quantity of mineral and energy resources, and changes to these resources over time, is a central feature of SEEA-Energy. Asset accounts focus on the various components making up mineral and energy resources. They measure the stock of each resource at the beginning and end of an accounting period and record the various changes in the stock due to extraction, discovery, catastrophic loss or other factors.

1.35 The compilation of asset accounts in physical terms provides valuable information on mineral and energy resource availability. An important feature of the SEEA asset accounts is the estimation of depletion of mineral and energy resources in physical terms. For mineral and energy resources the quantity of depletion is equal to the quantity of resource extracted.

1.36 The compilation of asset accounts in monetary terms can also provide valuable information to assist in understanding the relationship between rates of extraction and current economic activity, and in understanding the economic costs of extraction on future incomes. The monetary value of depletion used in asset accounts is the same as that used in the depletion-adjusted measures of income and saving described above.

1.37 The underlying basis for valuation in SEEA-Energy is market prices, the same basis as used in the SNA and SEEA Central Framewok. The use of this valuation basis allows mineral and energy resources to be readily compared to produced and financial assets.

1.38 Because there is no market for many mineral and energy resources assets (i.e. the environmental assets *in situ* such as coal and oil are rarely bought and sold), alternative valuation methods often must be used to compile asset accounts in monetary terms. The method described in SEEA-Energy is the net present value (NPV) method which calculates the value of an asset based on the future income streams that are expected to accrue from the use of the asset.

The relationships between the accounts

1.39 The accounts within the SEEA-Energy framework are connected to each other but each focuses on a different part of the interaction between the economy and the environment. Examples of the relationships between the different accounts include:

- Changes in the stock of mineral and energy resources (from the asset account) are most often the result of economic activity which in turn is the focus of physical flow accounts. Measurement of flows of mineral and energy resources within the PSUT is consistent with the measurement of extraction in the asset accounts.
- Measures of the flows of energy from natural inputs and energy residuals can also be related to transactions recorded in accounts for energy-related transactions, including investment in cleaner technologies and flows of energy taxes and subsidies.

1.40 These examples serve to highlight the many and varied relationships between the accounts, each taking a different perspective. Throughout SEEA-Energy these relationships are supported by the use of common concepts, definitions and classifications as described and explained in this book.

1.3.3 Building on existing energy information

1.41 As an integrated accounting system, SEEA-Energy stands apart from individual sets of energy statistics. While sets of energy statistics are usually internally consistent, there is, for good reason, often no strict consistency between one set of statistics and another. Energy statistics are often collected with a particular regulatory or administrative purpose in mind and the way in which they are structured may be specific to this need. For example, data on energy use by energy products from industrial sources would ideally be classified according to the industrial classification used in ISIC (which is used in SEEA-Energy, the SEEA Central Framework and the suite of international economic statistics standards, including the SNA). This would allow their incorporation into physical flow accounts and combined accounts.

1.42 In contrast, SEEA-Energy is an integrated system of accounts which, to the fullest extent possible, provides consistency between its various accounts in terms of concepts, definitions and classifications. In addition, implementation of such an integrated system aims for consistency over time. This is of the utmost importance in developing the comparable time-series estimates that are important in the policy process.

1.43 A final important difference between energy statistics and SEEA-Energy is the latter's coherence with the economic information of the SNA and other environmental-economic accounts of the SEEA Central Framework and its other subsystems. This adds considerable value to both the physical and monetary information, as it facilitates integrated analyses within a common framework.

1.44 Nevertheless, SEEA-Energy relies heavily upon energy statistics for the basic inputs required in its implementation. In this regard, the use of IRES complements and supports the implementation of SEEA-Energy. IRES uses concepts, definitions, data sources, data compilation methods, methods of quality assessment and classifications that provide the basic data allowing the compilation of SEEA-Energy accounts and tables. For example, the energy balances used in IRES employ an organising principle very similar to the PSUT. And IRES and SEEA-Energy use the same energy product definitions. In effect, by taking data collected through IRES and organising these data into a framework coherent with the SNA, we develop SEEA-Energy. Thus SEEA-Energy and IRES are complementary frameworks.

1.45 It is reasonable to expect that over time the implementation of SEEA-Energy and IRES will result in changes to the way in which energy statistics are collected and structured in a given country. However, a spirit of collaboration and respect between environmental accountants and energy statisticians is needed for this to happen. The former group must understand that collecting data for energy accounts may be a secondary concern for energy statisticians responsible for providing information to, for example, a regulatory programme. The latter group must be convinced of the importance of generating highly structured and consistent data within an accounting framework. The beneficiaries, among others, include policymakers in the field of energy using this information and members of the community who benefit from better-informed policy decisions.

1.3.4 Combining information in physical and monetary terms

1.46 One of the most powerful features of SEEA-Energy is its organisation of information in both physical and monetary terms following consistent scope, definitions and classifications. This feature especially applies to the compilation of accounts and tables where information in physical and monetary terms is combined. The structure of combined presentations depends on the topic of the measurement (e.g. decoupling of energy use from economic output, decoupling of energy use from emissions to air, cost per Joule of various energy products used by various industries etc.), the questions of interest and the availability of data. Nonetheless for combined presentations there are certain common features and benefits.

1.47 First, combined presentations allow users to find a range of relevant information in a single location and without needing to make special adjustments to ensure coherence and consistency.

1.48 Second, combined presentations promote dialogue between those familiar with data organised according to economic accounting structures and those familiar with information organised with reference to specific physical flows. Thus these combined presentations provide a basis to integrate energy, environmental and economic analyses and thereby reduce the tendency to divide analysis of issues along disciplinary lines, in which analyses of issues are carried out independently of each other.

1.49 Third, combined presentations structure information in a manner that supports the derivation of combined indicators – for example, decoupling indicators that track the link between the use of energy from natural inputs and growth in production and consumption.

1.50 Fourth, combined presentations provide an information base for the development of models and detailed analysis of energy-related interactions between the economy and the environment.

1.51 Overall, the power of SEEA-Energy and its standard concepts and definitions can be clearly seen in the development of presentations that combine physical and monetary data.

1.3.5 Flexibility in implementation

1.52 Although SEEA-Energy is presented as an internally consistent and complete system, its design is such that it can be implemented equally well in part or in whole. A country may choose to implement only a selection of the accounts included in SEEA-Energy, with such decisions dependent upon the extent and type of its energy from natural inputs, the characteristics of its energy production and use, and any specific energy-related issues faced. Even if a country wants eventually to implement the full system, it may decide to focus its initial efforts on those accounts that are most relevant to the issues it most urgently wants to address.

1.53 For example, a country with few mineral and energy resources may choose not to compile asset accounts these resources. Even those countries with abundant mineral and energy resources may wish to concentrate first on those inputs with greatest economic value, or on those that are subject to discussion for the way in which government appropriates revenue from their extraction.

1.54 Countries with a high dependence on imports of certain energy products may find it useful to build physical flow accounts for these products in order to highlight which industries and outputs are most exposed to this dependence. Thus, a country may not feel a need to record physical flows for all energy products and might instead decide to focus on those energy products where imports are most critical.

1.55 If a country is concerned to reduce its energy-related carbon emissions through the use of tradable permits to emit carbon, it would most likely be informed about carbon emissions arising from the use of specific types of energy products, and about the industries and households using these products.

1.56 These examples illustrate the flexibility of application of SEEA-Energy. It is important to bear in mind, however, that whatever parts of SEEA-Energy are implemented, these parts should be implemented in such a way as to be internally consistent, and complementary to the broader system as a whole.

1.57 While there is flexibility in the implementation of the system, much benefit from SEEA-Energy comes from it being implemented at an international level. Consequently, the ability to compare and contrast relevant information from a range of countries is a significant advantage supported by the widespread adoption of SEEA-Energy for specific modules, particularly with regard to energy-related issues that are multi-national or global in nature.

1.4 SEEA-Energy and related statistical standards and publications

1.58 The integrated nature of SEEA-Energy and in particular its coverage of data in both physical and monetary terms means that it has relationships to a number of other international statistical standards and frameworks. These relationships are of four main types: relationships to the SEEA Central Framework and to other SEEA sub-systems; relationships to the IRES and the ESCM; relationships to the SNA and related economic accounts standards; and relationships to standard international classifications. Each of these is described in turn.

1.4.1 SEEA-Energy and related environmental accounts manuals

1.59 SEEA-Energy is a sub-system of the SEEA Central Framework, the international statistical standard for environmental economic accounting, and is entirely consistent with this framework. The starting point for the development of SEEA-Energy is the SEEA Central Framework. The SEEA-Energy brings together the energy-specific tables and accounts of the SEEA Central Framework and elaborates in greater details the links between energy accounts and energy statistics and balances as described in IRES.

1.60 Users of the present manual include energy statisticians/analysts and environmental/national accountants. As such the present manual provides a bridge between the two communities by elaborating on energy concepts which are familiar to energy statisticians, and accounting concepts and rules, including the integration of basic energy statistics into the accounting framework, which are familiar to national/environmental accountants. It is fully consistent with the SEEA-Central Framework and coherent with IRES. One of the contributions of the SEEA-Energy is that it provides an all encompassing document linking the concepts in energy statistics to the concepts used in energy accounts. It therefore provides a useful tool for those experts willing to compile energy accounts coming from different disciplines.

1.61 Some of the elaborations include, for example, providing further details on definitions and concepts related to energy from natural inputs, energy products and energy residuals. Physical flow accounts are extended to explicitly include own use of energy products.

From the physical flow accounts a number of related tables are derived including tables on energy transformation and end use of energy. The discussion on monetary accounts is expanded to include transactions for energy. Physical and monetary asset accounts are presented not only for mineral and energy resources but also for inventories of energy products.

1.62 The SEEA Central Framework provides the overarching framework for all SEEA sub-systems. These sub-systems will contain more detailed structures and explanations. Sometimes some of these issues may be overlapping between different subsystems. In this case both subsystems will address the issue. For example, the practice of hydraulic fracturing to release coal seam gas relates to both hydrological systems and the production of energy. An integrated analysis of economic and environmental aspects of this issue could potentially utilise data from SEEA Water and SEEA-Energy, as well as from the SEEA Central Framework.

1.4.2 SEEA-Energy, IRES and ESCM

1.63 SEEA-Energy has a close relationship with IRES. IRES provides valuable input to the production of tables and accounts of SEEA-Energy. In particular, it recommends use of harmonised definitions of energy products following a standardised energy product classification (the *Standard International Energy Product Classification* - SIEC) and guidance on data sources and data compilation. Where a country has produced energy statistics and balances according to IRES, the compilation of SEEA-Energy tables and accounts becomes an extension to the existing body of official energy statistics.

1.64 The concepts presented in IRES are therefore a key input to SEEA-Energy. However, it should be noted that a number of important extensions and adjustments before their integration within physical and monetary accounts following principles of the SNA are needed. In addition, SEEA-Energy incorporates a number of structures that are needed to undertake integrated environmental-economic analyses in the area of energy. That is, while IRES and SEEA-Energy are complementary, SEEA-Energy is essential for those who wish to undertake energy-related analyses of the interaction between economy and environment.

1.65 The SEEA-Energy remains a conceptual manual and needs to be supported by compilation manuals. The Energy Statistics Compilers Manual (ESCM) is an important document for the implementation of both IRES and SEEA-Energy. It will cover the implementation of the recommendations contained in IRES as well as SEEA-Energy to ensure that countries set up a multi-purpose energy information system. While IRES provides internationally agreed recommendations on the statistical production process for energy statistics, the ESCM is expected to provide more practical guidance to assist countries in the implementation of IRES and SEEA-Energy. In particular, it will provide clear guidelines on data sources, on the use of administrative data and on a range of best country practices.

1.4.3 SEEA-Energy and the 2008 SNA

1.66 The relationship between SEEA-Energy and the SNA is fundamental. The 2008 SNA is the conceptual framework used as reference for the SEEA and in turn SEEA-Energy. In many respects SEEA-Energy might be viewed as a satellite account of the 2008 SNA.

1.67 Many of the accounting concepts and definitions used in SEEA-Energy are drawn from the SNA and users of SEEA-Energy may be required to consult the 2008 SNA for more detailed guidance on particular accounting issues. Two primary areas of distinction between the systems, which are also represented in the SEEA-Central Framework, are: the scope of the recording of physical flows compared to monetary flows (which is somewhat broader in SEEA-Energy); and the incorporation in SEEA-Energy of depletion as a cost against the income earned from the extraction of natural energy resources i.e. in addition to being a reduction in the value of these resources.

1.4.4 SEEA-Energy and standard international classifications

1.68 The consistent use of classifications in the compilation of data in physical and monetary terms is a central feature of SEEA-Energy. International comparability of data is enhanced through the collective use of standard international classifications where these are available.

1.69 Several classifications used in SEEA-Energy are central to integrated environmental and economic analysis including the classification of economic units to industries, the International Standard Industrial Classification for All Economic Activities (ISIC); and the Standard International Energy Product Classification (SIEC). These classifications are used throughout SEEA-Energy and the SEEA Central Framework.

1.70 In the physical measurement of energy products SEEA-Energy uses the Standard International Energy Product Classification (SIEC). SIEC should be linked to the Central Product Classification (CPC) in order to best support integrated environmental-economic analysis. The CPC is used throughout the SEEA and its sub-systems. In the assessment of the status of different mineral and energy resources, the UN Framework Classification for Fossil Energy and Mineral Reserves and Resources (UNFC-2009) is the relevant international standard.

1.71 In addition, SEEA-Energy contains a range of other lists and sets of classes that are aimed at providing support for the compilation of data. Examples include the SEEA-Energy classification of energy from natural inputs by type and the description of types of residuals.. These are not standard statistical classifications but do provide a structure for compilation and international comparison.

1.72 The organisation of data following standard classifications is an important step that facilitates the development of accounts that are as coherent, consistent and comparable as possible over time and across countries.

1.5 Overview of SEEA-Energy

1.5.1 Introduction

1.73 SEEA-Energy is the internationally agreed conceptual framework relating to environmental-economic accounting for energy. It utilises accounting concepts, definitions and principles from the SEEA Central Framework, the SNA and IRES and describes the relevant accounting concepts and structures that are needed for to present a variety of environmental-economic accounts including physical supply and use tables, monetary accounts for energy-related transactions and asset accounts for mineral and energy resources.

1.74 The conceptual framework presented here is designed to be applicable to countries around the world. This publication therefore recognises the different conditions and different institutional arrangements that may be found in developed and developing countries. Further, it attempts to present the rationale for the treatments applied so that statisticians can better decide on treatments for new developments and new institutional arrangements in the future.

1.75 The publication does not attempt to provide guidance on how to make estimates or on the priority with which different accounts should be implemented. Instead, practical guidance is to be found in the ESCM. Specialised guidance on accounting for economic statistics is available in the 2008 SNA and in related manuals.

1.76 The following provides an overview of each of the chapters of SEEA-Energy.

1.5.2 Reader's guide to chapters of SEEA-Energy

1.77 SEEA-Energy is made up of seven chapters. The first chapter introduces SEEA-Energy and provides an indication of its policy relevance and the general aims and purposes of environmental and economic accounting for energy. The chapter briefly outlines key elements of the SEEA-Energy framework and its place in the broader suite of statistical information and conceptual frameworks on environmental and economic measurement.

1.78 The second chapter, "The SEEA-Energy framework", outlines the key elements of the SEEA-Energy framework and the accounting approach used. Much of the organising principles and accounting rules used in SEEA-Energy are drawn from the SEEA Central Framework. The chapter aims to describe the main types of accounts and the key classifications used in SEEA-Energy. It also describes the basic principles of accounting for stocks and flows, the definition of economic units and the rules of recording and principles of valuation.

1.79 An important aspect of SEEA-Energy that Chapter 2 aims to highlight is the integrated nature of SEEA-Energy with all of the different parts being founded within a common accounting approach. The chapter concludes with a description of concepts and building blocks used in combining physical and monetary data.

1.80 The third chapter, "Physical flow accounts", explains in detail the recording of physical flows in SEEA-Energy. The different physical flows: energy from natural inputs; energy products; and energy residuals, are placed in the form of a physical supply and use table. Chapter 3 describes the boundary between the economy and the environment since flows of energy products are considered to be 'within the economy' while flows of energy from natural inputs and energy residuals are, respectively, 'from the environment to the economy' and 'to the environment from the economy'.

1.81 In addition to the presenting the physical supply and use tables which follow the general structure of those in SEEA Central Framework, Chapter 3 also describes the various types of flows making up the physical supply and use of energy, including production, consumption, changes in inventories and exports and imports. Presentations to emphasise the purpose of energy use are discussed. The chapter also provides a detailed discussion of the relationship between energy statistics, energy balances and energy accounts and the use of bridge tables to link these presentations.

1.82 The fourth chapter, "Monetary accounts and combined presentations" focuses on the identification of economic transactions within the SNA that are considered to be energy-related. It presents a supply and use table for energy products, measured in monetary terms.

1.83 Of particular interest within this chapter are those energy-related transactions with clear significance for the environment. This includes various energy-related taxes, subsidies and similar transfers and a range of other payments and transactions that are all recorded in the SNA framework but are often not explicitly identified as related to the environment.

1.84 Finally, the fourth chapter also covers the topic of combined monetary and physical presentations. This is a key area where the SEEA-Energy demonstrates its capacity to inform energy-related interactions between the economy and the environment.

1.85 The fifth chapter, "Physical energy asset accounts", focuses on the recording of physical stocks and flows associated with mineral and energy resources. This chapter also includes a discussion of the United Nations Framework Classificaton for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) which is used to determine which mineral and energy resources meet the SNA definition of an economic asset. The chapter presents a physical asset account with a detailed description of the various data items within the account. Many practical and conceptual measurement challenges that are unique to energy assets are discussed in chapters 5 and 6.

1.86 The sixth chapter, "Monetary energy asset accounts" describes the monetary valuation of those mineral and energy resources considered to be economic assets. It essentially makes the link between physical asset accounts presented in Chapter 5 and the accounts of the 2008 SNA. Monetary asset accounts are presented and the structure and principles underpinning these accounts are described. Included in this chapter is a discussion of monetary asset accounts for assets related to the generation of energy from renewable sources

1.87 Chapter 6 provides a detailed example of the net present value (NPV) approach to the valuation of mineral and energy resources and a discussion on discount rates and other factors important to the NPV approach.

1.88 The seventh chapter, “Presentation and use of energy accounts”, aims to build a bridge to those people conducting specific research on energy-related environmental-economic topics who could usefully employ SEEA-Energy datasets. As such it takes a different tone than the rest of the chapters by demonstrating how analyses of energy-related interactions between the economy and environment might be carried out. This is done by presenting various extensions and techniques that can utilise the data of SEEA-Energy. The chapter also introduces a range of indicators that may be compiled from the SEEA-Energy dataset.

Chapter 2: The SEEA-Energy framework

2.1 Introduction

2.1 The conceptual framework for the *System of Environmental Economic Accounting for Energy* (SEEA-Energy) is a subsystem of the *System of Environmental-Economic Accounting Central Framework* (SEEA Central Framework) focusing exclusively on energy. While the two frameworks are coherent, SEEA-Energy gives further details on issues of energy accounting as well as provides guidance on a number of additional tables that can be of use to policymakers, researchers and the public at large. This ensures that SEEA-Energy uses principles that are consistent with the 2008 SNA. Data in SEEA-Energy can be used to assess such things as changes in energy intensity and decoupling of energy use from economic production. Importantly, it means that SEEA-Energy can inform on issues within the broader context of integrated environmental economic accounting, for example how energy-related issues relate to various environmental protection activities.

2.2 *International Recommendations for Energy Statistics* (IRES) provides a basis for high quality energy statistics by recommending data items to be collected and their concepts and definitions, and classifications for energy statistics and balances. Basic energy statistics collected using the recommendations of IRES can be used as a data source for the compilation of the physical supply and use tables in SEEA-Energy. SEEA-Energy builds upon basic energy statistics by presenting an integrated set of accounts that allow full accounting for energy-related stocks and flows (in physical and/or monetary terms) and by combining the presentations of these physical and monetary data. It is underpinned by a systems approach which ensures that it achieves full coverage without gaps or overlaps and that all statistics within SEEA-Energy can be related to each other.

2.3 The SEEA-Energy framework expands the conventional economic measurement framework (the SNA), to incorporate flows between the economy and the environment, and to highlight certain environmental activities and expenditures not shown explicitly in conventional national accounts presentations. The SEEA-Energy framework also incorporates energy from natural inputs both inside and outside of the scope of conventional economic measurement, and records stocks of mineral and energy resources and changes in these stocks over time. This chapter provides an overview of the SEEA-Energy accounting structure and its rules and recording principles.

2.4 Section 2.2 provides an overview of the SEEA-Energy framework placing various energy-related aspects of the economy and the environment into a coherent framework. Using the broad framework described in Section 2.2, Section 2.3 presents the accounting structure of SEEA-Energy which is reflected in supply and use tables, asset accounts, and functional accounts. Sections 2.4 and 2.5 describe economic units and classifications respectively.

2.5 Section 2.6 presents a range of specific accounting rules and principles that form the basis of the recording and compilation of SEEA-Energy accounts. Section 2.7 concludes the chapter by introducing combined presentations of physical and monetary data which is one of the key outputs from the SEEA-Energy framework.

2.2 Overview of the SEEA-Energy Framework

2.2.1 Introduction

2.6 This section provides an overview of the SEEA-Energy Framework discussing the scope of the economy for the energy accounts. Details are provided on the definition of national economy and the application of the resident principle. Moreover an elaboration of certain measurement issues is presents.

2.2.2 Scope of economy for energy accounts

2.7 The definitions of national economy and environment as used in SEEA-Energy constitute the initial measurement boundaries and must be clearly defined so that information can be organised in a consistent way over time, across countries and between different areas of analysis.

2.8 The national economy is defined in accordance with the concept of economic territory. Economic territory is the area under effective economic control of a single government (including the EEZ) and is the concept used by the SNA and the SEEA Central Framework. A national economy therefore comprises the set of institutional units that are resident in an economic territory. An institutional unit in turn is an economic entity that is capable, in its own right, of owning assets, incurring liabilities and engaging in economic activities and in transactions with other entities. A resident of a country is an institutional unit with a centre of economic interest in the economic territory of that country (residence principle). A unit is non-resident if its centre of economic interest is not in the economic territory of a country. In general, there will be a large overlap between those units that are resident and those units located within the geographically defined boundaries of a country. For energy accounts there are two important points related to this overlap.

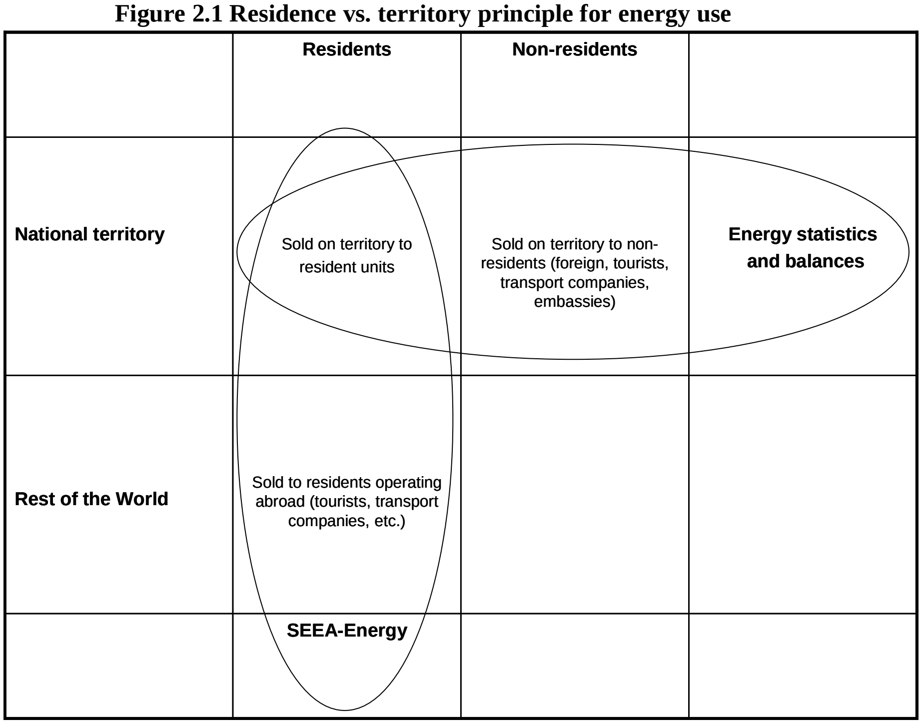
i. Resident producing units may operate outside of the national territory, for example ships and aircraft, and fishing operations in international and other nation's waters. In these cases they are considered to remain residents of their national economy irrespective of their location of operation.

ii. Extraction of mineral and energy resources is always considered to be undertaken by resident units. This is consistent with the SNA treatment which states that an enterprise that undertakes extraction is deemed to become resident when the requisite licences are issued, if not before (2008 SNA, paragraph 4.15).

2.9 The SEEA-Energy geographic scope of the economy thus aligns with the scope of the economy as defined in the SNA and SEEA Central Framework, allowing a strong alignment between flows in physical and monetary terms. However, this geographic boundary is different from that commonly used for some important energy related statistics such as air emissions, energy statistics and energy balances. Such statistics are usually based on the territory principle which assigns flows to the country in which the producing or consuming unit is located at the time of the flow. Where these latter statistics are an information source for the compilation of SEEA-Energy accounts, adjustments to the data are likely to be needed to account for differences in geographic coverage. This is especially true for countries with significant international transport operations, where marked difference may exist between energy accounts and energy balances for certain aggregates.

2.10 Figure 2.1 illustrates the principles for recording energy use according to the territory principle and residence principle. Energy statistics and balances capture operations in the national territory as designated in the second row. In particular energy statistics and balances include energy used in the territory by resident units and energy used in the territory by non-residents which includes energy products used within the territory by transport equipment operated by non residents or foreign entities. In contrast, SEEA-Energy aims to capture activity of residents (as designated in the second column) regardless of geographic location. SEEA-Energy includes energy products sold to residents, whether operating within the national territory or abroad including energy products sourced from bunkers (i.e. from stores of inventories) located abroad and used by transport equipment operated by residents.

Figure 2.1 Residence vs. territory principle for energy use



2.11 The measurement scope of the economy is generally defined by the production boundary. SEEA-Energy does not measure flows that are considered entirely 'outside of the economy'. The production boundary defines the scope of those economic activities that are carried out under the control and responsibility of economic units and that use labour, assets and goods and services to produce outputs of goods and services (collectively known as products).

2.12 The production boundary is significant for SEEA-Energy since all goods and services that are considered to be produced are effectively considered 'inside the economy', while materials that are considered non-produced are 'outside the economy'. For example, oil in its natural state is considered non-produced but petroleum products made from oil are considered 'produced'. Flows between the economy and the environment are thus determined by whether they cross the production boundary.

2.13 The economy can also be considered from the perspective of economic assets. Economic assets are stores of value which are owned and from which benefits can be derived over time; such assets have a monetary value. They provide capital inputs to production processes and are a source of wealth for economic units, including households. Many economic assets are produced (e.g. buildings and equipment) but many are non-produced, for example, mineral and energy resources.

The measurement of physical flows related to energy

2.14 A key focus of measurement in SEEA-Energy is the use of physical units (joules) to record flows of energy and energy-related materials that enter and leave the economy and corresponding flows within the economy itself. In broad terms, energy from natural inputs flow from the environment into the economy, energy products circulate within the economy, and energy residuals i.e. energy losses and other energy residuals – flow from the economy into the environment

2.15 From Figure 2.2 we see that energy may enter the economy as a natural input. Alternatively, energy enters the economy through imports of energy products from the rest of the world.

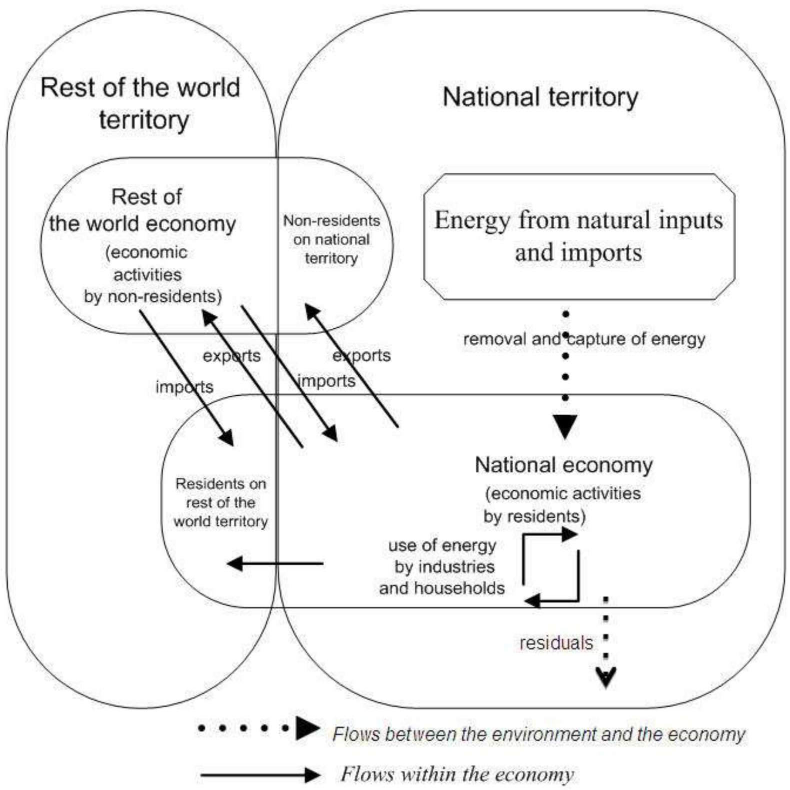
2.16 For energy products a distinction is made between primary energy products and secondary energy products. Primary energy products are the result of the removal or capture of energy from natural inputs from the environment. In Figure 2.2 we see that once energy from natural inputs have been extracted they become energy products and are delivered to economic units for use within the economy. Primary energy products include heat and electricity produced by harnessing energy from renewable sources from the environment (for example solar or hydropower).

2.17 Secondary energy products result from the 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.

2.18 Energy products may be used directly for fuels, they may be converted into other energy products or they may be exported to the rest of the world. However, in some cases, energy products may be used to produce non-energy products such as plastics or lubricants. Further, some energy products are produced from inputs which are not normally considered to be energy products, for instance, energy produced from the incineration of waste, and crops transformed into biofuels.

2.19 Energy products may be temporarily accumulated in inventories for use in a subsequent period. Similarly, some energy products accumulated in an earlier period may be taken from inventories to be used in the economy or for export.

Figure 2.2 Physical flows of energy



2.20 Energy products used as fuels are subjected to combustion or fission in order to release the stored energy. These processes are accompanied by an output of residuals in the form of solid waste such as fly ash and slag, emissions of greenhouse and other gases, and evaporation of water, and so on. These residuals are represented by the dotted line in Figure 2.2 going from the national economy to the environment. The solid waste from energy combustion is used either as inputs into the production of products (for example, fly ash may be used in the production of plasterboards; energy content of residual might be unknown) or it is accumulated in waste disposal sites. In some cases, waste may be exported to other countries, just as some may be imported into the economy in reference.

2.21 Energy residuals flow from the economy to the environment. Examples of energy residuals include: mineral and energy resources lost during the process of extraction (such as flaring of natural gas during extraction); energy lost between the point of extraction/supply and a point of use (for example, electricity lost from the distribution network into the environment); losses during storage (for example leakages of energy products such as LNG during storage) and losses occurring during transformation, such as occurs when coal is used to generate electricity.

2.22 Flows within the economy include flows between the national economy and the rest of the world, as seen in Figure 2.2. Since the national economy is defined in terms of the activities of resident units, a one-to-one relationship does not exist between the national economy and the national territory. Some of the flows to the national economy may take place on foreign territory and some flows on the national territory may relate to activities of foreign units. Such flows are often related to international transport activity and tourism, and their treatment is described in Chapter 3.

The measurement of energy from natural inputs

2.23 The use of certain natural inputs such as coal by the economy is linked to changes in the stock of assets that generate those inputs. Accounting for energy from natural inputs in both physical and monetary terms is an important feature of SEEA-Energy.

2.24 SEEA-Energy includes as environmental assets mineral and energy resources such as coal, oil, natural gas and uranium ore to the extent that they are able to bring benefits to humanity. Timber and cultivated biomass are also included in SEEA-Energy in so far as they are used in energy production. Chapter 5 of the SEEA Central Framework provides extensive guidance on the definition of environmental assets and the principles of asset accounting.

2.25 An overview of the measurement of mineral and energy resources including various individual components is presented in Chapter 5 of SEEA-Energy.

Other energy-related stocks and flows

2.26 In addition to the measurement of stocks of mineral and energy resources, and energy-related flows between the environment and the economy, the SEEA-Energy framework includes certain other energy-related economic stocks and flows. Examples of other energy-related economic stocks and flows include inventories of energy products and produced assets used in the extraction of mineral and energy resources and in the generation of energy products; expenditures to decommission power plants, and taxes and subsidies designed to change the amount and type of energy used. These types of flows are becoming increasingly important tools in achieving energy-related environmental policy objectives.

2.3 Main accounts and tables of SEEA-Energy

2.3.1 Introduction

2.27 SEEA-Energy organises and integrates the information on the various energy-related stocks and flows of the economy and the environment in a series of tables and accounts. SEEA-Energy utilises the following types of tables and accounts: (i) supply and use tables showing flows of energy from natural inputs in physical terms, products in physical and monetary terms and residuals in physical terms; (ii) asset accounts for mineral and energy resource in physical and monetary terms showing the stock of resources at the beginning and end of each accounting period and the changes in the stock; and (iii) accounts showing energy-related stocks and transactions. In addition, functional accounts may be prepared to highlight certain economic activities undertaken for environmental purposes. A range of additional data may be introduced into these tables and accounts, including population, demographic and employment information relevant to the analysis of energy-related issues.

2.28 The strength SEEA-Energy framework comes from consistently applying definitions for stocks and flows across different types of energy from natural inputs - defining the different economic units and locations in the same way; and using common classifications for physical and monetary accounts.

2.29 The compilation of energy accounts using SEEA-Energy does not require completion of every table and account. SEEA-Energy can be implemented in a modular way taking into account those aspects of the environment and the energy situation that are most important to a country. At the same time the ambition should be to fully account for the environment-economic energy structure within a country and to provide information on energy-related issues of national and global concern using a common measurement framework.

2.30 This section introduces the different tables that are part of the SEEA-Energy framework and shows the nature of their statistics and the integration between them. The explanation is stylised, as the reality of accounts compilation is more complex, but the basic logic and intent of the approach explained in this section applies throughout SEEA-Energy.

2.3.2 Supply and use tables

Physical supply and use tables (PSUT)

2.31 Physical flows are recorded in SEEA-Energy by compiling supply and use tables in physical units of measure. These tables are commonly known as physical supply and use tables, or PSUT. PSUT are used to assess how an economy supplies and uses energy products and can also be used to examine changes in production and consumption patterns over time. In combination with data from monetary supply and use tables, changes in productivity and intensity in the use of energy from natural inputs and the release of residuals can be examined.

2.32 The physical supply and use table is an accounting construct for compiling and presenting all energy flows that enter, leave and are used within the national economy of a given country for a period of time. It necessarily expresses energy flows in a common unit (joules) and shows the relationship between inputs to and outputs from energy transformation processes. The physical supply and use table for energy aims to be comprehensive and records all energy flows within the economy and between the economy and the environment.

2.33 Table 2.1 provides an introduction to PSUT. There are a range of additions and refinements that are required to this basic PSUT to cover all relevant flows of natural inputs, products and residuals. These are explained in greater detail in Chapter 3.

2.34 The PSUT structure is similar to the monetary supply and use tables described in the next section with the PSUT containing extensions to incorporate rows for energy from natural inputs and energy residuals.

2.35 The column for Government does not appear in the PSUT for energy because, in physical terms, government activity is completely recorded within the second column, industries. The column for Households relates purely to the consumption activity of households. Many households also undertake a range of production activity including the collection of fuelwood and the generation of energy through the use of solar panels, etc. All of this production activity and the associated natural inputs and residuals are recorded in the column 'Industries'.

2.36 The supply and use identity applies within the PSUT for energy. Thus as shown below, for each product measured in physical terms (for example joules of coal) the quantity of domestic production (output) and imports (total supply of energy products) must equal the consumption (both intermediate and final), changes in inventories and exports (total use of products). The equality between supply and use also applies to the total supply and use of natural inputs and the total supply and use of residuals.

Total Supply of Energy Products = Output + Imports

is identical to

Total Use of Energy Products = Intermediate consumption + Household Consumption + Changes in inventories + Exports

2.37 Physical energy flow accounts are a special case and a subset of the physical flow accounts of the SEEA Central Framework. Physical energy supply and use tables may be 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 from natural inputs and energy products by their calorific energy content, it is recommended that accounts use a common energy unit of Joules.

Table 2.1 Basic form of a Physical Supply and Use Table for Energy

SUPPLY TABLE						
	Industries	Households	Accumulation	Rest of the World	Environment	Totals
Energy from natural inputs					Energy inputs from the environment	Total supply of energy from natural inputs
Energy products	Output			Imports		Total supply of energy products
Energy Residuals	Energy residuals generated by industry	Energy residuals generated by household consumption	Energy residuals from accumulation	Energy residuals received from the rest of the world	Energy residuals recovered from the environment	Total supply of energy residuals

USE TABLE						
	Industries	Households	Accumulation	Rest of the World	Environment	Totals
Energy from natural inputs	Extraction of energy from natural inputs					Total use of energy from natural inputs
Energy products	Intermediate consumption	Household consumption	Changes in inventories	Exports		Total use of energy products
Energy residuals	Collection & treatment of energy residuals		Accumulation of energy residuals	Energy residuals sent to the rest of the world	Energy residual flows direct to environment	Total use of energy residuals

2.38 The SEEA-Energy framework includes additional tables compared to SEEA Central Framework which follow the general supply and use format, but which introduce a range of features specific to energy accounts. One such additional SEEA-Energy table is a use table showing the purpose for which the energy product is used, for example, for transport, heating, etc., and for other energetic and non-energetic purposes.

2.39 Three additional SEEA-Energy tables focus on a) the supply of primary energy and imports; b) the conversion of energy; and c) the end use of energy. The latter presents energy use without the gross recording of energy which is a general feature of the standard supply and use tables. This arises from the inclusion of both primary energy (for example, coal) and converted energy (electricity); the latter being the result of primary energy used by energy supply industries. The specific presentation of the energy flows and the split between supply of primary energy, energy conversion and end use of energy is similar to the presentation of energy flows in energy balances according to IRES.

2.40 In addition to the supply and use identity, the PSUT incorporates an identity concerning flows between the environment and the economy. This second identity, known as the input-output identity, requires that the total flows into the economy (for example in the form of natural gas extracted from natural deposits) are, over an accounting period, either used in production processes, consumed by final users, accumulated in the economy or returned to the environment. The input-output identity also applies at the level of households and industries. 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.

Energy into the economy = Energy inputs from the environment + Imports + Energy residuals received from the rest of the world + Energy residuals recovered from the environment

is equal to

Energy out of the economy = Energy residual flows direct to environment + Exports + Energy residuals sent to the rest of the world

plus

Net additions to stock in the economy = Changes in inventories + Accumulation of energy residuals

Monetary supply and use tables

2.41 The basic form of a Monetary Supply and Use Table for Energy is shown in table 2.2. Monetary supply and use tables in SEEA-Energy fully articulate in monetary terms the flows of energy products in an economy between different economic units. Monetary supply and use tables have their origins in economic accounting and the PSUT utilise the organisational principles and characteristics of these tables. Nevertheless, while the PSUT for energy contain three main types of flows i.e. energy from natural inputs, products and residuals, the monetary supply and use table for energy records only those flows related to energy products.

Table 2.2 Basic form of a Monetary Supply and Use Table for Energy

	Industries	Households	Government	Accumulation	Rest of the world	Total
Supply table						
Energy products	Output				Imports	Total supply
Use table						
Energy products	Intermediate consumption	Household final consumption expenditure	Government final consumption expenditure	Changes in inventories	Exports	Total use
	Value added					

2.42 Monetary supply and use tables for energy provide structural information on the energy sector and the level of activity in this sector. They also provide detailed information on the industries within the economy that are using these energy products. Monetary supply and use tables for energy can readily be integrated with PSUT for energy to create a powerful analytical tool.

2.43 Chapter 4 provides greater detail on the organisational structure of monetary supply and use accounts for energy, as well as the flows recorded and aggregates contained in these accounts. Full details on the definitions of the different variables that comprise the monetary supply and use tables are described in Chapter 14 of the 2008 SNA.

Classifications for supply and use tables

2.44 In the compilation of supply and use tables in both physical and monetary terms, an important factor is the use of consistent classifications for the main economic units and products. In SEEA-Energy, industries are consistently classified using the International Standard Industry Classification of All Economic Activities (ISIC), energy products are consistently classified using the Standard International Energy Classification (SIEC) and the determination of whether particular economic units are within a particular national economy is based on the concept of residence.

2.3.3 Asset accounts

2.45 The intent of asset accounts is to record the opening and closing stock of assets and the various types of stock changes over an accounting period. In SEEA-Energy asset accounts are compiled only for mineral and energy resources.[2] A key motivation for accounting for mineral and energy resources is to assess whether current patterns of economic activity are depleting and/or degrading available mineral and energy resources. More broadly, information from asset accounts can be used to assist in the management of energy from natural inputs.

2.46 Mineral and energy resources within SEEA-Energy include known deposits of oil resources, natural gas resources, coal and peat resources, and uranium and thorium resources[3], including those with no present economic value. As such, they are defined more broadly than in the 2008 SNA which includes only those inputs meeting the definition of an economic asset.

2.47 An asset account is generally structured as shown in Table 2.3. It starts with the opening stock of resources and ends with the closing stock of resources. In physical terms, the changes between the beginning and the end of the accounting period are recorded as either additions to the stock or reductions in the stock and wherever possible the nature of the addition or reduction is recorded. In monetary terms, the same entries are made but an additional term is included to record revaluations to the resource stocks. This entry accounts for changes in the value of assets over an accounting period due to price movements for the resources.

[2] SEEA Central Framework provides guidance for compiling asset accounts for timber.

[3] In SEEA Central Framework, mineral and energy resources include known deposits of oil resources, natural gas resources, coal & peat resources, non-metallic minerals and metallic minerals. In SEEA-Energy mineral and energy resources are restricted to those resources related to energy production.

Table 2.3 Basic form of an asset account

Opening stock of resources		
Additions to stock of resources		
	Growth in stock	
	Discoveries of new stock	
	Upwards reappraisals	
	Reclassifications	
	Total additions to stock	
Reductions in stock of resources		
	Extractions	
	Normal loss of stock	
	Catastrophic loss	
	Downwards reappraisals	
	Reclassifications	
	Total reductions in stock	
Revaluation of the stock of resources *		
Closing stock of resources		

* Only applicable for asset accounts in monetary terms

2.48 Other changes in environmental assets are caused by natural phenomena, for example, an earthquake causing the collapse and abandonment of a mine. Some changes between the opening and closing stock are more purely accounting in nature and reflect changes due to improved measurement (reappraisals) or due to differences in the definition or composition of the asset (reclassifications). The reassessment of the size and quality of oil resources is an example of a reappraisal. Reclassifications are recorded when for example a mineral and energy resource is reclassified as another type of mineral and energy resource.

2.49 Asset accounts can be compiled for individual types of mineral and energy resources. However, in monetary terms, there may be interest in aggregating the values of all mineral and energy resources at the beginning and end of the accounting period. Such aggregations can be presented in balance sheets alongside the value of various other assets (e.g. produced assets and financial assets).

2.50 Energy from renewable sources presents a special case in that renewable sources used in the generation of energy cannot be exhausted in a similar manner to non-renewable natural inputs such as oil. In SEEA-Central Framework the value of the renewable source is in general included as part of the value of associated land (for solar, wind, wave and tidal and geothermal) or water (hydro). The treatment of asset accounts for assets related to the generation of energy from renewable sources is further discussed in Chapter 6.

2.51 The capacity to account for levels of mineral and energy resources and changes in these levels, and to analyse the state of these inputs, is a fundamental role of SEEA-Energy. There are however many conceptual and practical measurement challenges, often unique to particular energy assets. These measurement issues are discussed in detail in SEEA-Energy Chapters 5 and 6.

The connections between supply and use tables and asset accounts

2.52 The different tables of SEEA-Energy are compiled for different purposes and highlight different aspects of the relationship between the economy and the environment. At the same time, there are close links between the supply and use tables and the asset accounts, such as the inclusion of flows of energy from natural inputs in both accounts.

2.53 The opening and closing stocks for a given period appear in the asset account. Some components of the changes in the stocks also appear in the supply and use tables, for example, gross capital formation and extraction of energy from natural inputs are included in both tables. Some aspects of changes in stocks are not recorded in the supply and use tables and these are labelled 'other changes in assets'. Examples of such changes include discoveries of mineral and energy resources, losses of energy from natural inputs following catastrophic natural events and, within the monetary accounts, changes in the values of mineral and energy resources due to price changes.

2.3.4 Specific-purpose accounts

2.54 While monetary supply and use tables can be used to organise and present certain types of energy related transactions of particular relevance to the environment, such transaction within supply and use tables usually require additional disaggregation because the conventional industry and product classifications do not necessarily highlight environmental activities or products.

2.55 By highlighting energy related activities and products, information can be presented on the economic response to environmental issues. Particular items of interest could include energy-related subsidies and taxes; transactions related to tradable permits to emit carbon; and expenditures to decommission nuclear power plants.

2.56 The construction of specific-purpose accounts and associated information is discussed further in Chapter 4.

2.4 Economic units

2.4.1 Introduction

2.57 In addition to defining various stocks and flows, the key component in accounting for the interaction between the economy and the environment is the definition of the units involved.

2.58 For SEEA-Energy, the units involved are economic units who interact with each other and that are able to make decisions about the production, consumption and accumulation of goods and services. They are classified in different ways depending on the type of analysis being undertaken. The focus of this section is a description of these economic units. The section also provides a discussion on reporting units for statistical purposes. In this context, both economic units and 'units' within the environment – for example mineral and energy deposits, are relevant notions.

2.4.2 Institutional sectors

2.59 The starting point for considering economic units is a focus on the purposes, objectives and behaviours of individual economic units. Institutional units are those individual economic units that are capable of owning assets, incurring liabilities, and engaging in transactions and other economic activities with other economic units. These institutional units may be either households, or legal or social entities (such as corporations) that are recognised independently of the people that own or control them. Groupings of units that are similar in their purposes, objectives and behaviours are defined as institutional sectors.

2.60 SEEA-Energy, consistent with the SEEA Central Framework and SNA, recognises five institutional sectors: households, non-financial corporations, financial corporations, general government and non-profit institutions serving households (NPISH). Although important in the context of the SNA, the distinction between non-financial and financial corporations is far less significant in SEEA-Energy and hence, generally, these are presented as one sector, Corporations. The 2008 SNA Chapter 4 defines and describes the different institutional sectors in detail.

2.4.3 Enterprises, establishments and industries

2.61 An enterprise is the view of an institutional unit as a producer of goods and services. Enterprises undertake production in a range of different ways including as profit making businesses, as a part of household activity or as part of the function of government. Importantly, an enterprise can own assets and acquire liabilities and has the capacity to engage in transactions and other economic activities with other economic units.

2.62 An enterprise may be comprised of one or more establishments and hence may be located across multiple locations within a single economy. An establishment is a unit situated in a single location and within which only a single type of productive activity is carried out or within which a single productive activity (the primary activity) accounts for the majority of the value added.

2.63 The ability to define and observe establishments and enterprises and determine the types of goods and services they produce is at the heart of supply and use accounting. Meaningful analysis can be undertaken at an aggregate level by grouping units that undertake similar types of productive activity and by grouping goods and services that display similar characteristics.

2.64 In SEEA-Energy, as in the SEEA Central Framework and the SNA, the groupings of establishments that undertake similar types of productive activity are referred to as industries. Within SEEA-Energy, establishments are classified into industries using the International Standard Industrial Classification of All Economic Activities (ISIC). Industries cover, broadly, agriculture, mining, manufacturing, construction and services – the latter including electricity, gas, steam and air conditioning supply services. Ideally, an industry is composed of establishments that undertake the same activity and only that activity – i.e. the grouping should be homogenous. In practice, many establishments undertake a variety of activities but have a primary activity that can be used to assign a specific industry class for that establishment.

2.65 In both physical and monetary terms the production and use of goods and services within establishments are referred to as 'own-account' activities. In the SNA, own-account activity covers activity relating to either final consumption or investment undertaken by the economic unit (own account final use). The SNA does allow the possibility of recording separately some own account intermediate use activity, described as ancillary activity, but this is limited to a specific set of activities.[4]

2.66 For some purposes of environmental and economic accounting, it may be relevant to identify the secondary activities of an establishment and also activities undertaken within an establishment but where output is not sold to other units. This is particularly the case in accounting for physical flows of energy where measuring all transformations of energy products is likely to be of interest. Generally, the recording of physical flows internal to establishments is only undertaken in specific circumstances. However in some cases there may be great interest in these types of flows, for example, there is considerable interest in cogeneration of energy within business sites using heat recovery steam generators.

2.67 In the compilation of functional accounts, it may be relevant to identify the secondary and other activities of establishments that are being undertaken for environmental purposes such that a complete description of relevant activity can be made. An example of such activity is the use of equipment designed to remove sulphur dioxide from coal. For the compilation of functional accounts on energy-related activities and flows, SEEA-Energy aims to separately identify these types of activities and flows.

2.68 A particular area of own-account activity in both physical and monetary terms concerns households. The activities of households are of potential interest in SEEA-Energy, for example, in informing of household use of certain energy from natural inputs e.g. collection of fuel wood; or the use of solar panels sited on houses. As in the SEEA Central Framework where such activity is significant, it is recorded together with that of industrial units undertaking the same activity.

[4] See 2008 SNA Chapter 5.

2.4.4 Reporting units for statistical purposes

2.69 The discussion of economic units in this section has focused on the ability of these units to operate within an economy as active participants. In statistical terms, these units are often also the focus of measurement as units of observation or reporting units. Depending on the structure of information within a country, economic data are likely to be available for most types of economic units particularly for enterprises and, in some cases for individual establishments. However, since the ownership structures of enterprises can vary significantly and since some enterprises may produce a range of different products, matching the conceptual model to the information available may not be straightforward.

2.70 In the physical supply and use table of SEEA-Energy the environment is added as an additional column alongside industries, households and the rest of the world. This reflects the importance of recording flows between the economy and the environment. Nevertheless, in SEEA-Energy the environment is not considered an additional type of unit akin to economic units. Rather, the environment is seen as passive with decisions regarding the supply of natural inputs to the economy and the receipt of residuals from the economy being made by economic units.

2.71 At the same time, the collection of information about the environment, particularly as it concerns environmental assets, requires consideration of appropriate environmental reporting units for statistical purposes. These reporting units reflect the parts of the environment about which statistics may be collected and presented, for example, mineral and energy deposits. In many cases, it will be possible to align the environmental reporting unit and an associated economic unit.

2.5 Classifications

2.5.1 Introduction

2.72 The SEEA-Energy framework covers a range of disciplines and therefore utilises a number of classification systems ranging from those with an essentially physical focus to those typically used for economic accounts. SEEA-Energy is a subsystem of the SEEA Central Framework and its defining characteristic is its specific focus on energy-related flows and stocks – in both physical and monetary terms. It is therefore important how SEEA-Energy defines and classifies the various stocks and flows of energy included in the framework.

2.73 It is important to know those industries that are extracting mineral and energy resources; producing and using energy products; and undertaking energy-related transactions. The classification of industries is therefore important. This section starts by describing the basic structure of the International Standard Industrial Classification of All Economic Activities (ISIC) and presents a more detailed correlation between various mineral and energy resources and the industries that typically extract them.

2.74 This section also introduces the classification of energy from natural inputs. These inputs are discussed more fully in Chapter 3 and are closely related to the energy products arising from these inputs. In turn, the definition and classification of energy products is of fundamental importance to SEEA-Energy since this essentially determines the scope of this framework. SEEA-Energy and IRES use identical notions and classifications of energy products as set out in the *Standard International Energy Product Classification* (SIEC). From an analytical viewpoint, there is great interest in knowing whether energy products are primary or secondary in character. There is also considerable interest in whether these sources are renewable or non-renewable. Therefore, a discussion of primary /secondary and renewable/non-renewable energy products appears below.

2.5.2 Classification of industries

Industries

2.75 Industries are groupings of establishments engaged in the same, or similar, kinds of activities. An establishment is assigned to an industry according to its principal activity, i.e. the activity whose value added exceeds that of any other activity carried out within the same establishment. An establishment may in addition carry out secondary activities for own use, or for delivery outside the establishment or ancillary activities. Steam, for instance, may be produced by a steelworks from surplus heat as secondary activity and a manufacturing company may, for instance, produce electricity for own use as an ancillary activity.

2.76 The classification of industries in SEEA-Energy follows the International Standard Industrial Classification of All Economic Activities, ISIC, Revision 4[5].

2.77 ISIC includes all the relevant economic activities for describing the removal or capture of energy from natural inputs, and the transformation and distribution of energy products. These activities mainly take place within the following three sections:

- Section B – Mining and quarrying
- Section C – Manufacturing
- Section D – Electricity, gas steam and air conditioning supply

2.78 Establishments extracting mineral and energy resources as a *principal activity* are included in ISIC Section B, Mining and quarrying. The section is further divided into the following divisions:

- ISIC Division 05 - Mining of coal and lignite[6]
- ISIC Division 06 - Extraction of crude petroleum and natural gas

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[5] The following description of the industries is based on the description of ISIC rev. 4, http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27&Lg=1

[6] Specifically this division includes hard coal, sub-bituminous coal and lignite.

- ISIC Division 07 - Mining of metal ores
- ISIC Division 08 - Other mining and quarrying
- ISIC Division 09 - Mining support service activities

2.79 These industries also carry out certain supplementary activities aimed at preparing the crude materials for marketing, for example, crushing, grinding, cleaning, drying, sorting, concentrating ores, liquefaction of natural gas and agglomeration of solid fuels.

2.80 ISIC Divisions 05 and 06 are concerned with mining and quarrying of fossil energy (coal, lignite, petroleum, gas); while Divisions 07 and 08 relate to metal ores, various minerals and quarrying products.

2.81 Some of the technical operations of mining and quarrying, particularly related to the extraction of hydrocarbons, may also be carried out for third parties by specialized units as an industrial service. Such services are included in Division 09 and represent specialized support services incidental to mining provided on a fee or contract basis. It includes exploration services through traditional prospecting methods as well as drilling. Other typical services cover construction of oil and gas well foundations, cementing oil and gas well casings, draining and pumping mines, overburden removal services at mines, and so on.

2.82 Section B excludes the processing of the extracted materials (which is included instead in Section C - Manufacturing), separate site preparation activities for mining (see Class 4312) and geophysical, geologic and seismic surveying activities (included in Class7110).

2.83 The ISIC divisions are further subdivided into Groups and Classes on the basis of the principal mineral produced. Table 2.4 links specific mineral and energy resources to the ISIC industries which undertake the extraction activities for these specific resources.

Table 2.4 Mineral and energy resources and industries extracting them

Mineral and energy resources (SEEA-Energy classification, cf. Chapter 3)	**ISIC Groups and classes within Section B**
Oil resources	061 – Extraction of crude petroleum
Natural gas resources	062 – Extraction of natural gas
Coal and peat resources	05 - Mining of coal and lignite; 0892 - Extraction of peat
Uranium and thorium ores	0721 - Mining of uranium and thorium ores

Industries capturing energy from renewable sources

2.84 Energy from renewable sources is recorded as a flow of inputs of such sources to the economy equal to the actual output produced. The industry capturing this energy then records a produced output (same as the input) in the form of an energy product, for example electricity. Accordingly, the use table then records the use of this electricity product.

2.85 The principal activities of capturing heat and electricity from renewable sources, i.e. as primary energy, are included in ISIC Section D Electricity, gas, steam and air conditioning supply. More specifically Class 3510 Electric power generation, transmission and distribution include the operation of generation facilities that produce electricity including thermal energy, while Class 3530 - Steam and air conditioning supply include production of steam and hot water for heating, power and other purposes.

Further discussion of industries involved in extraction and production of energy

2.86 Within ISIC C, Division 19 Manufacture of coke and refined petroleum products is of specific relevance in relation to the production of energy products. It is further subdivided into the following Groups:

- ISIC Group 191 – Manufacture of coke oven products
- ISIC Group 192 – Manufacture of refined petroleum products

2.87 These industries transform crude petroleum and coal delivered from ISIC Section B Mining and quarrying into other energy products. The dominant process is typically petroleum refining, which involves the separation of crude petroleum into component products through techniques such as cracking and distillation, and results in the manufacturing, for own account or sale, of products such as coke, butane, propane, petrol, kerosene, fuel oil etc. Provision of processing services (e.g. custom refining) are also included. Petroleum refineries may also produce petroleum based gases such as ethane, propane and butane.

2.88 The enrichment of uranium and production of elements to allow the use of uranium in nuclear reactors takes place in ISIC Class 2011 Manufacture of Basic Chemicals.

2.89 ISIC Section D Electricity, gas, steam and air conditioning supply includes the following three Groups:

- ISIC Group 351 - Electric power generation, transmission and distribution
- ISIC Group 352 - Manufacture of gas; distribution of gaseous fuels through mains
- ISIC Group 353 - Steam and air conditioning supply

2.90 These industries provide electricity, natural gas, steam and hot water through a permanent infrastructure (network) of lines, mains and pipes. Also included is the distribution of electricity, gas, steam, hot water in industrial parks or residential buildings. The operation of electric and gas utilities, which generate, control and distribute electricity, gas and steam is also included.

2.91 These industries produce secondary energy by converting other energy products, but in addition they produce, as described above, primary energy by capturing, for instance, energy from sun and wind, and producing electricity and heat from it.

2.92 Note that the separate ISIC classification of electric power (ISIC Group 351) and steam (ISIC Group 353) is artificial, when it comes to units generating combined heat and power (CHP). The output of electricity and heat can be measured separately, but the inputs of energy products for the CHP process have to be split based on assumptions. As a default option the inputs of energy products for the CHP process may be split based on reference values for separate production of heat and electricity.

Other industries involved in extraction and production of energy

2.93 While the bulk of energy products are imported or produced by the abovementioned industries, other industries may in principle be involved in the capture of energy from natural inputs. Moreover, it is not unusual that other industries are involved in the production of energy products (such as electricity or heat) as a secondary or ancillary activity.

2.94 The starting position for recording such activities is that such activities should be assigned to the industries actually carrying them out. For instance, electricity and heat produced in relation to incineration of waste should be recorded as the result of activities of ISIC Class 3821 - Treatment and disposal of non-hazardous waste. Nevertheless, it should be observed, that in practice often a reallocation of activities in such industries as agriculture, construction, trade and energy supply take place when the national accounts are set up. This requires that data from basic statistics regarding secondary activities in industries be transferred to the relevant primary industries when the data are entered into the supply and use tables.

2.95 Therefore it may be necessary to make a similar reallocation of the flows of energy products in order to ensure consistency with the national accounts. If such a reallocation is made the result is that the supply table becomes sparse in the sense that all industries must be shown but that most flows are concentrated into a small number of industry columns (i.e. those industries described in the previous sections).

2.96 In addition to the core activities of extracting and producing energy products by the abovementioned industries, supplementary activities are carried out by other industries. Examples include transport activities such as long-distance transport of gas through pipelines, or transport of energy products by ships, trains and trucks carried out by ISIC Section H Transportation and storage.

2.5.3 Classification of energy from natural inputs

Energy from natural inputs

2.97 The classification of energy from natural inputs by type (Table 2.5) is used in the supply and use tables in order to show the flows of various energy from natural inputs to the economy. It is also used in the asset accounts to show the various types of mineral and energy resources held within the economy. This supports one of the aims of physical supply and use tables for energy, namely, the presentation of a full correspondence between the recording of energy-related flows and stocks.

Table 2.5: Energy from natural inputs

(Energy) natural resource inputs		
	Mineral and energy resources	
		Oil resources
		Natural gas resources
		Coal and peat resources
		Uranium and other nuclear
	Timber resources (natural)	
Inputs of energy from renewable sources		
	Solar	
	Hydro	
	Wind	
	Wave and tidal	
	Geothermal	
	Other electicity and heat	
Other natural inputs		
	Energy inputs to cultivated biomass	

2.98 The classification of energy from natural inputs provides a classification by *type* of resource and is based on the purpose of the natural inputs. At the top level the three types of energy from natural inputs are natural resource inputs, inputs of energy from renewable sources and other natural inputs. In order to make an assessment of whether mineral and energy resources are also economic assets it is also necessary to assess 'quality' and 'knowledge' aspects of these resources. Consequently, the classification of mineral and energy resources and the closely related determination of 'economic' mineral and energy resources are discussed more fully in Chapter 5.

2.99 When energy from natural inputs are removed or extracted from the environment and subjected to production processes, the resultant output typically takes the form of an energy product.

2.5.4 Classification of energy products

Energy products

2.100 IRES states that energy products relate only to those products exclusively or mainly used as a source of energy. Such products include energy in forms suitable for direct use (e.g. electricity and heat) and energy products which release energy while undergoing some form of conversion (e.g. coal for combustion, etc.). By convention, energy products include biomass and waste (either solid or liquid) that are converted for the production of electricity and/or heat (IRES, 2011, 2.B)[7].

2.101 This definition of energy product emphasizes the use of the product instead of its physical characteristics. Within the IRES definition of energy products, the qualifier *mainly* should be noted, since even if a product is normally characterized as an energy product, it might still be used for non-energy purposes. Similarly, many products which are not normally perceived as energy products may be to some extent used as a source of energy. In SEEA-Energy, the scope of energy products is defined in view of the purpose of the product.

2.102 For a product such as crude oil by convention, the full amount of its use is normally described as an energy product in SEEA-Energy. This is because it is mainly used for energy purposes, even though crude oil can be used for non-energy purposes, e.g. to produce plastics. In the SEEA-Energy accounts a distinction is therefore made between use of energy products for energy purposes and non-energy purposes.

2.103 Wood can be used as fuel wood or for other purposes, such as for building materials and pulp and paper. To the extent that wood is not used for energy purposes, it is excluded from the energy accounts; while the part used as fuelwood is included among energy products in SEEA-Energy accounts.

2.104 As a further example, corncobs can be burned to produce heat; they can be used in the production of ethanol-based biofuels; or they can be consumed as food. Although, it might be argued that corncobs used in the production of biofuels should be regarded as a source of energy, according to IRES they should not be included as energy products. Only those corncobs used for combustion are included as energy products (IRES, 2011, 2.11). This conclusion arises directly from the use of the distinction between primary and secondary energy products – a distinction that is important for analytical purposes and discussed more fully below.

2.105 Thus, those corncobs used for combustion are termed primary energy products, while the heat or electricity resulting from this combustion is classified as a secondary energy product. Biofuels made from corncobs are, however, characterized as a primary energy product and therefore all inputs used for the production of such biofuels fall outside the scope of energy products.

[7] IRES is currently being revised and this paragraph will be updated once the IRES revision is completed.

Primary and secondary energy products

2.106 Primary energy products result from the removal or capture of energy from natural inputs from the environment. When energy from natural inputs has been removed it typically becomes an energy product and it is delivered from extracting industries to other parts of the economy. Biofuels, heat and energy produced by capturing energy from renewable sources from the environment (e.g. hydropower, solar and wind) are included as primary energy products.

2.107 Secondary energy products result from the 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.

2.108 Note that electricity and heat may be produced either as primary or secondary products. If heat is captured directly from the environment through solar panels or from geothermal reservoirs it is considered to be a primary energy product. If heat is produced from other energy products such as coal, oil or electricity it is considered to be a secondary energy product. For electricity, similar distinctions apply.

Renewable and non-renewable energy from natural inputs

2.109 Energy products can be obtained from both renewable (e.g. solar, biomass, etc.) and non-renewable (e.g. coal, crude oil, etc.) energy from natural inputs. It is important for both energy planning and environmental concerns to distinguish between renewable and non-renewable energy from natural inputs, as well as to distinguish between non-depletable inputs (such as solar) and depletable renewable inputs such as biomass.

2.110 The notion of renewability involves energy from natural inputs that can be replenished for an indefinite time period. In its various forms it derives directly or indirectly from the sun, or it is generated within the earth. It includes solar energy, wind energy, geothermal energy, wave and tidal energy, hydropower and biofuels.

2.111 References to renewable energy inputs might also include the requirement that the energy from natural inputs should be replenished at a rate comparable or faster than its rate of extraction. Related to this requirement is the question of whether the input underpinning and providing the energy product is a non-depleting factor such as wind and solar energy, or whether it relies on a cyclical renewable input such as a forest.

2.112 For cyclical renewable inputs, time and appropriate management have a role to play in the replenishment of these inputs. For these energy inputs the re-growth and reproduction takes time. If a renewable energy input is used too rapidly, for example, under circumstances where forests are harvested more rapidly than they are re-growing, they cannot provide energy for an indefinite period of time. Hence, proper management of a potentially renewable input, such as a forest, could be considered necessary to uphold the ‘renewable’ status of the input.

2.113 In contrast, for renewable energy from natural inputs relying on non-depletable inputs, ongoing energy production depends largely on the capacity of the available fixed capital such as windmills and solar panels. In some cases changes to the surrounding area might impact energy production (for example a new tall structure blocking the sun to already installed solar panels).

2.114 Although sustainable management is a reasonable requirement for determining the renewability of the cyclical renewable energy input, it seems for statistical and accounting purposes appropriate not to include the management dimension since it relates to factors which cannot be observed directly when the information on supply and use of energy products is collected and recorded in the accounts.

Standard International Energy Product Classification (SIEC)

2.115 IRES presents a list of internationally agreed definitions of energy products. These products appear within the *Standard International Energy Product Classification* (SIEC) in IRES and are presented at the broadest level in Table 2.6.

Table 2.6 Standard International Energy Product Classification (SIEC)

Classes of energy products	
0	Coal
1	Peat and peat products
2	Oil shale / oil sands
3	Natural gas
4	Oil
5	Biofuels
6	Waste
7	Electricity
8	Heat
9	Nuclear fuels and other fuels n.e.c

Source: IRES, 2011

2.116 In contrast to the physical flow account of SEEA-Energy the monetary flow accounts use the Central Product Classification (CPC). The direct comparison of monetary and physical flow accounts for SEEA-Energy requires a working correspondence between the SIEC and CPC classifications.

2.117 Within SIEC the distinctions between primary and secondary energy products, as well as between renewable and non-renewable energy inputs are not explicit classification criteria - though in many cases an entire detailed SIEC category can clearly be assigned to either primary or secondary products; and also to either renewable or non-renewable.

2.118 IRES (Chapter 3 and Annex A) provides further discussion on SIEC and the definitions of energy products as well as the distinctions between primary and secondary energy products, and energy products derived from renewable and non-renewable sources. In addition, correspondences between SIEC and other international product classifications, such as the Harmonized Commodity

Description and Coding System (HS) and the Central Product Classification (CPC) are provided in IRES.

Main and Auto producers of electricity and/or heat

2.119 Within energy statistics and energy balances, an enterprise that produces electricity or heat as its principal activity is described as a Main Activity Producer. An enterprise that produces electricity for sale or own use where such activity is not their principal activity is described as an Autoproducer (electricity). The electricity production of an autoproducer can be also classified as ancillary activity when used by the producer or secondary activity when sold. And an enterprise that produces heat for sale where such activity is not their principal activity is described as an Autoproducer (heat).[8] The heat produced by an autoproducer is a secondary activity.

2.120 Information related to Main Activity Producer and/or Autoproducer status could be reflected in the tables to support specific analytical applications, though this has not been done in the standard tables of SEEA-Energy.

2.6 Accounting rules and principles

2.6.1 Introduction

2.121 The recording of accounting entries requires the use of a consistent set of accounting rules and principles. Without these, related transactions and flows may be recorded on different bases, at different times or with different values thus making accounting far less useful and reconciliation difficult.

2.122 SEEA-Energy uses accounting rules and principles consistent with those of the SEEA Central Framework and the SNA. This section introduces the rules and principles of most relevance to the SEEA. Readers are encouraged to refer to the 2008 SNA Chapter 3 for more detail.

2.6.2 Recording rules and principles

Time of recording

2.123 One requirement of SEEA-Energy and SEEA Central Framework accounting principles is that transactions and other flows must be recorded as occurring at the same point in time in the various accounts for both units involved.

2.124 In monetary accounts, the general principle is that transactions are recorded when ownership changes and the corresponding claims and obligations arise, are transformed, or are cancelled. Transactions internal to one unit are recorded when

[8] Paragraph 5.45, *International Recommendations for Energy Statistics*, 2011. http://unstats.un.org/unsd/statcom/doc11/BG-IRES.pdf

economic value is created, transformed or extinguished. This approach to timing of recording is called an accrual basis of reporting.

2.125 Under an accrual basis of recording, the timing of transactions may not align to the timing of the related cash flow. For example, if a good is purchased and the purchaser is invoiced for payment within 30 days, the time of recording under an accrual approach is the date of the purchase – not the date when the invoice is paid.

2.126 Ideally, the time of the recording of physical flows should align with the time of recording of the flows in monetary terms. Adjustments to account for different underlying cycles of data in physical and monetary terms should be made as required.

Units of measurement

2.127 For accounts compiled in monetary terms, the components from which the entries are built up and hence all entries must be measured in monetary terms. In most cases, the amounts entered are the actual transactions taking place, but in other cases the amounts entered are estimated by reference to equivalent monetary values (for own-account consumption) or valued at the cost of production (for non-market output).

2.128 For accounts compiled in physical terms, the unit of measurement will reflect the mass, volume or energy content of the resource or product. Measurement units that are specific to an energy product and are employed at the point of measurement of the energy flow are often referred to as 'original' or 'natural' units. Typical examples are kilograms or metric tons for solid fuels; and barrels, litres or tonnes for oil; and cubic metres for gases. The actual units used vary across countries and local conditions and often reflect historical practice within a country (IRES 2011, 4.9).

2.129 For statistical and accounting purposes and for many types of analyses it is useful to convert original units into a common unit, for example, to compare quantities of different energy products and/or to estimate efficiencies. The conversion from different units to a common unit requires conversion factors for each product. In the *International System of Units*[9] the joule is the common unit used, though other common energy units are also applied in practise, for instance, toe, GWh, Btu, calories, etc. The use of the joule as a common unit is recommended by SEEA-Energy and by IRES (2011, 4.29).

2.130 For each physical energy account, only one unit of measurement should be used within the account such that aggregation and reconciliation is possible across all accounting entries. For monetary energy accounts, only monetary units should be used. However, in combined presentations of physical and monetary data a range of measurement units may be used.

[9] See International Bureau of Weights and Measures (BIPM) http://www.bipm.org/en/si/

2.131 Reference is made to IRES (2011) for further information on measuring units and the conversion between units.

2.7 Combining physical and monetary data

2.7.1 Introduction

2.132 The presentation of information in a format that combines both physical and monetary data is one of the most powerful features of SEEA-Energy. It enables SEEA-Energy to provide a wide range of information on specific themes, to compare related information across different themes and to derive indicators that reflect the use of both physical and monetary data.

2.133 Given the integrated accounting structures for physical and monetary accounts and statistics, it is logical to use these structures and the common underlying accounting rules and principles to present both physical and monetary information. Such integrated formats are sometimes referred to as 'hybrid' presentations or accounts because they contain data in different units. Despite the use of different units of measure, the data sets are presented following common classifications and definitions, and hence these presentations are referred to as combined physical and monetary presentations in SEEA-Energy.

2.134 Different forms of combined physical and monetary presentations are possible and, indeed, there is no standard form for these presentations or accounts. Commonly, physical flow data are presented alongside information from monetary supply and use tables but even for this basic approach different combinations are possible. Ultimately, the structures of combined presentations of monetary and physical data are dependent on data availability and the various policy questions to be resolved.

2.135 While no standard structure can be prescribed, compiling and contrasting monetary and physical data in meaningful ways is at the heart of the SEEA-Energy. This section provides a general introduction to combined physical and monetary presentations. Chapter 4 discusses the compilation of these presentations. More detailed presentations involving structures such as presentations that cover a particular theme or topic, for example decoupling of energy use and economic growth, are considered in Chapter 7.

2.7.2 The concept of combining physical and monetary data

2.136 At the core of combining physical and monetary data is the logic of recording physical flows in a manner compatible with economic transactions as presented in the SNA. This data can be used to compile emission accounts for example and linkages can be made that guarantee a consistent comparison of environmental burdens with economic benefits, or environmental benefits with economic costs. This linkages can be examined not only at the national level but also at disaggregated levels, for example, in relation to regions of the economy, or specific industries, or for the purpose of examining the flows associated with the extraction of a particular natural resource and/or of certain types of emissions.

2.137 These presentations combine physical data that may be of more immediate use to scientists, with monetary data familiar to economists, and for environmental issues they therefore have the potential to form a bridge between the perspectives and concerns of these two groups.

2.138 Combined physical and monetary presentations may legitimately and usefully include only a limited set of variables, depending on the most relevant and pressing environmental concerns to be taken into consideration. It is not necessary to complete an exhaustive physical supply and use table in order to present useful combinations of physical and monetary data.

2.139 A combined physical and monetary presentation thus highlights the interaction between economy and environment and given the importance of this interaction to so many environmental issues, provides a powerful basis for analyses required to tailor the appropriate policy response. Because combined physical and monetary presentations provide consistent environmental and economic indicators, the trade-offs in environmental (and economic) terms between alternative environmental and economic strategies can be observed and analysed, particularly in the context of time series.

2.7.3 Building blocks for combined presentations

2.140 Within SEEA-Energy considerable flexibility exists in how compilers may choose to present combined physical and monetary data related to energy. However, there are some typical areas that combined presentations will generally include. At a broadest level these areas cover all of the content described in SEEA-Energy and from this content, combined presentations include the variables and aggregates that best inform on the topic or theme of interest.

2.141 SEEA-Energy presents a number of combined monetary and physical presentations in Chapter 4. These are supply and use tables in which the physical and monetary flows are combined and they are useful, first, for providing a basis for analysis of the links between these monetary and physical flows; and second in developing consistency between the physical and monetary supply and use tables.

2.142 The basic building blocks of a combined presentation could include energy-related monetary flows, physical flows, assets and key aggregates and indicators. Additional variables and levels of detail may be added according to the questions to be informed and as data and information requirements allow. SEEA-Energy is able to provide a quite comprehensive set of indicators concerning the state of mineral and energy resources; the supply and use of energy products; and the links between energy and the environment. Possible types of indicators are discussed more fully in Chapter 7.

Chapter 3: Physical Flow Accounts

3.1 Introduction

3.1 SEEA-Energy records various physical flows related to energy. This chapter describes the definition, organisation and purpose of the SEEA-Energy physical flow accounts. The physical flow accounts of SEEA-Energy share certain commonalities with the presentation of energy balances as described in IRES.

3.2 Physical flows of energy in SEEA-Energy are organised into three broad groups (energy from natural inputs, energy products and energy residuals) according to whether they represent a supply of energy or a use of energy. Energy is supplied when it becomes a product – either when extracted directly from the environment (e.g. extraction of natural gas or capture of energy using solar panels); or when an energy product is created from another source (e.g. transformation of coal into electricity). Energy may also be imported (e.g. imports of crude oil).

3.3 The supply of energy and the use of energy are organised and presented in supply and use tables. In concept and organisation these tables closely resemble supply and use tables as described in the 2008 SNA. They are also similar to energy balances; however the SEEA-Energy supply and use tables contain a number of important distinguishing features. These features such as the use of residence principle and the use of classifications consistent with economic accounts allow for direct comparison with key economic aggregates such as gross domestic product, value added, household consumption and imports and exports.

3.4 Physical energy flows recorded within the integrated framework of SEEA-Energy are coherent not only with monetary flow accounts of energy, but also with monetary and physical asset accounts. In such a system, a physical flow of energy (e.g. extraction of coal) can be directly linked to economic flows (e.g. resource rent generated by the coal extractor), physical assets (e.g. reduced coal resources) and economic assets (e.g. reduced market value of coal resources). The organisation and combined presentation of energy-related flows in both physical and monetary terms is discussed in Chapter 4.

3.5 The framework for measuring physical energy flows is also aligned with the monetary energy flow accounts (Chapter 4) and mineral and energy asset accounts (Chapter 5). This is a particularly important connection for mineral and energy resource flows and for the assessment of production processes undertaken within extracting industries. Relevant flows are recorded both in the asset accounts and in the physical supply and use tables.

3.6 Section 3.2 describes a number of principles of fundamental importance to understanding and recording physical energy flows in SEEA-Energy. In particular, it explains the treatment of international flows and the related accounting of goods sent abroad for processing. It also describes in general terms the practice of consolidating and aggregating the various energy-related physical flows.

3.7 Section 3.3 commences with a general description of the types of energy from natural inputs and energy products that are the focus of SEEA-Energy. The supply and use tables for energy contain a range of industry detail – this chapter provides guidance on the types of energy flows and specific treatments to be considered for each industry. The chapter then gives a description of the various tables making up the physical flow accounts of SEEA-Energy – and provides an explanation of the function and purpose of each of these tables. A number of tables closely related to the supply are use tables are shown including tables on the supply of primary energy products and imports, transformation of energy, end use of energy and energy use by purpose.

3.8 Section 3.4 completes the chapter with a description of interrelationships between energy statistics, energy balances and energy accounts. There is clearly much common ground between these three bodies of energy-related information; however this section focuses on the key differences between energy accounts and energy balances. It provides a description of how bridge tables can be used to reconcile data contained within energy accounts and energy balances.

3.2 Principles of physical flow accounting

3.2.1 Introduction

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

3.10 This section describes in detail some recording principles specific to physical flow accounting namely, consolidation and aggregation in the recording of physical flows, the treatment of international flows of goods and the treatment of goods for processing.

3.2.2 Treatment of international flows

3.11 In SEEA-Energy flows of energy are attributed to the country of residence of the producing or consuming unit (residence principle) at the time of the flow of energy. This differs from the territory principle of recording that is applied in a number of statistical frameworks, including IRES.

3.12 This treatment is consistent with the SEEA Central Framework and the SNA[10]. While in most cases energy flows would be assigned to the same country regardless of whether the resident or territory principle is applied, there are important activities, in particular international transport and tourism, which need to be considered directly so that the appropriate treatment can be defined. This part examines the key areas of international transport, tourist activity, timing of imports and exports and natural resource inputs, in turn.

International Transport

3.13 Since many countries have significant international transport activity, it is important to properly record information concerning the use of energy and the associated release of emissions. The appropriate and consistent attribution of physical flows relating to international transport to individual countries is therefore an important component of SEEA-Energy.

3.14 As with all other activities in scope of SEEA-Energy, the treatment of international transport is based on the residence of the operator of the transport equipment. The country of residence will generally 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; inputs (including fuel wherever purchased) and emissions are attributed to the country of residence of the operator.

3.15 Once the determination of the residence of the operator of international transport equipment using standard SNA and BPM principles has taken place, the appropriate accounting is illustrated in the following examples:

- A ship, whose operator is a 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 of fuel from Country C and imports of fuel of Country A). All energy used by the ship is attributed to Country A.
- A passenger aircraft, whose operator is a 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.

3.16 Special note is required in relation to the bunkering of fuel, primarily relating to ships and aircraft. Special arrangements may be entered into such that a unit resident

[10] See 2008 SNA, paragraph 4.10 – 4.15.

in a country stores fuel in another country while still retaining ownership of the fuel itself. Following the principles of the SNA and the BPM, the physical location of the fuel is not the primary consideration. Rather, focus must be on the ownership of the fuel. Thus if Country A establishes a bunker in Country B and transports fuel to Country B in order to refuel a ship that it operates, then the fuel is 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 to source data may be needed to align to this treatment.

Tourist activity

3.17 Akin to international transport, tourist activity is recorded using the residence principle. Tourists include all those travelling outside their country of residence including short term students (i.e. less than 12 months), people travelling for medical reasons and those travelling for business or pleasure. The use of energy by a tourist travelling abroad is attributed to the tourist's country of residence and not to the location of the tourist when the energy is used. Thus, for example, purchases of fuel 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.

3.18 Emissions from local transport used by tourists 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.

3.19 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.

Imports and Exports

3.20 Table 3.2 Imports and Exports of Energy Products shows the key adjustments to the foreign trade statistics needed to arrive at the import and export concepts based on the residence principle used in SEEA-Energy. The imports/exports of energy products need to be adjusted for purchases by residents abroad/purchases by non-residents on domestic territory.

Table 3.2 Imports and Exports of Energy Products

Imports (general trade system)
+ Energy products purchased by residents abroad
Of which:
Bunkering of oil abroad for sea transport and fishing vessels
Bunkering of jet fuel and kerosene abroad for air transport
Refuelling abroad of gasoline and diesel for land transport
Tourists' and business traveller's purchases of energy abroad including fuel for private cars
Energy purchased by military bases on foreign territories
Energy purchased by national embassies abroad
= total imports of Energy products
Exports (general trade system)
+ Energy products sold to non-residents on domestic territory
Of which:
Foreign ships' and fishing vessels' bunkering of oil on territory
Foreign planes bunkering of jet fuel and kerosene on territory
Foreign vehicles' refuelling of gasoline and diesel on territory
Foreign tourists' and business traveller's purchases of energy on territory including fuel for private cars
Energy sold to foreign military bases on national territory
Energy sold to foreign embassies on national territory
= total exports of energy products

Ownership of timber resources and mineral and energy resources

3.21 Energy from natural inputs denote physical flows from the environment to the economy. In the area of energy, they principally derive from stocks of timber and mineral and energy resources. All of these stocks are considered to be owned by residents of the country in which the stocks are located. By convention, even where these stocks are legally owned by non-residents they are considered to be owned by a national resident unit and the non-resident legal owner is shown as the financial owner of the national resident unit. This means that extraction of mineral and energy resources must by definition take place within a country's economic territory, by economic units that are resident in that country.

3.2.3 Treatment of goods for processing

3.22 Goods from one country may be sent to another country for further processing before being returned to the original country, sold in the processing country, or sent to other countries. In situations where the unprocessed goods are sold to a processor in a second country there are no unusual recording issues. However, in situations where the processing is undertaken on a fee for service basis and there is no change of ownership of the goods (i.e. the ownership remains with the original country) the financial flows are unlikely to relate directly to the physical flows of the goods being processed.

3.23 This goods-for-processing arrangement is commonplace in the production of petroleum products, for example. In the monetary supply and use accounts, such goods sent abroad for processing are not treated as having crossed national borders and therefore are not treated as exports or imports. This treatment applies because under these circumstances, typically no change of ownership takes place. For example, where crude oil is sent to another country to be refined, the crude oil is excluded from measures of exports, and likewise the returned refined products are excluded from imports to the country. Instead, the import of a service corresponding to the value of the processing undertaken abroad is recorded[11].

3.24 Nevertheless, within SEEA-Energy it is considered appropriate to record the physical flows as they take place. Therefore, in addition to the import and export flows as recognized by the national accounts, physical flows related to goods sent abroad for processing are recorded in the physical flow accounts. 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, including for example, emissions to air.

3.25 Information on the physical flow of goods between countries is generally available in international trade statistics – these statistics usually record flows of goods sent abroad for processing and the return flows, together with various other flows crossing the national border. However, it is necessary to identify those flows of goods where the ownership has not changed and to apply a different treatment in monetary terms compared to the international trade data.

3.2 Physical flow accounts for energy

3.3.1 Introduction

3.26 This section describes the full sequence of physical flow accounts for energy. These accounts describe energy flows in physical units, from the initial extraction or capture of energy from natural inputs from the environment into the economy, to the flows within the economy in the form of supply and use of energy products by industries and households and, finally, the flows of energy back to the environment (as energy residuals). Detail is provided here on the various types of physical energy flows (natural inputs, products and residuals) recorded in SEEA-Energy. In addition, guidance is provided on the recording of industry detail within the physical flow accounts for energy.

3.27 The purpose of compiling physical energy flow accounts is to support a consistent monitoring of supply and use of energy by flow type and industry. These physical flows can be combined with corresponding monetary information on supply and use

[11] IRES recommends that goods-for-processing be included as part of imports/exports.

of energy products to derive indicators of energy intensity, efficiency and productivity.

3.28 Energy accounts could be compiled by using data from energy balances, energy surveys and other sources which are presented in joules. Energy accounts data could also be compiled by converting physical measures of mass and volume such as tonnes, litres and cubic metres into a common unit representing energy content in calorific terms. The use of the joule as a common unit with SEEA-Energy is consistent with IRES.

3.3.2 Energy from natural inputs

3.29 Where energy is removed or captured from the environment by resident economic units, this is described in the flow of energy from natural inputs. Such flows include energy from natural resource inputs (e.g. oil, natural gas, uranium, coal and peat, timber resources), inputs from renewable energy sources (e.g. solar, wind, hydro, geothermal), and other natural inputs (energy inputs to cultivated biomass).

3.30 In SEEA-Energy terms, the supplier of these flows is the environment and the user is the economy or, more specifically, the user is the economic unit responsible for the extraction or capture of energy from the environment. Extraction of mineral and energy resources can only be undertaken by resident institutional units. An enterprise that undertakes extraction is deemed to have become a resident when the requisite licences or leases are issued, if not before (4.15, 2008 SNA)

3.31 Energy is removed or captured either to be used by the economic unit who undertakes the extraction (in which case, it is referred to as extraction for own use) or to be supplied to other economic units for further processing or for direct use. The industry which extracts mineral and energy resources from the environment as its principal activity is classified under Section B of ISIC Rev. 4, Mining and quarrying. The capture of energy from renewable sources is classified under ISIC Section A – Agriculture and forestry and fishing (e.g. biofuels) or ISIC Section D – Electricity, gas steam and air conditioning supply (e.g. solar, wind, hydro). The elements of the ISIC industry classification which are of specific interest to the energy accounts are presented in Section 3.4.3.

3.32 Energy from cultivated biomass, including from cultivated timber resources, is treated as being produced within the economy and hence is first recorded as the flow of an energy product. However, to ensure a complete balance of energy flows in the PSUT, a balancing entry equal to the energy products from cultivated biomass is recorded as a component of energy from natural inputs in both the supply and the use tables. In the energy from natural inputs part of the use table the corresponding value for energy inputs to cultivated biomass is generally split among a number of industries depending on end use.

3.33 Solid waste incinerated for energy purposes is also treated as being produced with the economy. The energy embodied in solid waste is shown as entering the energy system as a residual flow before becoming an energy product. By convention, the energy from solid waste is shown as supplied from within the economy in the accumulation column.

Classification of energy from natural inputs

3.34 Energy from natural inputs comprise flows of energy from the removal and capture of energy from the environment by resident economic units. Table 3.3 shows the types of flows included in energy from natural inputs.

Table 3.3: Energy from natural inputs

(Energy) natural resource inputs		
	Mineral and energy resources	
		Oil resources
		Natural gas resources
		Coal and peat resources
		Uranium and other nuclear
	Timber resources (natural)	
Inputs of energy from renewable sources		
	Solar	
	Hydro	
	Wind	
	Wave and tidal	
	Geothermal	
	Other electicity and heat	
Other natural inputs		
	Energy inputs to cultivated biomass	

3.35 In many cases, an item of energy will change little in form as it is extracted from environment to be used in the economy. For example, coal, peat, oil and natural gas do not undergo fundamental physical transformation as they first enter the economy. Consequently, the description of the characteristics and classification of coal, peat etc. is equally applicable whether the flow relates to its extraction from the environment to the economy, or to its subsequent use as an energy product within the economy.

3.36 In other cases, the item of energy extracted from the environment is very different from the resulting energy product subsequently used within the economy. The following paragraphs describe those types of energy from natural inputs that undergo a fundamental physical transformation as they enter the economy.

3.37 Natural timber resources represent an energy input from the environment. These resources may be incorporated into energy products such as biofuel or waste.

3.38 Inputs of energy from renewable sources are the non-fuel sources of energy provided by the environment and include the following items: solar, hydro, wind, wave and tidal, geothermal, and other electricity and heat. All of these natural inputs are used in the production of electricity or heat/steam. It is essential that natural inputs used in the generation of electricity are recorded so as to ensure a complete balance of flows of energy between the environment and the economy. The amount of electricity/heat produced from solar, hydro etc. sources must be shown as a corresponding (and equal) natural input of energy from the environment to the economy. Inputs of energy sourced from natural resources, such as natural timber resources, are not included under this heading, nor does it include energy inputs from cultivated timber resources, other cultivated biomass, or from solid waste.

3.39 Energy inputs to cultivated biomass is the energy input from the environment that gives rise to cultivated biomass, which in turn becomes an input to energy products such as ethanol and other biofuels. That is, biofuels are produced 'within the economy', but they are created using natural energy inputs from the environment. As with energy inputs from renewable sources, these inputs must be shown in the physical supply and use tables for energy in order to preserve the input output identity for energy flows.

3.3.3 Energy products (flows of energy products)

3.40 Energy products are those products that are used exclusively or mainly as a source of energy. They include fuels that are produced or generated by an economic unit; electricity that is generated by an economic unit and heat that is generated and sold to third parties by an economic unit. Some energy products may be used for non-energy purposes.

3.41 Supplies of energy products may arise from imports and through production activity undertaken by resident units. Energy products are used by businesses for intermediate consumption - either for direct use or for input into a transformation process to produce other energy or non-energy products. Energy products are also used by households as part of household consumption, by the rest of the world (as exports), or are stored in the form of inventories.

3.42 Energy-supplying industries and other industries typically carry inventories of energy products. Changes in inventories are recorded in the accumulations column of the supply and use table.

3.43 Energy products are classified based on the Standard International Energy Product Classification (SIEC). At the first level, energy products are classified into 10 sections and are described below.

Description of energy products[12]

3.44 Chapter 2 describes the broad categorisation of energy flows: energy from natural inputs from the environment to economy; energy products produced and used within the economy; and various residual flows from the economy back to the environment. This section provides a summary description of the energy products used in the physical flow accounts of SEEA-Energy. The descriptions relating to energy products are drawn from SIEC (2011 IRES, 3.19), while the classification of energy from natural inputs also draws heavily upon SIEC.

3.45 The following descriptions relate to the highest level of product detail presented in SIEC i.e. the 1 digit or section level. It is recommended that compilers attempt to produce data at the 2 digit or division level of SIEC in order to deliver a much richer data set for data users. Nevertheless, the level of product detail used in the physical flow accounts for energy will depend on the requirements of data users and on data availability; compilers will need to adapt the product detail used in their physical flow accounts.

3.46 Coal is a solid fossil fuel consisting of carbonized vegetal matter. Coal products can be derived directly or indirectly from the various classes of coal by carbonization or pyrolysis processes, by the aggregation of finely divided coal or by chemical reactions with oxidizing agents, including water.

3.47 Peat and peat products comprises peat, a solid formed by the partial decomposition of dead vegetation under conditions of high humidity and limited air access (initial stage of coalification) and any products derived from it.

3.48 Oil shale / oil sands are sedimentary rock containing organic matter in the form of kerogen. Kerogen is a waxy hydrocarbon-rich material regarded as a precursor of petroleum.

3.49 Natural gas is a mixture of gaseous hydrocarbons, primarily methane but generally also including ethane, propane and higher hydrocarbons in much smaller amounts and some non-combustible gases such as nitrogen and carbon dioxide.

3.50 Oil comprises liquid hydrocarbons of fossil fuel origins made up of (i) crude oil; (ii) liquids extracted from natural gas (NGL); (iii) fully or partly processed products from the refining of crude oil; and (iv) functionally similar hydrocarbons and organic chemicals from vegetal or animal origins.

3.51 Biofuels derive directly or indirectly from biomass. (Fuels produced from animal fats, by-products and residues obtain their calorific value indirectly from the plants eaten by the animals.)

3.52 Waste is made up of materials voluntarily discarded by the owner. Where the owner of the waste receives payment to pass the waste to another party, it is considered a

[12] IRES Chapter 3.

product. Where no payment is received by the discarding unit, the waste is a residual.

3.53 Electricity is the transfer of energy through those physical phenomena involving electric charges and their effects when at rest and in motion.

3.54 Heat is the energy obtained from the translational, rotational and vibrational motion of the constituents of matter, as well as changes in its physical state.

3.55 Nuclear fuels etc. include nuclear fuels such as uranium, plutonium and derived products that can be used in nuclear reactors as a source of electricity and/or heat. This category includes other fuels not elsewhere specified.

3.3.4 Residuals

3.56 Residuals are flows of solid, liquid and gaseous materials and energy that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation. For a general discussion of residuals see SEEA Central Framework.

Energy residuals

3.57 Energy residuals comprise energy losses and other energy residuals (primarily heat generated when end users use energy products for energy purposes). Energy losses are grouped into 4 groups: losses during extraction, losses during distribution, losses during storage and losses during transformation.

3.58 Oil tankers at sea may lose their cargo through being wrecked. Such flows should be recorded as losses during distribution flowing from the economy to the environment.

3.59 Efforts might be made to recover residuals, including natural resource residuals, from the environment and bring them back into the economy either for treatment or for disposal 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 and/or particular locations (such as the wreck of an oil tanker near a protected coast), may arouse a sufficient degree of concern to merit identifying these flows explicitly.

3.60 The attribution of residuals to individual national economies is consistent with the principles applied in the determination of the residence of economic units. Residuals are attributed to the country in which the emitting or discarding household or enterprise is resident.

Other residual flows

3.61 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 lead to the creation of other products or residuals, for example, waste from managed landfill sites may be combusted for energy purposes. When waste is combusted for energy purposes, it is recorded separately as energy from solid waste within other residual flows.

3.62 Other residual flows also include residuals from end–use for non-energy purposes such as the use of oil in the production of lubricants.

3.3.5 Industry reporting

3.63 The SEEA-Energy physical flow accounts are compiled by the ISIC industry classification, making it possible to integrate the physical energy flows reported in SEEA-Energy with economic statistics from the national accounts. It is recommended that countries report, at a minimum, the level of industry detail shown in Tables 3.4 to 3.9 in order to support internationally comparable data. The following paragraphs provide a descriptive guide to energy supply and use for those industries shown in the SEEA-Energy tables of this chapter.

3.64 Agriculture, forestry and fishing would not generally be expected to be a significant supplier of energy, although forestry operations may supply fuelwood and charcoal. These are energy products (biofuels) produced by forestry operations that utilise energy from natural inputs – specifically, ‘energy inputs to cultivated biomass’ when the forests are cultivated resources, and ‘natural timber resources’ when they are not. Energy from natural inputs is recorded in the ‘environment’ column of the supply table.

3.65 Agriculture may support biofuel production through for example the supply of corn and/or sugarcane for bioethanol. In this case the corn or sugarcane is not an energy product, but the production of biofuel from this source requires energy from natural inputs – which is reflected in the corn and sugarcane. Therefore, the production of biofuel is recorded as production by the manufacturing industry using energy from natural inputs (specifically ‘energy inputs to cultivated biomass’) supplied by the ‘environment’.

3.66 Mining and quarrying is often the most significant domestic supplier of energy products. This industry is responsible for the extraction of oil and natural gas – including the extraction of oil from oil shale and oil sands; the extraction of peat; and the mining of coal. The supply of these energy products by the mining and quarrying industry is matched by a corresponding amount of flow of energy from natural inputs (though, where energy is lost during extraction, the amount of energy from natural inputs will exceed the corresponding amount of energy product supplied).

3.67 Manufacturing is an important industry in the production of energy products since it is responsible for converting a range of primary energy products into a usable form, i.e. secondary energy products. For example, crude oil is extracted by the mining industry and refined by the manufacturing industry. Thus, the 'environment' supplies energy from natural inputs to the economy as oil resources – the mining industry extracts these as (crude) oil and supplies this crude oil as an energy product to the manufacturer, who refines the product and who in turn supplies the (refined) oil product to others.

3.68 In some instances the manufacturing entity will create energy products from other non-energy products. For example, corn is produced by the Agriculture, forestry and fishing industry that may be used to produce biofuel. In the supply and use tables for energy the environment supplies energy from natural inputs (in the form of cultivated biomass) to the economy (agriculture industry) – the manufacturing industry uses these to create a biofuel such as bioethanol. The Agriculture industry's production of corn is not explicitly recorded in the SEEA-Energy tables, since this supply is not of an energy product.

3.69 Electricity, gas, steam and air conditioning supply industry supplies energy in a number of forms and under various arrangements. Enterprises in this industry will frequently receive energy products from other enterprises and transform these products into secondary energy products. This is the case for electricity generated from the transformation of oil, natural gas, coal and uranium. Electricity may also be produced directly from energy from natural inputs– for example, from solar, hydro, wind, wave and tidal and geothermal inputs.

3.70 The supply of electricity includes the activity of distribution of electricity to the final consumer. The supply of gas through a system of mains is also included in this ISIC class; the activity of transporting gas through pipelines over long distances however is considered to be a transport activity. Thus, in the use table of the PSUT, transmission losses related to electricity supply are attributed to the electricity supply industry while losses related to gas supply are attributed to either the gas supply industry or the transport industry depending on where the losses occur.

3.71 Natural gas supply includes both distribution of gas through mains and the extraction of certain gases. Distributed and extracted natural gas are recorded into separate rows the PSUT. Sometimes natural gas is supplied directly by the extracting industries without further processing. In this case, the supply of gas would be recorded as output of the mining industry in the supply table and directly used for intermediate or final consumption by industries and households.

3.72 For waste, the PSUT records waste as an energy product for each industry supplying this product. By convention, the energy from solid waste is shown as supplied from within the economy in the accumulation column and a matching positive entry is recorded in the use table in the column for the industry incinerating the solid waste. Where the waste has not been purchased (i.e. it is a residual rather than a product) and is used for electricity generation, the waste is nevertheless treated as a flow of energy from other industries. In the use table, the related transformation losses are recorded against ‘waste’ and are attributed to the Electricity, gas, steam and air conditioning supply industry.

3.73 Supply by the Gas supply industry does not include the manufacture of fuel gases such as ethane, propane and butane. Such gases are supplied by the manufacturing industry and/or the mining and quarrying industry, depending on the processes involved.

3.74 Transport activity is an important energy consuming activity. The use of a fuel such as oil or gas in a car, truck, ship, plane etc. does not automatically constitute a transport industry use. What is critical is the predominate activity of the unit using the fuel. Thus, for example, if a business is predominately engaged in mining activity, then energy used by this business is attributed to the mining industry; whether the energy is used specifically to power extraction equipment, heat an office or power a motor vehicle. Similarly, all energy used by households is attributed to ‘households’– so that use of fuel to power a motor vehicle operated by a householder is attributed to households and not the Transport and storage industry. The treatment of fuel in relation to transport activity within SEEA-Energy is in contrast to energy balances where all fuel used in motor vehicles, ships, etc. is allocated to transportation activities.[13]

3.75 Energy used to transport steam and/or air conditioning is attributed to the Electricity, gas, steam and air conditioning supply industry.

3.76 Where units are predominately engaged in Storage activity related to energy products (such as gas), losses incurred during storage represent an end-use of these products by the Transport and storage industry.

3.77 Other industries will primarily appear in the PSUT for energy as users of energy products.

3.78 By convention the generation of electricity from solid waste incineration is treated as a flow of energy (‘waste’) from accumulation. There is no attempt to link waste flows back to energy from natural inputs. This is in contrast to the use of crops etc. for biofuels – because under those circumstances the crop is purpose-produced for biofuel production and the link to energy from natural inputs is much more direct and occurs within the same accounting period.

3.79 Where households generate energy products, this supply should generally be attributed to the industry that would typically supply such a product. For example, if households produce electricity through the use of solar photovoltaics panels, the supply table of the PSUT should show a flow of inputs of energy from renewable sources from the environment to the Electricity, gas, steam and air conditioning

[13] International marine and aviation bunkering is excluded from the balances of an individual country’s supply of energy and transport activities.

supply industry. The resulting supply of electricity is then used by households – unless households have generated electricity and routed this back into the grid. Under these circumstances, the use of the electricity routed back to the electricity supplier should be allocated across the industries and households served by the electricity supplier. In the absence of specific information to guide this allocation, it should be done on the basis of general patterns of electricity use observed for the various users of electricity.

3.3.6 Physical supply and use tables for energy

3.80 Physical supply and use tables for energy record the flows of energy from natural inputs, energy products and energy residuals in physical units of measure. They are based on the principle that the total supply of each flow is equal to the total use of the same flow (e.g. total supply of energy products is equal to the total use of energy products).

3.81 Table 3.4 Supply Table for Energy and Table 3.5 Use Table for Energy are the standard physical supply and use tables for energy flows. These tables include flows of all energy from natural inputs and energy 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.

3.82 The level of industry detail shown within the columns of the energy supply and use tables is designed to highlight those industry groups that most commonly play a significant role in energy production or use. But there is no restriction in the amount of industry detail that may be incorporated. The accumulation column records changes in the inventories of energy products that can be stored, for example coal, oil, natural gas and waste.

Key components of the PSUT for energy

3.83 The key components of the PSUT for energy concern (i) the supply and use of energy from natural inputs, (ii) the supply of energy products, including energy products produced on own account; (iii) imports and exports of energy products; (iv) energy residuals and energy incorporated into non-energy products; and (v) the transformation and end-use of energy products. Discussion of these five areas comprises the remainder of this section.

<u>Supply and use of energy from natural inputs</u>

3.84 The first part of Table 3.4 Supply Table for Energy and the first part of Table 3.5 Use Table for Energy record flows of energy from natural inputs. In Table 3.4 the various energy from natural inputs are shown as being supplied by the environment. In Table 3.5 the energy from natural inputs are shown as being used by the extracting industries. Across these two tables the total supply of each energy from natural input must equal its total use.

3.85 Flows of energy from natural inputs may be presented at varying levels of detail depending on those inputs of most relevance and of greatest analytical interest within a country.

3.86 In principle, the inputs of energy from renewable sources should reflect the amount of energy incident on the technology put in place to collect the energy. In practice, inputs of energy from renewable sources are recorded in terms of the amounts of heat and electricity produced via the technology used to harness the energy. Consequently, in practice, losses of energy in the capture of energy from renewable sources are not included in the PSUT. Energy from hydro-electric schemes is also recorded here in terms of electricity produced.

3.87 For inputs of mineral and energy resources, losses of energy during extraction are included in the total amount of resources extracted from the environment, in line with the general treatment of natural resource residuals and losses. Entries for losses during extraction should also be made in the bottom parts of the supply and use tables concerning energy residuals.

Supply of energy products

3.88 All energy products supplied from one unit to another (including between units of a single enterprise) are included in the flow accounts regardless of whether the energy product is sold or exchanged as part of a barter or provided free of charge.

3.89 Energy products are mainly 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, energy products will mainly be supplied by imports from the rest of the world. Extracted and distributed natural gas are recoded separately to distinguish between natural gas that is taken out of the environment and natural gas that is processed and is ready for consumption. The difference between extracted and distributed natural gas is accounted for in losses during distribution, storage and transformation. A similar approach should be taken with all energy products. For example, coal should be separated into primary coal products (hard coal, sub-bituminous coal and lignite) and secondary coal products.[14]

3.90 Energy products are produced as a secondary activity within many establishments, and in some cases as own account production and use. Where it is possible to quantify the own account, intra-establishment production and use of energy

[14] For presentation purposes such breakdown is not shown explicitly in the table.

products, these flows should be recorded separately in the accounts as flows of energy for own use.

Table 3.4 Supply table for energy, joules

Physical supply table for energy	Production (including household production on own-account); Generation of residuals							Accumulation	Flows from the rest of the world	Flows from the environment	Total supply
	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufacturing ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries	Households		Imports		
Energy natural inputs											
Natural resource inputs											
Mineral and energy resources											
Oil resources										744.0	744.0
Natural gas resources										417.0	417.0
Coal and peat resources											
Uranium and other nuclear fuels											
Timber resources										5.0	5.0
Inputs of energy from renewable sources											
Solar										20.0	20.0
Hydro										100.0	100.0
Wind										4.0	4.0
Wave and tidal											
Geothermal											
Other electricity and heat											
Other natural inputs											
Energy inputs to cultivated biomass										2.0	2.0
Total energy from natural inputs										1 292.0	1 292.0
Energy products											
Production of energy products by SIEC class (excluding own use)											
Coal									225.0		225.0
Peat and peat products											
Oil shale/ oil sands											
Natural gas (extracted)		395.0									395.0
Natural gas (distributed)				369.1							369.1
Oil (e.g. conventional crude oil)		721.0									721.0
Oil (oil products)			347.0						930.0		1 277.0
Biofuels	5.3		0.2	1.5							7.0
Waste	39.0		54.5						16.9		110.4
Electricity				212.0					22.0		234.0
Heat				78.5							78.5
Nuclear fuels and other fuels nec											
Production of energy for own use											
Coal											
Peat and peat products											
Oil shale/ oil sands											
Natural gas (extracted)											
Natural gas (distributed)											
Oil (e.g. conventional crude oil)											
Oil (oil products)											
Biofuels											
Waste											
Electricity											
Heat											
Nuclear fuels and other fuels nec											
Total energy products	44.3	1 116.0	401.7	661.1					1 193.9		3 417.0
Energy residuals											
Losses during extraction		45.0									45.0
Losses during distribution				12.0							12.0
Losses during storage			6.0								6.0
Losses during transformation			7.0	204.4							211.4
Other energy residuals	50.3	3.2	418.7	90.6	632.0	96.0	240.0				1 530.8
Total energy residuals	50.3	48.2	431.7	307.0	632.0	96.0	240.0				1 805.2
Other residual flows											
Residuals from end-use for non-energy			51.0								51.0
Energy from solid waste								93.5			93.5
Total supply	94.6	1 164.2	884.4	968.1	632.0	96.0	240.0	93.5	1 193.9	1 292.0	6 658.7

Table 3.5 Use table for energy, joules

Physical use table for energy

	Intermediate consumption; Use of energy resources; Receipt of energy losses						Final consumption	Accumulation	Flows to the rest of the world	Flows to the environment	Total use
	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufacturing ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries	Households		Exports		
Energy from natural inputs											
Natural resource inputs											
Mineral and energy resources											
Oil resources		744.0									744.0
Natural gas resources		417.0									417.0
Coal and peat resources											
Uranium and other nuclear fuels											
Timber resources	5.0										5.0
Inputs of energy from renewable sources											
Solar				20.0							20.0
Hydro				100.0							100.0
Wind				4.0							4.0
Wave and tidal											
Geothermal											
Other electricity and heat											
Other natural inputs											
Energy inputs to cultivated biomass	0.3		0.2	1.5							2.0
Total energy from natural inputs	5.3	1 161.0	0.2	125.5							1 292.0
Energy products											
Transformation of energy products by SIEC class											
Coal				223.0							223.0
Peat and peat products											
Oil shale/ oil sands											
Natural gas (extracted)				395.0							395.0
Natural gas (distributed)				87.0							87.0
Oil (e.g. conventional crude oil)			360.0								360.0
Oil (oil products)				16.0							16.0
Biofuels											
Waste				31.0							31.0
Electricity											
Heat											
Nuclear fuels and other fuels nec											
Total transformation of energy products			360.0	752.0							1 112.0
End-use of energy products by SIEC class (excluding own use)											
Coal	2.0	0.1	17.0				1.0	- 21.0	1.9		1.0
Peat and peat products											
Oil shale/ oil sands											
Natural gas (extracted)											
Natural gas (distributed)	2.0		39.0	0.1		12.0	26.0	2.0	201.0		282.1
Oil (e.g. conventional crude oil)									361.0		361.0
Oil (oil products)	34.0	2.0	326.0		621.0	49.0	102.0	- 3.0	80.0		1 211.0
Biofuels	0.3		0.2	1.5			5.0				7.0
Waste	3.0	0.1	4.0	37.0		1.0	33.0	0.3	1.0		79.4
Electricity	7.0	1.0	22.0	50.0	10.0	15.0	29.0		100.0		234.0
Heat	2.0		10.5	2.0	1.0	19.0	44.0				78.5
Nuclear fuels and other fuels nec											0.0
Total end-use for energy purposes	50.3	3.2	418.7	90.6	632.0	96.0	240.0	- 21.7	744.9		2 254.0
Own end-use of energy products by SIEC class											
Coal											
Peat and peat products											
Oil shale/ oil sands											
Natural gas (extracted)											
Natural gas (distributed)											
Oil (e.g. conventional crude oil)											
Oil (oil products)											
Biofuels											
Waste											
Electricity											
Heat											
Nuclear fuels and other fuels nec											
Total end-use for energy purposes											
End-use of energy products for non-energy purposes			51.0								51.0
Energy residuals											
Losses during extraction										45.0	45.0
Losses during distribution										12.0	12.0
Losses during storage										6.0	6.0
Losses during transformation										211.4	211.4
Other energy residuals										1 530.8	1 530.8
Total energy residuals										1 805.2	1 805.2
Other residual flows											
Residuals from end-use for non-energy purposes								51.0			51.0
Energy from solid waste	39.0		54.5								93.5
Total use	94.6	1 164.2	884.4	968.1	632.0	96.0	240.0	29.3	744.9	1 805.2	6 658.7

<u>Imports and exports of energy products</u>

3.91 Within Table 3.4, imports of energy products are recorded as a separate column item among the components making up total supply of energy. Table 3.5 similarly records exports of energy products as a separate column item among the various uses of energy.

3.92 In general, imports and exports of energy products should be recorded when a change of ownership of the product between a resident and a non-resident unit occurs.[15]

3.93 SEEA-Energy uses the general trade system to determine imports and exports, which is in accordance with the convention used in the national accounts. Thus, imports of energy products include those products brought into a free zone. 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. Energy products sent abroad for processing should be treated following the treatment of goods for processing described in Section 3.3.4.

3.94 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 (ships, planes, trucks and tourists) should be excluded.

Transformation and end-use of energy products

3.95 The use of energy products is split into two main sections in the use table. The first section, ‘Transformation of energy products’, records the transformation of energy products into other energy products. For example, the mining and quarrying industry may produce coal as an energy product in the supply table and the use of coal to produce electricity would be shown in the transformation of energy products as the use of coal by the electricity supply industry.

3.96 The second section, ‘End-use of energy products’, records the use of energy products to produce goods and services that are not energy products. These goods and services may be used for intermediate consumption, for household final consumption, as a change in inventories of energy products, or for export. 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. In this section a distinction is made based on whether the used energy products were produced for own use.

3.97 In total, intermediate consumption includes the 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

[15] “Imports and exports can be recorded according to either the general trade or the special trade system. Under the general trade system, goods are recorded as they enter or leave the national boundary including goods that are imported into and exported from custom-bonded warehouses and free zones. Under the special trade system, goods are recorded as trade only when they cross the customs boundary (i.e. enter free circulation).“ (2008 SNA, 3.166).

another energy product for further use in the economy (transformation), or whether it is a process which ultimately uses the energy content of the energy product so that no further use of the energy is possible (end-use), in some cases by incorporating the energy in a non-energy product.

3.98 During the extraction process, businesses may undertake re-injection of natural gas, as well as flaring and venting of natural gas. These flows are not recorded as part of the intermediate consumption of energy products, but instead as flows of residuals, as described below. The same applies to losses of energy products, when the losses are related to products before any change of ownership from the producer to the user has taken place. If a product is lost after it has been handed over from the producer to the final user of the product, the loss should not be recorded as part of intermediate consumption of the energy producer.

3.99 Some energy products may be stored by industries for later transformation or end-use. The net changes in the quantities stored are recorded as changes in inventories and are recorded in the accumulation column for each relevant energy product. Exports of energy products are also recorded as part of end-use.

3.100 Household consumption refers to the consumption by households of energy products purchased or otherwise obtained from energy suppliers. All such consumption reflects an end use of energy. Final consumption includes energy products produced by households themselves[16], for example, electricity generated by windmills owned by households. These ‘other uses’ correspond to what the national accounts would call ‘final use’ (or final demand). However, the term ‘final’ is avoided in SEEA-Energy because the same term is used with a somewhat different meaning in energy statistics and energy balances. In IRES, for instance, final consumption is measured by the deliveries of energy products to all consumers excluding deliveries of fuel and other energy products for use in transformation processes and the use of energy products for energy needs of the energy industry (IRES 2011, 8.33). In SEEA-Energy this concept is instead called ‘end use’ of energy.

Energy residuals

3.101 The bottom parts of Table 3.4 and Table 3.5 contain entries associated with energy residuals i.e. the materials and energy discarded or emitted as a result of energy-related production, consumption and accumulation activity. Different types of energy residuals are recorded – losses during extraction, distribution and storage, losses during transformation and other energy residuals. The different energy residuals are recorded as being supplied by various industries and households in the supply table and received by the environment in the use table.

Groups of residuals

[16] As noted earlier, household production of energy is shifted to the industry producing the product as a main activity.

3.102 There is a wide variety of different types of residuals and they are not usually accounted for as a single type of flow using mutually exclusive classes. Rather, different groups of residuals are analysed depending on the physical nature of the flow, the purpose behind the flow or simply to reflect the balance of physical flows leaving the economy. The following groupings of residuals are of relevance to SEEA-Energy.

Losses

3.103 Within the context of SEEA-Energy, losses of energy in physical terms are comprised of flows from the environment to the economy that are not available for further use within the economy because they have been returned to the environment.

3.104 Within this definition four types of losses of energy are identified by 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 – this accounts for some instances of flaring and venting of natural gas.

3.105 Four broad types of losses can be identified:

i. Losses during extraction
ii. Losses during distribution/transport
iii. Losses during storage
iv. Losses during transformation/conversion

3.106 Losses during extraction are losses that occur at the time of extraction of mineral and energy resources prior to any further processing, treatment or transportation of the extracted mineral and energy resource. Such losses include, for example, flaring and venting of natural gas during extraction. Some natural gas may also be re-injected into the deposit in order to increase the pressure and facilitate further extraction. These flows are not treated as losses since the re-injected gas could be extracted at a later period (and it is being used in a production process).

3.107 Losses during distribution/transport are losses that occur between a point of extraction (or production) and a point of use - or between points of use and reuse. These losses may be caused by a number of factors. In the case of energy, they may involve evaporation and leakages of liquid fuels, loss of heat during transportation of steam, and losses during gas distribution, electricity transmission and pipeline transport.

3.108 When losses during distribution are calculated as the difference between the amounts supplied and corresponding amounts received, such calculations may include errors in meter readings, malfunctioning meters, etc. These errors in the measurement of flows are commonly referred to as apparent losses and are recoded under distribution losses.

3.109 Losses during storage are losses of energy products held in inventories. They include evaporation, leakages of fuels wastage and accidental damage.

3.110 Losses of energy during transformation refer to the energy lost, for example, residual heat, during the transformation of energy from one form to another. It occurs, for instance, when coal is transformed into electricity. Such losses are linked to the difference between inputs and outputs of products and, as such, are part of that industry's intermediate consumption. It is different to the other types of losses described here and it is only measured in terms of energetic units. In mass terms it simply reflects the fact that intermediate consumption of energy products results in an output of other energy products, along with residuals in the form of air emissions and solid waste.

3.111 While losses due to evaporation and leakages are often initially measured in quantity terms (cubic metres, tonnes etc.), they should be converted to joules for the purposes of SEEA-Energy account. Losses of heat are frequently measured in energy terms (terajoules, KWh etc.).

3.112 From the perspective of suppliers of products, the amounts of electricity and other energy products that are illegally diverted from distribution networks or from storage may be considered losses due to theft. However, since in physical terms, the energy is not lost to the economy they are not considered losses in SEEA-Energy. Nonetheless there may be interest in compiling data concerning theft as a subset of overall use of energy. 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.

Other energy residuals

3.113 Other energy residuals result from the transformation of energy. They are that part of energy that is no longer available for economic purposes after a transformation process. Other energy residuals are most often generated from the end use of energy products (e.g. fuel used for vehicles, electricity used for heating).[17] In this case the flow of residual heat is equal to the energy input.

3.114 By convention, all energy products consumed by households are considered end use and are therefore recorded as other energy residuals. For example, fuelwood or gas used for heating by households is considered end use.

3.115 Other energy residuals are recorded to ensure the maintenance of the energy balance principle in the physical flow accounts.

Other residual flows

3.116 For other residual flows, the energy embodied in energy products used for non-energy purposes is shown as supplied by various industries and by households and is

[17] Energy can also dissipate in the form of light or noise.

by convention recorded as being retained within the economy within the accumulation column of the use table.

3.117 Solid waste covers discarded materials that are no longer required by the owner or user. Solid waste includes materials that are in a solid or liquid state but excludes small particulate matter released into the atmosphere. Energy from solid waste is recoded separately in the supply and use table. By convention it is shown as being supplied from within the economy in the accumulation column and matching positive entries are recorded in the use table in the column for the industry incinerating the solid waste.

3.3.7 Supply of primary energy products and imports

3.118 A set of tables are used to both highlight and exclude those flows of energy products that are used for transformation into other energy products or for non-energy purposes. These tables are Table 3.6 Supply of Primary Energy Products and Imports; Table 3.7 Transformation of Energy; and Table 3.8 End Use of Energy. These tables focus, respectively, on the supply of primary energy products and imports; the transformation of primary energy and imports into energy available for end-use; and the end use of the energy. These tables are very similar in concept and presentation to the energy balances (see, for example, the Energy Statistics Manual, IEA 2005, chapter 7) though the classifications and terminology used differ somewhat.

3.119 Table 3.6 presents the total inflow of energy to the economy from the environment and the rest of the world[18]. It includes the energy made available through domestic extraction of energy from natural inputs and through imports of primary and secondary energy products. To avoid double counting with regard to the domestic supply of energy, only the energy produced by the extracting industries is included. The flows from the environment to the extracting industries of energy from natural inputs are excluded. All types of energy, i.e. energy products, energy for own use and energy losses other than losses during extraction, are included. The table shows these three types of energy flows in aggregate.

3.120 The aggregation level of the energy products shown in the rows of Table 3.6 is different to the level shown in the previous tables because the focus here is on presenting the primary energy products. Electricity and heat produced by nuclear power plants should be included as supply of electricity and heat. This approach is adopted because the energy content of nuclear fuels is difficult to quantify until after it has been processed and used in electricity production i.e. for nuclear fuels, only the resultant electricity should be recorded in this table.

[18] Secondary products are only part of the imports column. The production columns include only primary products. For example, only hard coal, sub-bituminous coal and lignite are included in the row “Coal” for all columns “Production”.

Table 3.6 Supply of primary energy products and imports, joules

Physical supply table for energy

	Production						Flows from the rest of the world	Flows from the environment	Total primary energy supply and imports
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries	Imports		
	ISIC A	ISIC B	ISIC C	ISIC D	ISIC H				
Energy products									
Production of energy products by SIEC class									
Coal							225.0		225.0
Peat and peat products									
Oil shale/ oil sands									
Natural gas		395.0							395.0
Oil		721.0					930.0		1 651.0
Biofuels	5.3		0.2	1.5					7.0
Waste	39.0		54.5				16.9		110.4
Electricity				124.0			22.0		146.0
Heat									
Nuclear fuels and other fuels nec									
Total energy products	44.3	1 116.0	54.7	125.5			1 193.9		2 534.4

3.121 For each industry, the column sum shows the amount of primary energy products supplied. The figure in the intersection of the last row and last column of Table 3.6 represents the total domestic supply of primary energy products and imports of primary and secondary energy products.

3.3.8 Transformation and end-use of energy products

3.122 The recording of the use of energy products is spread across two tables: Table 3.7 Transformation of Energy; and Table 3.8 End Use of Energy. These tables show respectively the transformation of energy products to other energy products; and the use of energy products to produce goods and services that are not energy products.

3.123 Table 3.7 shows how energy products entering the economy through the domestic supply of primary energy products and through imports are converted to other types of energy products before being used by industries, or households – either for end use or for non-energy purposes. For example, the table would show that coal (initially produced by the mining and quarrying industry) is subject to an energy transformation by the electricity supply industry in the production of electricity.

3.124 Within Table 3.7 negative numbers correspond to inputs of primary energy or imports used by an industry for transformation processes (e.g. the coal used by the electricity supply industry) while positive numbers correspond to output of secondary energy (e.g. electricity produced from coal).

3.125 By following a column within Table 3.7, information is obtained about the amount and type of energy used by that industry as intermediate inputs for the transformation (i.e. the negative numbers), and how much of each secondary energy product is produced by the same industry as a result of the transformation (i.e. the positive numbers). A transformation from one type of energy to another is normally associated with some losses of energy. The total amount of energy lost from each of the industries' transformation processes is shown in the bottom row of the table.

Table 3.7 Transformation of energy, Joules

Physical supply table for energy

	Total	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufacturing ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries	Net	Available for end use
Energy products									
Production of energy products by SIEC class									
Coal	225.0				- 223.0			- 223.0	2.0
Peat and peat products									
Oil shale/ oil sands									
Natural gas	395.0				- 395.0			- 395.0	
Natural gas (secondary)					282.1			282.1	282.1
Oil	1 651.0			- 360.0				- 360.0	1 291.0
Oil (secondary)				347.0	- 16.0			331.0	331.0
Biofuels	7.0								7.0
Waste	110.4				- 31.0			- 31.0	79.4
Electricity	146.0				88.0			88.0	234.0
Heat					78.5			78.5	78.5
Nuclear fuels and other fuels nec									
Total energy products	2 534.4								2 305.0
								total losses	
Losses				13	216.4			229.4	

3.126 The rows of Table 3.7 show how much of each type of energy is produced as a result of the energy transformation processes (i.e. positive numbers) or used as inputs for energy transformation processes (in the case of negative numbers). When all inputs and outputs are respectively, subtracted and added, the total net output from the transformation processes is obtained.

3.127 The losses row includes losses due to distribution, storage and transformation. Losses during extraction are already accounted for in the entries for the specific product that incurred losses during extraction.

3.128 The amount of energy available for end use (shown in the last column of Table 3.7) is subsequently obtained by adding the total net output from the transformation to the domestic supply of primary energy and imports of primary and secondary energy products (shown in the first column). Subtracting losses from supply of primary energy and imports also leads to the amount of energy available for end use.

3.129 Table 3.8 End use of energy, records the use of energy products for purposes other than transformation into other energy products. For a specific energy product, 'end use' is what is available after the energy transformation processes are complete. These goods and services may be used for intermediate consumption, for household consumption, as a change in inventories of energy products, or for export. 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.

3.130 In total, intermediate consumption includes the use of all energy products by industries as inputs to a production process, regardless of the nature of that production process, i.e. whether it is a process converting an energy product into another energy product for further use in the economy (transformation), whether it is a process which ultimately uses the energy content of the energy product so that no further use of the energy is possible (end-use) or whether it is a process where the use of the energy content is possible at a later point (e.g. plastics)- in some cases by incorporating the energy into a non-energy product. Tables 3.7 and 3.8 can be used to calculate intermediate consumption of energy products.

Table 3.8 End use of energy, joules

	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufact uring ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries	Households	Accumul ation	Exports	Row sum
End-use of energy products by SIEC class										
Coal	2.0	0.1	17.0				1.0	- 21.0	1.9	1.0
Peat and peat products										
Oil shale/ oil sands										
Natural gas (extracted)										
Natural gas (distributed)	2.0		39.0	0.1		12.0	26.0	2.0	201.0	282.1
Oil (e.g. conventional crude oil)									361.0	361.0
Oil (oil products)	34.0	2.0	326.0		621.0	49.0	102.0	- 3.0	80.0	1 211.0
Biofuels	0.3		0.2	1.5			5.0			7.0
Waste	3.0	0.1	4.0	37.0		1.0	33.0	0.3	1.0	79.4
Electricity	7.0	1.0	22.0	50.0	10.0	15.0	29.0		100.0	234.0
Heat	2.0		10.5	2.0	1.0	19.0	44.0			78.5
Nuclear fuels and other fuels nec										0.0
Total end-use for energy purpo:	50.3	3.2	418.7	90.6	632.0	96.0	240.0	- 21.7	744.9	2 254.0
End-use of energy products for non-energy purposes			51.0							51.0
Total Use										2 305.0

3.131 Some energy products may be stored by industries for later transformation or end-use. The net changes in the quantities stored are recorded as changes in inventories and are recorded in the accumulation column for each relevant energy product.

3.132 Household consumption refers to the consumption by households of energy products purchased or otherwise obtained from energy suppliers. All such consumption reflects the end use of energy. Household consumption also includes the energy products produced by the households themselves for own use, e.g. energy produced from fuel wood gathered by households and electricity generated by windmills for own-use by households.

3.133 For each type of energy product, Table 3.8, shows the end use of energy by industries, households, as well as by other use categories. In contrast, most industries will have entries for use of secondary energy products in Table 3.8, since a range of energy products is typically used by businesses.

3.134 For each energy product the final column in Table 3.7 is equal to the final column 'Available for end use' in Table 3.8 Transformation of Energy, up to rounding error.

3.3.9 Use of energy by purpose

3.135 The tables in the previous part of this chapter do not include any specific information on the purposes of the energy use. However, for some types of analysis it is useful to know whether the energy is used for, say, transport or heating or for non-energy purposes. This section presents a physical use table which includes such information – Table 3.9 Energy Use by Purpose. Note that additional data sources to what is needed for the compilation of the physical supply and use tables might be required to complete Table 3.9 so as to distinguish between each end use. Depending on policy needs, countries might wish to have a more detailed energy product presentation within each purpose.

3.136 According to IRES, energy products can be used for three purposes: (i) energy purposes; (ii) non-energy purposes; and (iii) transformation. (IRES 2011, 5.78).

Table 3.9 Energy use by purpose

	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufacturing ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries	Households	Accumulation	Exports	Total
Transport										
Oil	22.0	1.0	150.0		600.0	40.0	65.0			878.0
Electricity					1.0					1.0
Heating										
Coal	2.0	0.1					1.0			3.1
Natural gas	1.0		5.0	0.1		12.0	26.0			44.1
Oil	10.0		110.0		21.0	9.0	37.0			187.0
Biofuels	0.2		0.1	1.5			5.0			6.8
Waste	3.0	0.1	4.0	37.0		1.0	33.0			78.1
Electricity	6.0		4.0	30.0	3.0	10.0	29.0			82.0
Heat	2.0		10.5	2.0	1.0	19.0	44.0			78.5
Other energy purposes										
Coal			17.0							17.0
Natural gas	1.0		34.0							35.0
Oil	2.0	1.0	66.0							69.0
Biofuels	0.1		0.1							0.2
Waste										
Electricity	1.0	1.0	18.0	20.0	6.0	5.0				51.0
Heat										
Non-energy purposes										
Coal								- 21.0	1.9	- 19.1
Natural gas								2.0	201.0	203.0
Oil			51.0					- 3.0	441.0	489.0
Biofuels								0.3		0.3
Waste									1.0	1.0
Electricity									100.0	100.0
Heat										
Total	50.3	3.2	469.7	90.6	632.0	96.0	240.0	- 21.7	744.9	2 305.0

3.137 An energy product is classified as being used for energy purposes if it is used to raise heat, or for transportation or for electrical services (IRES 2011, 5.74). In addition, within SEEA-Energy, energy products used in transformations (e.g., electricity used in the transformation crude oil into gasoline) are seen as being used for energy purposes.

3.138 Within the broader group of 'energy used for energy purposes' a distinction is made between energy used for transport, energy used for heating, etc, and other energy purposes. The category energy used for heating includes energy used for cooking, lighting, and household appliances. Other energy purposes includes energy used for stationary machines in industrial applications.

3.139 In some cases it is straightforward to determine the use of an energy product. Energy products bought by private households, for instance, are most likely used for energy purposes. In other cases, for instance, when the chemical industry buys oil products, it is necessary to obtain information from the relevant business units to determine the purpose of the product.

3.140 Non-Energy uses comprise those fuel uses for chemical feedstock and other non-energy applications. Chemical feed stock relates to fuels used as raw materials for the manufacture of products which contain hydrogen and/or carbon taken from the fuel. Non-energy products are fuel products used mainly for their physical and chemical properties in non-energy applications. Examples are lubricants, paraffin waxes, coal tars and oils as timber preservatives, etc. (IRES 2011, 5.21).

3.141 Almost all consumption of electricity is for power, heat and electronic use resulting in the disappearance of the electricity (as heat). Use of electricity for electrolysis occurs in some industries but statistics distinguishing this use from other uses in the enterprises are not usually available. (IEA, Energy Statistics manual, p. 30).

3.142 Exports, distribution losses and inventory changes related to energy products are always classified as non-energy purposes in SEEA-Energy even though the energy products being exported or put into inventories may of course ultimately be used for energy purposes. However, imports, exports and inventory changes are recorded as being for 'non-energy purposes' since the ultimate use is usually not known.

3.4 Energy statistics, energy accounts and energy balances

3.4.1 Introduction

3.143 Energy statistics, energy accounts and energy balances all provide information on energy supply and use. This section describes these broad approaches to energy information and how they are related. In doing so, the key differences between energy statistics, energy accounts and energy balances are described and bridge tables, which formally articulate these differences, are presented.

3.144 Energy statistics deal with the collection and compilation of information on production, imports, exports and domestic use of energy products on the basis of specific surveys and by using for example business statistics and foreign trade statistics. Energy balances reorganise the basic energy statistics by confronting and consolidating the supply and use sides, and by highlighting the transformation of energy within the economy. Similarly, energy accounts can be seen as a reorganization and extension to energy statistics and energy balances with the goal of producing a systems-based energy information structure that uses definitions, principles and classifications that are consistent with the national accounts. Both energy balances and energy accounts apply the principle that supply equals use, but total supply and total use are defined somewhat differently between these two systems in order to meet different needs.

3.145 The main differences between the energy balances and the energy accounts relate to the activities considered to be in scope, and how these activities are classified. The energy accounts use the residence principle to determine whether a specific energy transaction should be included (for instance, as imports) and whether it is included as part of energy use or not. The boundary of the energy balances follows the national territory just as basic energy statistics normally do.

3.146 Energy balances normally include only physical data on energy. Energy accounts support both physical and monetary measures of energy and a key purpose of energy accounts is to link these physical and monetary data in a consistent and meaningful way.

3.147 The following sections describe the main differences between energy balances and the energy accounts. A key difference between energy accounts and energy balances is the use of, respectively, residence and territory principles in defining the national boundary. This has been comprehensively described above in Section 3.3.3, treatment of international flows (though Section 3.4.4 is also relevant) and is not further discussed here. The text below corresponds in large part to descriptions contained in Chapter 11 of IRES.

3.4.2 Energy balances – products

3.148 As in SEEA Central Framework (and the SNA), in SEEA-Energy a physical energy unit is generally regarded as a 'product' when a transaction of positive monetary value occurs between two economic units. This ensures coherence between the physical flows of energy products and the monetary flows (Chapter 4). Note however that energy produced for own use is included as an energy product.

3.149 In contrast, the energy balances do not make this distinction between the different types of flows. Rather, all physical flows of energy are deemed flows of energy products. Therefore in order to compare information contained in energy balances and energy accounts it is first necessary to combine the relevant categories of energy products and losses from within the energy accounts.

3.4.3 Energy balances – industries

3.150 SEEA-Energy accounts use an industry classification scheme that is consistent with the national accounts i.e. it follows the principles of classification and the structure of the International Standard Industrial Classification of All Economic Activities (ISIC Rev. 4). Thus, information on any specific enterprise / establishment (on either the production or consumption sides) is, as a general rule, presented under the ISIC division/class of the principal activity of the unit involved.

3.151 While the ISIC is used for both the energy accounts and the energy balances, in some cases they include different activities. The clearest example of the difference relates to own-account transportation undertaken by enterprises – within the energy accounts this activity is allocated to the industrial section based on the principal activity of the enterprise, according to ISIC principles. While in the energy balances, consumption of fuels for own account transportation activity is simply allocated to the transport sector, regardless of what the predominant activity of the business might be.

3.152 A similar treatment applies to the generation of electricity and generation of heat for sale where this generation occurs outside of the energy-producing industries of ISIC. In the energy accounts this type of activity is regarded as secondary activity leading to the output of energy products from the specific industries involved. An example is the production of electricity and heat from the incineration of waste – such activity is generally allocated to the energy sector within the energy balances. However, the incineration of waste is an activity related to ISIC Class 3821 (Treatment and disposal of non-hazardous waste) which is not predominantly an energy-producing industry. Therefore, within the energy accounts, the production of electricity and heat from the incineration of waste will only be allocated to an energy-producing industry if the value added from the energy production exceeds that of other activities of the producer.

Energy industries and the energy transformation sector

3.153 More generally, the energy balances provide a description of the transformation of energy broken down by transformation technology. Within the energy balances, plants undertaking energy transformation are grouped by various transformation technologies. These include: electricity plants; combined heat and power plants; heat plants; coke ovens; patent fuel plants; brown coal briquette plants; coal liquefaction plants, and so on.

3.154 The transformation block of the energy balances describe inputs and outputs of energy for these technologies. However, the energy balances do not explicitly describe energy flows from the environment to the extraction industries. Though they do show the resulting production of energy products arising from the extraction activity.

3.155 As described above, within the energy balances all production of energy, including industries' own generation of electricity and heat for sale, is allocated to the energy industries. On the use side, the energy industries' own use of energy is included in the energy balances as a separate category.

3.156 The concept of Energy industries own use as defined in IRES is different from the concept of own use used in the SNA and SEEA. In IRES, energy industries own use refers to consumption of fuels and energy for the direct support of the production and preparation for use of fuels and energy, excluding use for transformation. In the SNA and SEEA, own use refer to intra-establishment production and use of energy products. As such, the concept of energy industries own use includes, using SEEA terminology, the end use of energy products from domestic production for energy purposes and the own use of energy products for energy purposes by energy industries.

3.157 SEEA-Energy accounts include the following ISIC categories of energy producing industries:

Mining and quarrying:

ISIC Division 05 - Mining of coal and lignite

ISIC Division 06 - Extraction of crude petroleum and natural gas

Energy production:

ISIC Group 191 - Manufacture of coke oven products

ISIC Group 192 - Manufacture of refined petroleum products

ISIC Group 351 - Electric power generation, transmission and distribution

ISIC Group 352 - Manufacture of gas; distribution of gaseous fuels through mains

ISIC Group 353 - Steam and air conditioning supply

3.158 It should be noted that the ISIC classification of energy production includes a distinction between the activities of producing electricity and heat. This distinction is irrelevant in the tables presented when we record production of heat and electricity in combination. The energy balances include heat and power generation as a combined activity.

3.4.4 Energy balances – transport activity and industry statistics

3.159 In the energy balances energy use related to road, rail, air, sea and pipeline transport are placed under the separate aggregate item: 'Transport'. The exceptions are energy used for fishing vessels, which are allocated to 'fishing' (IRES 2011, 5.89); and energy use for tractors and other off-road vehicles is not regarded as transport (IRES 2011, 8.41).

3.160 In contrast, the energy accounts attribute the consumption of fuels by transport activities to the industries actually using these fuels. Where fuel is used by a transport operator in carrying out transport services on a fee-for-service basis, such fuel is allocated to ISIC Section H. Transport and Storage. However, where an establishment operates its own transport activity for its own use, any fuel use associated with this activity is allocated to the industry to which this establishment belongs. That is, such use of fuel is recorded in exactly the same way as for other energy use undertaken by the establishment. The use of fuels for private cars, boats, planes, etc. is allocated to households' private consumption.

3.161 As a supplement to the SEEA-Energy standard tables, energy use for transport could be separated from the industries' and households' total energy use and shown as a memo item. Any such memo item should, however, not include the fuels used for off-roaders, lawn-mowers, etc.

3.4.5 Energy balances - supply, use and stock concepts

3.162 In the aggregated energy balances, the term 'supply' represents energy entering the national territory for the first time, less energy exiting from the national territory (through exports or international bunkering) and stock (inventory) changes. Thus (IRES 2011, 11.14):

Total energy supply =

Primary energy production
+ Imports of primary and secondary energy
- Exports of primary and secondary energy
- International (aviation and marine) bunkers
- Stock (inventory) changes

3.163 More generally, for individual energy products, the 'commodity balances' define supply in the following way (IRES 2011, Annex C)

Supply =
Production
+/- Transfers between commodities
+ Imports
- Exports
- International (aviation and marine) bunkers (as applicable)
- Stock changes

3.164 The latter supply concept can be characterised as a supply for use within the national territory.

3.165 Transfers between commodities refer to a reclassification (renaming) of products (IRES 2011, 5.17).

3.166 The terms 'stocks' and 'stock changes' as defined in the energy balances correspond, respectively, to 'inventories' and 'changes in inventories' in SEEA-Energy (and in the 2008 SNA, as well as in commercial accounting). Further, energy balances place stock changes (inventory changes) as part of supply, such that an increase of inventories is seen as decreasing the supply of the product, while a decrease in inventory is seen as increasing the supply.

3.167 Since the use is always equal to the supply, a consequence of defining the supply in this way is that the use concept of the energy balances excludes exports and fuel purchased abroad by domestic ships and aircraft undertaking international voyages.

3.168 SEEA-Energy, in contrast, defines supply consistently with the conventions of the national accounts:

Supply (SEEA-Energy) =
Production (output) + Imports (according to the residence principle)

3.169 Thus, the SEEA-Energy supply concept is broader than the supply concept of the energy balances, since it includes all energy made available for use, including fuel made available through international bunkering.

3.170 The 'use' concept operating within SEEA-Energy includes all final use – as defined in the national accounts – including exports and inventory changes. In addition, international bunkering is recorded in the energy accounts as intermediate consumption if the bunkering is undertaken by a ship operated by a resident unit, or as exports if the ship is operated by a non-resident unit. It should be noted that refueling and bunkering by resident airplanes and ships abroad is also included in the supply and use of the energy accounts.

3.171 By SNA convention, inventory changes are recorded as a use in SEEA-Energy, that is, an increase of inventories is a use, while a decrease in inventories is a negative use (since it leads to more of the product being available for other uses).

3.172 The term 'final consumption' within the energy balances excludes the use of energy products in the energy industries and by other energy producers as input into transformation and energy industry own-use. In the national accounts, the term 'final consumption' is used to denote the use of goods and services by individual households or the government to satisfy individual or collective needs or wants. As described earlier, the term 'final consumption' is not used in SEEA-Energy so as to avoid confusion with the different use of the same term within the energy balances. Instead reference is made explicitly to household consumption, changes in inventories, exports and so on. In addition, the term 'end use' is introduced into SEEA-Energy to denote a concept of energy use excluding the use for transformation processes.

3.5.6 Energy balances - statistical difference

3.173 In concept, supply of energy products will equal use of these products. However, in practice there are usually differences between the measures of supply and use generally due to the use of different data sources and conversion factors from mass to energetic units Energy balances will, in practice, explicitly include an item for statistical difference. The difference as calculated in the energy balances can be positive or negative depending on whether the calculated supply is higher or lower, respectively, than the calculated use.

3.174 SEEA-Energy accounts do not include an item for statistical difference as this is an issue of compilation practice. Energy accountants may wish to investigate the reasons for the discrepancies and decide on a case by case basis how to reduce and allocate them. The forthcoming ESCM will provide details on compilation issues related to statistical difference.

3.5.7 Bridge tables linking energy balances and energy accounts

3.175 When a country introduces SEEA-Energy accounts, generally the accounts will be implemented using energy statistics and energy balances as the basic data providing the vast bulk of information required. Under these circumstances, the most economical way to implement energy accounts is to make adjustments to existing energy statistics and energy balances to deliver energy accounts. In practice this means that adjustments and additions to the data presented by energy statistics and energy balances must be made. Box 3.1 summarizes the main adjustments needed.

3.176 Further, in order to show the links between the main concepts and aggregates of the energy accounts and the underlying energy statistics and energy balances, countries may choose to compile bridge tables. Tables 3.10 and 3.11 present bridge tables for supply and use, respectively. The bridge tables show the additions and subtractions needed to reconcile the bases used in the energy accounts and energy balances.

3.177 Table 3.10 starts with the supply of the energy balances. By adding international marine bunkers, exports, inventory changes and purchases by residents abroad the total supply as presented in the SEEA-Energy accounts is obtained.

3.178 Table 3.11 opens with the 'final consumption' of energy as presented (and defined) within the energy balances. International marine bunkers, exports, inventory changes and purchases by residents abroad are added in order to reach the end use as recorded in SEEA-Energy.

3.179 For both Table 3.10 and Table 3.11 the bridging is carried out in respect of energy product details. Such details are available in standard accounts of both the energy accounts and the energy balances.

3.180 Table 3.12 provides a summary of the key differences between energy accounts energy balances as described within this section.

Box 3. 1 Adjustments to energy statistics and energy balances needed to derive the energy accounts

Adjustments to imports/exports. In order to include imports and exports from the energy balances onto an energy accounts basis, adjustments are needed to relate them to transactions between resident and non-resident units independently of the location where the transaction takes place.

Other adjustments for geographical coverage. In order to compile energy accounts, a number of items in the energy balances, in addition to imports and exports, need to be adjusted for the residence of the units involved. This is the case for international marine bunkering and for the items in the bottom block of the energy balances related to 'final consumption' (IRES, paragraphs 8.33 – 8.34, and Table 8.1). In fact, the different uses of energy products of the energy balances need to be disaggregated so that they can be recorded as intermediate/household consumption when the unit is resident – or export when the unit is non-resident and need to be complemented with the use by resident units abroad. This is similar to the case of international bunkering.

It should also be noted that, in principle, there might be some additional adjustments necessary to the geographical coverage to exclude and/or include territorial enclaves in the rest of the world. These areas are clearly demarcated land areas (such as embassies, consulates, etc.) located in other territories and used by governments that own or rent them for diplomatic, military or scientific purposes. These areas are excluded from the basic statistics and energy balances, while they are included in the statistics presented by the accounting framework.

Reallocation/regrouping of data to the relevant ISIC division/class. In order to compile the energy accounts, information has to be regrouped according to the different ISIC division/classes. Information on 'transport', 'non-energy use', 'energy industry own use' and 'primary production' are example of items that need to be reallocated in order to present information on an ISIC-based tabulation such as that used in SEEA-Energy.

Additional data items necessary for the compilation of energy accounts

In order to compile energy accounts, it is important to have information that allows for the adjustments presented. Such information includes, for example, the breakdown of the deliveries for international bunkering of resident and non-resident units; deliveries to resident and non-resident final consumers; and use of energy products by resident units abroad. The additional data items depend to some extent on the methods used to make adjustments to the energy balances.

In view of the above differences countries are encouraged to clearly document and make available the methods used for the reallocation and adjustments of data provided by basic energy statistics and balances to the energy accounts. Details on good country practices in this respect will be provided in the forthcoming Energy Statistics Compilers Manual.

Source: International Recommendations for Energy Statistics (IRES, 2011), Chapter 11.

Table 3.10 Bridge table for domestic supply and total supply[19]

	Supply (Energy Balances)	+international marine bunkers	Exports	Accumulations	Purchased by residents abroad	Supply (SEEA-Energy)
Coal	244.1		1.9	- 21.0		225
Peat and peat products						
Oil shale/ oil sands						
Natural gas (extracted)	395					395
Natural gas (distributed)	166.1		201.0	2.0		369.1
Oil (e.g. conventional crude oil)	360		361.0			721
Oil (oil products)	996	44	80.0	- 3.0	160	1277
Biofuels	7					7
Waste	109.1		1.0	0.3		110.4
Electricity	134		100.0			234
Heat	78.5					78.5
Nuclear fuels and other fuels nec						

Table 3.11 Bridge table for final consumption and end use of energy

	Final consumption (energy balances)	+international marine bunkers	Exports	Accumulations	Energy sectors use of energy for supporting activities	Purchased by residents abroad	End use (SEEA-Energy)
Coal	21.1		1.9	- 21.0			2
Peat and peat products							
Oil shale/ oil sands							
Natural gas (extracted)							
Natural gas (distributed)	77.1		201.0	2.0	2.0		282.1
Oil (e.g. conventional crude oil)	930		361.0				1291
Oil (oil products)	44	44	80.0	- 3.0	6.0	160	331
Biofuels	7						7
Waste	78.1		1.0	0.3			79.4
Electricity	131		100.0		3.0		234
Heat	76.5				2.0		78.5
Nuclear fuels and other fuels nec							

[19] Exports are removed prior to the calculation of net supply or availability in the energy balances and hence need to be added back.

Table 3.12 Comparison of Energy Statistics, Energy Balances (IRES) and Energy Accounts (SEEA-Energy)

Energy Statistics	Energy Balances	Energy Accounts
Based on primary statistics (production, foreign trade, business survey)	Based on energy statistics	Based on energy statistics and balances
	Supply and and use balances	Supply and use balances
Specific energy surveys	Various formats (IEA, Eurostat, UN)	Uses national accounts SUT format
No specific format	Sectors and industries (ISIC)	Industries classified by ISIC
	Rearrangement of industries' energy use according to purpose (transport, auto-producers and heat for sale)	No re-arrangement of industries' energy use
	Detailed description of energy sector including technologies	Energy "sector" described by ISIC No description of technologies
	All transport in one separate sector	Own account transportation included in industries' activities
Territory principle	Territory principle	Resident principle
	Statistical differences	No statistical differences
Physical	Physical	Physical and monetary

Chapter 4: Monetary Flow Accounts

4.1 Introduction

4.1 The production and use of energy is important to both the economy and the environment. While energy production is an economically significant activity, energy itself is required for virtually all forms of economic production and therefore the energy products used, how they are produced, how they are distributed and by whom they are used are all of socio-economic importance. Equally, these choices have profound implications for the state of the physical environment.

4.2 SEEA-Energy provides a range of monetary information of interest to policymakers. The principles and structures underpinning this monetary information allow it to be integrated with a range of information about the physical environment and to thereby support powerful analyses of economic and environmental aspects of energy production and use.

4.3 Increasingly, economic instruments are being used to achieve environmental outcomes and many of these instruments are designed to influence the type and amount of energy used – for example to control the amount and type of emissions arising from energy production and use. It is instructive to identify environmental transactions within the key aggregates of the SNA and to combine this with information on changing environmental pressures. Information on these transactions may be used to assess whether economic resources devoted to reducing pressures on the environment and maintaining the capacity of the environment to deliver benefits are being used effectively. The information also supports a comparative assessment of various possible policies.

4.4 This chapter commences with a general description of monetary supply and use tables and presents a monetary supply table for energy and a monetary use table for energy. The chapter then describes the characteristics and uses of combined presentations and provides a combined presentation of monetary and physical supply and use tables for energy. The chapter concludes with a description of other environmentally related transactions for energy and introduces and explains a number of tables designed draw out a range of important energy-related transactions. This chapter largely summarizes the discussion in SEEA Central Framework which presents a more detailed treatment of some of the general concepts.

4.2 Valuation rules and principles for monetary flow accounts

4.2.1 Introduction

4.5 For monetary accounts, there are clear guidelines governing the valuation of various types of flows within the economy. This section describes valuation based on market prices, which is the starting point from which transactions are valued within SEEA-Energy. In many cases, the prices received by producers differ from the prices paid by purchasers. Accordingly, this section provides a general description of the various types of prices used in SEEA-Energy and their application within the monetary supply and use tables. It provides further description of the impact on these prices arising from the recommended treatment of taxes and subsidies on products, and trade and transport margins.

4.2.2 Valuation rules and principles

Valuation at market prices

4.6 In SEEA-Energy as in the SEEA Central Framework and the SNA values recorded in the accounts are, in principle, the current transaction values or market prices for energy and energy related transactions. Market prices are defined as amount of money that willing buyers pay to acquire something from willing sellers. Market prices involve an exchange between independent parties on the basis of commercial considerations only, sometimes called 'at arm's length'.

4.7 For more details on valuation at market prices see SEEA Central Framework, Section 2.7.3.[20]

Basic, producer and purchaser's prices

4.8 When energy is purchased or other energy related transactions occur, the amount ultimately received by the producer or supplier of the product is likely to differ from the amount paid by the purchaser. The difference could be due to a number of factors such as taxes, transport costs, wholesale and retail margins and/or subsidies. To take these different factors into account three different kinds of prices are defined reflecting the prices from supply and use perspectives. The relationship between these three prices is shown in Table 4.1.

4.9 The basic price measures the amount retained by the producer and is, therefore, the price most relevant for the producer's decision making. The purchasers' price of a good includes any transport charges paid separately by the purchaser to take delivery at the required time and place. This is the price most relevant for the purchaser. A more detailed description of prices is presented in SEEA Central Framework, Section 2.7.3

[20] Applying the market price principle to the valuation of mineral and energy assets is challenging since market prices are generally not observable. A number of techniques are suggested in the SNA (see 2008 SNA Chapters 10 and 13) for the estimation of market prices of assets in situations where no developed asset market exists. A full description of the different techniques and approaches relevant to environmental and economic accounting, in particular discussion on the use of Net Present Value (NPV) approaches, is contained in Chapter 6.

Table 4.1: Basic, producers' and purchasers' prices

Basic prices *plus*
Taxes on products excluding invoiced VAT *less*
Subsidies on products *equals*
Producers' prices *plus*
VAT not deductible by the purchaser *plus*
Separately invoiced transport charges *plus*
Wholesalers' and retailers' margins *equals*
Purchasers' prices

4.10 Due to the importance of imports and exports of energy products to the energy accounts it should be noted that imports c.i.f. (i.e. including costs, insurance and freight) is the price at the point of entry into the importing country and includes costs, insurance and freight incurred between the exporter's and importer's borders. For imported products, c.i.f. valuation corresponds to a basic price valuation.

4.2.3 Taxes and subsidies on products

4.11 Of special interest in the area of energy policy are those taxes and subsidies payable per unit of energy product. These taxes on products can be subdivided into value added type taxes and other taxes on products. The latter include taxes named for their tax base, e.g. petrol taxes, but also CO2 taxes where the tax base is the unit of energy involved in the transaction. However, if an emissions tax is levied on the emissions and not on the use of energy, the tax is not categorised as taxes on products, but instead as *other taxes on production*. (2008 SNA, 7.97).

4.12 Taxes and subsidies on products are often a point of high focus in the area of energy policy. Taxes are compulsory, unrequited payments, in cash or in kind, made by institutional units to government units.[21] The tax may be a specific amount per unit of quantity (e.g. volume or weight), or it may be calculated ad valorem as a specified percentage of the price per unit or value of the product transacted. A tax on a product usually becomes payable when the product is produced, sold or imported, but it may also become payable in other circumstances, such as when a good is exported, transferred, delivered, or used for own consumption. (2008 SNA, 7.88).

[21] For details on the definitions of the different types of taxes refer to 2008 SNA paragraphs 7.71 – 7.97, 8.52 – 8.64 and 10.207.

Examples of taxes on products include: value added tax (VAT); taxes on exports; and taxes on imports.

4.13 Subsidies on products are current unrequited payments made to enterprises by government units, including non-resident government units, on the basis of the quantities or values of the goods or services that the enterprise produces, sells or imports. (2008 SNA 7.98).

4.2.4 Trade and transport margins

4.14 When energy products are sold through wholesalers and retailers, these activities are allocated to ISIC Section G - Wholesale and retail trade, and the trade margins are recorded as output of this industry. The trade margin forms part of the difference between the basic price realised by the producer of the energy product and the purchasers' price paid by the user.

4.15 In addition to possible wholesale and retail activity, the delivery of an energy product often involves some form of transport activity. This transport activity may or may not be charged and invoiced separately to the buyer. If the transport activities are charged separately, regardless of whether it is the producer or another unit which undertakes these transport activities, the charges are recorded as transport margins. Transport margins, together with trade margins, and taxes and subsidies on products, make up the difference between basic prices and purchasers' prices.

4.16 If the producer of the energy product carries out transport activity without explicitly charging this to the buyer, or if the buyer collects the product directly from producer, transport margins are not recorded.

4.3 Monetary supply and use tables

4.3.1 Introduction

4.17 This section describes the form of a monetary supply and use table.Monetary supply and use tables are closely related to the physical supply and use tables, described earlier. This description is followed by a more detailed discussion of the workings of the monetary supply table for energy products and the monetary use table for energy products.

4.3.2 Monetary supply and use tables

4.18 Monetary supply and use tables in SEEA-Energy articulate the flows of energy products in an economy between different economic units in monetary terms. They are compiled to provide structural information on the energy sector and the level of activity in this sector. They also provide information about the types of entities within the economy that are using these energy products. Many of the flows of products recorded in monetary terms relate to the use of energy from natural inputs extracted from the environment, for example the manufacture of petroleum products.

4.19 In SEEA-Energy, the recording of the products that flow within the economy is consistent with the SNA principles used in recording these flows. Products are 'supplied' within the economy when they are

i. produced by industries in the national economy (a flow known as output)

ii. brought in from the rest of the world (a flow known as imports).

4.20 The supply-use identity requires that all supplied products must be recorded as being 'used'. Use can occur in a number of ways:

i. the products can be used by other industries to make different products (a flow known as intermediate consumption);

ii. the products can be consumed by households (a flow known as household final consumption);

iii. the products can be consumed by governments (a flow known as government final consumption);

iv. the products can be sold to the rest of the world (a flow known as exports); or

v. the products can be held as inventories for later use.[22].

4.21 These flows are classified by type of product and by type of economic unit and presented in a tabular format. For a more detailed discussion of the basic form of the monetary supply and use table see SEEA Central Framework, Section 2.3.2.

4.3.3 Monetary supply table for energy

4.22 The monetary supply table for energy products, Table 4.2, shows the value of domestic production for various energy products and the value of imports at basic prices. The table also presents, for each type of energy product, the amount of taxes and subsidies, and the sum of trade and transport margins.

[22] When products are withdrawn from inventories in subsequent accounting periods they are effectively re-supplied to the economy at that time. By accounting convention, the net change in inventories (additions to inventories less withdrawals) during an accounting period is recorded as a "use" of products.

Table 4.2 Monetary supply table for energy products

	Supply						Flows from the rest of the world	Total supply at basic prices	Taxes (net)	Trade and transport margins	Total supply at purchasers' prices
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries	Imports				
	ISIC A	ISIC B	ISIC C	ISIC D	ISIC H						
Energy products (currency units)											
Production of energy products by SIEC class											
Coal							3 783	3 783	203	104	4 090
Peat and peat products											
Oil shale/ oil sands											
Natural gas (extracted)		12 289						12 289			12 289
Natural gas (distributed)				19 344				19 344	4 252		23 596
Oil (e.g. conventional crude oil)		48 455						48 455			48 455
Oil (oil products)			26 818				52 757	79 575	27 372	7 800	114 747
Biofuels	105		10	171				286			286
Waste	768		257				932	1 957	482	894	3 333
Electricity				23 741			1 778	25 519	16 148		41 667
Heat				13 538				13 538	6 135		19 673
Nuclear fuels and other fuels nec											
Energy for own use											
Total	873	60 744	27 085	56 794			59 250	204 746	54 592	8 798	268 136

4.23 Following the typical national accounts practice amounts of taxes and subsidies are presented as taxes less subsidies (taxes, net) in Table 4.3. If information is available, it is possible to show the taxes and subsidies separately.

4.3.4 Monetary use table for energy

4.24 The monetary use table for energy is presented in several stages. The top part of Table 4.3 shows the monetary use table for energy in purchasers' prices. It records the amounts paid by users for the various energy products used. As in the physical use table for energy (Table 3.5), the use is divided into intermediate consumption by industries and other uses including household consumption, exports and inventory changes. In contrast to the physical use table, the monetary use table includes entries only where monetary transactions take place. Thus, for example, residuals do not appear in the monetary use table for energy.

4.25 For each energy product, the total use at purchasers' prices is equal to the total supply at purchasers' prices as presented in the last column of Table 4.2. This reflects the following accounting identity for the monetary energy flows:

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

=

Total use at purchasers' prices = Intermediate consumption + private consumption + inventory changes + exports

4.26 All energy used by the government is recorded as inputs to intermediate consumption; hence this column is omitted. The use of energy products is not regarded as capital formation with the exception of changes in inventories which is the only contributor to the accumulations column.

4.27 The rest of Table 4.3 presents a breakdown of the use of energy products at purchasers' prices into the elements of taxes less subsidies, trade and transport margins, and use at basic prices.

4.28 The taxes less subsidies paid in relation to each energy product are allocated to the users of the energy products. It is assumed that it is the users of the energy products, who ultimately pay taxes and receive subsidies on products, since taxes and subsidies affect the purchasers' price of energy. However, taxes and subsidies normally are collected or received by producers or by wholesale and retail traders on behalf of the users. The allocation of taxes and subsidies on products to the users of energy products is therefore based on modelled assumptions, and not on direct observation of flows of taxes and subsidies on products. The total of taxes less subsidies allocated to users of energy products, Table 4.3, corresponds to the total of taxes less subsidies in the supply table, Table 4.2.

4.29 The tax table is useful for analysing the net tax burden related to the use of energy products. The table can be broken down further by specific taxes and subsidies, for example, tables can be set up for VAT, CO2 taxes and other energy taxes.

4.30 Trade and transport margins are allocated to use of energy products. For each energy product, the total of trade and transport margins in Table 4.3 corresponds to the margins presented in the supply table, Table 4.2. As with taxes allocated to uses, the allocation of trade and transport margins has to be based on modelled assumptions, since the allocation is not directly observable.

4.31 Although the allocation of taxes less subsidies on products and transport margins by users may be challenging in practice, the resulting tables are useful for analysis. In addition, setting up supply and use tables that use the same concept of price is instructive for the compiler, since it ensures the consistency of data and provides a basis to estimate for missing data i.e. by using available information and using judgment to reach a balance by adjusting the components as necessary (2008 SNA, 14.6).

By subtracting taxes less subsidies on products and trade and transport margins from use of energy products at purchasers' prices, a use table at basic prices is obtained. This table shows, for each energy product and each of the user categories, the total use of imported and domestically produced energy products. A further breakdown may be made within separate tables for use of domestic produced energy products and imported energy products by using information and assumptions on market shares, etc.

4.32 The accounting identity that total supply at basic prices (Table 4.2) is equal to total use at basic prices (Table 4.3) for each energy product is fulfilled. This can also be expressed by the identity:

Total supply at basic prices = Imports, c.i.f. + Domestic production at basic prices

=

Total use at basic prices = Intermediate use at basic prices + Private consumption at basic prices + Inventory changes at basic prices + Exports at basic prices

Table 4.3 Use table (purchasers’ prices, intermediate tables and basic prices)

	Intermediate consumption							Private consumuption and other				Total use
	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufacturing ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries	Total	Households	Accumulation	Flows to the rest of the world	Total	
Energy products-Curreny units												
Energy products by SIEC class-Use table at puchasers prices												
Coal	58	10	423	3 446		16	3 953	339	- 254	52	137	4 090
Natural gas (extracted)				12 289			12 289					12 289
Natural gas (distributed)	117	109	2 858	3 578	73	1 906	8 641	5 587	138	9 230	14 955	23 596
Oil (e.g. conventional crude oil)			4 740				4 740			43 715	43 715	48 455
Oil (oil products)	4 377	114	22 621	964	35 744	9 461	73 281	26 218	2 279	12 969	41 466	114 747
Biofuels	10		63	213			286					286
Waste	40		102	848		67	1 057	2 224	10	42	2 276	3 333
Electricity	1 196	46	5 169	272	1 401	9 135	17 219	19 984		4 464	24 448	41 667
Heat	97		636		202	5 353	6 288	13 385			13 385	19 673
Total	5 895	279	36 612	21 610	37 420	25 938	127 754	67 737	2 173	70 472	140 382	268 136
Energy products by SIEC class-Taxes less subsidies on products												
Coal	2	6	23	18		3	52	151			151	203
Natural gas (extracted)												
Natural gas (distributed)	8	2	653		32	835	1 530	2 722			2 722	4 252
Oil (e.g. conventional crude oil)												
Oil (oil products)	749	17	941	49	2 963	4 304	9 023	16 103		2 246	18 349	27 372
Biofuels												
Waste				9		13	22	460			460	482
Electricity	123	4	499	- 3	519	3 914	5 056	11 141		- 49	11 092	16 148
Heat	42		95		46	1 317	1 500	4 635			4 635	6 135
Total	924	29	2 211	73	3 560	10 386	17 183	35 212		2 197	37 409	54 592
Energy products by SIEC class-Trade and transport margins												
Coal	21	1	49	28			99	5			5	104
Natural gas (extracted)												
Natural gas (distributed)												
Oil (e.g. conventional crude oil)												
Oil (oil products)	1 019	12	265	100	1 532	1 401	4 329	2 825		646	3 471	7 800
Biofuels												
Waste	10			114			124	770			770	894
Electricity												
Heat												
Total	1 050	13	314	242	1 532	1 401	4 552	3 600		646	4 246	8 798
Production of energy products by SIEC class-Use table at basic prices												
Coal	35	3	351	3 400		13	3 802	183	- 254	52	- 19	3 783
Natural gas (extracted)				12 289			12 289					12 289
Natural gas (distributed)	109	107	2 205	3 578	41	1 071	7 111	2 865	138	9 230	12 233	19 344
Oil (e.g. conventional crude oil)			4 740				4 740			43 715	43 715	48 455
Oil (oil products)	2 609	85	21 415	815	31 249	3 756	59 929	7 290	2 279	10 077	19 646	79 575
Biofuels	10		63	213			286					286
Waste	30		102	725		54	911	994	10	42	1 046	1 957
Electricity	1 073	42	4 670	275	882	5 221	12 163	8 843		4 513	13 356	25 519
Heat	55		541		156	4 036	4 788	8 750			8 750	13 538
Total	3 921	237	34 087	21 295	32 328	14 151	106 019	28 925	2 173	67 629	98 727	204 746

4.4 Combined presentations for energy

4.4.1 Introduction

4.33 The presentation of data in a format that combines physical and monetary information is one of the most powerful features of SEEA. This feature allows SEEA-Energy to provide a wide range of information across various energy-related themes and to derive indicators that combine physical and monetary information.

4.34 SEEA-Energy utilises integrated accounting structures within its physical and monetary tables – this, along with common underlying accounting rules and principles utilised throughout the physical and monetary accounts and data provides a strong basis for combined presentations. Such integrated formats are sometimes referred to as ‘hybrid’ presentations or accounts because they contain data in different units, for example, currency units and joules; or currency units and tonnes of CO2. While the units are different, the data sets are presented using consistent classifications and definitions, and therefore these presentations are called combined physical and monetary presentations.

4.35 Different forms of combined physical and monetary presentations are possible and indeed there is no standard form for these presentations. Often physical flows data are presented alongside information from the monetary supply and use tables but even for this basic structure a range of combinations is possible. The structures chosen for the combined presentations will depend on the available data and the questions to be informed.

4.36 Energy-related combined presentations could identify the following: relative costs associated with the production of various energy products by different producers; the implicit prices paid by different energy users for various types of energy products; and/or the emissions associated with use of energy products by various users of energy products. The combining of monetary and physical information related to energy can also support an informed assessment of policy trade-offs, for example, when considering the introduction of a tax on carbon emissions, a combined presentation could inform of potential impacts on energy prices paid by various energy users and of potential impacts on the profits of energy suppliers and on the total costs of energy users.

4.37 This section provides general guidance on the compilation of combined physical and monetary presentations. In doing so, it provides the example of a combined monetary and physical supply and use presentation for energy and suggests other possible combined presentations for energy.

4.4.2 General principles of combined presentations

4.38 While the presentation of information in a format that combines monetary and physical information is one of the most powerful features of SEEA-Energy and the

SEEA Central Framework, the success of these presentations requires the use of a range of practices and principles.

4.39 The overarching principle of combining energy-related monetary and physical information is the recording of physical flows in a manner consistent with economic transactions as presented in the SNA. That is, these different types of information must use similar definitions and classifications of energy products, energy flows and industries and institutional sectors. The time frame, recording principles (including consistent use of residence principle) should match throughout the combined presentation. This ensures a consistent comparison of environmental burdens with economic benefits, or of environmental benefits with economic costs. These linkages can be presented not only at the national level but also at disaggregated levels, for example, in relation to physical regions, or specific industries, or for the purpose of examining flows associated with the extraction of a particular type of energy product or the emissions of a particular substance.

4.40 When the combined presentations are put together it is important to be aware of any differences in principles used in the underlying statistics. Steps must be taken to remove or adjust for such differences to avoid inconsistencies within the combined presentations.

4.4.3 Combined supply and use presentations for energy

4.41 A common combined presentation for energy involves the juxtapositioning of monetary supply and use of energy products against the corresponding physical supply and use of these products. The flows considered within physical supply and use tables for energy include those related to energy from natural inputs, to residuals and to energy products. For monetary supply and use tables related to energy, the range of flows is essentially confined to energy products supplied and used. Consequently, it is possible to juxtapose monetary and physical supply and use flows for energy – but only for the supply and use of energy products.

4.42 Energy consumed through intermediate use, and energy lost after it has been produced, are both included in the physical supply table. In contrast, the monetary supply and use tables contain only those flows associated with an economic transaction. These flows correspond to the block within the PSUT related to the ‘energy products’.

4.43 The supply or use of energy may provide the basis for a tax (or subsidy) even where no monetary transaction takes place. For instance, the production of electricity by wind power may attract a subsidy, even where no economic transaction for the wind power is recorded in the accounts. If a tax (or subsidy) transaction occurs in relation to such non-marketed energy flows, it should be recorded in the monetary supply and use accounts.

4.44 The matching measures of monetary and physical supply and use of energy products support the calculation of implicit prices for these products. While such implicit prices must be interpreted with caution, they provide potentially valuable information about the supply and use of various energy products throughout the economy. In addition, these prices provide a powerful data editing tool for statisticians seeking to ensure the coherence and quality of their data outputs.

Combined physical and monetary supply table for energy

4.45 Table 4.4 shows the form of a standard combined phyiscal and monetary supply table for energy.

Table 4.4 Combined physical and monetary supply table for energy products

	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufacturing ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries		Imports						
Energy products-Monetary														
Production of energy products by SIEC class														
Coal								3 783	3 783			203	104	4 090
Peat and peat products														
Oil shale/ oil sands														
Natural gas (extracted)		12 289					12 289		12 289					12 289
Natural gas (distributed)				19 344			19 344		19 344			4 252		23 596
Oil (e.g. conventional crude oil)		48 455					48 455		48 455					48 455
Oil (oil products)			26 818				26 818	52 757	79 575			27 372	7 800	114 747
Biofuels	105		10	171			286		286					286
Waste	768		257				1 025	932	1 957			482	894	3 333
Electricity				23 741			23 741	1 778	25 519			16 148		41 667
Heat				13 538			13 538		13 538			6 135		19 673
Nuclear fuels and other fuels nec														
Total supply of energy products	873	60 744	27 085	56 794			145 496	59 250	204 746	54 592		54 592	8 798	268 136
Supply of other products	*64 261*	*4 488*	*583 437*	*261*	*351 256*	*1 773 950*	*2 777 653*	*741 950*	*3 519 603*	*210 888*	*- 16 726*	*194 162*		*3 704 967*
Total supply, all products	*65 134*	*65 232*	*610 522*	*57 055*	*351 256*	*1 773 950*	*2 923 149*	*801 200*	*3 724 349*	*265 480*	*- 16 726*	*248 754*		*3 973 103*
Energy products-Physical														
Production of energy products by SIEC class														
Coal								225	225					
Peat and peat products														
Oil shale/ oil sands														
Natural gas (extracted)		395					395		395					
Natural gas (distributed)				369			369		369					
Oil (e.g. conventional crude oil)		721					721		721					
Oil (oil products)			347				347	930	1 277					
Biofuels	5			2			7		7					
Waste	39		55				94	17	110					
Electricity				212			212	22	446					
Heat				79			79		79					
Nuclear fuels and other fuels nec														
Total energy products	44	1 116	402	661			2 223	1 194	3 629					

4.46 Table 4.4 is comprised of two parts. The top half describes the monetary supply of energy products in monetary units and is organised as described in the discussion related to monetary supply and use tables (in Section 4.3). Energy products appear in the rows of the table, while the columns present information on the industries supplying energy products. The supply of other products and the total supply of products in monetary terms are also show so as to better assess the role of the energy sector within the economy. The bottom half of Table 4.4 describes the physical supply of these products in joules, again energy product details appear in the rows of the table and details of the supplying industries appear in the columns. Own account production is excluded from the physical supply since there is no market transaction for such production.

Combined physical and monetary use table for energy

4.47 Table 4.5 shows the form of a standard combined physical and monetary use table for energy. The table contains two parts. The top half of Table 4.5 provides information in monetary terms on the use of energy products and is organised according to the principles of monetary supply and use tables as described in Section 4.2. Energy product detail appears in the rows of the table, while the columns present information on industry use of energy products and other monetary uses of energy products. The bottom half of Table 4.5 describes the physical use of energy products in joules. Again, energy product detail appears in the rows of the table and details of industry use appears in the columns, along with other types of energy use. The part of the table relating to physical use of energy conforms to the principles and structure of the physical use of energy table as described in Chapters 2 and 3.

4.48 The uses of energy products described in the columns of Table 4.5 include intermediate consumption by industries, household consumption, exports, and inventory changes and other changes.

Table 4.5 Combined physical and monetary use table for energy products

	Intermediate consumption							Private consumption and other				Total use
	Agriculture, forestry and fishing ISIC A	Mining and quarrying ISIC B	Manufacturing ISIC C	Electricity, gas, steam and air conditioning supply ISIC D	Transportation and storage ISIC H	Other industries	Total	Households	Accumulation	Flows to the rest of the world	Total	
Energy products												
Energy products by SIEC class-Use table at puchasers prices												
Coal	58	10	423	3 446		16	3 953	339	- 254	52	137	4 090
Peat and peat products												
Oil shale/ oil sands												
Natural gas (extracted)				12 289			12 289					12 289
Natural gas (distributed)	117	109	2 858	3 578	73	1 906	8 641	5 587	138	9 230	14 955	23 596
Oil (e.g. conventional crude oil)			4 740				4 740			43 715	43 715	48 455
Oil (oil products)	4 377	114	22 621	964	35 744	9 461	73 281	26 218	2 279	12 969	41 466	114 747
Biofuels	10		63	213			286					286
Waste	40		102	848		67	1 057	2 224	10	42	2 276	3 333
Electricity	1 196	46	5 169	272	1 401	9 135	17 219	19 984		4 464	24 448	41 667
Heat	97		636		202	5 353	6 288	13 385			13 385	19 673
Nuclear fuels and other fuels nec												
Total	5 895	279	36 612	21 610	37 420	25 938	127 754	67 737	2 173	70 472	140 382	268 136
End-use of energy products by SIEC class-Physical table												
Coal	2		17				19	1	- 21	2	- 18	1
Peat and peat products												
Oil shale/ oil sands												
Natural gas (extracted)												
Natural gas (distributed)	2		39			12	53	26	2	201	229	282
Oil (e.g. conventional crude oil)										361	361	361
Oil (oil products)	34	2	326		621	49	1 032	102	- 3	80	179	1 211
Biofuels				2			2	5			5	7
Waste	3		4	37		1	45	33		1	34	79
Electricity	7	1	22	50	10	15	105	29		100	129	339
Heat	2		11	2	1	19	35	44			44	79
Nuclear fuels and other fuels nec												
Total end-use for energy purposes	50	3	419	91	632	96	1 291	240	- 22	745	963	2 359

4.4.4 Other combined presentations for energy

4.49 It is not necessary to complete an exhaustive physical supply and use table for energy in order to present valuable combinations of physical and monetary data. On the contrary, it is possible to create highly informative combined presentations while using only limited data variables. In some cases, only a limited range of data may be available and often only a limited range of data is needed. In other cases, information on stocks of mineral and energy resouces in physical and monetary terms as well as other socio-economic variable such as employment can be added to the combined presentation. What is critical is that the data used in the combined presentation appropriately inform the environmental-economic concerns of policymakers.

4.50 For example, the introduction of a price on carbon emissions – either through a tax on such emissions, or through the introduction of a scheme requiring the use of tradeable permits to emit carbon – is typically motivated by a desire to reduce carbon emissions to air to improve the quality of the environment. Nevertheless, the use of these policy tools will usually have significant implications for the economy.

There may be concerns about the cost of such schemes to those businesses supplying energy products, as well as for businesses and households who use energy products. Governments will be acutely interested in the potential revenue raised by carbon taxes and carbon emissions trading schemes; and in the question (and cost) of any related monetary compensation for affected householders and/or businesses within the economy.

4.51 To assess the possible impacts of introducing a price on carbon emissions, therefore requires a range of monetary and physical data. For example, physical data on carbon emissions related to various energy products (and to various users and uses of these products) to assess whether carbon emission targets are being achieved. And a range of monetary data to assess the impact of the scheme on prices, profits, household and business expenditure (and saving) and government revenue and spending. As stated, these data must be coherent and relatable – in short, it requires a combined presentation of data using information based on the principles of integrated environmental-economic accounting, as described in SEEA-Energy and in the Central Framework of the SEEA. The use of combined presentations to inform this (and other) issues is further illustrated in Chapter 7.

4.52 Combined presentations are also useful in the derivation of many energy related indicators. Proper juxtaposition of information can be used to derive indicators on among others, energy efficiency, energy expenditures by different industries and households and energy intensity.

4.5 Environment related activities and expenditures

4.53 SEEA Central Framework describes in detail Environmental Protection (EP), Resource Management (RM) and the Environmental Goods and Services Sector (EGSS). In the context of SEEA-Energy relevant environmental protection (EP) expenditures include those expenditures for energy related pollution abatement. For example, it could be highly informative to combine time series information on expenditures linked to energy related SO2 abatement. These could be compared to corresponding data on energy related SO2 emissions and also to data on levels of production for those activities closely associated with SO2 emissions.

4.54 Another example relates to the energy-related part of EGSS statistics which includes data on expenditures on renewable production technology and production of energy-saving goods. This information can be of high policy relevance especially when considered in conjunction with other physical and monetary data in the SEEA-Energy Accounts.

4.6 Other transactions related to energy

4.6.1 Introduction

4.55 The national accounts contain a wide range of transactions related to energy. This section focuses on other transactions in the core national accounts framework that may be of interest in the analysis of the economic aspects of energy. Some of these transactions might also be identified as having an environmental purpose and hence are considered environmental transactions. When the transactions are related to the environment, they are within scope of SEEA Central Framework.

4.6.2 Presentation of certain transactions for energy

4.56 Table 4.6 shows taxes on production and subsidies related to energy production and use. Table 4.7 records energy-related property income, income taxes, social transfers and capital transfers.

Table 4.6 Taxes on production and subsidies related to energy production and use

	ISIC B				ISIC C		ISIC D						Other industries		Households		Government		Rest of the world		Total	
	05 -		06 -		19 - Manufac-		351 - Electric		352 -		353 - Steam											
	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able	Pay-able	Receiv-able
	Currency units																					
Taxes on production and imports																						
Taxes on products																						
Energy products			0		0		0		0		0		17		42			63	3		63	63
Other products			120		10		31		5		58							224			224	224
Other taxes on production			15		11		130		27		99							282			282	282
Subsidies																						
Subsidies on products																						
Energy products																7	8			1	8	8
Other products				52													52				52	52
Other subsidies on production				30				100				63					193				193	193
Total			**135**	**82**	**21**		**161**	**100**	**32**		**157**	**63**	**17**		**42.2**	**7**	**253**	**569**	**3**	**1**	**822**	**822**

4.57 In Table 4.6 the columns relating to industries, government, households and the rest of the world (exports) indicate whether the tax or subsidy is payable or receivable. In the example in Table 4.6 taxes are paid by various industries, households and the rest of the world (exports), while they are received by government. Subsidies are paid by the government and received by industries and households. The columns for the total economy, including the rest of the world, show that the total amounts payable equal total amounts receivable.

4.58 The payments of rents are presented in Table 4.7, but the payments are shown by institutional sector. In this table rent is paid by non-financial corporations and received by government. In principle, other institutional units may also receive such payments.

Table 4.7 Property incomes, income taxes, social transfers and capital transfers related to energy

	Non financial corporations		Households		Government		Rest of the world		Total	
	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable
	Currency units									
Property income										
Rent	5 000					5 000			5 000	5 000
Current taxes on income, wealth, etc.										
Taxes on income	14 158					14 158			14 158	14 158
Social contributions, benefits and transfers										
Social benefits other than social transfers in kind				330	330				330	330
Social transfers in kind				40	40				40	40
Other current transfers										
Current international cooperation					600			600	600	600
Capital transfers										
Capital taxes	50					50			50	50
Investment grants		410			410				410	410
Other capital transfers					100			100	100	100
Total	**19 208**	**410**		**370**	**1 480**	**19 208**		**700**	**20 688**	**20 688**

4.59 In Table 4.7 specific taxes on income, wealth, etc. related to mining activities is represented as a payment from non-financial corporations to government. To the extent that other taxes on income, wealth, etc. are specifically related to energy production they should be highlighted by entering them in a similar way within Table 4.7.

4.60 Social benefits and social transfers in kind received by households such as consumer subsidies for energy are normally recorded in the accounts as if the recipient has received monetary transfers which is then immediately used to purchase the products concerned (SNA 2008, 3.82). In the example presented in Table 4.7, the payments are entered as received by households from government.

4.61 In Table 4.7 Other current transfers is presented in the form of a payment from the government to the rest of the world related to international co-operation. Further below in this table a capital tax payment related to fixed capital used by energy producing corporations is entered as paid by non-financial corporations to government. And an investment grant is shown as being transferred from the government to non-financial corporations, and finally other capital transfer payment from government to the rest of the world is recorded.

4.62 The last row of Table 4.7 includes for each institutional sector the total amounts of property income, income taxes, social transfers and capital transfers received or paid in relation to energy.

Chapter 5: Physical asset accounts for energy

5.1 Introduction

5.1 Assets are items considered to be of value to society. In economics, assets are seen as stores of value that, in many situations, also provide inputs to production processes. More recently, there has been consideration of the value inherent in the components that comprise the environment and the inputs the environment provides to society. The term environmental asset has been used to denote the source of these inputs which may be considered in both physical and monetary terms.

5.2 Asset accounts for mineral and energy resources organise relevant information including the levels and values of stocks of the natural inputs and the changes in these over time. Flows of extraction, depletion and discoveries are central to the asset account and in turn these can provide valuable information about the mineral and energy resources that an economy relies upon.

5.3 Mineral and energy resources such as coal and oil are unique in that they can be extracted and used through economic activity but cannot be renewed on any human time scale. It is therefore important to know the amount of mineral and energy resources held and, over time, the type and extent of changes to these levels. This knowledge can be used by policymakers to determine, for example, the likely operating life of existing mineral and energy resources. This could provide an indication of future requirements for energy imports, and threats to national energy security. It could also provide motivation and time frame to plans to adopt renewable energy sources.

5.4 This chapter discusses mineral and energy resources and describes the relevant categorization of these inputs according their physical characteristics and according to criteria related to the extraction of these inputs. A number of basic physical asset accounts for energy are presented and explained, including the measurement of physical depletion of energy natural resource inputs. Inventories of energy products are also defined and discussed. A table is presented that records, in physical terms, inventories of energy products, including a decomposition of changes in inventories for a range of energy products

5.2 Definition and categorization of mineral and energy resources

5.2.1 Introduction

5.5 In physical terms, mineral and energy resources are categorised along two dimensions; firstly, according to the physical characteristics of the resource; and secondly, according to the viability, feasibility and geologic knowledge of the resources. This section defines mineral energy resources and, because of the lack of a standard international classification in this area, provides some practical guidance around this definition. An important exercise in relation to mineral and energy resources is the categorization of these resources in order to derive groupings of mineral and energy resources into ‘known deposits and ‘potential deposits’ – since the latter are not included in SEEA-Energy. The section concludes with a description of certain recording principles and of units used in physical asset accounts for energy.

5.2.2 Definition and categorization of mineral and energy sources

Definition and classification of mineral and energy sources

5.6 As defined in Chapter 3, energy natural resource inputs include mineral and energy resources which for the purposes of SEEA-Energy are composed of deposits of oil resources, natural gas resources, coal and peat resources, and uranium and thorium resources. Note that the definition of mineral and energy resource in SEEA-Energy is necessarily narrower than that in SEEA-Central Framework. As used in SEEA-Energy mineral and energy resources include only those resources that related to energy, while in SEEA Central Framework the definition is broader and it includes non-metallic and metallic minerals. There is no internationally agreed detailed classification for mineral and energy resources suitable for statistical purposes. In defining mineral and energy sources within SEEA-Energy, a number of clarification points are therefore required.

5.7 While firewood in forests and other stocks of biomass in nature can be used for energy purposes and are included as energy natural resource inputs, no asset accounts are compiled because, overall, these assets are not primarily used for energy purposes. They are instead recorded as biological resources within the asset accounts of SEEA Central Framework. Nevertheless, the supply and use of these inputs is presented in the flow accounts in Chapters 3 and 4 of SEEA-Energy.

5.8 Renewable sources of energy such as wind, solar and hydropower are not considered physical assets in SEEA-Energy. Except for energy sourced from biomass, other renewable sources of energy cannot be exhausted as is the case for mineral and energy resources – neither can they be regenerated. Thus in an accounting sense there is no physical stock of these types of renewable sources of energy that can be used up or sold. Nevertheless, physical flows of energy arise from renewable sources of energy and these flows are captured in Chapter 3 and 4.

Categorization of mineral and energy resources

5.9 Since mineral and energy resources are generally found below the ground it is often not known with complete precision the quantity of resources that might be reasonably extracted. Consequently, a key factor in the measurement of mineral and energy resources is the concentration and quality of the mineral and energy resources in the deposit, since this will influence the likelihood and cost of extraction and the degree of confidence that exists regarding the quantity that can be extracted in the future.

5.10 The following discussion is part of SEEA Central Framework which provides more details. (See SEEA Central Framework Section 5.5 and Annex 5.3)

5.11 The framework used to define the scope of known deposits is the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009). The UNFC-2009 is a generic and flexible scheme for classifying and evaluating quantities of fossil energy and mineral resources.

5.12 The UNFC-2009 categorizes mineral and energy resources by looking at whether, and to what extent, projects for the extraction or exploration of the resources have been confirmed, developed or planned. Based on the maturity of the projects, the underlying natural resources are classified according to a range of criteria. The UNFC-2009 is based on a breakdown of the resources according to three criteria affecting their extraction:

- Economic and social viability (E)
- Field project status and feasibility (F)
- Geological knowledge (G)

5.13 The first criterion (E) 'Economic and social viability' designates the degree of favourability of economic and social conditions in establishing the commercial viability of the project. The second criterion (F) 'Field project status and feasibility' designates the maturity of studies and commitments necessary to implement mining plans or development projects. These extend from early exploration efforts before a deposit or accumulation has been confirmed to exist through to a project that is extracting and selling a product. The third criterion (G) 'Geological knowledge' designates the level of certainty in the geological knowledge and potential recoverability of the quantities.

5.14 Known deposits are categorised into three classes each defined according to combinations of the abovementioned criteria from the UNFC-2009.

i. Class A: Commercially Recoverable Resources. This class includes deposits for projects that fall in the categories E1and F1 and where the level of confidence in the geological knowledge is either high (G1), moderate (G2) or low (G3).

ii. Class B: Potentially Commercially Recoverable Resources This class includes deposits for those projects that fall in the category E2 (or eventually E1) and at the same time in F2.1 or F2.2 and where the level of confidence in the geological knowledge is either high (G1) moderate (G2) or low (G3).

iii. Class C: Non-Commercial and Other Known Deposits are resources for those projects that fall in E3 and for which the feasibility is categorised as F2.2, F2.3 or F4 and where the level of confidence in the geological knowledge is either high (G1), moderate (G2) or low (G3).

5.15 Known deposits exclude potential deposits where there is no expectation of the deposits becoming economically viable and there is a lack of information to determine feasibility of extraction or to have confidence in the geological knowledge. Table 5.1 gives an overview of how the classes of energy resources are defined based on the UNFC criteria.

Table 5.1: Categorization of Mineral and Energy Resources

<table>
<tr><th rowspan="2"></th><th rowspan="2">SEEA Classes</th><th colspan="3">Corresponding UNFC-2009 project categories</th></tr>
<tr><th>E
Economic and social viability</th><th>F
Field project status and feasibility</th><th>G
Geological knowledge</th></tr>
<tr><td rowspan="3">Known deposits</td><td>Class A: Commercially Recoverable Resources[1]</td><td>E1. Extraction and sale has been confirmed to be economically viable</td><td>F1. Feasibility of extraction by a defined development project or mining operation has been confirmed</td><td rowspan="3">Quantities associated with a known deposit that can be estimated with a high (G1), moderate (G2) or low (G3) level of confidence</td></tr>
<tr><td>Class B: Potentially Commercially Recoverable Resources[2]</td><td>E2. Extraction and sale is expected to become economically viable in the foreseeable future[3]</td><td>F2.1 Project activities are ongoing to justify development in the foreseeable future
Or
F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay</td></tr>
<tr><td>Class C: Non-Commercial and Other Known Deposits[4]</td><td>E3. Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability</td><td>F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay
Or
F2.3 There are no current plans to develop or to acquire additional data at the time due to limited potential
Or
F4. No development project or mining operation has been identified</td></tr>
<tr><td>Potential deposits (not included in SEEA)</td><td>Exploration Projects
Additional quantities in place</td><td>E3. Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability</td><td>F3. Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data
Or
F4. No development project or mining operation has been identified</td><td>Estimated quantities associated with a potential deposit, based primarily on indirect evidence (G4)</td></tr>
</table>

Notes

1. Includes on-production projects, projects approved for development and projects justified for development
2. Includes economic and marginal development projects pending and development projects on hold
3. Potential Commercial Projects may also satisfy the requirements for E1.
4. Includes unclarified development projects, non-viable development projects, and additional quantities in place

Source: UNFC-2009, Figures 2 and 3

5.16 The scope of known deposits is broader than the scope of deposits that underpins the measurement of energy resources in the SNA. In the SNA the scope is limited to deposits that are commercially exploitable given current technology and relative prices.[23] The broader scope of known deposits is applied in SEEA Central Framework and SEEA-Energy to ensure that as broad an understanding as possible is obtained on the availability of the stock of energy resources. Issues associated with the scope of the valuation of mineral and energy resources are discussed further in chapter 6.

5.2.3 Units and recording principles

Units

5.17 The physical asset accounts for energy use different units such as tonnes, cubic metres, oil equivalents, petajoules (PJ), etc. depending on what is the most appropriate unit for a given resource. The same unit should be used throughout the account for a specific mineral and energy resource in order to ensure consistent accounting throughout the presentation (i.e. applying the various changes to the opening stock allows derivation of the closing stock). By applying conversion factors, it is possible to convert the accounts from one unit to another (e.g. from tonnes to PJ). Annex A1 includes general factors for use in the calculation of such conversions.

5.18 When all resource accounts for the various types of energy are converted to a common energy unit, usually joules, the accounts for individual mineral and energy resources can then be combined into one asset account expressing opening and closing stocks and changes within the period for all energy stocks.

Quantification

5.19 When quantifying natural gas assets based on potential future extraction care should be taken not to double-count quantities which are extracted and then re-injected into the same or other geological deposits. These quantities of gas should only be included in the output when they are extracted with the purpose of being used in the economy. Another operational arrangement is to place quantities of natural gas in controlled storage ready for further distribution to consumers. Under these circumstances the natural gas should be considered a product and the stocks of gas in controlled storage are treated as inventories of an energy product.

5.20 The above approach to quantifying mineral and energy resources ensures consistent recording within both the asset and flow accounts for energy i.e. consistent treatment of flaring of natural gas, own consumption of energy and extraction losses.

5.21 In practice, the implementation of asset accounts for mineral and energy resources will rely heavily on basic quantity estimates. These are published by companies, geological surveys, etc. and may reflect a range of different recording principles. It is therefore important to research the basis on which these data are recorded and

[23] See 2008 SNA, paragraph 10.179.

where necessary and possible to adjust the basic input data onto the required basis. Thus, for example, the Petroleum Resources Management System developed by the Society of Petroleum Engineers (SPE) states that in general the resource estimates should be based on sales quantities. Non-sale quantities include petroleum consumed as fuels, flared or lost in processing plus hydro-carbons that must be removed prior to sale (SPE-2007, p. 15). Where data are recorded on this basis it is necessary to adjust the quantity estimates based on additional information from the companies, geological surveys, etc. on the use by extractors, flaring and losses where information is available.

5.3 Physical asset accounts for mineral and energy resources

5.3.1 Introduction

5.22 This section describes physical asset accounts for mineral and energy resources. The first table reports on stocks of mineral and energy resources in physical units and aims to group mineral and energy resources into commercially recoverable resources; potentially commercially recoverable resources; and non-commercial and other known deposits. It reports information at a point in time. The second table reports on opening and closing stocks of various mineral and energy resources, and the changes in these stock positions over the accounting period. The various categories of change in these stocks are defined and described.

5.3.2 Physical asset accounts for mineral and energy resources

5.23 Physical asset accounts for mineral and energy resources should be compiled by type of resource and include estimates of the opening and closing stock of the mineral and energy resource and changes in the stock over the accounting period.

Measurement of opening and closing stocks

5.24 Ideally, opening and closing stocks of each resource should be classified by class of resource – i.e. Class A: Commercially Recoverable Resources, Class B: Potentially Commercially Recoverable Resources, or Class C: Non-commercial and other known deposits – following the presentation in Table 5.2.

5.25 It is not recommended that totals across all classes of individual types of resources be compiled. Because each class has a different likelihood of extraction, simple summation of the available resources for a specific resource (e.g. coal) may give a misleading indication of total available resources.

Table 5.2 Stocks of mineral and energy resources (physical units*)

Type of mineral and energy resource	Class of known deposit Class A: Commercially recoverable resources	Class B: Potentially commercially recoverable resources	Class C: Non-commercial and other known deposits
Oil resources (‘000 barrels)	800	600	400
Natural gas resources (m3)	1 200	1 000	1 500
Coal & peat resources (‘000 tonnes)	600	50	50
Uranium and other nuclear fuels (tonnes)			

5.26 In this framework it is important to clarify those resources for which a monetary valuation is to be established. If this distinction is not made, a subsequent comparison between physical and monetary accounts for individual resources may provide misleading indicators of average prices and relative availability of individual resources.

Physical asset account for mineral and energy resources

5.27 A basic physical asset account for mineral and energy resources is shown in Table 5.3. The following text describes the various categories of additions and reductions to stocks.

Table 5.3 Mineral and energy resource account (physical units*)

	Type of mineral and energy resource (Class A: Commercially recoverable resources) Oil resources (‘000 barrels)	Natural gas resources (m3)	Coal & peat resources (‘000 tonnes)	Uranium and other nuclear fuels (tonnes)
Opening stock of mineral and energy resources	800	1 200	600	
Additions to stock				
Discoveries				
Upwards reappraisals		200		
Reclassifications				
Total additions to stock		200		
Reductions in stock				
Extractions	40	50	60	
Catastrophic losses				
Downwards reappraisals			60	
Reclassifications				
Total reductions in stock	40	50	120	
Closing stock of mineral and energy resources	760	1 350	480	

Additions to and reductions in the stock of energy resources

5.28 The changes in the stock in physical terms should consider the following types of changes.

i. Discoveries. Discoveries should incorporate estimates of the quantity of new deposits found during an accounting period. To be regarded as a discovery the new deposit must be a known deposit – i.e. in Class A, B or C. In situations in which a quantity of potential deposits becomes known to a higher degree of confidence, this increase should be treated as discoveries. Discoveries should be recorded by type of resource and by category of resource.

ii. Reappraisals. Reappraisals may be upwards or downwards. They should only pertain to known deposits. In general, reappraisals will relate to either additions or reductions in the estimated available stock of a specific deposit or to changes in the categorization of specific deposits between Class A, B or C based on changes in geological information, technology, resource price or a combination of these factors.

iii. Extraction. Estimates of extraction should reflect the quantity of the resource physically removed from the deposit. It should exclude mining overburden, i.e. the quantity of soil and other material moved in order to extract the resource. As well the quantity should be estimated before any refinement or processing of the resource is undertaken. Estimates of extraction should include estimates of illegal extraction, either by residents or non-residents, as these amounts reduce the availability of the resource.

It is noted that for the extraction of natural gas the measurement of the quantity extracted may be more difficult due to the nature of the extraction process for some deposits. In cases where natural gas is found with oil, it is the pressure exerted by the natural gas that causes the oil (and some natural gas) to be expelled from the oil well. Some of the natural gas that is expelled may be flared rather than being put to direct use. Some natural gas, especially after extraction has been continuing for some time, may be re-injected to increase the pressure on the remaining oil and so allow more oil to be expelled. In such cases, if the natural gas associated with the oil is being accounted for, an allowance must be made for the decrease in the amount of natural gas available for other uses due to flaring and re-injection.

iv. Catastrophic losses. Catastrophic losses are rare for most energy resources. Flooding and collapsing of mines does occur but the deposits continue to exist and can, in principle, be recovered and the issue in this example is one of economic viability of extraction rather than actual loss of the resource itself. An exception to this general principle concerns oil wells that can be destroyed by fire or become unstable for other reasons leading to significant losses of oil resources. Losses of oil and related resources in this situation should be treated as catastrophic losses.

v. Reclassifications. Reclassifications may occur if certain deposits are opened or closed to mining operations due to a government decision concerning the access rights to a deposit. All other changes in the quantity of known deposits should be treated as reappraisals. Reclassifications may conceivably be recorded if asset accounts for energy resources are being compiled by institutional sector

5.3.3 Depletion measured in physical terms

5.29 In the compilation of asset accounts the measurement of depletion is often a particular focus. In SEEA Central Framework depletion is defined as the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a level greater than that of regeneration. Hence all extraction of mineral and energy resources are considered as depletion. Depletion will not usually fully account for all possible changes in the stock of an asset over an accounting period. Depletion measures for timber resources are part of the asset accounts discussed in SEEA Central Framework. As mentioned earlier, SEEA-Energy does not include asset accounts for natural inputs such as timber which are not primarily used for energy purposes.

5.30 In physical terms, the depletion of mineral and energy resources is equal to the quantity of resource that is extracted, since a given stock of resources at the beginning of a period cannot regenerate itself on human time scales.

5.4 Inventories of energy products

5.4.1 Introduction

5.31 The resource accounts described in the previous sections of this chapter refer only to accumulated quantities of mineral energy resources, i.e. the naturally occurring resources before they are extracted and thus become products. This section describes physical asset accounts for accumulated quantities of energy products. It presents a physical asset account for inventories of energy products which suggests a decomposition of changes in inventories for a range of energy products.

5.4.2 Inventories of energy products

Classification of energy products

5.32 SIEC provides the classification of energy products as used for the general physical supply and use tables for energy products as presented in Chapter 3. The same classification should be used for the asset accounts for inventories of energy products in order to ensure consistency between the physical supply and use tables and the physical asset accounts for inventories.

Physical asset accounts for inventories

5.33 In addition to accumulated quantities of mineral and energy resources, governments and enterprises in a country will often hold accumulated quantities of coal, oil and others sorts of energy products either for reasons of national security, self-sufficiency or for purely commercial reasons.

5.34 Those accumulations of energy products correspond to what are often called ‘stocks’ within energy statistics. Thus, IRES defines stocks as quantities of fuels that can be held and used to: (a) maintain service under conditions where supply and demand are variable in their timing or amount due to normal market fluctuations, or (b) supplement supply in the case of a supply disruption. IRES further defines stock changes as the increase (build up) or decrease (draw down) in the quantity of stock over the reporting period (IRES 2010, 5.16).

5.35 Using terminology consistent with the national accounts, these physical accumulations of energy products are called inventories in SEEA-Energy, while the term stocks is used to designate any point-in-time accumulation within the economy, whether they are mineral and energy resources or energy products.

5.36 The range of energy products included within the SEEA-Energy item ‘inventories’ includes primary energy products which are being accumulated after extraction and before processing takes place (coal, crude oil, and natural gas, etc.) as well as secondary energy products which are the result of a further processing (town gas, fuel oil, gasoline, diesel, etc.).

5.37 Besides having an analytical interest in their own right, the asset accounts for inventories can be instrumental within the physical supply and use tables for energy products since full asset accounts for inventories of energy products can be used to corroborate the data.

5.38 Table 5.4 represents a physical asset account for inventories of energy products. In line with the physical asset accounts for energy resources (Table 5.3) it shows the opening and closing stocks and the changes during the accounting period. However, the change items in the asset account for inventories are different when compared to the asset accounts for mineral and energy resources since the recording of discoveries and extraction is not applicable for the inventories of energy products.

5.39 An asset account for inventories should be set up for each important energy product. The heading of Table 5.4 lists various energy products. As mentioned in the previous section, it is important to use the same classification of the energy products as is used for the general supply and use tables.

5.40 Due to the non-material characteristics of electricity and heat, it is not possible to put these energy products into inventories and thus asset accounts are not applicable for electricity and heat. In practice, inventories for certain other energy products may not exist, or may not be relevant. For instance, it may not be relevant to set up accounts for inventories of waste.

Table 5.4 Physical asset accounts for inventories of energy products

	Coal ('000 tonnes)	Peat and peat products ('000 tonnes)	Oil shale/ oil sand ('000 tonnes)	Natural gas ('000 m3)	Oil ('000 tonnes)	Biofuels*	Waste*	Nuclear and others*
Opening level of inventories	**1899**			**2004**	**5336**			
Changes due to transactions								
Additions	100			55	505			
Withdrawals	-800				-500			
Recurrent losses	-96			-2	-64			
Total changes due to transactions	-796			53	-59			
Other changes								
Catastrophic losses								
Uncompensated seizures								
Changes in classification								
Other changes in inventories n.e.c.	99				-14			
Closing level of inventories	**1202**			**2057**	**5263**			

* Units different for different subcategories

5.41 The heading of Table 5.4 only shows aggregated groups of energy products - in practice it is appropriate to implement the physical asset accounts for inventories at a much more detailed level, for instance, by distinguishing by various types of oil and oil products.

5.42 The units used in the inventories asset accounts can be specific to the various energy products, as in the example in Table 5.4, or it can be converted into a common physical unit, e.g. tonnes or into calorific values, such as joules.

5.43 The various accounting items in the rows of the table are explained below. In most cases, it is only relevant to record the opening and closing stocks, and the total change in inventories.

Opening level of inventories The level of the inventories at the beginning of the accounting period. It is equal to the closing stock of the previous accounting period.

Changes in level of inventories is the sum of ***additions, withdrawals and recurrent losses*** to inventories. ***Additions*** to inventories are recorded when energy products are purchased, produced or otherwise acquired. ***Withdrawals*** from inventories are recorded when products are sold, used as intermediate consumption or otherwise relinquished. In addition, ***recurrent losses*** are included i.e. such losses in inventories that normally take place and should be expected. Even large losses, if they occur regularly, should be taken into account when calculating the change in inventories. *Changes in inventories* are also recorded in the physical supply and use tables in Chapter 3.

Catastrophic losses and uncompensated seizures Catastrophic losses cover the effects of earthquakes, volcanic eruptions, tidal waves, hurricanes, droughts, floods and other natural disasters as well as wars. Blow-outs and conflagration of oil in pipelines also fall under this category. In addition to catastrophic losses, inventories owned by a specific institutional unit can be reduced by uncompensated seizures.

Changes in classifications involve no change in the volume of the inventories but relate mainly to the change of a unit from one institutional sector to another (e.g. the owner of the inventories moves from the household sector to the non-financial corporations sector). This item is only relevant if the asset account is set up for individual institutional units, and not if the accounts are set up for the total economy. Also changes from work-in-progress to finished goods may be recorded here, if such a distinction between inventories of products is made in the accounts.

Other changes in inventories n.e.c. When the assumption underlying the calculation of the rate of current shrinkage of inventories is revised (in relation to changes in inventories above) this should be reflected as *other changes in inventories* (2008 SNA, 12.50).

Closing stocks This is the level of the inventories at the end of the year and is equal to the opening stock of the subsequent year.

Annex A5.1: Tables on conversion factors, calorific values and measurement units (IRES 2011)

Table A5.1: Mass equivalents

INTO / FROM	Kilograms	Metric tons	Long tons	Short tons	Pounds
	MULTIPLY BY				
Kilograms	1.0	0.001	0.0009	0.00	2.2046
Metric tons	1000.	1.0	0.984	1.10	2204.6
Long tons	1016.	1.016	1.0	1.12	2240.0
Short tons	907.2	0.9072	0.893	1.0	2000.0
Pounds	0.454	0.000454	0.0004 46	0.00 05	1.0

Note: The units of the columns can be converted into the units of the rows by dividing by the conversion factors in the table.

Example: Convert from metric tons (ton) into long tons:1 ton= 0.984 long ton.

Table A5.2: Volume equivalents

INTO / FROM	U.S. gallons	Imperial gallons	Barrels	Cubic feet	Litres	Cubic metres
	MULTIPLY BY					
U.S. gallons	1.0	0.8327	0.02381	0.1337	3.785	0.0038
Imp. Gallons	1.201	1.0	0.02859	0.1605	4.546	0.0045
Barrels	42.0	34.97	1.0	5.615	159.0	0.159
Cubic feet	7.48	6.229	0.1781	1.0	28.3	0.0283
Litres	0.2642	0.220	0.0063	0.0353	1.0	0.001
Cubic metres	264.2	220.0	6.289	35.3147	1000.0	1.0

Note: The units of the columns can be converted into the units of the rows by dividing by the conversion factors in the table.

Example: Convert from barrels into cubic meters. 1 barrel = 0.159 cubic meter.

Table A5.3: Conversion equivalents between energy units

Into / From	TJ	Million Btu	GCal	GWh	ktoe	ktce
	MULTIPLY BY					
Terajoule (TJ)	1	947.8	238.84	0.2777	$2.388x10^{-2}$	$3.411x10^{-2}$
Million Btu	$1.0551x10^{-3}$	1	0.252	$2.9307x10^{4}$	$2.52x10^{5}$	$3.6x10^{5}$
GigaCalorie (GCal)	$4.1868x10^{-3}$	3.968	1	$1.163x10^{3}$	10^{4}	$1.429x10^{-4}$
Gigawatt hour (GWh)	3.6	3412	860	1	$8.6x10^{-2}$	$1.229x10^{-1}$
Ktoe	41.868	$3.968x10^{4}$	10^{4}	11.63	1	1.429
Ktce	29.308	$2.778x10^{4}$	$0.7x10^{-4}$	8.14	0.7	1

Note: The units of the columns can be converted into the units of the rows by dividing by the conversion factors in the table.

Example: Convert from Gigawatt-hours (GWh) into Terajoules (TJ):1 GWh = 3.6 TJ.

Table A5.4: Difference between net and gross calorific values for selected fuels

Fuel		Percentage
Coke		0
Charcoal		0 – 4
Anthracite		2 – 3
Bituminous coals		3 – 5
Sub-Bituminous coals		5 – 7
Lignite		9 – 10
Crude oil		5 – 8
Petroleum products		3 – 9
Natural gas		9 – 10
Liquefied natural gas		7 – 10
Gasworks gas		8 – 10
Coke-oven gas		10 – 11
Bagasse (50% moisture content)		21 – 22
Fuelwood	(10% moisture content)	11 – 12
	(20% moisture content)	22 – 23
	(30% moisture content)	34 – 35
	(40% moisture content)	45 – 46

Sources: UN (1987).

Table A5.5: Influence of moisture on solid volume and weight of standard fuelwood

	Percentage moisture content of fuelwood								
	100	80	60	40	20	15	12	10	0
Solid volume in m^3 per ton	0.80	0.89	1.00	1.14	1.33	1.39	1.43	1.45	1.60
Weight in tons per m^3	1.25	1.12	1.00	0.88	0.75	0.72	0.70	0.69	0.63

Source: UN (1987).

Table A5.6: Fuelwood to charcoal conversion table

Influence of parent wood density on charcoal production (Weight (kg) of charcoal produced per cubic metre fuelwood)				
	Coniferous wood	Average tropical Hardwoods	Preferred Tropical hardwoods	Mangrove (rhizophora)
Charcoal	115	170	180	285

Influence of wood moisture content on charcoal production (Quantity of wood required to produce 1 ton of charcoal)							
Moisture content (dry basis)	100	80	60	40	20	15	10
Volume of wood required (cubic metres)	17.6	16.2	13.8	10.5	8.1	6.6	5.8
Weight of wood required (tons)	12.6	11.6	9.9	7.5	5.8	4.7	4.1

Sources: UN (1987).

Table A5.7: Fuelwood requirement for charcoal production by kiln type

(Cubic metres of fuelwood per ton of charcoal)

Kiln Type	Percentage moisture content of fuelwood					
	15	20	40	60	80	100
Earth kiln	10	13	16	21	24	27
Portable steel kiln	6	7	9	13	15	16
Brick kiln	6	6	7	10	11	12
Retort	4.5	4.5	5	7	8	9

Source: FAO (2004) *Unified Bioenergy Terminology*.

Table A5.8: Energy values of selected animal and vegetal wastes

Wastes	Average moisture content: dry basis (percentage)	Approximate ash content (percentage)	Net calorific value (MJ/kg)
Animal dung	15	23-27	13.6
Groundnut shells	3-10	4-14	16.7
Coffee husks	13	8-10	15.5-16.3
Bagasse	40-50	10-12	8.4-10.5
Cotton husks	5-10	3	16.7
Coconut husks	5-10	6	16.7
Rice hulls	9-11	15-20	13.8-15.1
Olives (pressed)	15-18	3	16.75
Oil-palm fibres	55	10	7.5-8.4
Oil-palm husks	55	5	7.5-8.4
Bagasse	30	10-12	12.6
Bagasse	50	10-12	8.4
Bark	15	1	11.3
Coffee husk,	30	8-10	13.4
Coffee husk,	60	8-10	6.7
Corncobs	15	1-2	19.3
Nut hulls	15	1-5	18.0
Rice straw &	15	15-20	13.4
Wheat straw &	15	8-9	19.1
Municipal	..	..	19.7
Paper	5	1	17.6
Sawdust	50	1	11.7

Sources: UN (1987).

Note: Two dots (..) indicate that data are not available.

Chapter 6: Monetary asset accounts for energy

6.1 Introduction

6.1 Monetary asset accounts for mineral and energy resources provide a market based valuation of physical stocks of mineral and energy resources and the changes in the value of these stocks over time. These estimates can be related to both physical asset accounts for energy as presented in chapter 5 and the asset accounts and national balance sheet of the 2008 SNA. The scope of SNA asset accounts and balance sheets includes all economic assets.

6.2 Mineral and energy resources are a critically important input to almost all types of economic activity, and the value of these resources may be relevant to the measurement of a country's total wealth i.e. where wealth includes not only human-made capital such as buildings, machinery and transport equipment but also the natural resources of the country. When all types of assets are measured in a common currency unit it is possible to assess the extent to which decreasing mineral and energy resources are counterbalanced by increases in other types of capital.

6.3 When a monetary value is assigned to the mineral and energy resources of a country it becomes possible to assess what kind of return is being achieved on these assets, and how this return compares to those achieved for other types of assets being used within the economy. These values may also serve to inform on a number of flows related to the use of mineral and energy resources for example rent payments for the use of mineral and energy resources and payments related to mineral and energy resources use for protecting and/or repairing the environment.

6.4 The production of monetary asset accounts for mineral and energy resources allows the development of estimates of the value of the depletion of these resources. These estimates are vitally important because they allow the calculation of depletion-adjusted economic aggregates such as depletion-adjusted value added for the extractive industries and depletion-adjusted gross domestic product (GDP). These measures provide a superior indication of the sustainability of the use of mineral and energy resources because they treat the depletion of mineral and energy resources as a cost to the extractive industries and to the economy. In contrast, the 2008 SNA treats the using up (or consumption) of fixed capital as a cost to industries but does not extend this treatment to non-produced (natural) assets such as mineral and energy resources.

6.5 Section 6.2 of this chapter describes those mineral and energy resources considered to be in scope of the SEEA-Energy monetary asset accounts. Section 6.3 describes the conceptual form of the monetary asset account for mineral and energy resources. Section 6.4 discusses monetary valuation of mineral and energy resources, while section 6.5provides a worked example of the derivation of asset values and depletion using the NPV approach.

6.6 In addition to energy resources, monetary asset accounts record inventories of energy products, and these are described in section 6.6. The measurement of energy resources in volume terms is explained in section 6.7. Section 6.8 describes the possible inclusion of monetary asset accounts for other relevant assets owned by extractive industries, for example, extractive equipment, gas pipelines and transport equipment. Section 6.9 discusses monetary asset accounts for assets related to the generation of energy from renewable sources.

6.2 Scope of mineral and energy resources inputs in monetary asset accounts

6.7 All known deposits of mineral and energy resources could potentially be included in the monetary asset accounts. If market values for stocks of mineral and energy resources can be observed and quantified, these observed values should be used for the accounts. However, in practice, many deposits of mineral and energy resources are seldom if ever exchanged on a market and therefore, even if the resources have a market value, these cannot be observed. Thus, under these circumstances a market valuation of the mineral and energy resources must be based on assumptions of what the market prices would have been, if the resources were traded in a market.

6.8 An estimate of these market values can be based on the assumption that a market value reflects the expected future income an investor would derive from owning and using the resource. This expected future income is determined by considering the quantities (number of physical units) of the resources that will be extracted in the future, and also the economic surplus each physical unit brings to the owner and extractor.

6.9 It follows, that we can only expect that quantities of mineral and energy resources have an associated positive market value if there is an expectation that the resources will be extracted and sold with a profit at some point in the future. Where there is no expectation that a resource will be extracted and sold the market value of this resource is assumed to be zero.

6.10 As explained in Chapter 5, mineral and energy resources are divided into three groups:

Class A Commercially Recoverable Resources includes resources for which extraction is currently taking place or is underway or for which the feasibility of extraction has been demonstrated. Further, the extraction of the resources in this class is expected to be economically viable on the basis of current market conditions and on realistic assumptions for future market conditions.

The second *Class B Potential Commercial* resources may also be extracted in future, but since the feasibility of extraction is subject to further evaluation and since extraction and sale has not yet been confirmed to be economic, the uncertainty related to whether future extraction will take place is quite high.

The uncertainty related to future extraction of energy resources included in *Class C Non Commercial and Other Quantities in Place* is even higher than for energy resources included in *Class B*.

6.11 As in the SEEA Central Framework and the SNA, it is recommended that for the purposes of SEEA-Energy only the valuations of deposits in Class A: Commercially Recoverable Resources are included in the monetary asset accounts. Class B Potential Commercial resources and Class C Non Commercial and Other Quantities in Place are not included in the monetary asset accounts of SEEA-Energy due to the degree of uncertainty regarding expected extraction profiles and incomes.

6.12 Countries might find it policy relevant to valuate Class B and Class C deposits of mineral and energy resources to for example understand future potential flows of income to the government. In such a case, a clear distinction should be made between the valuations of deposits in each class.

6.3 Conceptual form of the monetary asset account and links to SNA

6.3.1 Conceptual form of the monetary asset account

6.13 The structure of the monetary asset account for mineral and energy resources is shown in Table 6.1. All entries should be made in the same currency unit, and prices may be expressed in either current prices or constant prices. The use of current prices is relevant in current period analysis while the use of constant price is useful in time series analysis. A monetary asset account as illustrated in Table 6.1 may be set up for any individual mineral and energy resource of interest (e.g. for crude oil, natural gas, coal, etc.). If asset accounts have been set up for individual resource, these may be added into an over-arching monetary asset account showing details for the combined total of all resources.

Table 6.1 Conceptual form of the monetary asset account for energy resources

	Type of mineral and energy resource (Class A: Commercially recoverable resources)
	(000's currency units
Opening value of stock of resources	
Additions to value of stock	
Discoveries	
Upwards reappraisals	
Reclassifications	
Total additions to stock	
Reductions in value of stock	
Extractions	
Catastrophic losses	
Downwards reappraisals	
Reclassifications	
Total reductions in stock	
Revaluations	
Closing value of stock of resources	

6.14 The definitions of the flows presented in the monetary accounts align exactly with the corresponding physical flows. Thus, the monetary account reflects a valuation of physical flows as recorded in the physical asset account. The only additional flow recorded in the monetary asset account compared to the physical asset account concerns revaluations, which is related to the effect of price changes on the value of the existing stock and reflect the nominal holding gains and losses.

6.15 Price changes will affect the value of the existing stock of mineral and energy resources. But price changes also have the ability to affect the proportion of the physical resource considered to have an economic value. The latter are quantity/volume effects arising from changes in price - these are not accounted for as holding gains and losses but instead as reappraisals under increases in stocks (if prices goes up) or decreases in stock (if prices go down).

6.3.2 The link to the 2008 SNA

6.16 The scope of SEEA-Energy monetary asset accounts and the 2008 SNA asset accounts for mineral and energy resources are in principle the same. However, SEEA-Energy carefully defines the scope of mineral and energy resources to be included in the monetary asset accounts by making reference to the UNFC-2009. The 2008 SNA, without reference to any specific classification system, simply states:

> Mineral and energy resources consist of mineral and energy reserves located on or below the earth's surface that are economically exploitable, given current technology and relative prices. (2008 SNA, 10.179).
>
> In the 2008 SNA, subsoil assets are defined as those proven subsoil resources of coal, oil and natural gas, of metallic minerals or of non-metallic minerals that are economically exploitable, given current technology and relative prices. (2008 SNA, 12.17)

6.17 Thus, the 2008 SNA makes reference both to *economically exploitable reserves* in general and to *proven resources*. Although these terms are not well-defined, the condition that the resources should be economically exploitable given current technology and relative prices, indicates that the scope of the 2008 SNA asset accounts for mineral and energy resources is the same as for SEEA-Energy, namely Class A *Commercially Recoverable Resources*, and that energy resources belonging to Class B and Class C fall outside the asset boundary of the 2008 SNA.

6.18 The 2008 SNA general reference to reserves can be assumed to relate to a broader estimate of the quantities of energy resources that can be extracted (G1+G2+G3, in Chapter 5), while the specific reference to proven resources (reserves) relates to the narrow estimate (G1 only). In contrast, SEEA-Energy recommends that the best estimate (G1+G2) of the commercial recoverable resources is used.

6.19 Table 6.2 summarises the scope of the asset accounts for mineral and energy resources.

6.20 For a discussion of the relationship between SEEA asset account entries and 2008 SNA asset account entries see SEEA Central Framework Section 5.3.3

Table 6.2 Scope of mineral and energy resources within SEEA-Energy and SNA asset accounts

SEEA-Energy classification		**SEEA-Energy asset accounts**		**2008 SNA asset accounts**
		Physical asset accounts	**Monetary asset accounts**	
A	Commercial Energy Resources	Quantities	Market value assigned to the moderate (best) estimate (G1+G2)	Market value assigned, but some ambiguity about which estimate to use
B	Potential Commercial Energy Resources	Quantities	Market value assumed to be zero	Outside asset boundary
C	Non Commercial and Other Known Deposits	Quantities	Market value assumed to be zero	Outside asset boundary
	Potential resources	Outside asset boundary		

6.4 Valuation of stocks of mineral and energy resources

6.21 One general advantage of applying valuation to mineral and energy resources is that different resources can be compared using a common numéraire. Further, mineral and energy resources can be compared with other assets in order to assess relative returns, national wealth, potential future revenues to the government and other similar types of analyses. Since it is commonly the case that governments have a high degree of ownership or influence over the extraction of mineral and energy resources, valuation of resources in monetary terms may be a useful approach to assessing future streams of income for government, for example in the estimation of future government revenue from the extraction of oil and natural gas.

6.22 It is also the case that in business accounts, enterprises involved in extraction make assessments in terms of their future income streams and it is useful to be able to place these individual enterprise based valuations into a broader, national perspective. There is also increasing use of market based mechanisms, such as quotas, to allocate access rights to environmental assets. These mechanisms may relate directly to aggregate valuations for mineral and energy resources.

6.23 Since many mineral and energy resources are not purchased in a market place and have not been produced in a manner like buildings and equipment, there are generally no observable prices for the value of the opening and closing stock of these assets, or for the flows between opening and closing stock positions.

6.24 Where market prices do not exist, the estimation of approximate values requires the use of assumptions and models. Overall, these models have proved to be sound tools to the development of meaningful valuations for produced assets. Nevertheless, there are complexities in the application of these models to the valuation of mineral and energy resources that compilers and users should be aware of before applying the models in practice.

6.25 In SEEA-Energy as well as in SEEA Central Framework, the Net Present Value (NPV) approach is recommended for estimating asset values. The NPV approach provides reasonable proxies for observable market prices but does not take into account the full range of benefits (and costs) that might be considered relevant. Using the NPV approach generally requires the following: measurement of the returns on the environmental asset (resource rent); estimate of the extraction profile and future resource rents; and selection of rate of return and discount rate to be used in the estimate of the asset value. For more details on the general NPV approach including potential uses and limitations see SEEA Central Framework Chapter 5. In the section below an empirical example of the NPV approach is shown.

6.5 An empirical example of the NPV approach

6.5.1 Introduction

6.26 This section provides practical guidance on the operation of the NPV approach. The value of an mineral and energy resource can be estimated using the NPV approach by working through the steps described below. Much of the data required for the valuation of stocks using the NPV approach can be found in the monetary flow accounts which are described in Chapter 4.

6.5.2 Variable estimates

6.27 In SEEA-Energy resource rent provides a gross measure of the return on environmental assets. There are a number of methods to estimate resource rent the most common of which is the residual value method. Under this method resource rent is estimated by deducting user costs of produced assets from gross operating surplus after adjustments for any specific taxes and subsidies. As shown in table 6.3, the first step in estimating resource rent requires estimates of gross operating surplus (GOS), specific subsidies and taxes on extraction and the user cost of produced assets for the extractive activity. Such estimates are generally based on data from the national accounts.

6.28 As defined in Table 6.3, GOS is equal to output less operating costs. Operating costs include intermediate consumption, compensation of employees, and other taxes and subsidies on production. User cost of produced assets is the sum of consumption of fixed capital and return to produced assets.

6.29 *Output* is the value of the extracted mineral and energy resources above ground at the wellhead or mine. The output is measured at basic prices, i.e. excluding all taxes and subsidies on products and trade and transport margins related to transport and delivery from the wellhead or mine to the buyer.

6.30 Intermediate consumption is the value of products used by the extraction industry. The intermediate consumption is valued at purchasers' prices i.e. including trade margins and all taxes and subsidies on products. It excludes fixed assets whose consumption is recorded as consumption of fixed capital.

Table 6.3 Relationship between operating surplus and resource rent

Output (sales of extracted environmental assets at basic prices, includes all subsidies on products, excludes taxes on products)	
Less Operating costs	
	Intermediate consumption (input costs of goods and services at purchasers' prices, including
	Compensation of employees (input costs for labour)
	Other taxes on production plus Other subsidies on production
Equals **Gross Operating Surplus – SNA basis***	
Less Specific subsidies on extraction	
Plus Specific taxes on extraction	
Equals **Gross Operating Surplus – for the derivation of resource rent**	
Less **User costs of produced assets**	
	Consumption of fixed capital (depreciation) + Return to produced assets
Equals **Resource rent**	
	Depletion + Net return to environmental assets**

*Strictly this accounting identity also includes Gross Mixed Income (the surplus earned by unincorporated enterprises) and should be adjusted for net taxes and subsidies on production. These details do not affect the logic of the explanation here.
** In principle the return to energy resources derived here also incorporates a return to other non-produced assets (e.g. marketing assets and brands) as these assets also play a role in generating the operating surplus. These returns are ignored in the formulation described here.

6.31 Compensation of employees is the total remuneration payable by an enterprise to employees. For self-employed persons in the extraction industry, an estimate of the value of their labour services should be added to the compensation of employees.

6.32 Other taxes on production consist mainly of taxes on the ownership or use of land, buildings or other assets used in production or on the labour employed, or compensation of employees paid.

6.33 Other subsidies on production consist of subsidies on goods or services produced as the outputs of resident enterprises, or on imports, that become payable as a result of the production, sale, transfer, leasing or delivery of those goods or services, or as a result of their use for own-consumption or own capital formation.

6.34 Specific taxes and subsidies on extraction are instruments which the government uses to partly appropriate or subsidise, respectively, the operations of the extractive industry. Since intermediate consumption at purchasers' prices includes all taxes and subsidies on products, the resource rent is being affected by the specific taxes and subsidies on extraction when intermediate consumption is subtracted from the output. Therefore, it is necessary to add them back to the resource rent in order not to let them influence the estimation of the resource rent.

6.35 Consumption of fixed capital is the decline in the current value of the stock of fixed capital used in production, including mineral exploration and evaluation activities. Consumption of fixed capital related to any terminal costs should be included.

6.36 Return to the produced assets is that part of the operating surplus, which can be attributed to the use of the produced assets in the process of extracting the energy.

6.5.3 Resource rent estimate

6.37 The *resource rent* is that part of an extractor's operating surplus that represents a return on the mineral and energy resource. In practice, the resource rent is calculated by subtracting all extraction costs from the total output of products, i.e. the extracted mineral and energy resources. The extraction costs should include intermediate consumption, compensation of employees and the costs of using fixed capital such as platforms, buildings and other extractive equipment.

6.38 The value of output (or operating surplus) and most cost information for the extraction industry can be obtained from the national accounts. Care must be taken to ensure that the national accounts data for the extraction industry does not include secondary activities, which have no direct reference to extraction activities itself.

6.39 Table 6.4 presents an actual calculation of resource rent and per unit resource rent.

Table 6.4 Resource rent calculation

	Extraction of energy resources currency units
Output	**60 744**
Operating costs	**7 289**
Intermediate consumption	6 487
Compensation of employees	802
Other taxes and subsidies on production	17
Gross Operating Surplus	**53 455**
Specific taxes and subsidies	- 100
Consumption of fixed capital	5 084
Return to produced assets	5 519
Resource rent	**42 952**
Quantities of resource extacted, million m^3	20
Per unit resource rent (currency units per million m^3)	**2 148**

6.40 *Quantity of resources extracted* is the amount of resources extracted in the current year in focus. The total resource rent for the same year is divided by this quantity in order to get the per unit resource rent, i.e. the price of the commercial mineral and energy resources in ground.

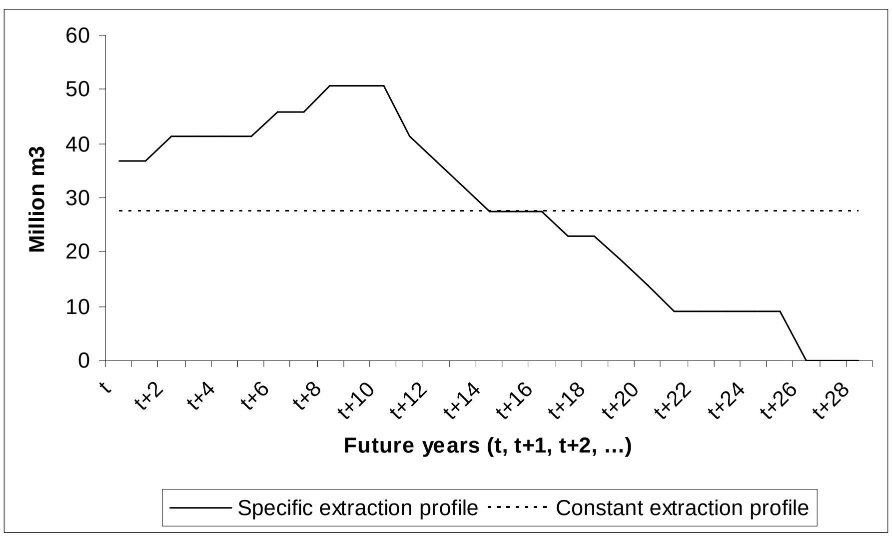
6.5.4 Future extraction profile

6.41 Future extraction profile is an estimate of future reductions in stock due to the physical removal of a given mineral and energy resource through a process of production. If extraction profiles are available from experts, energy agencies, geological institutes, etc. these profiles should be used. Care should be taken to ensure that the extraction profile is consistent with the best estimate of the commercially recoverable resources. Thus, the sum of future year's extraction should be no greater to the estimate of the quantity of Class A as described in the physical asset account in chapter 5.

6.42 If no information on the expected resource extraction profile is available, a profile may be constructed by assuming that the extraction will continue at the current level until the resource is exhausted or extraction stops whichever occurs first. Alternatively, the extraction may be assumed to be constant until a certain point and linearly decreasing after that point and until all Class A mineral and energy resources are extracted. It is important that extraction profiles are reassessed on a yearly basis to ensure that the most up to date information is used including any information on new discoveries.

6.43 Figure 6.1 illustrates two examples of such extraction profiles. In both cases the area under the curves i.e. the total amount of the mineral and energy resources extracted, should correspond to the physical opening stock of Class A as presented in Table 5.3.

Figure 6.1 Future extraction profiles for an energy resource



6.5.5 Estimated future resource rent

6.44 In order to calculate the future income associated with future physical extraction, the expected future per unit resource rent must be determined. Making a forecast of the future resource rent requires assumptions about the development of prices, extraction costs and the level of extraction. For accounting purposes it is advisable to use relatively simple and transparent assumptions.

6.45 The simplest assumption is that the per unit resource rent will be the same in constant price terms in all future years. The starting point is the unit resource rent for the most recent year available, calculated according to the principles described above.

6.46 Similarly to the extraction profile, assumptions need to be made on the evolution of the per unit resource rent. One approach is to assume that the per unit resource rent rr_t evolves in line with an expected general rate of inflation.

$$rr_{t+i} = rr_t \ * (1+\rho_{t+i})^i$$

where ρ_{t+i} is the expected general inflation rate in year $t+i$

6.47 In this example the per unit resource rent rr_t is 2148 while the expected general inflation rate ρ_{t+i} is 3% for all t+i.

6.5.6 NPV asset values

6.48 Once the yearly unit resource rents have been calculated, they must be discounted back to the reference year because a given amount of income received next year is considered to be worth less than the same amount received this year, and the difference in value is reflected by the discount rate. A discount rate at, for example, 6 per cent means that $106 next year corresponds to $100 this year.

6.49 Having discounted future resource rents, they sum up to a total net present value of future extraction, which then is assumed to correspond to the value of the total quantity of economic energy resources in situ.

6.50 Assuming that the income from the extraction falls in the beginning of the year, the value of the opening stock in year t can be calculated as:

$$V_t = \sum_{\tau=1}^{N_t} \frac{RR_{t+\tau}}{(1+r_t)^{\tau}} = (rr_t e_t) + \frac{(rr_{t+1}e_{t+1})}{(1+r)^1} + \frac{(rr_{t+2}e_{t+2})}{(1+r)^2} + \ldots + \frac{(rr_{t+n}e_{t+n})}{(1+r)^n}$$

6.51 If, more realistically, we assume that the income in a given year is spread over the year and we assume that on average all the income falls in the middle of the year, each of the yearly incomes have to be discounted half a year in addition to the discounting already done. The formula for calculating the opening stock in year t is then:

$$V_t = \frac{1}{(1+r)^{0.5}} * \left(\frac{(rr_t e_t)}{(1+r)^0} + \frac{(rr_{t+1}e_{t+1})}{(1+r)^1} + \frac{(rr_{t+2}e_{t+2})}{(1+r)^2} + \ldots + \frac{(rr_{t+n}e_{t+n})}{(1+r)^n} \right)$$

6.52 This can also be written

$$V_t^{opening} = \frac{1}{(1+r)^{0.5}} \sum_{i=t}^{t+n} rr_i e_i \frac{1}{(1+r)^{i-t}}$$

Where

V_t is the value of the resource at the beginning of period t.

RR_t is the resource rent at period i as expected at the beginning of period t.

rr_t is the unit resource rent at period i as expected at the beginning of period t.

e_i is the physical extraction of the resource taking place during period i as expected at the beginning of period t.

r is the discount rate.

n is the number of periods in which extraction take place.

6.53 Table 6.5 presents calculations of the value of the asset of the mineral and energy resources as the sum of present values of future resource rents. The table includes two alternative calculations, one using a specific extraction profile, and one using a constant extraction profile (as described in Figure 6.1). In both cases, the per unit resource rent from Table 6.4 and a discount rate at 6 per cent per year is used. It is assumed that on average the resource rent falls in the middle of the year, and all resource rent is discounted back to the beginning of year t (following the formula given above).

6.54 In the fictitious case presented in Table 6.5 a somewhat lower opening stock value is estimated when the constant extraction profile is used compared to when the specific extraction profile is used. In the latter case relatively larger quantities of resources are extracted in the first years, and since the corresponding resource rents are discounted less than resource rents which fall in later years a higher total present value of resource rents is obtained. The example demonstrates the importance of carefully determining the extraction profile used for the estimation, since realistic extraction profiles increase the accuracy and reliability of the estimates of resource values.

Table 6.5 Calculation of the asset value

	Specific extraction profile					Constant extraction profile				
	1. Specific extraction profile	2. Per unit resource rent	3.Un-discounted resource rent (=1*2)	4. Discount factor (6 per cent per year)	5. Present value of ressource rent (=3*4)	1. Specific extraction profile	2. Per unit resource rent	3.Un-discounted resource rent (=1*2)	4. Discount factor (4 per cent per year)	5. Present value of ressource rent (=3*4)
Year	Million m3	Currency units/ Million m3	Currency units		Currency units	Million m3	Currency units/ Million m3	Currency units		Currency units
t	37	2 148	79 007	0.97	76 738	28	2 148	59 255	0.97	57 554
t+1	37	2 212	81 377	0.92	74 566	28	2 212	61 033	0.92	55 925
t+2	41	2 279	94 296	0.86	81 513	28	2 279	62 864	0.86	54 342
t+3	41	2 347	97 125	0.82	79 206	28	2 347	64 750	0.82	52 804
t+4	41	2 418	100 038	0.77	76 964	28	2 418	66 692	0.77	51 310
t+5	41	2 490	103 039	0.73	74 786	28	2 490	68 693	0.73	49 857
t+6	46	2 565	117 923	0.68	80 744	28	2 565	70 754	0.68	48 446
t+7	46	2 642	121 461	0.65	78 459	28	2 642	72 876	0.65	47 075
t+8	51	2 721	137 615	0.61	83 862	28	2 721	75 063	0.61	45 743
t+9	51	2 803	141 743	0.57	81 489	28	2 803	77 315	0.57	44 448
t+10	51	2 887	145 996	0.54	79 182	28	2 887	79 634	0.54	43 190
t+11	41	2 973	123 035	0.51	62 952	28	2 973	82 023	0.51	41 968
t+12	37	3 063	112 645	0.48	54 374	28	3 063	84 484	0.48	40 780
t+13	32	3 154	101 521	0.46	46 230	28	3 154	87 018	0.46	39 626
t+14	28	3 249	89 629	0.43	38 505	28	3 249	89 629	0.43	38 505
t+15	28	3 347	92 318	0.41	37 415	28	3 347	92 318	0.41	37 415
t+16	28	3 447	95 087	0.38	36 356	28	3 447	95 087	0.38	36 356
t+17	23	3 550	81 616	0.36	29 439	28	3 550	97 940	0.36	35 327
t+18	23	3 657	84 065	0.34	28 606	28	3 657	100 878	0.34	34 327
t+19	18	3 767	69 270	0.32	22 237	28	3 767	103 904	0.32	33 356
t+20	14	3 880	53 511	0.30	16 206	28	3 880	107 021	0.30	32 412
t+21	9	3 996	36 744	0.29	10 498	28	3 996	110 232	0.29	31 494
t+22	9	4 116	37 846	0.27	10 201	28	4 116	113 539	0.27	30 603
t+23	9	4 239	38 982	0.25	9 912	28	4 239	116 945	0.25	29 737
t+24	9	4 366	40 151	0.24	9 632	28	4 366	120 454	0.24	28 895
t+25	9	4 497	41 356	0.23	9 359	28	4 497	124 067	0.23	28 077
t+26						28	4 632	127 789	0.21	27 283
t+27						28	4 771	131 623	0.20	26 511
t+28						28	4 914	135 572	0.19	25 760
Total quantity extracted	800					800				
Total undiscounted value			2317 395					2679 451		
Total discounted value of economic energy ressource (opening stock year t)					**1289 432**					**1149 127**

6.6 Monetary asset accounts for inventories of energy products

6.55 Monetary asset accounts related to inventories of energy products closely follow the form of the physical accounts for inventories of energy products as described in chapter 5. All items included in SEEA-Energy monetary asset accounts for inventories are included in the 2008 SNA.

6.56 Monetary asset accounts for inventories for energy products show for each type of energy product the values of opening and closing stocks and various categories of change between these opening and closing stock positions. Table 6.6 is an example of such a monetary asset account for inventories of energy products.

Table 6.6 Monetary asset account for inventories of energy products

	Coal	Peat and peat products	Oil shale/ oil sand	Natural gas	Oil	Biofuels	Waste	Nuclear and others
Opening level of inventories	**760**			**5319**	**15189**			
Changes due to transactions								
Changes in level of inventories	-254			138	2279			
Other changes								
Catastrophic losses								
Uncompensated seizures								
Changes in classification								
Other changes in inventories n.e.c.	22			207	-430			
Revaluation	17				516			
Closing level of inventories	**545**			**5664**	**17554**			

6.57 The various accounting items are explained below. Nevertheless, in most cases, it is sufficient to record only the opening and closing level of inventories and the changes in inventories.

Opening level of inventories: The value of the inventories at the beginning of the year. It is equal to the value of the closing stock of the previous year.

Changes due to transactions

Changes in level inventories**:** Measures the value of the entries of energy products into inventories (***additions)*** less the value of ***withdrawals*** and less the value of any ***recurrent losses*** of energy products held in inventories during the accounting period. (2008 SNA, 10.118). Recurrent losses include losses that normally take place and should be expected. *Changes in inventories* are also recorded in the monetary supply and use tables of SEEA-Energy.

Other changes in the volume

Catastrophic losses and uncompensated seizures: This item records the effects on the value of inventories from earthquakes, volcanic eruptions, tidal waves, hurricanes, droughts, floods and other natural disasters as well as wars. Conflagration of oil in pipelines falls under this category. Uncompensated seizures rarely occur but would be recorded here.

Changes in classifications involve no change in the value of the total inventories as such but instead relate mainly to the change of a unit from one institutional sector to another (e.g. the owner of the inventories moves from the household sector to the non-financial corporations sector). It is only relevant if the asset account is set up for institutional units, and not if the accounts are set up only for the total economy. Also changes from work-in-progress to finished energy products would be recorded here if such a distinction between inventories of products is made in the accounts.

Other changes in inventories n.e.c. If the assumption about the value of normal shrinkage/recurrent losses of inventories is revised (see changes in inventories above) this should be done as other changes in inventories (2008 SNA, 12.50).

Revaluation is an item specific to the monetary asset accounts and no equivalent is found in the physical assets accounts for inventories. It reflects the effect of price changes on the value of the inventories during the period.

Closing level of inventories The value of the inventories at the end of the year. It should be equal to the value of the opening stock of the subsequent year.

6.7 Measurement of energy from natural inputs in volume terms

6.58 Volume measures of assets are not measures of quantities but rather are estimates of changes in the value of assets after removing the effects of price change. Thus, volume measures comprise changes due to changes in quantities and changes in quality.

6.59 Volume measures of mineral and energy resources may be compiled to assist in the analysis of the changes in mineral and energy resources over time. Removing the effect of price change may be undertaken for two main purposes. First, the effect of price change may be removed to provide an indicator of the purchasing power of mineral and energy resources, i.e. an estimate of the capacity of a set of resources to be used to acquire a given set of goods and services. Second, the effect of price change may be removed to assess whether there has been a change in the underlying aggregate physical stock of a number of mineral energy resources. Both of these rationales may be important considerations when undertaking an aggregate analysis of the wealth of a country and considering the relative importance of mineral and energy resources compared to other economic and social assets. Approaches to calculating volume measures are presented in SEEA Central Framework Section 5.4.6.

6.8 Monetary accounts for other assets used by extractive industries

6.8.1 Other assets potentially used by extractive industries

6.60 In addition to the asset accounts for mineral and energy resources it may be useful to record asset accounts for other assets owned and used by the extraction industry for exploration, evaluation and exploitation of mineral and energy resources. Equipment used for transportation of the energy products e.g. pipelines transporting the oil from the wellhead to the point of processing or sale at land should also be included if it is owned by the extraction industry.

6.61 Information on the assets used for the extraction and handling of the energy can be analytically useful in its own right but the information is required for the calculation of both the consumption of fixed capital and the return to fixed capital, which are part of the total extraction costs, and thus needed for the calculation of resource rent.

6.62 Asset accounts for these types of assets are included in the accounts of the 2008 SNA, though the required detail may not be explicitly identified in standard national accounts outputs. In principle all types of non-financial assets (except the mineral and energy resources) listed by the 2008 SNA could be used by the mining and quarrying industry, but in practice fixed assets like AN113 Machinery and equipment and AN1172 Mineral exploration and evaluation activities are often the most important. Table 6.7 lists some of the more important assets that can potentially be used by the extractive industries.

6.63 Table 6.8 shows a sample asset account for other assets used by the extraction industries presented in short form. Gross fixed capital is the acquision less disposal of produced assets for purposes of fixed capital formation. Consumption of fixed capital is the decline in the current vale of the stock of fixed assts owned and used by a producer as a result of normal production activities. Non-produced assets are assets that have come into existence in ways other than through processes of production. Other changes in the volume of assets is an aggregate. It includes the various items belonging to the 2008 SNA Other Changes in the volume of assets account, for instance, economic appearance and disappearance of assets and catastrophic losses (see 2008 SNA, Annex 2).

Table 6.8 2008 SNA asset account for other assets[1)] owned by the mining and quarrying industry

	Total	AN11 Fixed assets	*Of which:* *AN1172 Mineral exploration and evaluation*	*Terminal costs (part of AN116)*	AN2 Non-produced non-financial assets [1)]	*Of which:* *AN22 Contracts, leases and licenses*
	Currency unit					
Opening stock	**68 987**	**54 967**	***43 900***		**14 020**	***14 020***
Total changes in assets	**11 514**	11 514	*4 008*			
Of which						
Gross fixed capital formation (P51g)	**5 399**	5 399	*3 027*			
Consumption of fixed capital (P51c)	**-1 117**	-1 117	*- 875*			
Acquisitions less disposals of non-produced assets (NP)	**300**	300	*413*			
Other changes in the volume of assets						
Revaluation						
Closing stock	**85 083**	**71 063**	***50 473***		**14 020**	***14 020***

1) Excludes commercial energy resources

6.8.2 Mineral exploration and evaluation

6.64 Mineral exploration and evaluation consists of the value of expenditures on exploration for mineral and energy resources and subsequent evaluation of the discoveries made. Exploration and evaluation activities include (2008 SNA, 10.106) activities such as:

- Pre-licence costs
- Licence and acquisition costs
- Appraisal costs and the costs of actual test drilling and boring
- Costs of aerial and other surveys
- Transportation costs, etc., incurred to make it possible to carry out the tests

6.65 Exploration and evaluation activities may be undertaken on own account by enterprises engaged in the extraction of mineral and energy resources. Alternatively, specialized enterprises may carry out exploration and evaluation and sell the information to the extracting enterprises. The information obtained from exploration influences the production activities of those who obtain it over a number of years. The expenditures incurred on exploration within a given accounting period, whether undertaken on own account or not, are therefore treated as expenditures on the acquisition of an intellectual property product and included in the enterprise's gross fixed capital formation (2008 SNA, 10.107). The values are included in the asset accounts as a specific item, AN1172.

6.66 The value of the exploration and evaluation as an asset is not measured by the value of new deposits discovered by the exploration but by the value of the resources allocated to exploration during the accounting period. When the activities are carried out by contractors the prices charged by these contractors, including their operating surplus, forms part of the value of the expenditures incurred (2008 SNA, 10.108).

6.9 Monetary asset accounts for assets related to the generation of energy from renewable sources

6.67 Energy from renewable sources has been an important source of energy in many countries and increasingly is being seen as an alternative source of energy for those countries that have primarily used energy from non-renewable sources. Energy from renewable sources can be produced in various ways, including but not limited to wind energy, hydropower energy (including run of river resources), solar energy, biomass including wood, and geothermal energy.

6.68 Inputs of energy from renewable sources cannot be exhausted in a manner akin to mineral and energy resources and they do not regenerate in a manner akin to timber resources or cultivated biomass. Thus in an accounting sense there is no physical stock of these renewable energy sources (solar, hydro, wind, wave and tidal, and geothermal) that can be used up or sold.

6.69 Therefore, the measurement scope of SEEA-Energy in relation to these resources relates to the amount of energy that is produced given current levels of fixed assets and associated technology. Excluded from scope are potential amounts of energy that could be produced using available renewable energy sources if investment and technology were to increase in the future.

6.70 The presence of investments in renewable energy capture facilities and equipment impacts on the value of the land associated with those facilities. For example, other things being equal, the land in a particularly windy area would be priced more highly than similar land in a non-windy area if investment was made to construct windmills to capture the energy from the wind resource. Thus, opportunities to earn resource rent based on resources like wind, solar radiation and geothermal energy are expected to be reflected in the price of associated land.

6.71 In situations where the only income generated from the relevant land is from the generation of energy from renewable sources, the value of the land will, in theory, be equal to the net present value of the future income stream. However, it is also possible that other income is earned from the same area – for example agriculture may take place under wind farms. In these cases the valuation of the land must also take into account the income generated from these other activities. Nonetheless, where possible, the value of the land should be partitioned to provide an estimate of the value of the land that is attributable to income arising from the generation of energy from renewable sources.

6.72 Special mention must be made concerning the valuation of future income streams from hydropower. In this case it is more relevant to consider the income stream in relation to a stock of water rather than to an area of land. Thus, in the case of hydropower, it is the value of the water resource that should be partitioned to provide an estimate of the value of the water resource that is attributable to income arising from the generation of renewable energy from hydropower.

6.73 It is recognised that some investments in the capture of energy from renewable sources take place offshore (e.g. wind farms in the sea). By convention, the value of income streams from these sources is attributed to the value of land where the extraction equipment is located.

6.74 Generally, since the renewable sources themselves are not sold on markets, it is necessary to use NPV approaches for valuation purposes. In undertaking such valuations all costs should be deducted including the costs of fixed assets used in the capture of energy.

6.75 These accounting treatments do not apply in the case of energy sourced from timber and other biomass resources. Unlike the renewable sources of energy listed above, a stock of timber resources can be observed and measured. In concept the volume and value of timber resources encompasses all possible uses of the timber including its use as an energy source.

6.76 The various asset values related to the generation of energy may be combined to provide an overall value of environmental assets associated with energy production. Such an aggregate may include values of energy resources (e.g. coal, oil, natural gas), the value of land attributable to renewable sources of energy (e.g. wind, solar, geothermal), the value of timber resources used for energy, and the value of water resources used for hydropower.

Further details on monetary asset accounts for assets related to the generation of energy from renewable sources

6.77 Table 6.9 presents the monetary asset account for assets related to the generation of energy from renewable energy sources. Monetary asset accounts for assets related to the generation of energy from renewable sources differ from other asset accounts in that the monetary value of the asset is associated with either the land in which the energy producing asset is located or the water used to generate the energy. The starting point of the asset account then is the value of the land or water.

6.78 For solar, wind, geothermal and wave and tidal, opening overall asset value corresponds to the overall value of the land in which the asset is located at the beginning of the accounting period. Contributing the value of the land are a number of assets including the renewable energy source. For example the value of the land in which a wind farm is based includes also the value of the soil. By convention for hydro, the overall asset value is assigned to water.

6.79 Opening asset value attributable to renewable energy is the contribution to the opening overall asset value by the renewable energy source. In most cases a majority of the opening overall asset value can be attributed to the renewable energy source. The NVP approach can effectively be used to estimate the future income stream from the sale of energy from any of the renewable sources.

6.80 Additions include the following:

i. Additions due to capital expenditures in new establishments. Similar to discoveries for energy resources, this category includes any capital expenditures made in new establishments that capture energy from renewable sources. It includes any new wind farms, solar panel establishments or new dams constructed to capture hydropower. For geothermal, this category also includes any new discoveries of energy sources. Only contributions from establishments that were not in operation at the beginning of the accounting period should be included

ii. Additions due to capital expenditures in current establishments. Increases in asset value due to increased production in current establishments due to investments in improved technology are recorded here. Also if there is an expansion in the establishment, such as more wind turbines, it should be recorded here. Only establishments that were already included at the beginning of the accounting period should be included. Note that increases due to improved technology could be recorded separately from increase due to expansion if deemed important.

iii. Upward reappraisals. This category includes increases in value due to changes in the pattern of the renewable energy source that lead to higher energy production. For example if there is an expectation that there will be lower precipitation which would lead to lower hydro energy production, it should be recorded here.

Table 6.9 Monetary asset account for assets related to the generation of energy from renewable sources

		Solar	Hydro	Wind	Geothermal	Wave and tidal
Opening overall asset value						
Opeining asset value attributable to renewable energy source						
Additions						
	Additions due to capital expenditures on new establishments					
	Additions due to capital expenditures on current establishments					
	Upward reappraisals					
Reductions						
	Catastrophic losses					
	Downward reappraisals					
Revaluation						
Closing asset value attributable to renewable energy source						

6.81 Reductions include the following:

i. Catastrophic loses. These are reduction in assets due to catastrophic or exceptional events. Examples include wind farms being destroyed by hurricanes.

ii. Downward reappraisals. This category includes decreases in value due to changes in the pattern of the renewable energy source that lead to lower energy production.

iii. Revaluations relate to changes in the value of the asset solely due to changes in price. Revaluations should also incorporate changes in the value of environmental assets due to changes in the assumptions made in the valuation approaches that are often used to estimate the value of the renewable energy source, in particular the NPV approach.

6.82 Caution should be exercised when determining upward and downward reappraisal. Furthermore, if the prior accounting period was an outlier with respect to certain variables that impact energy production from renewable sources, it should be properly adjusted when used in NPV calculations.

Chapter 7: Uses of Energy Accounts

7.1 Introduction

7.1 Energy accounts developed using the ideas and methods discussed in the prior chapters can be used in a variety of manners to effectively present and summarize the collected data revealing linkages between different variables. Integration of energy accounts with other sources of information is important and can provide greater insights for policy makers, researchers, and other users of the energy accounts.

7.2 This chapter showcases potential uses of the energy accounts, giving a number of examples as to what can be accomplished through their use. The tone and style of the chapter is different from the previous chapters in that it focuses on presenting the information in the energy counts in a concise, easily accessible format (usually graphical) and on providing a number of descriptive statistics, aggregates and indicators. The fictitious dataset used in the analysis is the same as the one used throughout SEEA-Energy. It is not the purpose of the chapter to give an exhaustive presentation of all possible uses and applications of the energy accounts. Furthermore the conclusions drawn from the analysis are relevant only for the data being analyzed and should not be generalized.

7.3 Following the general structure of the "Energy Indicators for Sustainable Development: Guidelines and Methodologies", energy indicators can be grouped along 3 dimensions: social, economic and environmental. The social dimension includes a number of important indicators related to energy access such as share of households without electricity and share of income spent on fuel and electricity.

7.4 SEEA-Energy can inform a number of important elements that are necessary to properly understand the policy implications of such social indicators. For example energy accounts contain a wealth of information on the efficiency of production and consumption of energy, capital investments by industry (in particular the energy sector) and stocks, flows and depletion of mineral and energy resources such as coal and gas.

7.5 All these seemingly unrelated pieces of information once combined can provide unparalleled, powerful and coherent insights into not only the current state of energy access but also into how to best structure policy for present and future generations. The advantage of using the details in the SEEA-Energy accounts is that users not only get a better understanding of the current state but also the necessary information as to how and why a given aggregate or indicator is at a particular level.

7.6 All 16 indicators in the economic dimension in the "Energy Indicators for Sustainable Development: Guidelines and Methodologies" directly use information contained in the energy accounts. Combining the information in the accounts with supplementary demographic and economic information would make it possible to calculate energy use per capita or per unit of GDP for example. A major strength of the SEEA-Energy accounts lies in the intuitive presentation of energy use by economic sector which plays a significant role in a number of efficiency and intensity related indicators.

7.7 On the environmental dimension, the energy accounts again play a key role in filling the information gaps required not only for the derivation of the indicators but also by providing necessary background and contextual information. For example, energy accounts not only provide information that aids in the calculation of emissions by energy product but also by industries using the ISIC classification. Such information allows for a more complete understanding of emissions not only by energy product but also by industry. It supports the formulation of strategies and policies that target emitters and does so in a way that could address the larger emitters.

7.8 Often analysis can be carried out on the basis of information from multiple sources. In many cases, it does not matter whether the starting point is the energy statistics, the balances or the accounts, since the basic information and the concepts are the same. In other cases, each of these statistical systems has their advantages and disadvantages depending on the purpose of the analysis. For instance, energy statistics and balances are often more appropriate to use when it comes to analysis focusing on specific energy technologies. Energy accounts on the other hand are a better information system when it comes to comparing the physical data with information on the economic activities or to show specific monetary information related to energy issues.

7.9 It should be noted that all the examples presented are preceded by background information on the purpose and detailed explanations of what aggregates are being used. Appropriate conclusions are made after each example with emphasis placed on what are the general implications of the analysis. Often this is followed by a short discussion of potential indicators that directly follow.

7.10 This chapter is structured as follows. Section 7.2 presents information on energy supply and use. The main focus is the energy sector along with a number of immediate extensions and applications that rely and build upon the supply and use data. This is followed by a discussion of the relationship between the energy sector and the economy at large in Section 7.3. Section 7.4 analyses the relationship between the energy sector and particular sectors of the economy. The last section looks at some of the impacts of the energy sector on the environment.

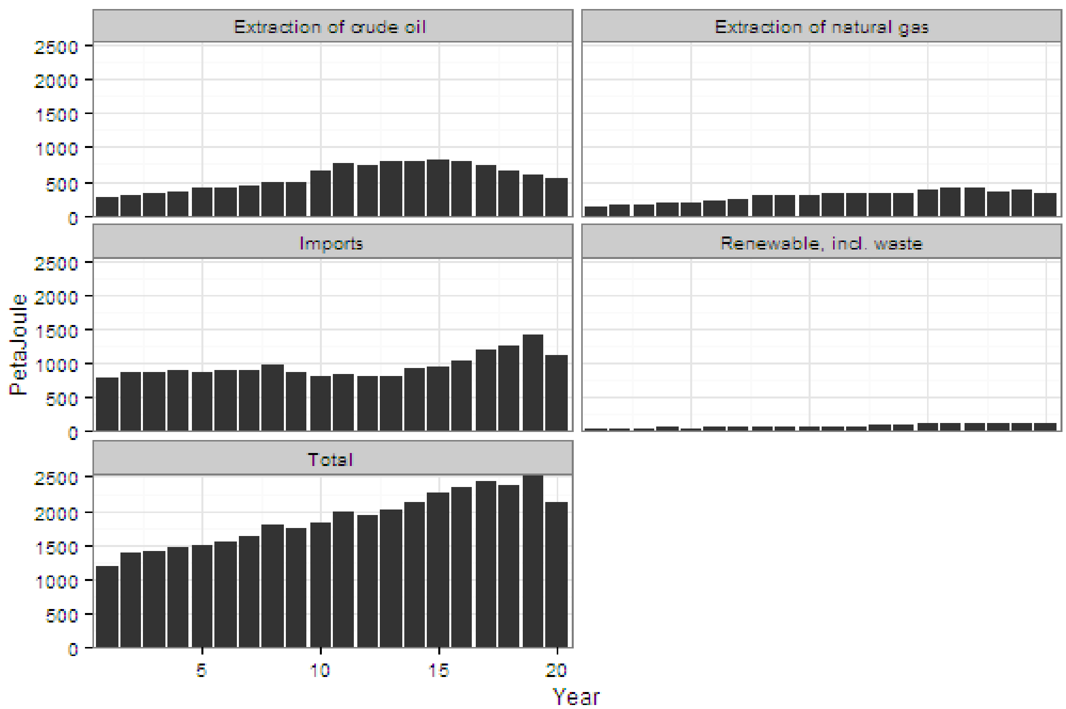
7.2 Energy supply and use

7.11 A natural initial step in the analysis of the energy sector is to consider energy supply and use. Having a good understanding of supply and use is necessary in order to better manage energy natural resource inputs as well as plan for the future. Furthermore, such information is crucial to deriving a number of indicators. For example, augmenting this data with data on population leads to the important indicator of energy use per capita.

7.2.1 Overall supply and use of energy

7.12 The total quantity of energy supply in a country during a year is the sum of the production of primary energy and imports of energy products. Measuring the supply in this way avoids problems of double counting, which occur when, for instance, both the production of crude oil and the production of refined oil products are included. Figure 7.1 shows the extraction of crude oil and natural gas, renewable energy, imports as well as their total over time.

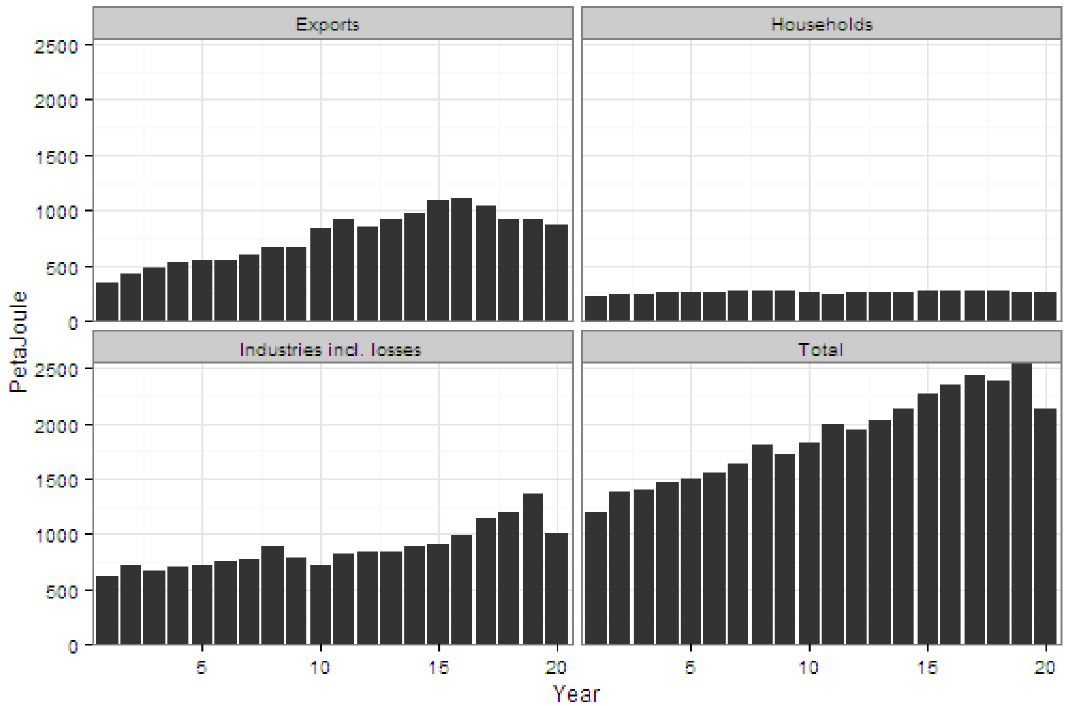
Figure 7.1 Total primary supply and imports of energy



7.13 A number of immediate conclusions can be drawn from the figure above. Energy supply has generally increased over time, with the exception of the last year. Extraction of fossil fuels (crude oil and natural gas) has leveled off /decreased over the last 5 years of available data, while energy supplied from renewable sources has increased. Over half of the energy supply in during the last year came from imports.

7.14 Next we consider how the supplied energy is used. Figure 7.2 shows how much of the energy supplied is exported, and how much is used by households and industries. Household use has stayed roughly constant during the two decades while exports have more than doubled during the same period. Industry use of energy has generally increased as well though not at the same pace as exports.

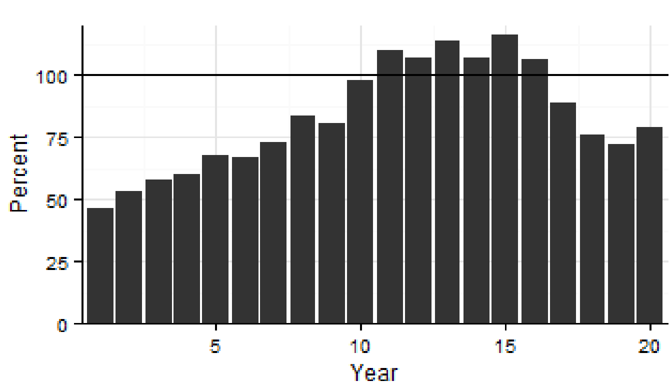
Figure 7.2 End use of energy including losses



7.2.2 Degree of energy self-sufficiency

7.15 An immediate indicator that can be derived using the data in Figure 7.1 and Figure 7.2 is the ratio of the primary energy production to domestic end use. Values greater than 100% indicate the ability to meet domestic demand for energy while values lower that 100% indicate dependence on foreign sources of energy. Figure 7.3 shows that the degree of self-sufficiency increased from less than 50% at the beginning of the period to more than 100% in the middle of the period. After some years of full self-sufficiency the reliance on imports has again increased in recent years. This development has a close connection with the pattern of extraction of energy resources presented above.

Figure 7.3 Degree of energy self-sufficiency



7.2.3 Use of energy and expenditures by industries and households

7.16 Figure 7.1 and Figure 7.2 above provide a broad, aggregated view of energy supply and use. Often though, a further breakdown of the data is required to answer more specific questions. For instance, what energy products are being used by households and industries and at what cost? Figure 7.4 and Figure 7.5 provide the answers to these questions for a particular year.

Figure 7.4 Physical use of energy by industries and households

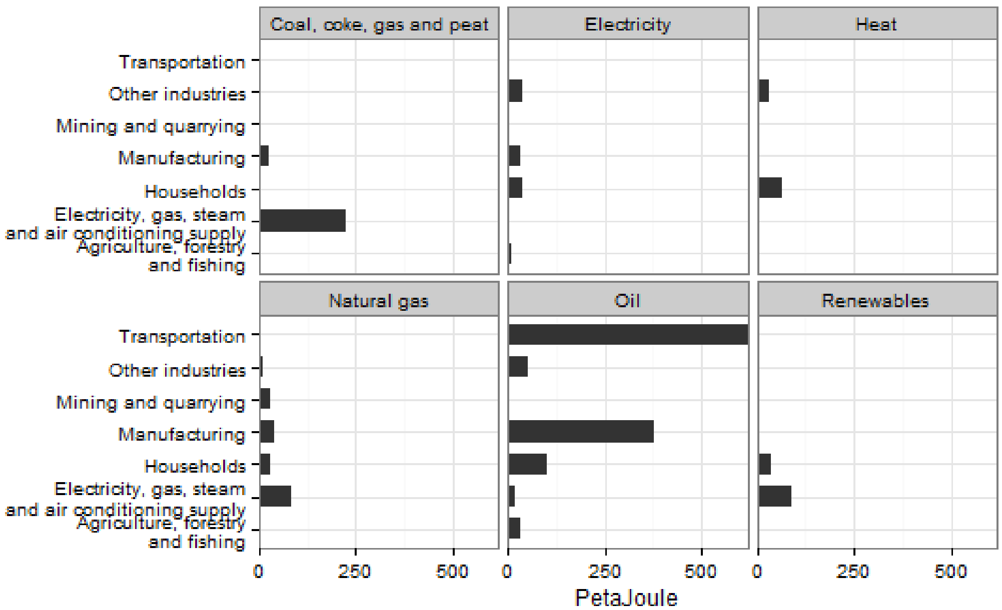
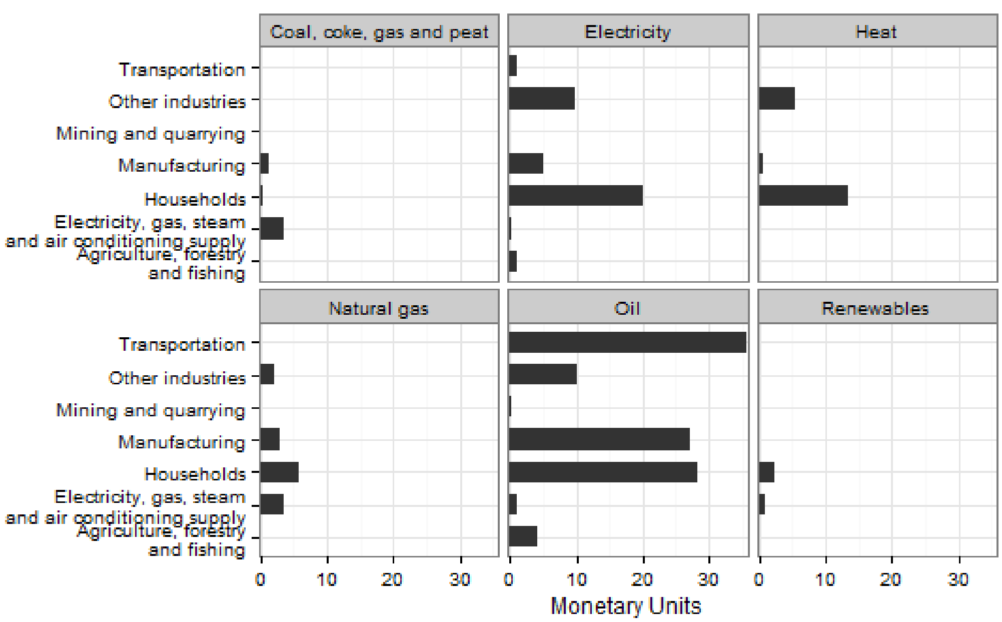


Figure 7.5 Expenditures for energy by industries and households

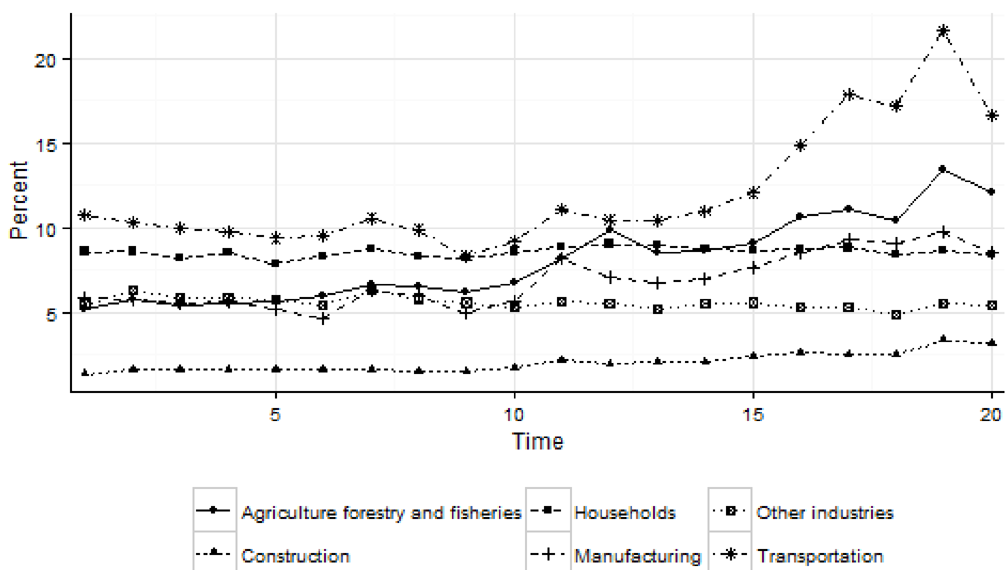


7.17 A number of policy relevant conclusions can be reached by looking at graphs above and the underlying data. Manufacturing and transportation rely heavily on oil as their main source of energy. Oil is the largest source for households as well; other sources such as electricity and heat are also important. Having the above information and depending on relevant circumstances, policy makers can design policies so as to impact the demand for certain energy products.

7.18 Even though the data underlying each of the graphs are useful on their own, there is added value when one considers the monetary data along with the physical data. Household expenditures on energy are the highest among the 7 groups. This is especially striking given that households are only the 4th largest group of energy users.

7.19 A number of further extensions can be made to the data above using the information collected in the accounts. Figure 7.6 shows one such extension in looking at the share of energy expenditures to overall intermediate consumption for industries and overall final consumption for households over time. This information puts into proper context the impact of energy expenditures.

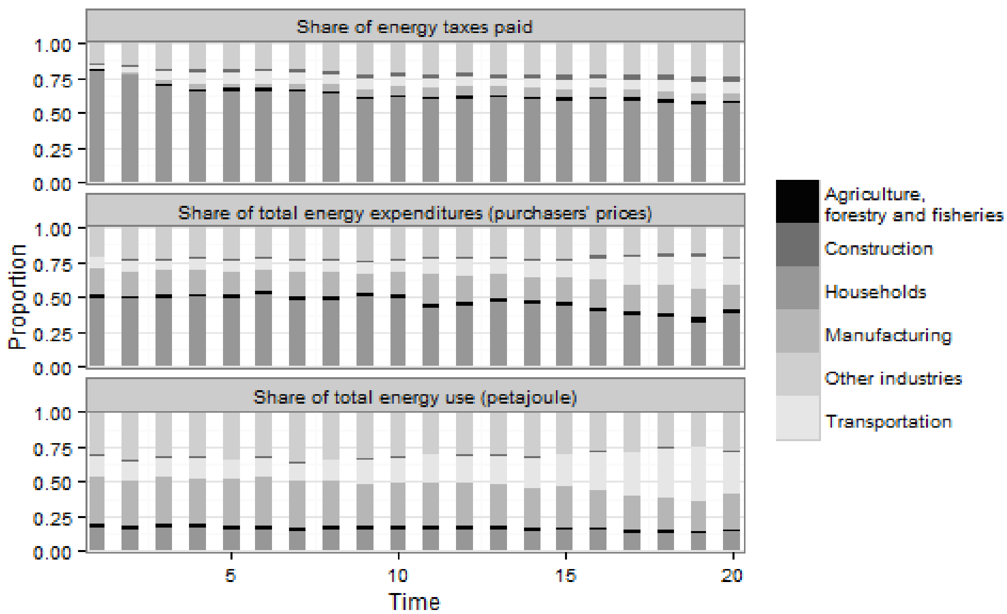
Figure 7.6 Share of energy costs to overall intermediate industry/final household consumption



7.20 As can be seen from Figure 7.6, household energy expenditures as a proportion of final household consumption have been stable over the two decades varying within the narrow range of 7.8%-9.0%. As mentioned in the introduction this is an important energy indicator for sustainable development along the social dimension. Furthermore except for the transportation sectors, energy expenditures as a proportion of intermediate consumption have remained fairly stable for all other sectors of the economy. For the transportation sector the share has generally increased since the time period 10 likely due to increases in oil costs.

7.21 Another potential extension is to consider the share of energy expenditures and use over time by different sectors of the economy, further enhancing the policy relevance of the information collected. This, along with the shares of energy taxes paid is shown in Figure 7.7. Other extensions such as energy use by resource for different sectors over time are also possible depending on the needs of the users and the available data.

Figure 7.7 Energy use, expenditures and taxes



7.22 Juxtaposing the energy tax data with the physical and monetary data of energy use leads to a number of conclusions with policy implications. The most striking feature is that households pay by far the largest share of energy taxes, around 60% of the total energy taxes paid in the last time period, even though their share of energy use in physical terms is about 20% and about 40-50% in monetary terms. Over the two decades household share of energy taxes has decreased from about 80% to about 60% of the total. The cause of such a shift could be due to a number of factors, including changes in tax law, energy regulations and the increasing levels of extraction activity by domestic producers and associated taxation. Clearly such information would provide insights to policy makers regarding the impacts of different policies.

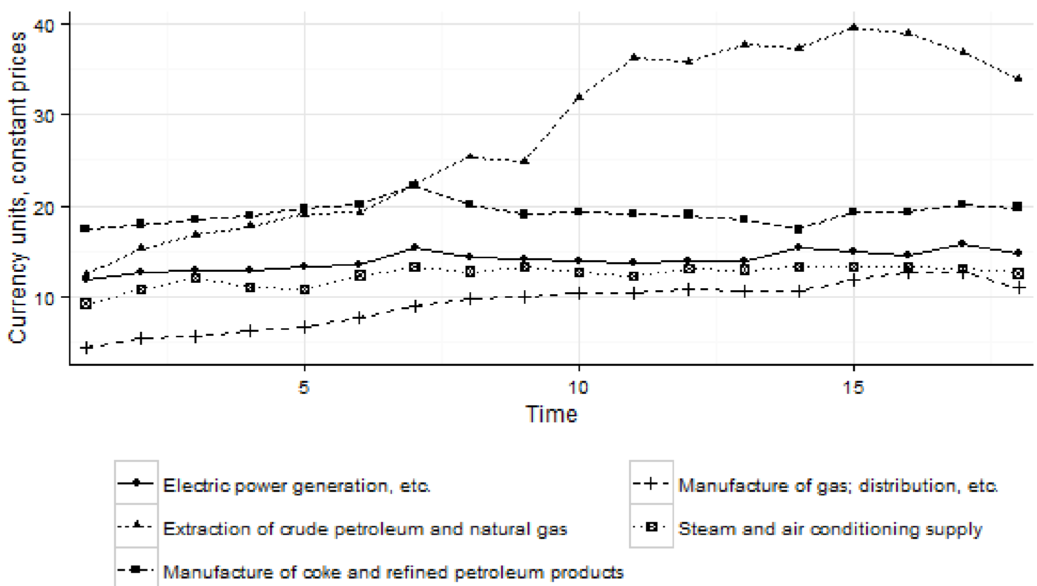
7.3 The energy sector within the economy

7.23 The importance and contribution of the energy sector to the economy at large cannot be overstated. All sectors of the economy depend on the energy sector for necessary inputs to the production processes. Hence the energy sector is an important player in the economy at large and as such monetary data collected via the energy accounts are an invaluable tool to properly understanding the role of this sector within the economy.

7.3.1 Output and value added from the energy sector

7.24 Figure 7.8 shows the output from the energy sector measured in constant prices (chained values) over time. The value of crude petroleum and natural gas output increased at the beginning of the period, but has in recent years been decreasing. Despite the decrease, the extraction of crude petroleum and natural gas contributes the most to the overall output of the energy sector. The output from the manufacturing and distribution of gas has increased about five fold over the two decades while the other sectors have experienced little variation in output over time.

Figure 7.8 Energy sector output over time



7.25 Figure 7.8 presents the output of the energy sector, without giving any indication as to how important this sector is to the national economy. It would be useful to consider the contributions of the energy sector in relation to the overall economy by comparing elements of this sector in relation to the overall economy. Such statistics which are easily accessible through the accounts are presented in Table 7.1.

7.26 In particular Table 7.1 shows in monetary terms the output, intermediate consumption, gross value added, consumption of fixed capita and net value added by ISIC for all industries for a particular year. The data clearly show how important the energy sector is to the economy at large, counting for 5% of output and about 6% of gross and net value added.

7.27 Within the groups of energy industries it is the extraction of the mineral and energy resources which generates the largest value added. The share of intermediate consumption in relation to the output is much smaller for the mining industry, since the resource itself contributes considerably to the value of output. This is related to resource rent, i.e. the contribution to the net value added by the resource itself, and depletion, i.e. the decrease in the value of the resource due to the extraction. The role of depletion is further investigated in the section that follows. Resource rent is further discussed in section 7.3.3.

Table 7.1 Certain industries' share of output and value added

ISIC		Output	Intermediate consumption	Gross value added	Consumption of fixed capital	Net value addded
		1000 currency units				
A	**Agriculture, forestry and fishing**	**65**	**47**	**18**	**13**	**5**
B	**Mining and quarrying**	**65**	**7**	**59**	**5**	**54**
B. 05	*Mining of coal and lignite*					
B. 06	*Extraction of crude petroleum and natural gas*	*60*	*7*	54	*5*	49
	Other mining and quarrying	*5*		*5*		*5*
C	**Manufacturing**	**611**	415	196	31	**165**
C. 19	*Manufacture of coke and refined petroleum products*	*28*	*27*	1	*1*	**0**
	Other manufacturing	*583*	*388*	*195*	*30*	*165*
D	**Electricity, gas, steam and air conditioning supply**	**57**	**29**	**28**	**10**	**18**
D. 351	*Electric power generation, etc.*	*24*	*12*	12	*4*	**8**
D. 352	*Manufacture of gas; distribution, etc.*	*20*	*13*	7	*2*	**5**
D. 353	*Steam and air conditioning supply*	*14*	*5*	9	*3*	**6**
E	**Water supply; etc.**	**3**	***2***	**1**	**1**	**0**
F	**Construction**	**215**	***136***	**79**	**6**	**73**
G	**Wholesale and retail trade; etc.**	**334**	***145***	**189**	**16**	**173**
H	**Transportation and storage**	**351**	***206***	**174**	**25**	**149**
I-U	**Other service industries**	**1 221**	***554***	**667**	**151**	**516**
	Total industries	**2 923**	**1 541**	**1 411**	**257**	**1 154**
	Energy related industries total (B.05, B.06, C.19, D)	145	63	83	16	67
	Energy related industries, per cent of total industries	**5.0**	**4.1**	**5.9**	**6.0**	**5.8**

7.3.2 Operating surplus of energy industries and the role of depletion

7.28 One of the important stories conveyed by the data in Table 7.1 is that the majority of the net value added for the energy sector comes from the extraction of crude petroleum and natural gas. Net value added (NV) can be further decomposed as follows:

$$NV=NOS+CE+OT-SU$$

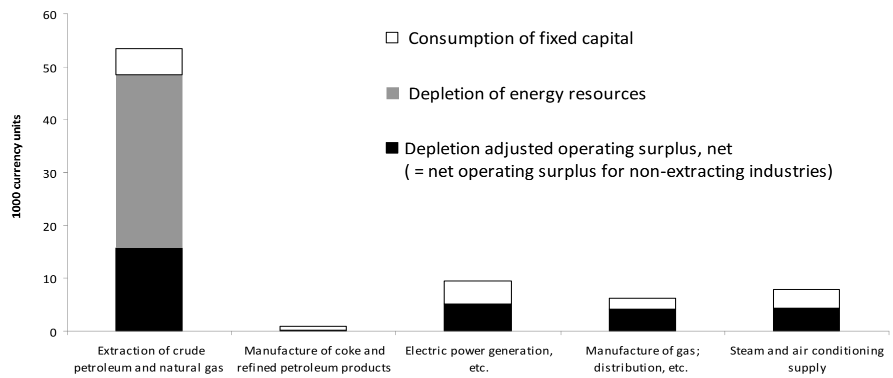
where NOS is net operating surplus, CE is compensation to employees, OT is other taxes paid by the industry and SU is subsidies received by the industry.

Once net operating surplus has been isolated, gross operating surplus can also be calculated by adding to it the consumption of fixed capital. The decomposition of gross operating surplus by industry is presented in Figure 7.9.

7.29 Depletion, which is one of the more important concepts in the energy accounts, is the largest component of gross operating surplus for the extraction of crude petroleum and natural gas industry. When depletion is taken into account by subtracting it from the net operating surplus, the contribution of the mining to value added is considerably smaller and the differences between the mining industry and the other energy industries are less pronounced.

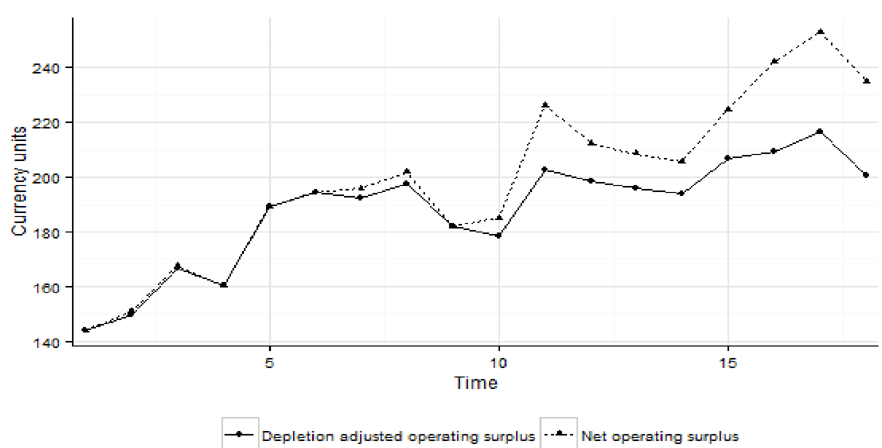
7.30 The effect of the depletion on net operating surplus is higher than the effect from the consumption of fixed capital. However, this is something specific for the mining and quarrying industry while for all other industries no adjustments take place.

Figure 7.9 Gross operating surplus of the energy industries and its components, 1000 currency units, 2006



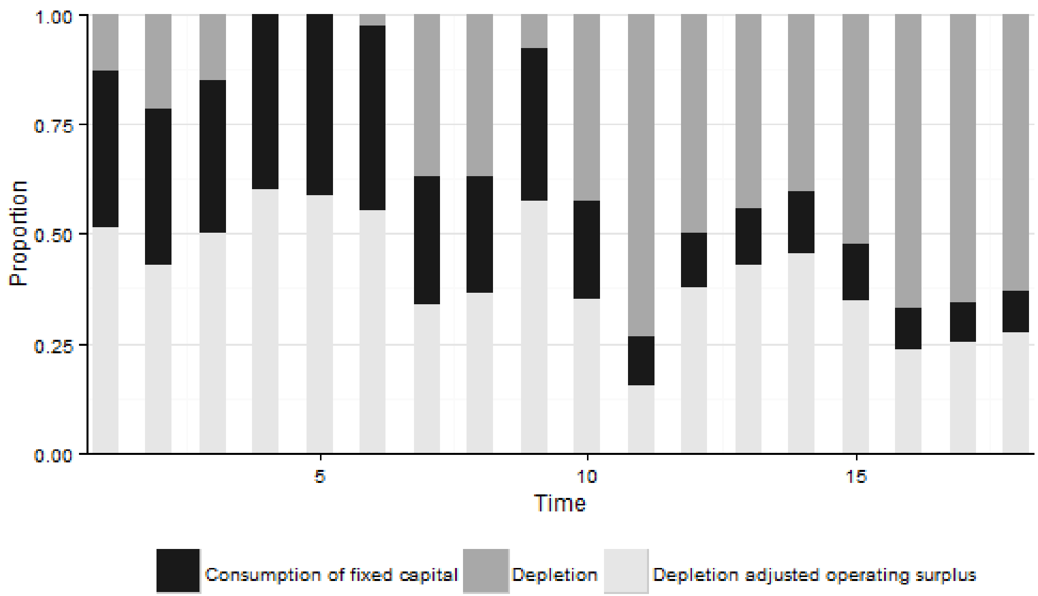
7.31 The impact of depletion of mineral and energy resources can also be viewed in the context of the operating surplus for the overall economy. Figure 7.10 shows two curves presenting net operating surplus and depletion adjusted net operating surplus. The distance between the two lines corresponds to depletion of mineral and energy resources. The effect of taking depletion into account corresponds to a downward adjustment of the operating surplus by approximately 30 currency units during the last year shown.

Figure 7.10 Net and depletion adjusted operating surplus



7.32 In order to get a better understanding of the magnitude of mineral and energy resource depletion, it might also be useful to look at what percent of operating surplus is attributed to depletion. As mentioned earlier gross operating surplus can be decomposed into 3 components: consumption of fixed capital, depletion and depletion adjusted operating surplus. The figure below shows the relative weight of each of the 3 components of gross operating surplus over time for the extraction of crude petroleum and natural gas industry.

Figure 7.11 Operating surplus components extraction of crude petroleum and natural gas



7.33 During the period an increasing share of gross operating surplus is attributed to the depletion of crude petroleum and natural gas. At the end of the period the depletion corresponds to almost two thirds of the gross operating surplus. The increase in the share of depletion reflects partly an increase in the physical quantities of mineral and energy resources being extracted.

7.34 Related to this, and also reflected in Figure 7.11, is that the share of depletion may vary significantly from one year to the next, although the physical extraction does not necessarily vary much. This is again explained by the convention that the total value of the mineral and energy resources influences the estimate of the depletion. All else equal, large increases in the stock of the mineral and energy resources due to new discoveries and revaluations of the quantities lead to drastic downward changes in the estimate of the depletion even if the extraction of the resources is at the same level when measured in physical quantities.

7.35 The relative role of consumption of fixed capital is decreasing over time. This may, among other things, be due to an increase in productivity leading to more mineral and energy resources being extracted by the same input of fixed capital and/or possibly a decision not to replace production capital as the accompanying natural resource nears full exhaustion. In addition, an increase in the oil and natural gas prices relative to the prices on fixed assets used for the extraction will lead to a decreasing share for the consumption of fixed capital.

7.36 When depletion and the consumption of fixed capital are subtracted from the gross operating surplus the depletion adjusted operating surplus is obtained. As can be seen, the share of adjusted operating surplus varies over time reflecting the volatile nature of the depletion estimate and operating surplus especially at current prices. This points at the importance of establishing time series for depletion and depletion adjusted operating surplus, and the danger of drawing conclusions on long term patterns based on only accounts for a single year or short time series.

7.3.3 Energy taxes and resource rent

7.37 As discussed in Chapter 6, gross operating surplus is the starting point for the calculation of resource rent[24], which as it can be clearly seen from Figure 7.12, makes up a considerable part of the gross value added of the extraction of crude oil and natural gas industry.

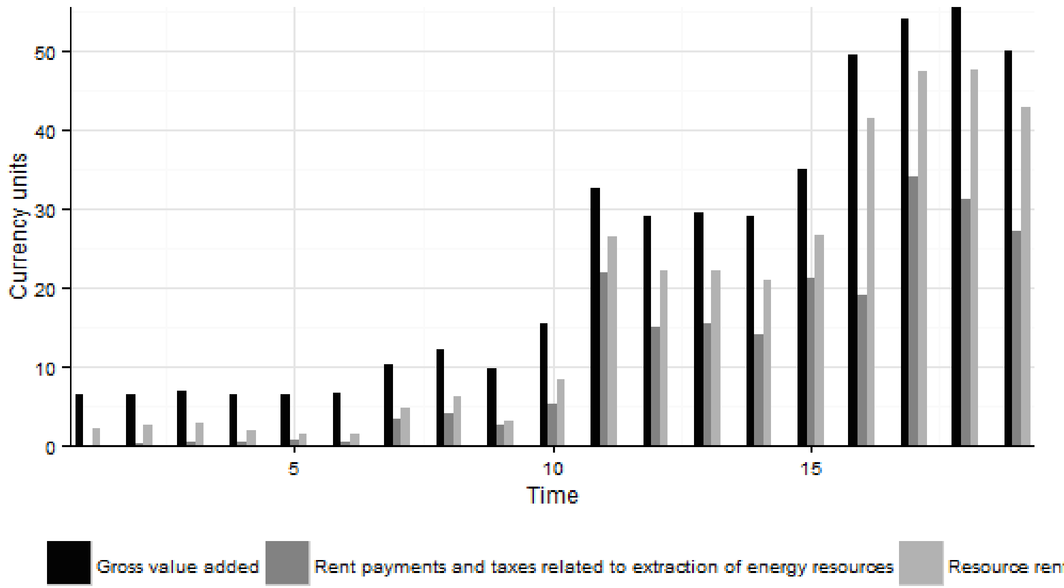
7.38 From a policy perspective, a question of interest is whether the owner of the resource, i.e. the government, has recovered a significant portion of the resource rent through rent payments and taxes. The accounts are perfectly suited to answer such question. Figure 7.12 shows that the share of resource rent to value added was relatively low in the first few years when extraction was low but it increases once the value of extractions is increasing. Similarly, the share of rent payments and taxes was low in the beginning of the period, while in recent years the share has remained high. However, it is also clear that in this case the appropriation of the resource rent does not make up a constant share of either value added or the resource rent. Other factors seem to influence the payments of rents and taxes. The magnitude of payments to government has in general increased over time.

7.39 This analysis emphasises the importance of maintaining a time series and regularly assessing the relationship between resource rent earned by extractors and related payments to government such as taxes and rent.

7.40 The importance of the energy sector to the finances of the government can also be seen by looking at the share of total government revenues that comes from payments related to the extraction of mineral and energy resources and other energy related taxes. (See Figure 7.13)

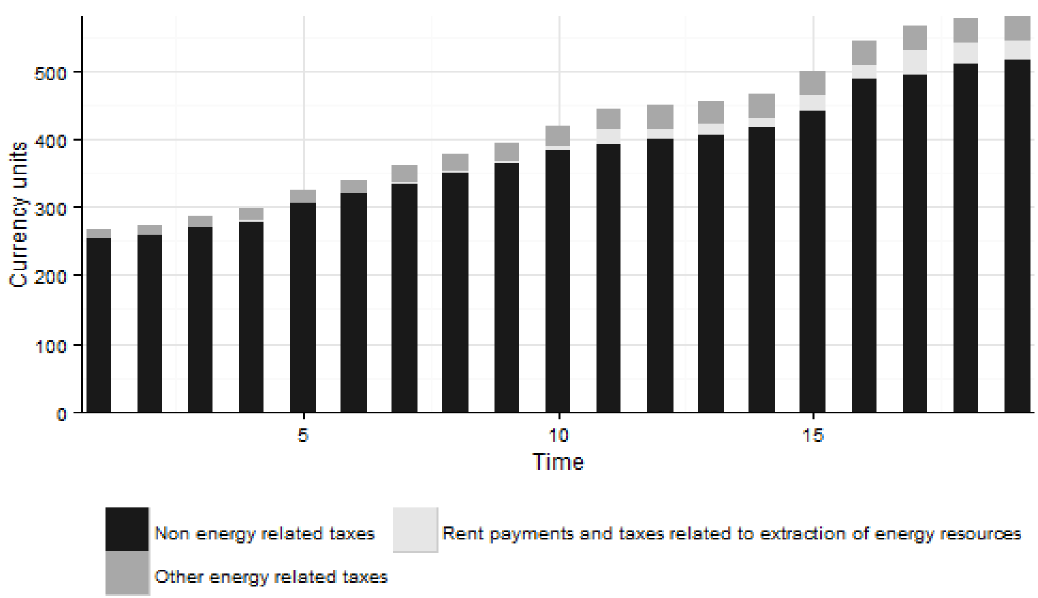
[24] Resource rent = Gross operating surplus - consumption of fixed capital - return to fixed capital

Figure 7.12 Value added, resource rent and payments of rent and taxes to the government



7.41 In recent years energy related taxes have made up approximately 10 per cent of the total government revenue. Of this, roughly half comes from payments related to the extraction of mineral and energy resources and half from other energy related taxes, including taxes on CO2 emissions. Over the years the energy sector has contributed an increasing share to government revenues.

Figure 7.13 Breakdown of total taxes (total economy) by energy related and non-energy related taxes



7.3.4 Energy and foreign trade

7.42 An important conclusion from the initial supply and use analysis in Section 1 of this chapter was that imports and exports of energy products are significant components of the overall picture. Furthermore, data on imports and exports are key to understanding energy security. In this section we explore some of the details of this relationship with the help of the data available through the accounts.

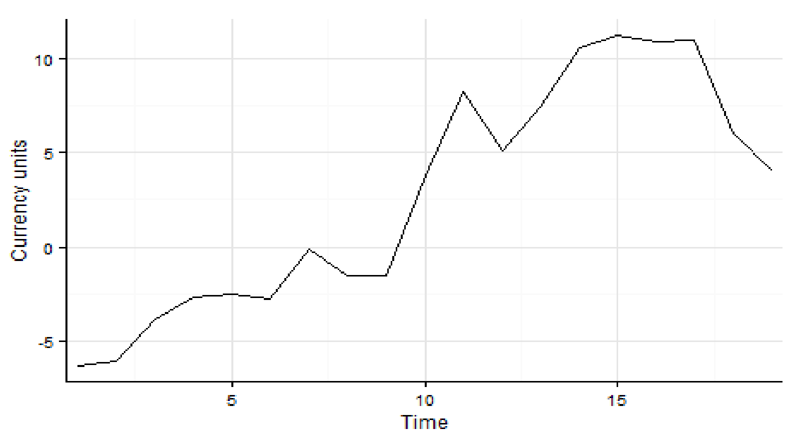
7.43 The data presented in Table 7.2 show that, in monetary terms, crude oil was the most important energy product being exported, while processed oil in the form of fuel oil was the main energy product import. Overall there was a trade surplus for energy products which was mainly due to the extraction of crude oil and natural gas.

Table 7.2 Imports and exports of energy products

	Imports	Exports	Trade balance
	1000 Currency units		
Crude oil	8	32	24
Natural gas	0	9	9
Electricity	2	4	3
Gasoline and diesel	7	8	1
Others	6	5	-1
Coal	3	0	-3
Fuel oil	33	10	-23
Total, energy products	**59**	**69**	**10**
All products	520	538	18
Energy products share of all products, per cent	**11**	**13**	**53**

7.44 The trade balance for energy products over time is shown in Figure 7.14 where it can be seen that the first trade surplus occurred during year 9, increasing until year 15. By comparing to Figure 7.8, which shows the output of the extraction industry, there is a close connection between the extraction activities and the trade balance for energy products. In years with significant domestic extraction activities, there tends to be a surplus in the national energy trade balance.

Figure 7.14 Trade balance for energy products



7.3.5 Wealth

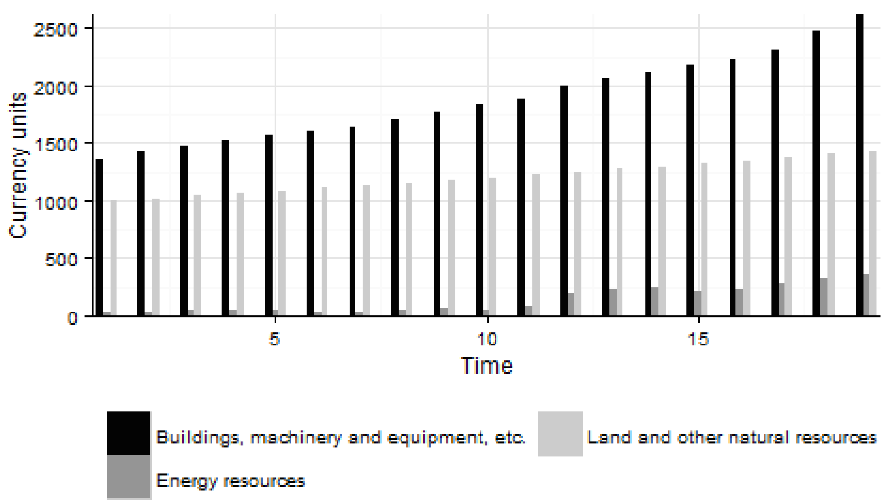
7.45 In this section, the energy sector is viewed within the larger context of national wealth. The value of mineral and energy assets comprises only one component of the total value of the assets belonging to a country. Other components are human capital, land and other natural resources and fixed assets in the form of buildings, machinery and equipment.

7.46 Leaving aside the value of human capital, the market values of man-made and natural capital are presented in Figure 7.15.

7.47 In this case we find that the fixed assets (buildings, machinery and equipment, etc.) make up the biggest part of the value of the assets. Although the mineral and energy assets are important for the economy (the trade balance, for instance) their contribution to the total wealth when measured as the value of the assets is modest.

7.48 It should be noted that the value of the mineral and energy assets has increased over time. The increase can be partly attributed to the fact that assets such as oil acquire a market value when exploration and evaluation activities have been carried out. A further contributor is that increases in oil prices have affected the value of the asset, and when the oil price increases more than the general price level, the value of the assets will also tend to increase relatively to the value of other assets[25].

Figure 7.15 Contribution to national wealth by fixed assets, mineral and energy assets, land and other natural resources

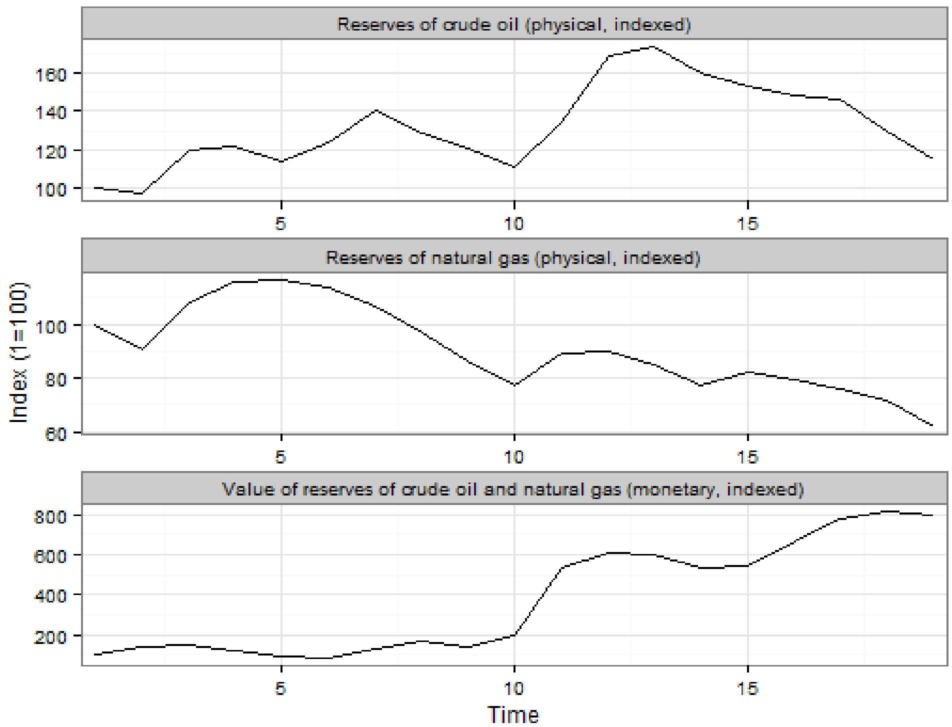


7.49 Clearly the value of the mineral and energy assets is tied to the available physical quantity of the asset. Figure 7.16 illustrates how the value of the energy natural resource assets have changed compared to the physical quantities. The value index is

[25] Using current prices is standard practice in this type of analysis because the value of a given asset depends on the period of the valuation.

calculated from the current price value deflated by the GDP deflator[26]. Therefore the changes in the index are influenced by the fact that the energy prices have evolved differently than the general price level. Changes due to new discoveries also influence the index.

Figure 7.16 Quantity and value index for the development of the stock of energy resources



7.50 The physical stock of oil resources increased by 15 per cent over the period as a whole. In contrast, the physical stock of natural gas decreased substantially by almost 40 percent. The GDP deflated value index was almost 8 times higher in the end of the period than in the beginning of the period.

7.51 To further shed light on the size of the mineral and energy assets Figure 7.17 presents the so-called R/P ratio for oil and natural gas resources. For a given year the R/P ratio is equal to the available stock at the opening of the period divided by the extractions in the given year.

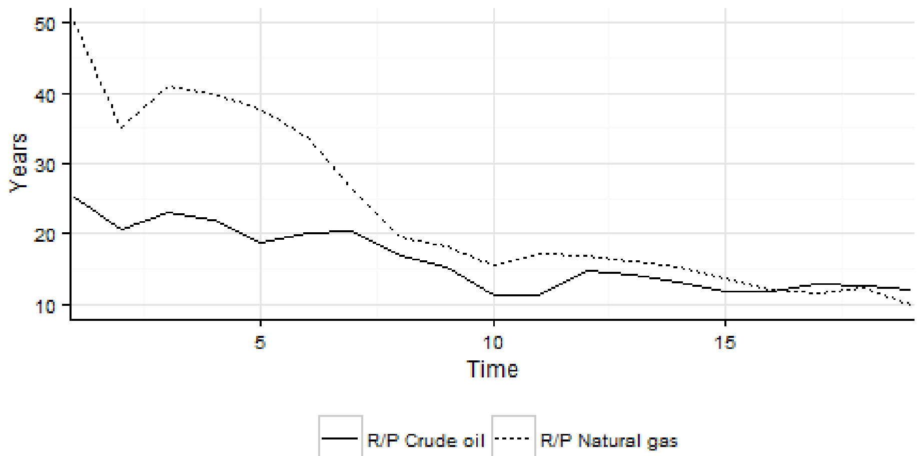
$$\frac{R}{P} = \frac{Stocks}{Extraction}$$

7.52 It represents the number of years of extraction left before the energy resource has been exhausted assuming continuation of current levels of stocks and extractions.

[26] Recall that $\text{GDP Deflator} = \frac{\text{GDP Current Prices}}{\text{GDP Constant Prices}}$

For natural gas 50 years of extraction was left at the beginning of the time series, while a little more than 10 years is left at the end of the time series. This decrease is due to the gradual exhaustion of the natural gas deposits and the increasing level of extraction. For oil, the R/P proportion decreased from 25 years to a little more than 10 years at the end of the period. It is worth noting that despite a high level of extraction in all years, the R/P proportion remains fairly constant above 10 years for the last decade. The stabilization of the R/P proportion is often seen, and is partly a result of increased exploration and evaluation activities, which make it possible to extract from newly discovered deposits as other deposits are being exhausted.

Figure 7.17 Years of extraction left with current levels of stocks and extractions

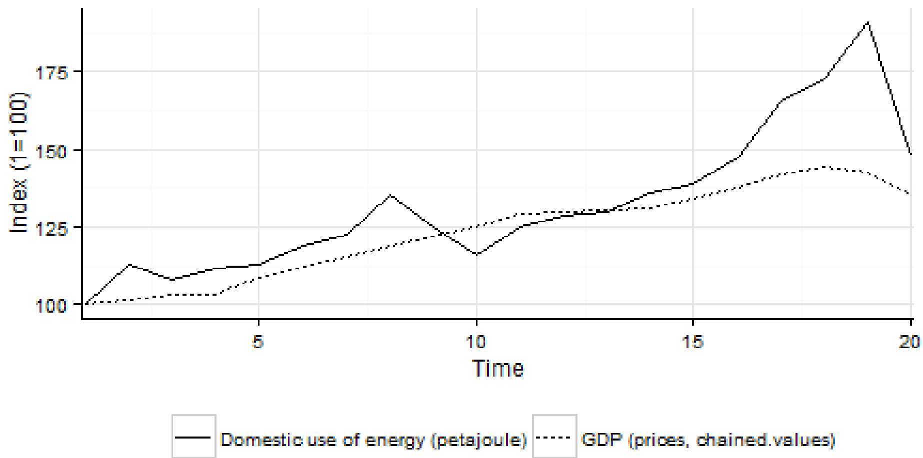


7.3.6 Economy wide energy decoupling

7.53 Decoupling of energy use and economic growth is generally seen as a necessity to ensure a sustainable development. The extent to which such decoupling takes place can be illustrated by comparing changes in GDP with changes in domestic use of energy as in figure 7.18. The underlying data can also be used to calculate energy use per unit of GDP.

7.54 In this example we find that no decoupling has taken place. In fact, there has been a parallel development in GDP and energy use in most years during the period. Towards the end of the period we find first big increase in energy use followed by a steep decrease. Indexed energy use and GDP are at roughly the same value in the last year.

Figure 7.18 Economic growth and domestic use of energy



7.4 Energy and other sectors of the economy

7.55 Increased efficiency in energy use and decreasing energy intensities can contribute to sustainable development. A number of energy intensity indicators can be generated using the data in the energy accounts. This section analyzes energy use in relation to economic growth and the efficiencies of industries. Energy intensities for various groups of industries are presented, and results from decomposition analysis are shown.

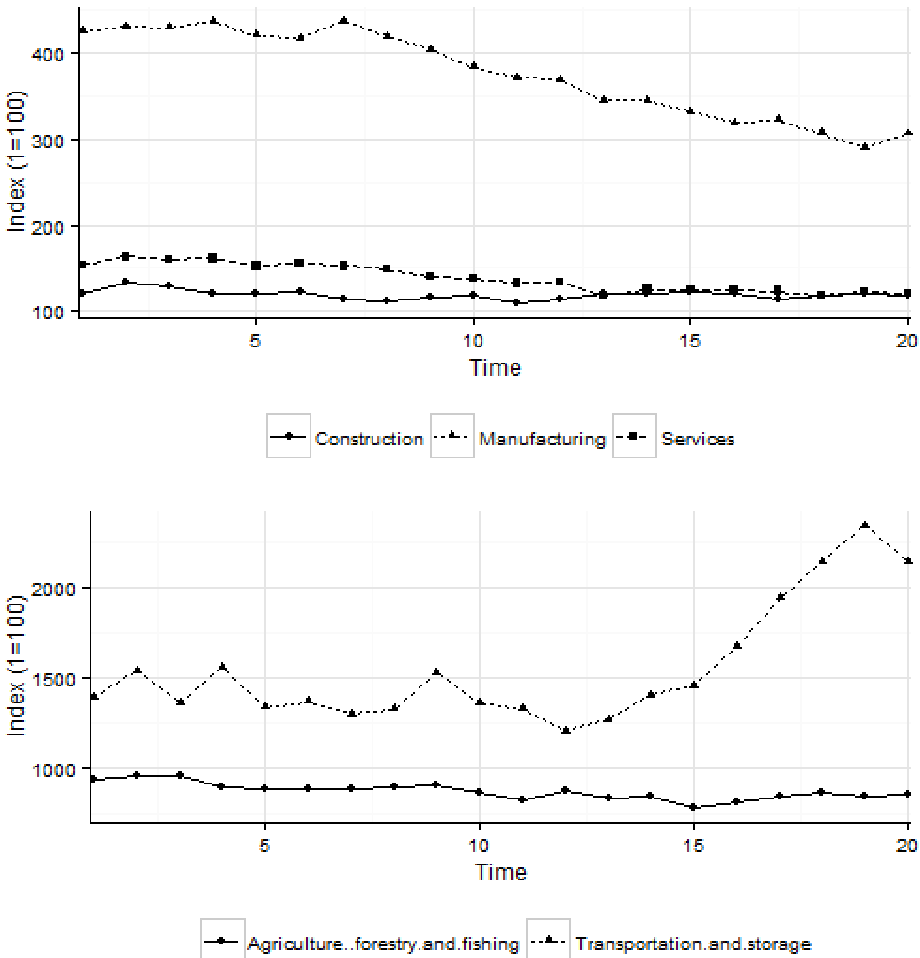
7.4.1 Energy intensities for selected industries

7.56 Figure 7.19 sums up the development of economic activity and energy use for selected industries by presenting energy intensities. The energy intensities are calculated as the ratio of value added in constant prices to energy use by the given industry.

7.57 The first graph shows the development for industries with relatively low intensities. Manufacturing shows decreasing intensities, which indicates a tendency over time to use energy more efficiently and/or an increase in the use of energy transformed outside of the manufacturing sector as suppose to autoproduced energy. For construction and services we see that the energy intensities now lie at a constant low level after a decrease in the beginning of the period.

7.58 The second graph shows the energy intensities of transport services and agriculture, forestry and fishing. Both industries report high energy intensities. While the intensities for agriculture have decreased slightly during the period, the opposite is the case for transport services.

Figure 7.19 Energy intensities for selected industries



7.59 Because the data in the energy accounts are collected in a manner consistent to the SNA, it allows for easy integration of data from these two systems. One such example which is relevant to energy intensity is integration with employment data which leads to the ratio of energy use to number of employees in a particular sector.

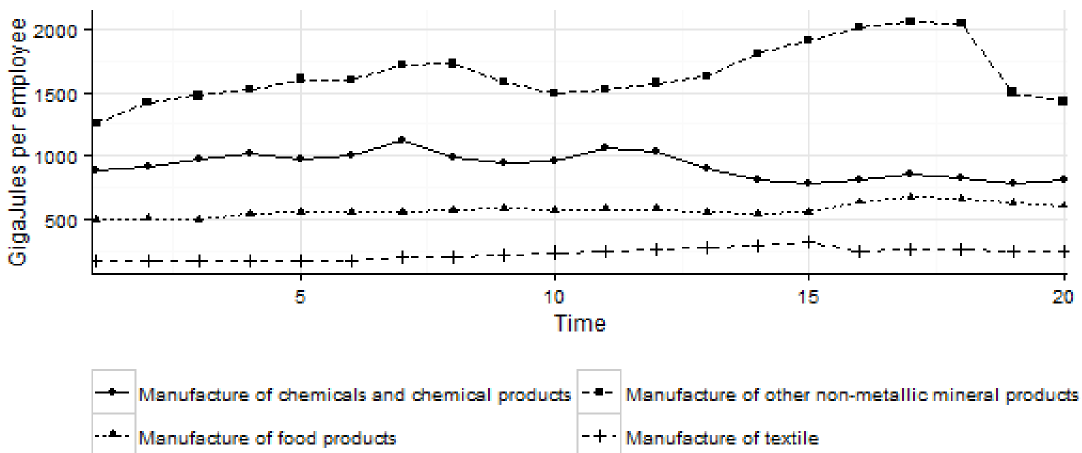
7.60

7.61

7.62 **Figure 7.20** presents such information for selected manufacturing industries. The energy use per employee varies considerably between the manufacturing industries.

For these industries no clear conclusion can be reached on the question of whether there is decoupling between energy use and employment.

Figure 7.20 Use of energy per employee in selected manufacturing industries



7.4.2 Factors behind changes in energy use

7.63 In order to shed light on the factors behind the changes in energy use, structural decomposition analysis based on input-output modelling can be applied. Structural decomposition analysis is a well-established method and reference can be made to a large number of articles of reports describing the method and presenting results.

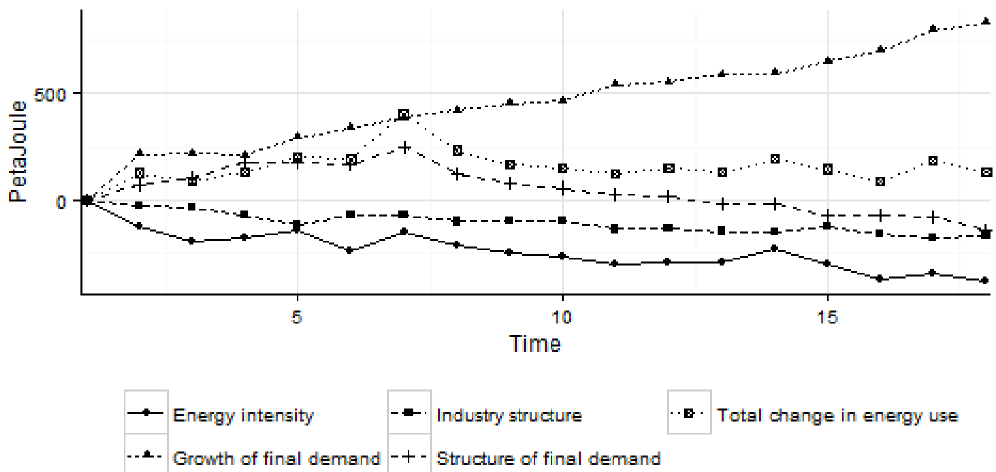
7.64 Figure 7.21 presents the results of such an analysis. The total change in actual energy use by industries excluding the transportation services[27] are decomposed into 4 components. Over the period, overall energy use increased by about 200 petajoules. The other lines show how the changes in energy use can be further explained by changes in the growth of final use/demand (i.e. private and government consumption, exports, gross fixed capital formation, etc.), the structure of final demand (shifts and changes in final demand between different sectors of the economy), the industry structure and the energy intensities of the industries.

[27] The transportation services have been excluded here because they show a pattern which is much different from the other industries

7.65 Growth of final demand increased by over 800 petajoules during the 18 years while energy use attributed to the other three components decreased. If growth in energy use had followed the growth in final demand, we would have seen an increase in energy use of over 800 petajoules. In fact the total increase in energy use was about 200 petajoules. The difference is due to reduced energy intensity in industries, i.e. their use of energy per unit of output. This factor alone decreased by about 400 petajoules. Changes in the composition of final demand (i.e. which products were demanded) and the industry structure (i.e. how did the industries interact) also decreased over the time series.

7.66 It should be noted that this analysis, and others based on input-output modelling, cover a shorter period than many of the other time series in this chapter. This is due to the fact that that input-output tables are normally published with a larger time lag than other statistics.

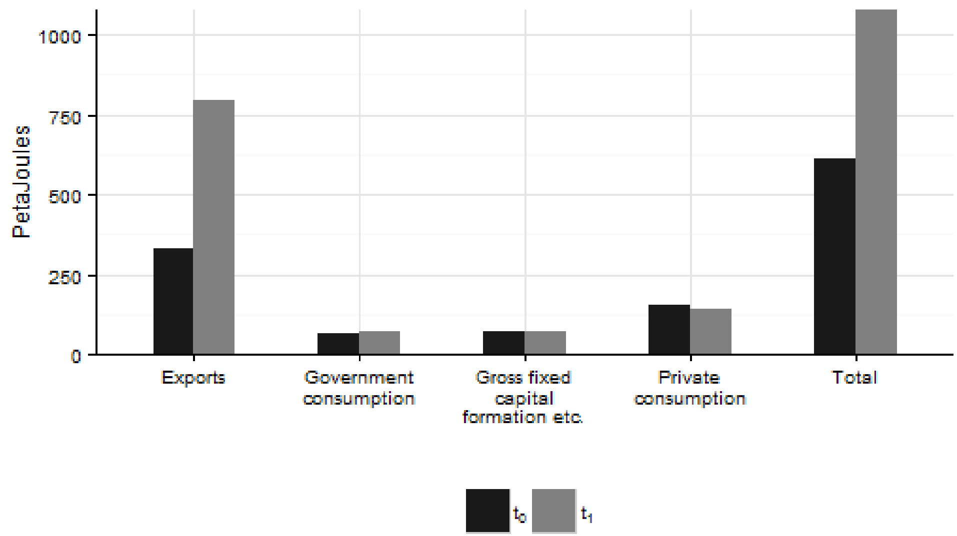
Figure 7.21 Changes in industry energy use and the factors behind the change



7.4.3 Energy use attributed to final use of products

7.67 Increasingly, in relation to sustainable production and consumption policies, policy makers and others are focusing on the fact that resource use and environmental pressures can be seen from the perspective of the final use and consumption of products. The rationale is that any kind of final use initiates a production chain including domestic and foreign activities. Therefore, the resource uses and the environmental pressures, which occur at the production level, can in fact be seen as being caused by the final use, which have initiated the production chain.

Figure 7.22 Industries' energy use by final use categories

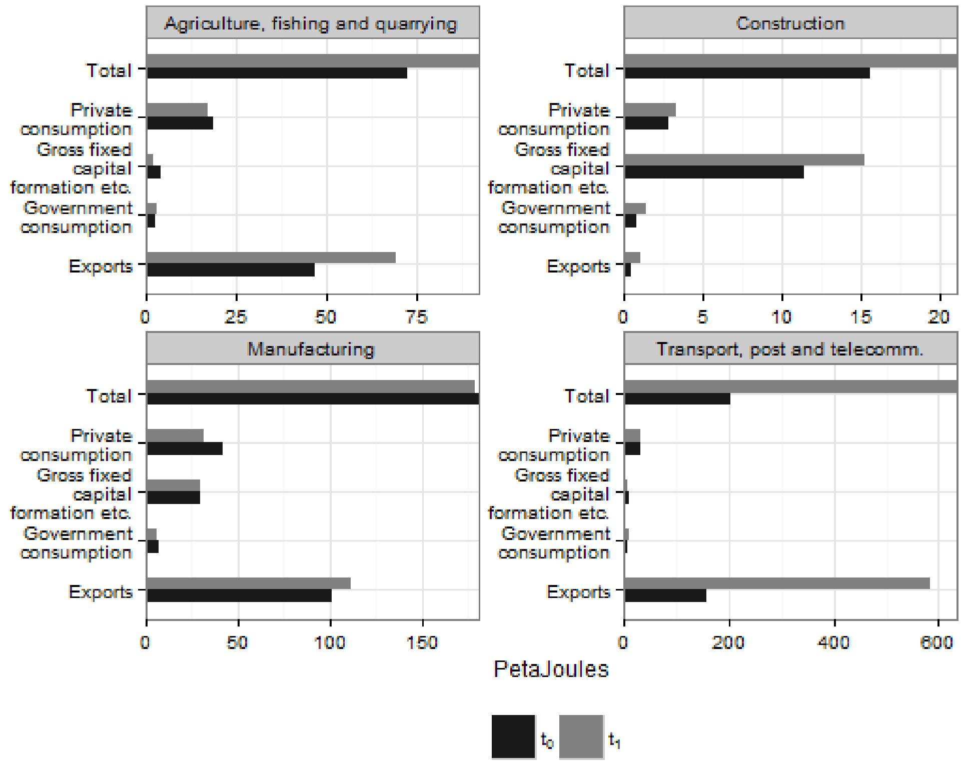


7.68 The data in the accounts can be used to properly understand how final demand drives energy use. In particular, input-output analysis gives the allocation of energy use by final use categories or specific products. Figure 7.22 shows the results of an input-output model based allocation of the total domestic energy use to the overall final use categories, which lies behind the production and corresponding energy use in all industries.

7.69 The figure shows that the steep increase in energy use between t_0 and t_1 was mainly related to an increase in export activities. In contrast private and government consumption and gross fixed capital formation, etc. caused almost the same energy use in industries in t_1 as in t_0.

7.70 This type of analysis can also be done for particular industry groups. Figure 7.23 clearly shows that the activities and energy use of different industries are driven by different final use categories. Exports are behind the energy use of agriculture, etc., manufacturing, and transport services. The increase in exports of transport services lies behind much of the increase in overall energy use. Finally, gross fixed capital formation is the main driver of energy use in the construction industry.

Figure 7.23 Energy use of industry groups by causing final use categories



7.4.4 Domestic and global energy use attributed to household consumption

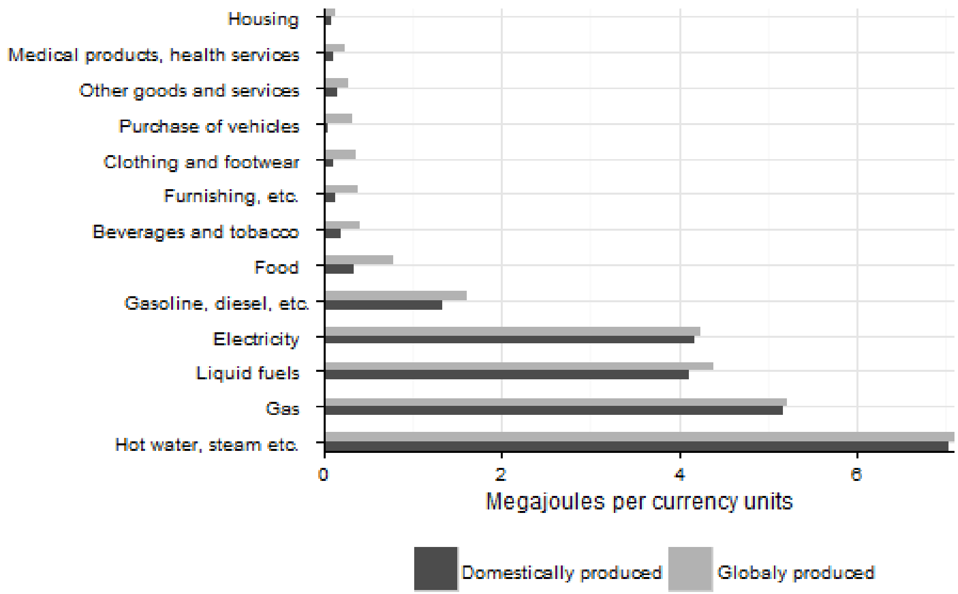
7.71 For each of the final use categories it is possible to further decompose the energy use in the production chains by distinguishing between the final uses of different products. As an example of such analysis Figure 7.24 presents results for household consumption. The figure shows how much energy is used directly and indirectly per one currency unit spent on products by households. A distinction is also made between energy used in the production process domestically and energy used in the production process both domestically and abroad. The latter production processes include products that are imported and products that are domestically produced using imported intermediate products.

7.72 Of the energy products, hot water and steam, etc. is the most energy intensive, while gasoline and diesel, etc. is the least energy intensive. It should be noted that the intensities are calculated from purchasers' prices, which include energy taxes. Therefore, products which are heavily taxed appear to have lower energy intensity per unit of currency. For other types of products, it is clear that food is the most energy intensive product group followed by beverages and tobacco, furnishing and clothing, etc.

7.73 For energy products the difference between embedded domestic energy use and global energy use is small since most energy products used by households are produced domestically using energy extracted domestically.

7.74 For other products there are considerable differences between domestic and global energy use in production. Generally, the global energy intensities are twice as large as the domestic intensities. This is in part explained by the fact that many of the products used by households are imported. Furthermore, industries in the production chain also use imported products, which require energy use abroad.

Figure 7.24 Domestic and global energy intensities of household consumption



7.5 Energy and the environment

7.75 In this section we focus on how energy accounts can help in clarifying the relationship between the energy sector and environment. We discuss the role of energy related air emissions and renewable sources of energy. The former is important because of its direct impact on the environment while the latter allows for less pressure on the environment. The data presented are also necessary for the derivation of a number of indicators related to sustainable development such as air quality indicators and climate change indicators.

7.5.1 Energy sector and air emissions

7.76 One important use of the physical use table for energy is in the calculation of air emissions. The first part of this section describes how the accounts for energy related emissions might be set up. The second part presents results from modelling based on the energy accounts and the emission accounts. The results show which factors affect energy related emissions.

7.77 Energy related air emissions are the main (though not the only) contributors to most types of air-emissions because most economic activities are connected to combustion that is needed for energy production. Combustion processes take place in many production and consumption activities, such as heating of houses and buildings, production of electricity, various industrial processes and transportation.

7.78 The SEEA-Energy accounts may be used as the basis for the establishment of energy-related air-emissions accounts. Such emissions accounts are compatible with the SEEA and the SEEA-Energy physical flow accounts, and, more generally, with the National Accounts principles.

7.79 Before proceeding with the analysis it is worth noting that the term ‘air- emissions accounts’ is different from the term ‘emission inventories’. The latter is commonly used when referring to data on greenhouse gas emissions and emissions of air pollutants assembled following certain formats as agreed upon under international conventions (e.g. United Nations Framework Convention on Climate Change, UNFCCC and the Convention on Long Range Transboundary Air Pollution, CLRTAP). Emission inventories are technology-oriented and may serve as the appropriate basis for technology-oriented questions and analysis. In contrast, air emissions accounts are economically-oriented and assign air emissions to those economic entities that actually are carrying out the activities from which the air emissions are originating. Air emissions accounts are developed to answer more economically oriented questions and analyses. Both information systems – emission inventories and air emissions accounts – complement each other. (Eurostat, 2009 , p.9).

7.80 The presentation of energy related air emission accounts in this section is developed in continuation and accordance with Chapter 3 on the physical flow accounts on energy. They are of course consistent with all the components of the SEEA-Energy system, including monetary aggregates.

7.5.2 Use of energy accounts for estimation of emissions

7.81 Energy accounts can be a useful tool in estimating emissions from the energy use. Table 3 gives an example of a detailed supply table for CO2 emissions. Similar tables can be created for all types of air emissions which are primarily caused by energy use, and they can be established in the same way as the account for CO2 emissions.

7.82 Generally, the emission accounts for energy related emissions can be established on the basis of the energy use table (Table 3.5) by multiplying the energy use recorded in the energy use table by a technical emission factor expressing the emission per unit of energy use. Formally it can be expressed by:

$$\text{Emissions (E)} = \text{Energy use (EU)} \times \text{Emission Factor (EF)}$$

7.83 It should be noted that in practice, it is necessary to carry out the estimations at a more detailed level than presented in Table 3.5 and Table 7.3. This is to ensure that the emission factors are representative for the activity and the energy use in question. It is necessary to distinguish between all energy products since different products usually have different emission factors. For certain air emissions types, it may also be necessary to have information and data on types of technologies within industries because the choice of technologies influences the amount of air emissions per unit of energy used[28].

7.84 The table presents the quantities of CO2 emissions generated by the use of the various types of energy products. Thus, the items in the leading column of Table 7.3 correspond to those items in the energy use table (Table 3.5), which are of interest in relation to air emissions.

7.85 The air emissions data related to energy use are allocated to the economic activities in a consistent manner with how the energy use is recorded. In other words, if for a specific unit (industries and households) use of energy for combustion is recorded, then the corresponding emissions are attributed to the unit in question.

7.86 It follows that the use of certain types of converted energy does not lead to the recording of emissions. This is the case, for instance, for the use of electricity and heat by industries and households. Emissions that arise when heat and electricity producers use coal and oil in the production of the electricity and the heat are recorded as emission to such producers. Since the main part of the production often takes place within ISIC D Electricity, gas steam and air conditioning supply, this is where the main part of these emissions is normally recorded. Other parts of these emissions are recorded for other industries, to the extent that combustion of energy products for electricity and heat generation takes place there for own use or for sale.

7.87 Emissions related to the use of gasoline and diesel for transport are similarly attributed to the units carrying out the transport activities. Thus, only parts of the

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[28] Eurostat's Manual for Air Emissions Accounts provides more information on how air emission accounts can be established on the basis of energy accounts

Table 7.3 Supply table for CO_2 emissions based on the SEEA-Energy use table

	Industries by ISIC											Consumption			Capital	Total residents	Rest of the world		Total supply
	A	B	C	D	E	F	G	H	I-U	A-U									
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas steam and air conditioning supply	Water supply; etc.	Construction	Wholesale and retail trade; etc.	Transportation and storage	Other Industries	**1. Total industries**	*of which residents in the rest of the world*	Own account transport	Other consumption	**2. Total Consumption**	**3. Emissions from equipment, durables, landfills, etc.**	**4. Total supply of air emissions by residents**	**5. Cross boundary inflows from the ROW by air currents**	**6. Emissions by non-residents on national territory**	**7. Supplied by residents and RoW (=1. 6.)**
	1000 tonnes																		
Energy related emissions																			
Coal	203	14	1 695	21 472			1		1	**23 385**			83	**83**		23 469			**23 469**
Peat and peat products																			
Oil shale/Oil sands																			
Natural Gas	115	1 728	2 211	4 705		21	236	26	433	**9 475**			1 606	**1 606**		11 081			**11 081**
Oil	2 039	149	2 693	1 263	2	1 406	1 130	48 160	1 214	**58 056**	*43 509*	5 950	2 504	**8 454**		66 510		100	**66 610**
Biofuelfs	25		14	126						**165**						165			**165**
Waste	263	9	396	6 636					85	**7 389**			3 391	**3 391**		10 780			**10 780**
Electricity																			
Heat																			
Nuclear fuels and other fuels nec																			
Energy related emissions, total	**2 645**	**1 900**	**7 008**	**34 202**	**2**	**1 427**	**1 367**	**48 186**	**1 733**	**98 471**	**43 509**	**5 950**	**7 584**	**13 534**		**112 004**		**100**	**112 104**
Non-energy related emissions, total		**425**	**1 465**							**1 890**						**1 890**			**1 890**
Total air emissions	**2 645**	**2 324**	**8 473**	**34 202**	**2**	**1 427**	**1 367**	**48 186**	**1 733**	**100 360**		**5 950**	**7 584**	**13 534**		**113 894**		**100**	**113 994**

Source: Calculation based on SEEA-E Table X.X and technical emission coefficients (at detailed level) emissions are allocated to ISIC H Transportation and storage, while other parts are attributed to the households and industries, which use the gasoline and diesel. For households, transport related emissions include the use of energy for private cars. Energy use and emissions caused by public transport are attributed to ISIC H.

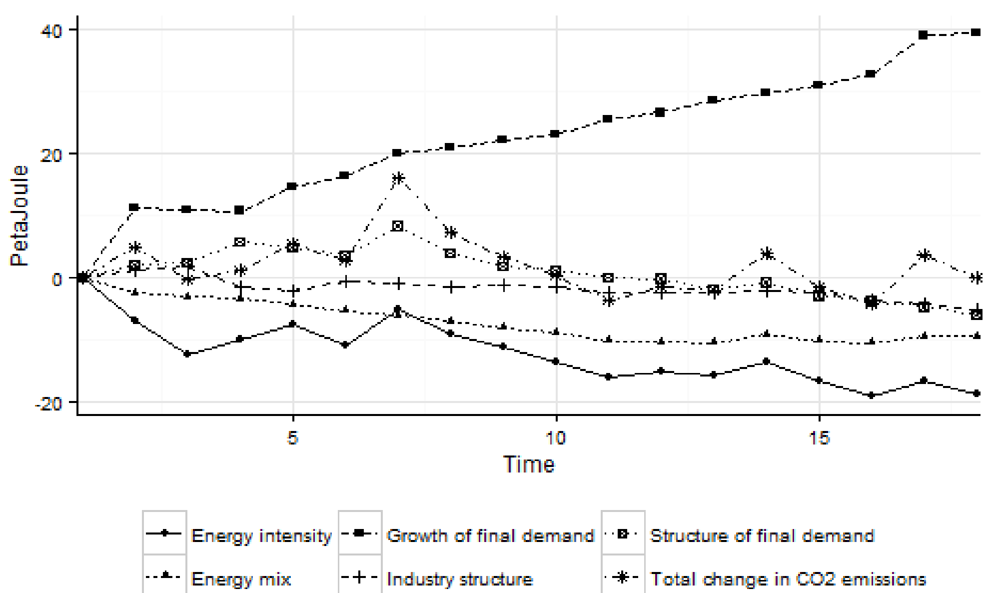
7.88 In order to complete the picture of the CO2 emissions, non-energy related CO2 emissions are presented at the bottom of the table. These non-energy related emissions are based on additional information, for instance, from the emission inventories complied in complying with the United Nations Framework Convention on Climate Change, UNFCCC.

7.5.3 Analysis of energy related emissions based on the energy accounts

7.89 Once the emissions accounts have been set up based on the energy accounts it is possible to extend the analysis and consider what factors underlie the changes in the energy related emissions. Figure 7.25 presents the results of such analysis. Figure 7.25 is similar to the Figure 7.21 on energy use. Overall CO2 emissions have been fairly constant over the 18 year period. Of the 5 components shown in figure 7.25, growth in final demand has created substantial upward pressure on CO2 emissions while the other components represent factors driving down overall CO2 emissions.

7.90 Changes in the energy mix imply that industries and household increasingly are using less CO2 intensive energy products. Examples of such a change in energy mix are substitution of natural gas for coal and wind energy for fossil based electricity.

Figure 7.25 Change in industries CO2 emissions and the factors behind the change

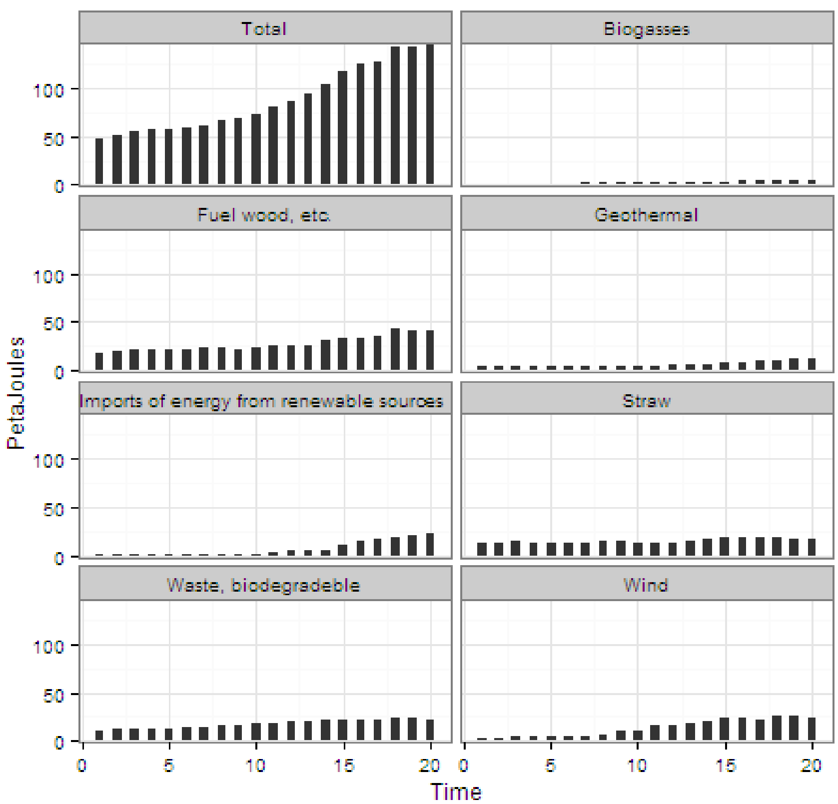


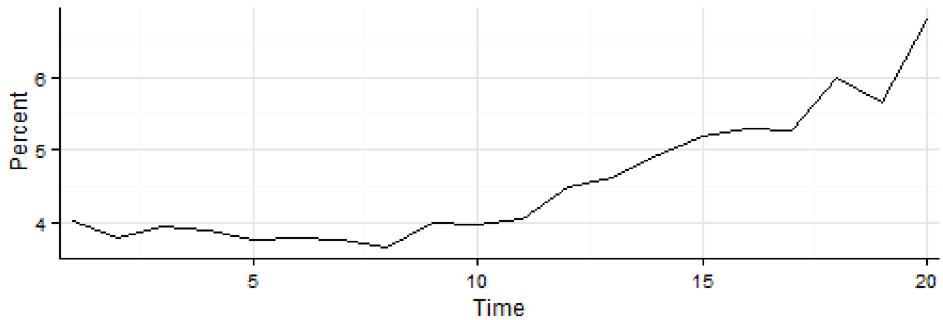
7.5.4 The role of energy from renewable sources and waste

7.91 Energy from renewable sources is high on the policy agenda in many countries, and therefore it is important to monitor the development in the production and use of energy from renewable sources and to assess the share of such sources to the total energy supply and use. This section presents details on the use of energy from renewable sources and waste and clarifies how much of the total use of energy is covered by renewables and waste.

7.92 Figure 7.26 shows the development in the supply (production and imports) of energy from various renewable sources, and the share of the total primary production and imports of energy products that comes from renewable sources. The production of energy from wind and the imports of energy from renewable sources have been increasing. Similarly the use of fuel wood and biodegradable waste for energy production has been increasing. Altogether the share of energy from renewable sources has increased from 4 per cent to close to 7 per cent of the total supply during the period.

Figure 7.26 Supply of energy from renewable sources and its share of total primary energy production and imports





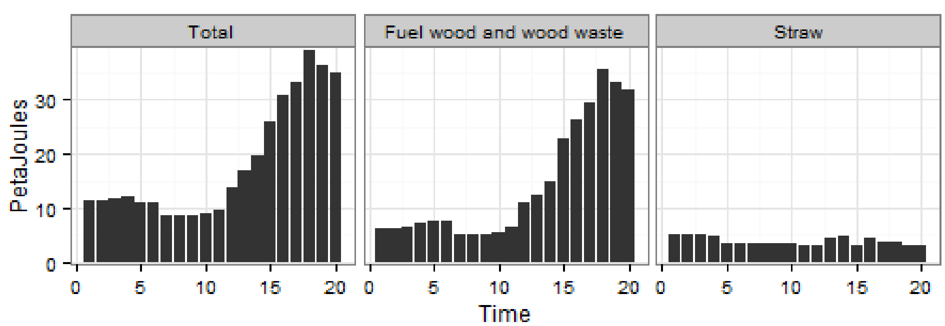
7.93 Energy from renewable sources is used both by households and industries. Figure 7.27 presents the use of energy from renewable sources in physical terms by households, by the manufacturing industry and by the electricity, gas, steam and air conditioning supply industry.

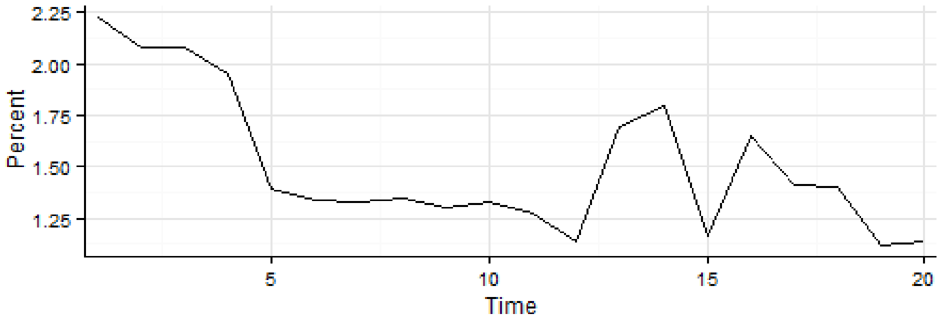
7.94 Household use of fuel wood increased drastically during the period, but despite this the share of renewable sources was reduced by half from 2 per cent to 1 per cent of the total energy use by households.

7.95 The use of energy from renewable sources in the manufacturing industries in absolute and relative terms has been fairly constant over the time period. Households on the other hand have increased their use of energy from renewable sources in absolute terms, though the growth was less than the overall growth in household use of energy. As a result households' use of energy from renewable sources has decreased from over 2% of household energy use at the beginning of the time period to about 1% at the end. The electricity, gas, steam and air conditioning supply industry increased its use of energy from renewable sources considerably from 10 per cent to 30 per cent of its total energy use. It should be noted that part of this increase is due to an increase in the use of wind power.

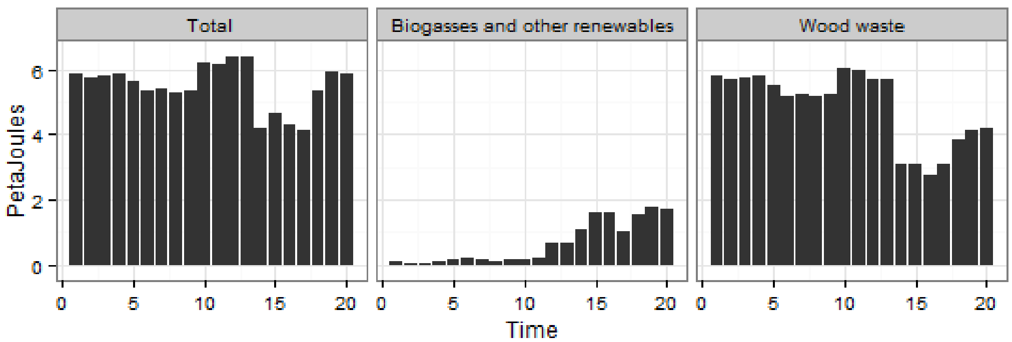
Figure 7.27 Use of renewable energy by main users and share of total energy use

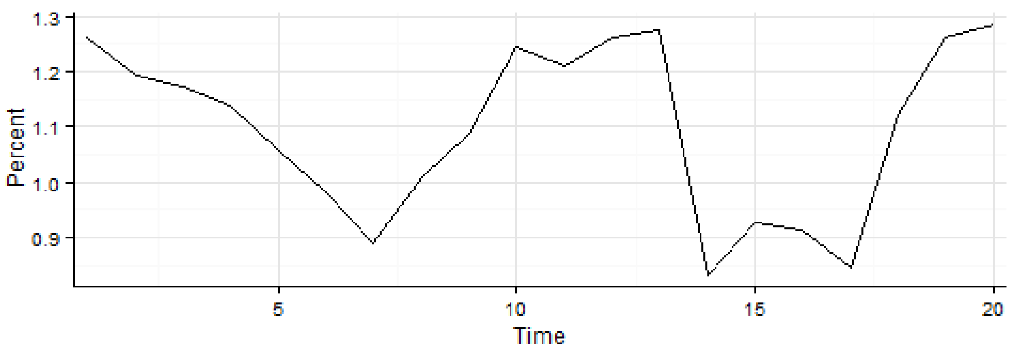
Households





Manufacturing





Electricity, gas, steam and air conditioning