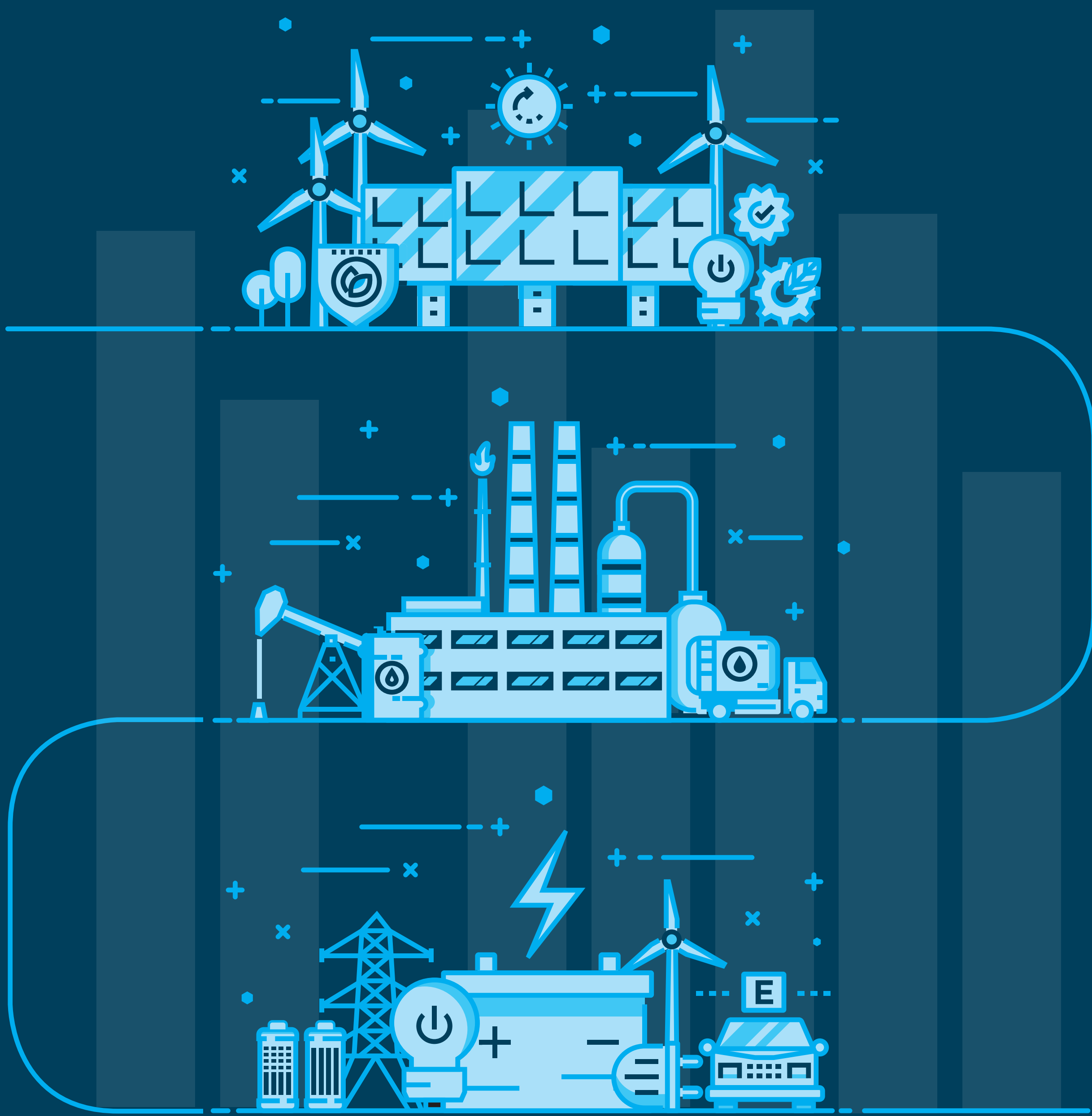
Department of Economic and Social Affairs

SEEA-Energy

System of Environmental-Economic Accounting for Energy



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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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Preface

The *System of Environmental-Economic Accounting for Energy* (SEEA-Energy) is a statistical framework consisting of a comprehensive set of tables and accounts for energy-related information. The concepts, definitions and classifications facilitate the organization of that information in support of policy analysis and research.

The starting point for the development of SEEA-Energy is the *System of Environmental-Economic Accounting 2012—Central Framework* (SEEA Central Framework), the international statistical standard for environmental-economic accounting. SEEA-Energy is a subsystem of the SEEA Central Framework and is entirely consistent with it. SEEA-Energy brings together the energy-specific tables and accounts of the Central Framework and elaborates in greater detail the links between energy accounts and energy statistics and balances, as described in the *International Recommendations for Energy Statistics* (IRES 2018). The aim of SEEA-Energy is to serve as a bridge between the statistical and energy communities.

SEEA-Energy was prepared under the auspices of the United Nations Committee of Experts on Environmental-Economic Accounting, as mandated by the Statistical Commission at its thirty-eighth session in 2007. The Committee of Experts, which is composed of senior representatives of national statistical offices and international organizations, is chaired by a representative of one of the country members of the Committee. The Statistics Division of the Department of Economic and Social Affairs of the United Nations Secretariat serves as the Committee secretariat. Regular oversight of the project was provided by the Bureau of the Committee.

As mandated by the Statistical Commission at its forty-seventh session, held from 8 to 11 March 2016, the Committee of Experts endorsed SEEA-Energy as the internationally agreed methodological document for energy accounts in support of the SEEA Central Framework.[1]

[1] See *Official Records of the Economic and Social Council, 2016, Supplement No. 4* (E/2016/24), chap. I, sect. B, decision 47/106.

Acknowledgements

Background

SEEA-Energy represents the outcome of a process that was notable for its transparency and the wide involvement of the international statistical community, economists and policymakers, among others. The process encompassed five steps:

(a) Identifying and reaching agreement on the topics and issues to be considered in the drafting of SEEA-Energy, including through the convening of members of the United Nations Committee of Experts on Environmental-Economic Accounting for this purpose;

(b) Gathering technical material and examples covering the various topics, including from the submissions of nominated contributors;

(c) Drafting and editing provisional chapters;

(d) Consulting with country representatives and experts on specific issues as well as on completed chapters;

(e) Preparation of a final draft of SEEA-Energy incorporating comments received at the consultation stage. That final draft was endorsed by the Committee of Experts on Environmental-Economic Accounting at its eleventh meeting in June 2016.[2]

[2] See minutes of the eleventh meeting (p. 10), available at https://unstats.un.org/unsd/envaccounting/ceea/meetings/eleventh_meeting/11th%20UNCEEA%20Minutes_Final.pdf.

Committee of Experts on Environmental-Economic Accounting and its Bureau

The following organizations and persons participated in the SEEA-Energy drafting process: the United Nations Committee of Experts on Environmental-Economic Accounting; international, regional and non-governmental organizations; project staff; many country agencies responsible for compiling official statistics; city groups; other expert groups; and individual experts in the economics, energy, policy and related fields from many regions of the world. As could be expected of the product of such a sustained and complex process, SEEA-Energy incorporates a diverse array of contributions.

At its thirty-sixth session in March 2005, the Statistical Commission established the Committee of Experts.[3] Its mandate was, inter alia, to oversee and manage the revision of SEEA.[4] The Committee of Experts is composed of senior representatives of national statistical offices and international agencies.

The preparation of SEEA-Energy was managed and coordinated by the Bureau of the Committee of Experts, which acts under the authority delegated by the Committee. The members of the Bureau are elected from among the members of the Committee. The Committee of Experts was chaired by Walter Radermacher (Germany), 2006–2008; and the Committee and its Bureau (which was formed in 2008), have been chaired by Peter Harper (Australia), 2009–2013; Ian Ewing (Australia, interim chair), 2013–2015; and Bert Kroese (Netherlands), 2015–2018.

[3] *Official Records of the Economic and Social Council, 2005, Supplement No. 4* (E/2005/24), chap. V, sect. A, para. 7.

[4] Ibid., *2009, Supplement No. 4* (E/2009/24), chap. I, sect. B, decision 40/104.

The following persons have served as members of the Bureau of the Committee of Experts: Peter Harper (Australia), 2009–2013; Ian Ewing (Australia), 2013–2015; Lisa Wardlaw-Kelly (Australia), 2015–2017; Karen Wilson (Canada), 2009–2011; Art Ridgeway (Canada), 2012–2013; Andre Loranger (Canada), 2013–2018; Peter van de Ven (Netherlands), 2009–2011; Geert Bruinooge (Netherlands), 2012–2013; Gerard Eding (Netherlands), 2013–2015; Bert Kroese (Netherlands), 2015–2018; Olav Ljones (Norway, Chair, Oslo Group on Energy Statistics), 2009–2015; Joe de Beer (South Africa), 2010–2017; Pietro Gennari (Food and Agriculture Organization of the United Nations), 2011–2017; Alessandra Alfieri, Paul Cheung, Ivo Havinga and Eszter Horvath (Statistics Division of the Department of Economic and Social Affairs of the United Nations Secretariat), 2009–2013; Pedro Diaz (Eurostat), 2009–2013; Brian Newson (Eurostat), 2013–2015; Anton Steurer (Eurostat), 2015–2018; Peter van de Ven (Organization for Economic Cooperation and Development), 2013–2018; Glenn-Marie Lange (World Bank), 2010–2018; Mark de Haan (Chair, London Group on Environmental Accounting), 2009–2012; and Joe St. Lawrence (Chair, London Group on Environmental Accounting), 2013–2016.

The staff of the Economic Statistics Branch of the Statistics Division, under the overall supervision of Ivo Havinga and with the assistance of Alessandra Alfieri, provided secretariat services to the Committee of Experts and its Bureau.

The following country representatives served as members of the Committee of Experts: Zaida Contreras, Mark Eigenraam, Ian Ewing, Peter Harper, Gemma van Halderen, Lisa Wardlaw-Kelly and Christine Williams (Australia); Norbu Ugyen (Bhutan); Luiz Paulo Souto Fortes, Jose Antonio Sena do Nascimento, Wadih Joao Scandar Neto, Eduardo Nũnes, Rebeca Palis and Sandra Silva Paulsen (Brazil); Martin Lemire, André Loranger, Art Ridgeway, Kevin Roberts and Robert Smith (Canada); Jiantang Chen, Huaju Li, Faqi Shi, Qin Tian, Yixuan Wang and Zhitao Zhang (China); Luz Amparo Castro, Monica Rodriguez Diaz, Paula Caballero Gómez, Carlos Eduarte Sepulveda Rico and Luz Dary Yepes Rubiano (Colombia); Ole Gravgård Pedersen, Bent Thage and Kirsten Wismer (Denmark); Miguel Jimenez Cornielle, Roberto Blondet Hernandez, Olga Luciano Lopez and Olga Diaz Mora (Dominican Republic); Mahmoud Ismail Sarthan (Egypt); Leo Kolttola (Finland); Guillaume Mordant and Claire Plateau (France); Sven Kaumanns, Michael Kuhn, Walter Radermacher and Karl Schoer (Germany); Ramesh Chand Aggarwal, Jogeswar Dash, James Mathew and Shri V. Parameswaran (India); Buyung Airlangga, Kecuk Suhariyanito and Slamet Sutomo (Indonesia); Cesare Costantino, Aldo Femia and Angelica Tudini (Italy); Khaled Alshatarat (Jordan); Zarinah Mahari (Malaysia); Raúl Figueroa Díaz (Mexico); Badamtsetseg Batjargal and Erdenesan Eldevochir (Mongolia); Karima Bensouda, Nezha El M. Rabet and Chaoui Souad (Morocco); Bastian Buck, Geert Bruinooge, Mark de Haan, Gerard Eding, Bert Kroese, Sjoerd Schenau and Peter van de Ven (Netherlands); Torstein Bye and Olav Ljones (Norway); Khalaf Al-Sulaimani (Oman); Lisa Grace Bersales, Lina V. Castro, Estrella Domingo, Romeo Recide and Raymundo Talento (Philippines); Sergey Egorenko, Igor Kharito and Andrey Tatarinov (Russian Federation); Aliilelua Salani (Samoa); Joe de Beer and Anemé Malan (South Africa); Inger Eklund, Viveka Palm and Nancy Steinbach (Sweden); Chris Mukiza (Uganda); James Evans, Melanie Giggs and Rocky Harris (United Kingdom of Great Britain and Northern Ireland); and Dennis Fixler and Dixon Landers (United States of America).

The following representatives of international organizations served as members of the Committee of Experts: Markus Lehmann (Convention on Biological Diversity secretariat); Jillian Campbell, Daniel Clarke, Margarita Guerrero and Joel Jere (Economic and Social Commission for Asia and the Pacific); Wafa Aboul Hosn (Economic and Social Commission for Western Asia); Xiaoning Gong and Emmanuel Ngok

(Economic Commission for Africa); Lidia Bratanova, Michael Nagy and Anu Peltola (Economic Commission for Europe); Salvador Marconi and Kristina Taboulchanas (Economic Commission for Latin America and the Caribbean); Jan-Erik Petersen, Caitriona Maire Maguire, Jock Martin and Jean-Louis Weber (European Environment Agency); Pedro Díaz Muñoz, Pieter Everaers and Anton Steurer (Eurostat); Pietro Gennari, Sachiko Tsuji and Francesco Tubiello (Food and Agriculture Organization of the United Nations); Manik Shrestha and Kimberly Zieschang (International Monetary Fund); Gernot Brodnig and Neil Cox (International Union for Conservation of Nature), Myriam Linster, Pierre-Alain Pionnier and Peter van de Ven (Organization for Economic Cooperation and Development); Yves de Soye, Linda Ghanimé, Maria Netto, Gabriel Normand, Massimiliano Riva, Tim Scott, Veerle van de Weerd and Riza Yikmaz (United Nations Development Programme); Kathleen Abdalla, Tariq Banuri, Matthias Bruckner, Jean-Michel Chéné, Manuel Dengo, Keneti Fausto, Liisa-Maija Harju, David O'Connor, Mary Pat Silveira and Friedrich Soltau (Division for Sustainable Development, Department of Economic and Social Affairs of the United Nations Secretariat); Hussein Abaza, Nicolas Bertrand, Jillian Campbell, Derek Eaton, Elliott Harris, Maaike Jansen, Pushpam Kumar, Jacqueline McGlade, Fulai Sheng, Guido Sonnemann and Jaap van Woerden (United Nations Environment Programme); Alessandra Alfieri, Ivo Havinga and Eszter Horvath (Statistics Division of the Department of Economic and Social Affairs of the United Nations Secretariat); Lis Mullin Bernhardt and William Reidhead (UN-Water); Sophia Ahlroth, Grant Cameron, Juan Pablo Castañeda, Kirk Hamilton, Barbro Elise Hexeberg, Glenn-Marie Lange, John M. Matuszak and Marian S. de los Angeles (World Bank) and Oliver Hermann and Clara van der Pol (World Tourism Organization).

Members of various international organizations contributed substantively to the drafting process, including Jessica Ying Chan, Julian Chow, Peter Comisari, Ole Gravgård Pedersen, Leila Rohd-Thomsen and Sokol Vako.

The Statistics Division of the Department of Economic and Social Affairs of the United Nations Secretariat has developed and maintains the project website (seea.un.org), which provides additional information on the contributions summarized here.

Expert group on energy accounts

An expert group on energy accounts composed of experts on energy statistics and environmental-economic accounts representing their countries or international agencies was convened to guide the drafting of SEEA-Energy. Members of the expert group included Peter Comisari, Karen Connaughton and Brendan Freeman (Australia); Barbara Mayer (Austria); Lies Janssen (Belgium); Joe St. Lawrence (Canada); Ole Gravgård Pedersen (Denmark); Jukka Muukkonen (Finland); Helmut Mayer (Germany); Geeta Singh Rathore (India); Sjoerd Schenau (Netherlands); Julie Hass, Kristine Kolsush and Olav Ljones (Norway); Alexander Kevesh (Russian Federation); Donna Livesey (United Kingdom of Great Britain and Northern Ireland); Stephan Moll (Eurostat); and Roberta Quadrell and Karen Treanton (International Energy Agency).

London Group on Environmental Acconting

The London Group on Environmental Accounting has discussed issues related to SEEA-Energy at several of its meetings.

The following persons have participated in meetings of the London Group since 2006: Alessandra Alfieri, Sofia Ahlroth, Anna Andriianets, Jairo Arrow, Charles Aspden, Giles Atkinson, Dominic Ballayan, Jose Miguel Barrios, Sacha Baud, Jean-Pierre

Berthier, Wolfgang Bitterman, James Blignaut, Michael Bordt, Gerhadt Bouwer, Gerry Brady, Lidia Bratanova, Hanna Brolinson, Ali Salim Buhroon, Torstein Bye, Julio Cabeca, Pablo Campos, Alejandro Caparrós, Annica Carlsson, Juan Pablo Castañeda, Maja Cederlund, Silvia Cerilli, Jean-Michel Chéné, Julian Chow, Kyusoong Chung, Peter Comisari, Emily Connors, Sebastian Constantino, Jeff Cope, Cesare Costantino, Jackie Crafford, Valeriano da Conçeiçao Levene, Jogeswar Dash, Michel David, Joe de Beer, Mark de Haan, Rixt de Jong, Arturo de la Fuente, Roel Delahaye, Raul Figueroa Diaz, Ilaria DiMatteo, Estrella Domingo, Gary Dunnet, Subagio Dwijosumono, Danuta Dziel, Derek Eaton, Mats Eberhardson, Bram Edens, Mark Eigenraam, Inger Eklund, Markus Erhard, Tammy Estabrooks, James Evans, Pieter Everaers, Federico Falcitelli, Aldo Femia, Brendan Freeman, Alessandro Galli, Per Arild Garnåsjordet, Jean-Yves Garnier, Ian Gazley, Chazhong Ge, Marina Anda Georgescu, Alfredo Gomez, Xiaoning Gong, Kyle Gracey, Cor Graveland, Ryan Greenaway-McGrevy, Patrice Gregoire, Roy Haines-Young, Jorge Hanauer, Jane Harkness, Peter Harper, Rocky Harris, Julie Hass, Ivo Havinga, Wafa Aboul Hosn, Li Huaju, Duong Manh Hung, Elisabeth Isaksen, Christine Jasch, Gary Jones, Matt Jones, Fredrik Kanlen, Aljona Karlõševa, Sven C. Kaumanns, Jawed Khan, Tonje Køber, Ester Koch, Kristine Kolshus, Michael Kuhn, Glenn-Marie Lange, Ursula Lauber, Sylvie Le Laidier, Cindy Lecavalier, Dongsoo Lee, Martin Lemire, Kirsty Leslie, Myriam Linster, Donna Livesey, Olav Ljones, Sandre Jose Macia, Monica Magaua, Zarinah Mahari, Anemé Malan, Lars Marklund, James Mathew, Farid Matuk, John Matuszak, Helmut Mayer, Robert Mayo, Warwick McDonald, Roeland Mertens, Kyung Sam Min, Stephan Moll, Elisabeth Mollgaard, Richard Mount, Chris Mukiza, Rainer Muthmann, Jukka Muukkonen, Michael Nagy, Urvashi Narain, Frederic Nauroy, Wahid Neto, Yvonne Newland, Brian Newson, Tea NõMann, Eduardo Nunes, Carl Obst, Martin O'Connor, Julio Oleas, Thomas Olsen, Kaia Oras, Sara Overgaard, Morrice Nyattega Oyuke, Viveka Palm, Jean-Louis Pasquier, Ole Gravgård Pedersen, Jan-Erik Petersen, Pierre-Alain Pionnier, Cristina Popescu, Walter Radermacher, Irene Ramashala, Elsa Varela Redondo, Kevin Roberts, Ute Roewer, Leila Rohd-Thomsen, Jesus Romo y Garcia, Giovanni Ruta, Masahiro Sato, Sjoerd Schenau, Karl Schoer, Paul Schreyer, José Antonio Sena do Nascimento, Fulai Sheng, Faqi Shi, Manik Shrestha, Gabriel Kulomba Simbila, Robert Smith, Tone Smith, Nancy Steinbach, Anton Steurer, Joe St. Lawrence, Suresh Sukumarapillai, Khalaf Al Suleimani, Jana Tafi, Raymundo Talento, Peter Tavoularidis, Joachim Thomas, Qin Tian, Karen Treanton, Sachiko Tsuji, Angelica Tudini, Arnold Tukker, Stephanie Uhde, Sokol Vako, Stefan van der Esch, Gemma van Halderen, Maarten van Rossum, Michael Vardon, Anders Wadeskog, Yixuan Wang, Jeremy Webb, Jean-Louis Weber, Adrian Whiteman, Fang Yu, Žiga Žarnić, Kimberly Dale Zieschang and Oliver Zwirner.

Other expert groups

Other consultations also informed the process. These included meetings of the Olso Group on Energy Statistics that discussed issues related to energy accounts at several of its meetings.

Country contributions

National statistical offices, ministries responsible for energy, ministries responsible for the environment and other national agencies made significant in-kind contributions to the drafting of SEEA-Energy. Forty-eight countries and international organizations submitted comments during the broad consultation on the draft, held in January and February 2013. Heads of national statistical offices contributed to the process through their participation in the work of the Statistical Commission.

Abbreviations and acronyms

GDP	gross domestic product
IEA	International Energy Agency
IRES	International Recommendations for Energy Statistics
ISIC	International Standard Industrial Classification of All Economic Activities
OECD	Organization for Economic Cooperation and Development
SEEA	System of Environmental-Economic Accounting
SIEC	Standard International Energy Product Classification
UNFC 2009	United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources
2008 SNA	System of National Accounts 2008

Contents

Tables

Note: The data presented in all he tables and figures contained in the present publication have been generated for illustrative purposes only and do not correspond to any real-world situations.

Figures

Chapter I
Introduction

1.1. What is the *System of Environmental-Economic Accounting for Energy* (SEEA-Energy)?

1.1. The *System of Environmental-Economic Accounting for Energy* (SEEA-Energy) is a multipurpose conceptual framework for organizing energy-related statistical information. It supports analysis of both the role of energy within the economy and the relationship between energy-related activities and the environment.

1.2. The concepts and definitions that underpin 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 resources.

1.3. At the core of SEEA-Energy is an accounting approach that records the stocks and flows of energy within the territory of reference. This accounting approach is based on the *System of Environmental-Economic Accounting* (SEEA), a conceptual framework that has been developed over the past two decades to integrate the measurement of environmental and economic phenomena. In particular, SEEA-Energy is a subsystem of the *System of Environmental-Economic Accounting 2012—Central Framework* (SEEA Central Framework), which was adopted by the Statistical Commission in 2012 as the international statistical standard for environmental-economic accounts.[5] More broadly, SEEA-Energy and the SEEA Central Framework are satellite accounts of the *System of National Accounts 2008* (2008 SNA).[6]

1.4. Drawing on the *International Recommendations for Energy Statistics* (IRES 2018),[7] SEEA-Energy formalizes the possible range of accounts required to inform policymakers, analysts and the public at large. This entails the presentation of an integrated set of energy stock and flow accounts in physical and monetary terms as well as combined presentations of physical and monetary data on energy-related matters. IRES, which was adopted by the Statistical Commission at its forty-second session in February 2011,[8] provide guidance on relevant concepts and definitions, classifications, data sources and data compilation issues 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 within monetary supply and use tables. As regards stocks, SEEA-Energy expands the typical focus of energy statistics (which record physical extraction of mineral and energy resources) so as to encompass the assignment of monetary values for the resources and depletion arising from extractions. In particular, the monetary measure of depletion can be directly related to physical measures of extraction of energy from natural inputs, and is at the same time a component of the calculation of such measures as depletion-adjusted national saving and depletion-adjusted gross domestic product (GDP).

[5] See *Official Records of the Economic and Social Council, 2012, Supplement No. 4* (E/2012/24), chap. I, sect. B, decision 43/105, para. (c).

[6] European Commission, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations and World Bank, *System of National Accounts 2008* (United nations publication, Sales No. E.08.XVII.29).

[7] *International Recommendations for Energy Statistics (IRES),* Statistical Papers, Series M, No. 93 (United Nations publication, Sales No. E.14.XVII.11), hereafter referred to as "IRES 2018".

[8] *Official Records of the Economic and Social Council, 2011, Supplement No. 4* (E/2011/24), chap. I, sect. B, decision 42/105, para. (b).

1.6. SEEA-Energy has not been designed to replace various existing types of energy information in all their richness and depth. Instead, the value added of SEEA-Energy lies in its ability to bring a broader and more structured perspective to bear on the energy-related information already available. Through their coherence with SNA, the data in the energy accounts can be easily linked with other information collected for the national accounts, which allows for a more detailed and policy-relevant analysis of energy information.

1.7. The capacity of SEEA-Energy to link energy accounts with economic and other environmental accounts underlines its power. Essential to the formulation of a policy response to an environmental issue such as climate change, which is affected by energy-related emissions of carbon into the air, is understanding both human impacts on the physical environment (through determining, for example, which industry is generating the carbon emissions and the energy products involved); and energy needs and possible constraints and solutions (through determining, for example, ongoing energy requirements and what kind of low-carbon energy sources can be utilized).

1.8. Information generated from SEEA-Energy accounts can also enhance the understanding of issues related to the effects of using economic instruments (such as tradable carbon emission permits) on both the economy and the environment. Those effects may include impacts on energy prices, household spending and business profitability and, crucially, on emissions of carbon generated by domestic producers and as embodied in imports.

1.9. It should be noted that one of the benefits of SEEA-Energy is derived from its implementation at an international level. A significant advantage that arises from the widespread adoption of SEEA-Energy is the ability to compare and contrast relevant information across a range of countries, particularly with regard to energy-related issues that are multinational or global in character.

1.2. Policy relevance and uses of SEEA-Energy

1.10. As energy plays an integral role in the life of humans, how we use it becomes an essential consideration within the context of sustainable development. The effect on the environment of our energy use is a critical policy issue. Concerns are growing regarding the impact of countries' energy use and related emissions globally as well as upon local environments. At the same time, it is recognized that continuing human welfare and development are dependent upon the benefits to be derived from energy use.

1.11. With regard to informing policy decisions related to the supply and use of energy, the SEEA-Energy framework functions as a multipurpose system, which can (a) provide broad guidance on those issues and areas of concern that should be the focus of decision makers tasked with formulating indicators of progress towards policy objectives, including the Sustainable Development Goals; (b) enrich, through its detailed information, our understanding of the issues including potential identification of the key drivers of change; and (c) support the development of models and scenarios for use in assessing the possible intra- and intercountry impact of specific policies.

1.12. SEEA-Energy and IRES provide the conceptual framework for monitoring progress towards realizing energy policy objectives both in countries and on an international scale. Energy policy involves several actors, including civil society, enterprises and political entities. These actors differ in their perspectives and interests, and exert pressure on different components of the energy sector and the environment.

1.13. The use of energy by households and industry imposes a broad range of pressures on the physical environment, which are a result of the specific choices regarding energy supply and use that are made both at the national level (the decision to build, for example, new hydropower plants or to adopt widespread use of coal-powered electricity) and at a more local level. Those choices give rise to pressures in terms of both depletion of non-renewable sources and environmental degradation arising from energy-related emissions or shifts towards the use of energy from renewable sources. Those pressures impact, inter alia, the stocks of mineral and energy resources and air and water quality.

1.14. Environmental pressures often impact the policy dimension, resulting in the development of responses to these pressures by actors from the realms of politics, enterprises and civil society. Given the range of actors involved in energy-related policymaking, fully informed decisions on energy policy require utilization of multidisciplinary information systems to ensure effective alignment among the various competing social, economic and environmental interests.

1.15. The specific characteristics and needs of each country will determine the degree to which any particular type of policy aimed at achieving secure and sustainable energy production and use will be emphasized. In general, however, countries' overarching policy objectives can typically be framed within three major categories: improving energy distribution and access; managing energy supply and demand; and reducing environmental pressures associated with energy supply and use.[9]

[9] Mitigating disaster risks can also be an energy policy objective.

1.16. The first objective, *improving energy distribution and access* requires policies whose aim is 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 provides a range of measures, including information on capital outlays, designed to guide policymakers in assessing those providers' overall performance in supplying energy.

1.17. SEEA-Energy accounts can also monitor the various energy products supplied to households, government and enterprises (as well as energy products that are exported) and thereby assist policymakers in their efforts to ensure uninterrupted provision of energy supply services. Capturing the cost of the energy products offered to energy users is an important undertaking. Costs associated with providing these services, including current and future capital costs as well as the means of financing operations, need to be taken into account. SEEA-Energy can provide, on an ongoing basis, the information required to assess the operational efficiency of energy providers. This is significant since, in general, providers should be able to deliver a service reliably to energy users, recover the costs of providing these services and generate a return sufficient for addressing recurrent capital needs, such as infrastructure repairs and upgrades, while remaining commercially viable.

1.18. The second objective, *managing energy supply and demand*, requires policies that address issues related to energy supply and allocation. Energy accounts can be used in policy implementation to monitor the amounts of energy allocated for different uses, both by the *type of user* consuming the energy and by the *purpose of use*. It is essential to measure the allocation of energy, as certain resources such as timber and oil resources are scarce and should be used efficiently. Energy accounts can link information on the use of energy products by industries to the associated value added generated by those industries. This information can be further assessed alongside information on the relative prices paid for energy products by different consumers.

1.19. *Managing energy supply and demand* is closely linked with the first objective of *improving energy distribution and access.* A policy whose primary goal was either of these two objectives would, in pursuing that objective, have an effect on the other. The major distinction between these objectives lies in the fact that improving energy distribution and access is generally focused on energy availability, while the focus of managing energy supply and demand is usually on how the available energy is used.

1.20. Underpinning the third objective, *reducing environmental pressures associated with energy supply and use,* is the recognition that energy production can generate adverse environmental outcomes, including impacts on, for example, land use, water quality, biodiversity and air quality. In this respect, it is important to identify and measure the variables associated with energy production and delivery that may exert a negative environmental impact such as coal combustion-related sulfur dioxide (SO_2) emissions or gas use–related carbon dioxide (CO_2) emissions. SEEA-Energy can provide information on taxes and other instruments aimed at controlling these variables (such as tradable carbon emission permits) and, through its links to SNA framework, SEEA-Energy can connect such policies with their impact on measures such as household expenditure and saving, government revenue and GDP.

1.21. Expenditure on environmental protection and resource management activities related to energy supply are also relevant to this objective. SEEA-Energy captures both current expenditures and relevant investment expenditures, including, among others, those related to (a) carbon capture and storage and (b) the infrastructure for capturing energy from renewable sources. Various categories of environmental clean-up, including costs of decommissioning coal mines and energy-related equipment, are recorded in SEEA-Energy.

1.22. Underpinning this objective is a recognition of the importance of management of energy from natural inputs. In this respect, SEEA-Energy provides several fundamental extensions to information presented in 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 of depletion-adjusted measures of economic activity.

1.23. The SEEA-Energy framework supports several applications that can inform a variety of policy-related interests. For example, the framework supports the estimation of carbon emissions required for the production of 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 *improving energy distribution and access* and *managing energy supply and demand* (as discussed above). It should be noted that a full assessment of the carbon "footprint" of the country would consider carbon embedded in imports; this information is also relevant for *reducing pressures on the environment*.

1.24. Owing to the nature of energy issues, a full understanding of the implications of energy-related decisions requires the measurement of a large range of variables. Measurement of progress towards the achievement of the goals set out in each of the policy categories described above therefore requires integrated information systems, which would assist in the collection of data and their conversion to information to be used in baselining, monitoring progress and identifying trends. More importantly, these systems would provide the capacity to consider various environmental and economic dimensions of energy-related policy questions within a single framework. A comprehensive conceptual framework is therefore required to guide the process of data integration and the transformation of those data into policy-relevant information. SEEA-Energy is the framework capable of meeting this need.

1.3. SEEA-Energy as a system

1.25. SEEA-Energy, which consists of a coherent, consistent and integrated set of tables and accounts related to energy, provides information 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 can 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

1.26. In general, the accounts are compiled within the context of a national economy, defined in accordance with SNA and the SEEA Central Framework. In geographical 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 recognized). The economic units of interest are determined to be those enterprises, households and governments with a centre of interest in the economic territory (on the basis of a concept known as the residence principle). The economy is defined by the production, consumption and accumulation activities 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.

1.27. 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

1.28. There are three main types of accounts in the SEEA framework: (a) physical flow accounts, (b) monetary flow accounts for energy-related transactions and (c) asset accounts in physical and monetary terms. Descriptions of these three types of accounts form the core of SEEA-Energy as explained in chapters III–VI.

Physical flow accounts

1.29. In physical flow accounts for energy, energy flows are recorded in physical units. The aim of these physical flow accounts is to record flows of energy (a) from the environment to the economy, (b) within the economy (as energy products) and (c) from the economy to the environment (as losses, mainly in the form of dissipative heat). Within SEEA-Energy, the joule, which is the unit used to express physical energy flows, provides a common basis for their direct comparison and/or combination. In other types of accounts, physical flows of energy may be recorded in a variety of units. For example, mass units (e.g., tons) and volumetric units (e.g., cubic metres) are utilized in material flow accounts.

1.30. Accounting for these various physical flows entails the application of the basic laws of the conservation of mass and energy, as well as accounting rules covering 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 for non-energy purposes and the immediate return of those inputs to the environment (through, for example, the flaring of natural gas during its extraction). In addition, within the economy, the supply of energy products must equal their use (with relevant adjustments for the trade in goods and services between countries). Finally, the economy's generation of residuals must be matched either by their collection by other economic units (as in the use of fly ash in building materials[10]) or by their release to the environment. Energy produced through the incineration of solid waste is recorded in the accounts as supplied from within the economy.

[10] In practice, residuals collected by other economic units may have no energy content or if there is some energy content, its value may be unknown.

1.31. Accounting for the various physical energy flows in this way serves as the basis for constructing a physical supply and use table in which the various types of energy-related physical flows can be recorded. The physical supply and use table in SEEA-Energy is based on supply and use tables of the SEEA Central Framework, which have been developed for environmental-economic accounting more generally. The physical supply and use table for SEEA-Energy includes energy flows only in joules. For example, although all timber could potentially be used as a source of both heat and energy, flows of timber are included in the SEEA-Energy accounts only when its use is to be energy-related.

Monetary flow accounts for energy-related transactions

1.32. Many of the physical flows of energy have corresponding monetary flows reflecting various transactions between economic units, that is, industries, households and governments. For example, the use of refined petroleum products by households cannot only be measured physically in joules, but also recorded in terms of household spending on these products. All such transactions between economic units are recorded in SNA.

1.33. Accordingly, in addition to being recorded in physical terms in the physical supply and use tables, flows related to the supply and use of energy products are recorded in monetary terms in the monetary supply and use tables for energy. Monetary supply and use tables for energy, however, have a narrower scope than the corresponding physical supply and use tables, since they record flows of energy products solely *within the economy* and not *between the economy and the environment*.

1.34. Other energy-related transactions are of interest as well. Many of them are related to the environment, including transactions associated with activities that reduce or eliminate pressures on the environment and that aim at making more efficient use of energy resources, such as investment in technologies designed to prevent or reduce pollution and in technologies whose application leads to more efficient use of energy.

1.35. Taxes and subsidies are two of the tools relied upon by government to implement policies. Given the policy interest in certain energy-related monetary flows to and from government for environmental purposes, it is appropriate to measure energy-specific taxes and subsidies and similar flows (such as investment grants for capturing renewable sources of energy).

1.36. Several other economic aggregates, related to extraction and exploration activity, would likely be of interest. In this regard, measures of value added, as well as rent payments for access to 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, the condition of a country's gas extraction infrastructure). All of this information can be organized into relevant accounts for energy-related transactions.

Asset accounts in physical and monetary terms

1.37. Measurement of the quantity of mineral and energy resources, including changes in these resources over time, is a central feature of SEEA-Energy. Asset accounts focusing on the various components of mineral and energy resources 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 such factors as extraction, discovery and catastrophic loss.

1.38. The compilation of asset accounts in physical terms provides valuable information on mineral and energy resource availability. An important facet of the SEEA-Energy asset accounts is their estimation of the depletion of mineral and energy resources in physical terms. For those resources, the quantity of depletion is equal to the quantity of the resource extracted.

1.39. The information yielded through the compilation of asset accounts in monetary terms can provide valuable assistance in understanding the relationship between rates of extraction and current economic activity, as well as the economic costs of extraction as related to future incomes. The monetary value of depletion used in asset accounts is the same as the valuation used in the depletion-adjusted measures of income and savings.

1.40. Market prices are the underlying basis for valuation of stocks of mineral and energy resources in SEEA-Energy just as they are the basis for valuation in 2008 SNA (para. 3.119) and the SEEA Central Framework (para. 2.143). Using market prices for this purpose enables mineral and energy resources to be readily compared with produced and financial assets.

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

Relationships between the accounts

1.42. The various accounts within the SEEA-Energy framework are connected, although each focuses on a different dimension of the interaction between the economy and the environment. For example:

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

1.43. Such examples serve to highlight the variety of relationships subsisting among the accounts, with each reflecting a different perspective. Those relationships are elucidated through the application of the common concepts, definitions and classifications underpinning the SEEA-Energy framework.

1.3.3. Building on existing energy-related information

1.44. SEEA-Energy relies heavily on energy statistics for the basic inputs required for its implementation. The concepts, definitions, data sources, methods of data compilation and quality assessment, and classifications covered by IRES are used to provide the basic data needed to compile SEEA-Energy accounts and tables. For example, the energy balances presented in IRES are constructed according to an organizing principle very similar to the principle underpinning the physical supply and use table. Further, IRES and SEEA-Energy utilize the same definitions of energy products. In effect, SEEA-Energy has been developed through organizing data collected based on IRES within a framework coherent with SNA. IRES therefore constitute a framework that is complementary to SEEA-Energy and supports its implementation.

1.45. SEEA-Energy, as an integrated accounting system, stands apart from individual sets of energy statistics. While sets of energy statistics are usually internally consistent, there is often no strict consistency between one set of statistics and another, in many instances, for a good reason. As energy statistics are frequently collected with a particular regulatory or administrative purpose in mind, their structure may be specific to that purpose. With respect to existing energy statistics, it is often the case that the industrial classification used to categorize the use of energy products by industries is not the *International Standard Industrial Classification of All Economic Activities* (ISIC) (which is applied in the SEEA Central Framework and the suite of international standards for economic statistics, including SNA). The use of ISIC in energy statistics would allow the incorporation of these statistics in physical flow accounts and combined accounts.

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

1.47. Finally, an important difference between energy statistics and SEEA-Energy is the coherence of SEEA-Energy with the economic information of SNA and other environmental-economic accounts of both the SEEA Central Framework and its other subsystems. Such coherence adds considerable value to both physical and monetary information, as it facilitates integrated analyses within a common framework.

1.48. It is reasonable to expect that, over time, the implementation of SEEA-Energy and IRES will result in changes related to how energy statistics are collected and structured within a given country. Close collaboration between those tasked with compiling energy statistics and those responsible for energy accounts will assist in the creation of a multipurpose system that contributes to the collection and dissemination of energy information. The beneficiaries would include, among others, policymakers in the energy field and members of the community who benefit from better-informed policy decisions.

1.3.4. Combining information in physical and monetary terms

1.49. One of the most powerful features of SEEA-Energy is its organization of information in both physical and monetary terms within a context of consistency in scope, definitions and classifications. The power of SEEA-Energy in this regard is especially evident in 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 measurement (e.g., decoupling of energy use from economic output, decoupling of energy use from emissions to air, or cost per joule of various energy products used by diverse industries), the questions of interest and the availability of data. On the other hand, combined presentations have certain characteristics in common and share certain similarities with respect to the benefits they yield.

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

1.51. Second, combined presentations promote dialogue between persons familiar with data organized according to economic accounting structures and those familiar with information organized with reference to specific physical flows. Thus, combined presentations provide a basis for integrating analyses of energy-related, environmental and economic issues and thereby reduce the tendency to analyse those issues independently of one another.

1.52. Third, combined presentations structure information in such a way as to support the derivation of policy-relevant indicators, for example, decoupling indicators that are defined as the ratio of the use of energy from natural inputs to growth in production and consumption.

1.53. 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.

1.54. Overall, the power of SEEA-Energy and its standard concepts and definitions is clearly on display in the development of presentations that combine physical and monetary data.

1.3.5. Flexibility in implementation

1.55. 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 as a whole. A country may choose to implement only selected accounts included in SEEA-Energy, basing such decisions on policy priorities and the extent and type of its mineral and energy resources, the characteristics of its energy production and use, and any specific energy-related issues it faces. Even if a country eventually aims towards implementing the full system, it may decide to focus initial efforts only on the accounts that are most relevant to the issues it most urgently wishes to address.

1.56. For example, a country with few mineral and energy resources may choose not to compile asset accounts for those resources. Even countries with abundant mineral and energy resources may wish to concentrate first on the inputs with the greatest economic value, or on those that have become subjects for discussion regarding how government appropriates revenue from their extraction.

1.57. Countries with a high level of dependence on imports of certain energy products may find it useful to build physical flow accounts for those products in order to highlight which industries and outputs are most affected by this dependence. Such countries might focus on compiling physical flow accounts for only those energy products whose imports are policy-relevant rather than on compiling physical flow accounts for all energy products.

1.58. If a country is concerned about reducing its energy-related carbon emissions through the use of tradable permits to emit carbon, it would most likely be concerned as well about the use of specific types of energy products (as detailed in the physical flow accounts) and the carbon emissions resulting from their use, as well as the industries and households using those products.

1.59. These examples illustrate the flexibility of application of SEEA-Energy. It is important to bear in mind, however, that regardless of which parts of SEEA-Energy are implemented, they should be implemented in such a way as to ensure their internal consistency and complementarity to the broader system as a whole.

1.4. SEEA-Energy and related statistical standards and publications

1.60. The integrated character of SEEA-Energy, in particular its coverage of data in both physical and monetary terms, signifies that it has a relationship with several other international statistical standards and frameworks, namely: (a) the SEEA Central Framework and other SEEA subsystems; (b) IRES; (c) SNA and related economic accounts-related standards; and (d) standard international classifications. These relationships are described below.

1.4.1. SEEA-Energy and related manuals for environmental-economic accounting

1.61. The SEEA Central Framework, the international statistical standard for environmental-economic accounting, has been the starting point for the development of SEEA-Energy, which is a subsystem of, and entirely consistent with, the Central Framework. Bringing together the energy-specific tables and accounts of the SEEA Central Framework, SEEA-Energy elaborates in greater detail the links between energy accounts and the energy statistics and balances presented in IRES.

1.62. As users of the present manual may include energy statisticians/analysts and national/environmental accountants, it is designed to serve as a bridge between the two communities through elaboration of (a) energy-related concepts that are familiar to energy statisticians and (b) accounting concepts and rules, including the integration of basic energy statistics into the accounting framework, which are familiar to national/environmental accountants. One of the contributions of SEEA-Energy is its all-encompassing presentation of the linkages between energy statistics-related concepts and the concepts applied to energy accounts. Being fully consistent with the SEEA-Central Framework and coherent with IRES, SEEA-Energy can serve as a useful tool for experts from a variety of disciplines who are engaged in the compilation of energy accounts.

1.63. The unique scope of SEEA-Energy includes a further elaboration of the definitions and concepts related to energy from natural inputs, energy products and energy residuals; an explicit extension of physical flow accounts to encompass own use of energy products; the derivation from the physical flow accounts of several related tables, including those on energy transformation and end use of energy; a discussion of monetary accounts that includes energy transactions; and a presentation of physical and monetary asset accounts not only for mineral and energy resources but also for inventories of energy products.

1.64. The SEEA Central Framework constitutes the overarching fabric of all SEEA subsystems, which were constructed to present more detailed structures and explanations. There may sometimes be overlap in the scope of the issues considered by different subsystems, in which case more than one subsystem would end up addressing the same issue. For example, the practice of hydraulic fracturing for the release of coal seam gas is related to both hydrological systems and the production of energy. Hence, an integrated analysis of economic and environmental aspects of this issue could potentially utilize data from both SEEA-Water and SEEA-Energy, as well as from the SEEA Central Framework.

1.4.2. SEEA-Energy and IRES

1.65. SEEA-Energy has a close relationship with IRES, which contributes valuable inputs into the production of the tables and accounts of SEEA-Energy. In particular, IRES support the use of harmonized definitions of energy products in accordance with the Standard International Energy Product Classification (SIEC) and offer guidance regarding data sources and data compilation. In cases where a country has produced energy statistics and energy balances in accordance with IRES, the compilation of SEEA-Energy tables and accounts becomes an extension to the existing body of official energy statistics.

1.66. The concepts presented in IRES are therefore a key input to SEEA-Energy. However, it should be noted that several important extensions and adjustments to those concepts are needed before they can be integrated in physical and monetary accounts following the principles of SNA. In addition, SEEA-Energy incorporates several structures that are needed for integrated environmental-economic analyses in the area of energy. The differences between SEEA-Energy and IRES are discussed further in section 3.4.

1.67. It should be emphasized that as SEEA-Energy remains a conceptual manual, it needs to be supported by manuals focused on compilation. In this regard, the Eurostat manual on physical energy flow accounts, entitled "PEFA guidelines for data collection 2017" (1 June 2017), provides some general compilation guidance.

1.4.3. SEEA-Energy and 2008 SNA

1.68. The relationship between SEEA-Energy and SNA is a fundamental one. 2008 SNA is the conceptual framework used as a reference for the SEEA and, by extension, for SEEA-Energy. Indeed, in many respects, SEEA-Energy may be viewed as a satellite account of 2008 SNA.

1.69. As many of the accounting concepts and definitions used in SEEA-Energy are drawn from SNA, users of SEEA-Energy may need to consult 2008 SNA for more detailed guidance on particular accounting issues. However, these systems need to be distinguished in their treatment of two primary areas, namely: (a) the scope of the recording of physical flows compared with monetary flows (which is somewhat broader in SEEA-Energy in that it includes, inter alia, own use of energy); and (b) the incorporation in SEEA-Energy of depletion from the extraction of mineral and energy resources not only as a reduction in the value of these resources but also as a cost against the income earned from that extraction. The SEEA-Central Framework must be distinguished from 2008 SNA in the same way.

1.4.4. SEEA-Energy and standard international classifications

1.70. 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 by countries of standard international classifications where they are available.

1.71. Several classifications used in SEEA-Energy are key to integrated environmental and economic analysis, including the classification of economic units into industries under the above-mentioned ISIC; and the also above-mentioned SIEC. These classifications are used throughout SEEA-Energy and the SEEA Central Framework.

1.72. SEEA-Energy uses SIEC in the physical measurement of energy products. Monetary flows of energy products, on the other hand, are often classified using the Central Product Classification. As a one-to-one relationship does not exist between SIEC and Central Product Classification categories, a correspondence between these classifications will be needed for detailed analysis of combined physical and monetary data sets. For the assessment of the status of different mineral and energy resources, the *United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources* (UNFC-2009)[11] is the relevant international standard.

[11] United Nations, Economic Commission for Europe, *United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009*, ECE Energy Series No. 39 (2010).

1.73. A range of additional listings and categorizations whose aim is to support the compilation of data are found in SEEA-Energy as well, including a breakdown of the types of residuals. While these are not standard statistical classifications, they do provide an structure for compilation and international comparison.

1.74. The organization of data following standard classifications is an important step towards facilitating 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

1.75. As the conceptual framework presented in this publication has been designed for application around the world, it necessarily reflects the recognition that different conditions and different institutional arrangements may prevail in different countries, especially with regard to developed countries as compared with developing countries. It is hoped that the rationales offered for the methods used will help enable statisticians to decide on the proper approaches within the context of future developments and new institutional arrangements.

1.76. The publication does not attempt to provide guidance on the making of estimates or on prioritization with respect to the implementation of different accounts. Specialized guidance on economic statistics-related accounting is available in 2008 SNA.

1.77. Provided directly below is an overview of the chapters that follow.

1.5.2. A chapter-by-chapter reader's guide to SEEA-Energy

1.78. SEEA-Energy comprises seven chapters. The introductory first chapter encapsulates the policy relevance of SEEA-Energy, sets forth the general aims and purposes of environmental and economic accounting for energy and briefly outlines key elements of the SEEA-Energy framework and its place in the broader suite of statistical information and conceptual frameworks associated with environmental and economic measurement.

1.79. Chapter II, entitled "SEEA-Energy framework", examines the key elements of SEEA-Energy and the accounting approach used, while noting that most of the organizing principles and accounting rules used in SEEA-Energy are drawn from the SEEA Central Framework. The main types of accounts and the key classifications used in SEEA-Energy are covered, along with the basic principles of accounting for stocks and flows, the definition of economic units and principles of valuation.

1.80. Chapter II highlights an important facet of SEEA-Energy—its integrated character. This signifies that different components of the framework are governed by a common accounting approach. A description of the concepts and building blocks used in combining physical and monetary data concludes the chapter.

1.81. Chapter III, entitled "Physical flow accounts", offers a detailed examination of how SEEA-Energy handles the recording of the different physical flows (i.e., of energy from natural inputs, energy products and energy residuals), which are organized within a physical supply and use table. The chapter focuses on the boundary between the economy and the environment within a context where flows of energy products are considered to be "within the economy" while flows of energy from natural inputs and energy residuals are regarded as "from the environment to the economy" and "to the environment from the economy", respectively.

1.82. Besides presenting physical supply and use tables that follow the general structure of those in SEEA Central Framework, that chapter describes the different types of flows that make up the physical supply and use of energy, including production, consumption, changes in inventories, and exports and imports; discusses energy use by purpose and presents an illustrative physical use table; and examines in detail the relationship between energy statistics, energy balances and energy accounts and the use of bridge tables to link energy balances and energy accounts.

1.83. Chapter IV, entitled "Monetary flow accounts", focuses on identifying economic transactions within SNA that are considered to be energy-related. It presents a supply and use table for energy products, measured in monetary terms.

1.84. In that chapter, particular attention is paid to the energy-related transactions that have clear-cut implications and significance for the environment. These include various types of energy-related taxes, subsidies and similar transfers, as well as a range of other payments and transactions that are all recorded within SNA framework but often are not explicitly identified as related to the environment.

1.85. Chapter IV also covers the topic of combined monetary and physical presentations, a key area where SEEA-Energy demonstrates its capacity to inform energy-related interactions between the economy and the environment.

1.86. Chapter V, entitled "Physical asset accounts for mineral and energy resources", focuses on the recording of physical stocks and flows associated with mineral and energy resources; discusses the UNFC-2009 that is used to determine which mineral and energy resources meet SNA definition of an economic asset; and presents a physical asset account along with a detailed description of the various data items within it. Many practical and conceptual measurement challenges that are uniquely associated with energy assets are discussed in chapters V and VI.

1.87. Chapter VI, entitled "Monetary asset accounts for mineral and energy resources and for energy product inventories", describes the monetary valuation of those mineral and energy resources that are considered economic assets; and establishes the essential link between physical asset accounts as presented in chapter V and the accounts of 2008 SNA. Monetary asset accounts are presented and the structure and principles underpinning those accounts are described.

1.88. That chapter also provides a detailed example of the application of the net present value approach to the valuation of mineral and energy resources and discusses discount rates and other factors that are important within the context of this approach.

1.89. The aim of chapter VII, entitled "Uses of energy accounts", is to build a bridge with those who, in conducting specific research on energy-related environmental-economic topics, could employ SEEA-Energy data sets. In pursuit of that aim, a different perspective from that of the other chapters has been adopted. A demonstration is provided of how analyses of energy-related interactions between the economy and the environment might be carried out and, in that regard, various extensions and techniques entailing the use of data from SEEA-Energy are presented. The chapter also discusses the potential application of the energy accounts to inform the Sustainable Development Goals and introduces a range of relevant indicators that can be compiled using information contained in the accounts.

Chapter II
SEEA-Energy framework

2.1. Introduction

2.1. The conceptual framework of SEEA-Energy, which is a subsystem of the SEEA Central Framework and is fully consistent with it, focuses exclusively on energy. SEEA-Energy provides further details on issues related to energy accounting as well as guidance on the utilization of several additional tables that can be of use to policymakers, researchers and the public at large. The consistency of SEEA-Energy with the SEEA Central Framework ensures that the principles that it applies are consistent with 2008 SNA. SEEA-Energy can be used to assess such factors as changes in energy intensity and decoupling of energy use from economic production. This means, significantly, that SEEA-Energy can provide information on challenges within the broader context of integrated environmental-economic accounting, such as how energy-related issues relate to various environmental protection activities. The present chapter provides an overview of the SEEA-Energy accounting structure, including its rules and recording principles.

2.2. The IRES recommendations with regard to, inter alia, the data items that should be collected and the concepts, definitions and classifications relevant for energy statistics and energy balances, provide a basis for the production of high-quality energy statistics. Basic energy statistics that are collected according to IRES can serve as a data source for the compilation of the physical supply and use tables in SEEA-Energy. Building upon basic energy statistics, SEEA-Energy (a) produces an integrated set of accounts that allow for full accounting of energy-related stocks and flows, in physical and/or monetary terms and (b) combines the presentations of those physical and monetary data. The SEEA-Energy framework is underpinned by a systems approach that ensures that there is full coverage without gaps or overlaps and that all the statistics within SEEA-Energy can be interrelated.

2.3. The SEEA-Energy framework expands the conventional economic measurement framework (i.e., SNA) to incorporate flows between the economy and the environment, and to highlight certain environmental activities and expenditures that are not shown explicitly in conventional national accounts presentations. The SEEA-Energy framework also encompasses mineral and energy resources, both inside and outside of the scope of conventional economic measurement, and records stocks of mineral and energy resources and changes in those stocks over time.

2.4. Section 2.2 places various energy-related dimensions of the economy and the environment within a coherent context. Using the broad framework examined in section 2.2, section 2.3 presents the accounting structure of SEEA-Energy, as exhibited through its supply and use tables, asset accounts and functional accounts. Sections 2.4 and 2.5 discuss economic units and classifications, respectively.

2.5. Section 2.6 focuses on a range of specific accounting rules and principles that form the basis for the recording of accounting entries and the compilation of SEEA-Energy accounts. The concluding section introduces the topic of combined presentations of physical and monetary data (key outputs of the SEEA-Energy framework), including the conceptual basis for combining those data and the building blocks of combined presentations.

2.2. Overview of the SEEA-Energy framework

2.2.1. Introduction

2.6. The present section considers the scope of the economy for energy accounts. The definition of the national economy and the application of the residence principle are discussed and specific measurement issues are elaborated.

2.2.2. Scope of the economy for energy accounts

2.7. As the national economy and the environment constitute the initial measurement boundaries, they must be clearly defined so as to ensure that information can be organized consistently over time, across countries and for use in different areas of analysis. Essential definitions are provided in the following paragraphs.

2.8. In accordance with the concept applied by SNA and the SEEA Central Framework, an *economic territory* (including the exclusive economic zone) is the area under effective economic control of a single government. The *national economy*, which is defined in accordance with that concept, comprises the set of institutional units that are resident in an economic territory, where the term *institutional unit* refers to an economic entity that is capable, in its own right, of owning assets, incurring liabilities and engaging in transactions and other economic activities 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 (under the residence concept or residence principle); a unit is considered *non-resident* if its centre of economic interest does not lie within the economic territory of a country. In general, there will be a large overlap between those units that are resident and those units that are located within the geographically defined boundaries of a country. For energy accounts, there are two important points to be considered as regards this overlap:

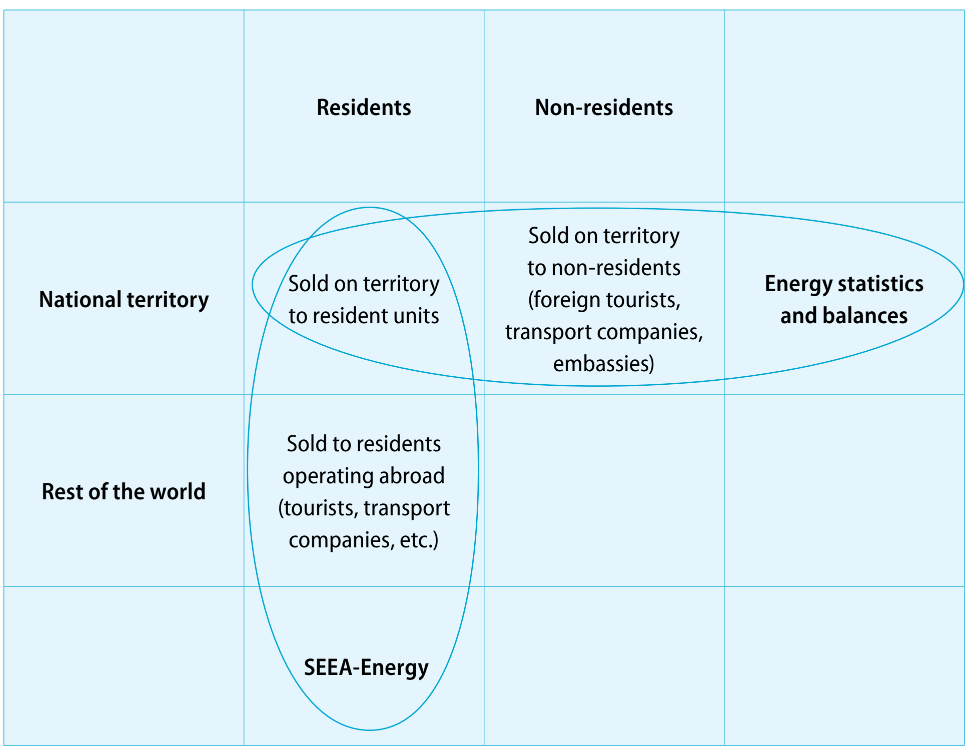
(a) Resident producing units may operate outside of the national territory, for example, ships and aircraft, and fishing operations in international and other nations' waters. In these cases, they are regarded as remaining residents of their national economy irrespective of their location of operation;

(b) Extraction of mineral and energy resources is always regarded as being undertaken by resident units. Such treatment is consistent with that of 2008 SNA (para. 4.15 (e)), which states that an enterprise that will undertake extraction is deemed to become resident when the requisite licences are issued, if not before.

2.9. The definition of the geographical scope of the economy in SEEA-Energy thus aligns with the definitions found in SNA and the SEEA Central Framework, which allows for alignment between flows in physical and monetary terms. However, this definition of the geographical boundary differs from that commonly used within the context of energy statistics and energy balances. Energy 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 those 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 geographical coverage. This is especially true for countries with significant international transport operations, where marked differences 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 and residence principles. 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, the aim of energy accounts is to capture the activity of residents, as displayed in the second column, regardless of geographical location. Energy accounts include 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 versus territory principle for energy



2.11. SEEA-Energy does not measure flows that are considered to be entirely “outside of the economy”. The measurement scope of the economy is generally defined by the production boundary. 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 (known collectively 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 to be “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, which are stores of value that 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. While many economic assets are produced (for example, buildings and equipment), many (e.g., mineral and energy resources) are non-produced.

Measurement of physical flows related to energy

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

2.15. The recording of energy flows in physical terms must follow the principle of the conservation of energy, which states that energy cannot be created or destroyed—it can only be changed from one form to another. For example, when oil is extracted from the ground, its energy content is recorded as energy from natural inputs that flows from the environment to the economy. When the oil is transformed into oil products (e.g., motor gasoline), the energy content of the resulting products is recorded as energy products and the losses arising from the transformation as energy residuals. The total energy content of the energy products and the various losses must be equal to the energy content of the oil. Finally, when the end user utilizes the oil products (e.g., motor gasoline to drive a vehicle), the heat generated from the final use of the energy product that enters the environment is recorded as an energy residual (and the value recorded is equal to the energy content of the motor gasoline).

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

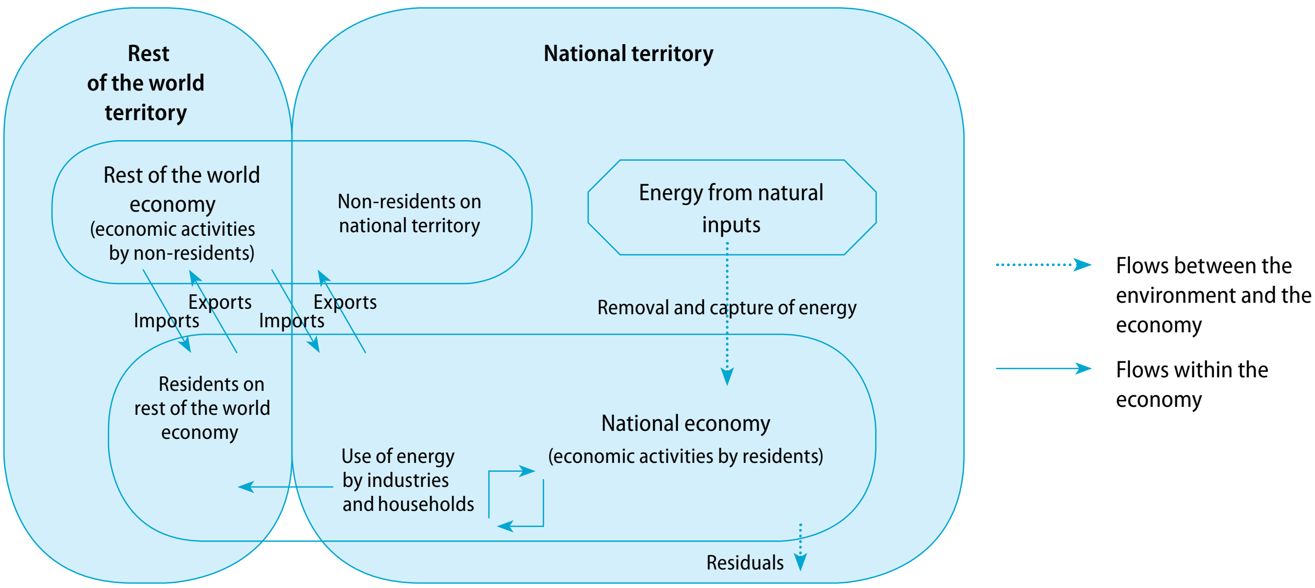
2.17. A distinction needs to be made between primary energy products (e.g., crude oil, natural gas and coal) and secondary energy products. Primary energy products are obtained through the removal or capture of energy from natural inputs from the environment. Figure 2.2 demonstrates that once energy has been extracted from natural inputs, it is transformed into energy products, which are delivered to economic units for use within the economy. Primary energy products include heat and electricity that are produced by harnessing energy from renewable sources within the environment (for example, solar or hydropower).

2.18. Secondary energy products are derived 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 oil and charcoal produced from fuelwood.

2.19. Energy products may be used directly for fuels, converted into other energy products, or 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 that are not normally considered to be energy products, for instance, energy that is produced from the incineration of waste and biofuels produced through the transformation of crops.

2.20. 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 removed from inventories for use in the economy or for export.

Figure 2.2
Physical flows of energy



2.21. Energy residuals flow from the economy to the environment.[12] Examples of energy residuals include mineral and energy resources lost during the process of extraction (e.g., natural gas lost through flaring during extraction); energy lost between the point of extraction or supply and the point of use (for example, electricity lost through entry into the environment from the distribution network); energy lost during storage (e.g., energy products such as liquefied natural gas lost through leakage); and losses during transformation, such as those that occur when coal is used to generate electricity. There are other energy residuals, mainly heat generated when end users use energy products for energy-related purposes. The recording of these other energy residuals is required in order for the flows of energy back to the environment to be fully accounted for. Moreover, such recording is required in order to satisfy the principle of the conservation of energy.

2.22. Flows within the economy include flows between the national economy and the rest of the world, as shown in figure 2.2. Since the national economy is defined in terms of the activities of resident units, a one-to-one relationship between the national economy and the national territory does not exist. Some of the flows to the national economy may occur on foreign territory and some of the flows on the national territory may be associated with activities of foreign units. The treatment of such flows, which are often related to international transport activity and tourism, is described in chapter III.

Measurement of energy from natural inputs

2.23. The use by the economy of certain natural inputs such as coal is linked to changes in the stock of the 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 mineral and energy resources such as coal, oil, natural gas and uranium ore as environmental assets to the extent that they can offer benefits to humanity, as well as timber to the extent that it is used in energy production. It should be noted that, for the purposes of SEEA-Energy, the sun and wind are

[12] Energy products used as fuels are subjected to combustion or fission for the purpose of releasing their 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, or evaporation of water.

not to be considered environmental assets despite the fact that the inputs of energy from renewable sources do include solar and wind. Chapter V of the SEEA Central Framework provides extensive guidance on the definition of environmental assets and the principles of asset accounting.

2.25. Chapter V of SEEA-Energy provides an overview of the measurement of mineral and energy resources including various individual components.

Other energy-related stocks and flows

2.26. The SEEA-Energy framework measures stocks of mineral and energy resources, and energy-related flows between the environment and the economy, as well as certain other energy-related economic stocks and flows. These 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 on the decommissioning of 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 for achieving energy-related environmental policy objectives.

2.3. Main accounts and tables of SEEA-Energy

2.3.1. Introduction

2.27. SEEA-Energy organizes and integrates the information on the various energy-related stocks and flows in a series of tables and accounts, which include (a) supply and use tables presenting flows of energy from natural inputs in physical terms, products in physical and monetary terms and residuals in physical terms; (b) asset accounts for mineral and energy resources in physical and monetary terms displaying the stock of resources at the beginning and the end of each accounting period and the changes therein; and (c) accounts presenting energy- and environment-related transactions. Functional accounts may also be prepared for the purpose of highlighting certain economic activities undertaken for environmental purposes. A range of additional data may be incorporated in these tables and accounts, including population, demographic and employment information relevant to the analysis of energy-related issues.

2.28. The strength of the SEEA-Energy framework is derived from its consistency in the application of definitions for stocks and flows across the spectrum of different types of mineral and energy resources; the uniformity of its definitions of the different types of economic units and locations; and its use of 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 every account. Instead, it can be implemented through a modular approach that takes into consideration those facets of the environment and the energy situation that are of most importance to a country. At the same time, the goal should be to account fully for the environmental-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. Section 2.3 presents the various tables that make up the SEEA-Energy framework and considers the nature of the statistics involved and their integration. As in reality, the compilation of accounts is more complex than the approach elucidated in this section would indicate, the presentation is necessarily stylized; nonetheless, the basic logic of the intent underlying this approach apply throughout SEEA-Energy.

2.3.2. Supply and use tables

Physical supply and use tables

2.31. SEEA-Energy records physical flows, measured in physical units of energy content, through the compilation of supply and use tables. These tables, which are commonly known as physical supply and use tables, are used to assess how an economy supplies and uses energy products, as well as to examine changes in production and consumption patterns over time. Through combination with data from the national accounts, physical supply and use tables can examine changes in intensity and productivity in the use of energy from natural inputs and the release of residuals.

2.32. The physical supply and use table is an accounting construct for the compilation and presentation of all those energy flows that enter, are used within and leave a country's national economy for a given period of time. It necessarily expresses energy flows in a common unit (joules) and illustrates the relationship between inputs to and outputs from energy transformation processes. The physical supply and use table for energy aims at comprehensiveness that entails recording all energy flows both within the economy and between the economy and environment.

2.33. Table 2.1 provides an introduction to the physical supply and use table. This basic table requires a range of additions and refinements if it is to cover all relevant flows of natural inputs, products and residuals. These are explained in greater detail in chapter III.

2.34. A column for "government" does not appear in the physical supply and use table for energy because, in physical terms, government activity is completely recorded within the second column, "industries". The "households" column relates purely to the consumption activity of households. Many households also undertake a range of production activities, including the collection of fuelwood and the generation of energy through the use of solar panels. All of this production activity and the associated natural inputs and residuals are recorded in the "industries" column.

2.35. The supply and use identity applies within the physical supply and use table for energy. Thus, as shown below, for each product, as measured in physical terms (for e.g., coal in joules), the quantity of domestic production (output of coal) plus imports (i.e., total supply of coal) must equal the sum of consumption (both intermediate and final consumption of coal), changes in inventories and exports:

Total supply of energy products = output + imports

is equal to

Total use of energy products = intermediate consumption
+ household consumption + changes in inventories + exports.

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.

2.36. Physical energy flow accounts, which constitute a special case, are a subset of the physical flow accounts presented in the SEEA Central Framework. While the first iteration of physical supply and use tables for energy may be compiled using original mass and volume measures such as tons, litres and cubic metres or units specific for energy, such as standard cubic metres (m^3), it is recommended that, ultimately, the accounts use joules as the common energy unit. This is because it is useful to measure energy from natural inputs and energy products by their calorific energy content.

Table 2.1
Basic form of a physical supply and use table for energy (joules)

Supply table						
	Industries	Households	Accumulation	Rest of the world	Environment	Total
Energy from natural inputs					A. Energy inputs from the environment	Total supply of energy from natural inputs
Energy products	C. Output			D. Imports		Total supply of energy products
Energy residuals	I. Energy residuals generated by industry	J. Energy residuals generated by household consumption	K. Energy residuals from accumulation	L. Energy residuals received from the rest of the world	M. Energy residuals recovered from the environment	Total supply of energy residuals

Use table						
	Industries	Households	Accumulation	Rest of the world	Environment	Total
Energy from natural inputs	B. Extraction of energy from natural inputs					Total use of energy from natural inputs
Energy products	E. Intermediate consumption	F. Household consumption	G. Changes in inventories	H. Exports		Total use of energy products
Energy residuals	N. Collection and treatment of energy residuals		O. Accumulation of energy residuals	P. Energy residuals sent to the rest of the world	Q. Energy residual flows direct to environment	Total use of energy residuals

Note: Dark grey cells are null by definition.

2.37. There are additional SEEA-Energy tables, which focus on (a) supply of primary energy products and imports (table 3.6); (b) transformation of energy (table 3.7); and (c) end use of energy (table 3.8). Table 3.8 presents energy use without the double-counting of energy that is a general feature of the standard supply and use table. Double-counting arises from the inclusion of both primary energy (e.g., coal) and converted energy (e.g., electricity), which is the result of primary energy use by energy supply industries. The specific presentation of the energy flows and the separate treatment of 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.

2.38. The SEEA-Energy framework includes tables that are in addition to those in the SEEA Central Framework that, while following the general supply and use format, introduce a range of features specific to energy accounts. Belonging to this group is a use table (see table 3.9) demonstrating the energy-related purposes for which the energy product is used (e.g., transport or heating) as well as non-energy-related purposes.

2.39. In addition to the supply and use identity, the physical supply and use table incorporates an identity regarding flows between the environment and the economy. Known as the input-output identity, it requires that the total flows into the economy (for example, in the form of natural gas extracted from natural deposits) over an accounting period be 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, the recording of 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 the 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

2.40. Monetary supply and use tables in SEEA-Energy fully articulate in monetary terms the flows of energy products within an economy and between different economic units. The basic form of a monetary supply and use table for energy is laid out in table 2.2.

2.41. Monetary supply and use tables have their roots in economic accounting and utilize the same organizational principles and display the same characteristics as physical supply and use tables. Nevertheless, while the physical supply and use table for energy contain three main types of flows, namely, energy from natural inputs, energy products and energy 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						
Products	Output				Imports	Total supply
Use table						
Products	Intermediate consumption	Household final consumption expenditure	Government final consumption expenditure	Gross capital formation (including changes in inventories)	Exports	Total use
	Value added					

Note: Dark grey cells are null by definition.

2.42. Monetary supply and use tables for energy provide information on the structure of, and the level of activity in, the energy sector as well as detailed information on those industries within the economy that use energy products. They can be readily integrated with the physical supply and use tables for energy to create a powerful analytical tool.

2.43. Chapter IV examines in greater depth the organizational structure of monetary supply and use accounts for energy, as well as the flows recorded and aggregates contained within these accounts. Full details on the definitions of the different variables that make up the monetary supply and use tables are described in chapter 14 of 2008 SNA.

Classifications for supply and use tables

2.44. An important requirement for the compilation of supply and use tables in both physical and monetary terms is the use of consistent classifications for the main economic units and products. In SEEA-Energy, industries are classified consistently using ISIC, energy products are consistently classified using SIEC and the determination of whether particular economic units are to be found within a given national economy is based on the concept of residence. Classifications are further discussed in section 2.5 below.

2.3.3. Asset accounts

2.45. The purpose of asset accounts is to record the opening and closing stock of assets and the various types of changes in stock over an accounting period. The asset accounts in SEEA-Energy are compiled only for mineral and energy resources.[13] They are used for, inter alia, assessing whether current patterns of economic activity are depleting and/or degrading available mineral and energy resources. More broadly, information from asset accounts can assist in the management of mineral and energy resources.

[13] The SEEA Central Framework provides guidance on compiling asset accounts for timber (sect. 5.8).

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, including those with no current economic value. Those resources are defined more broadly than in 2008 SNA, which includes only those inputs that meet the definition of an economic asset. In the SEEA Central Framework, mineral and energy resources include known deposits of oil resources, natural gas resources, coal and peat resources, non-metallic minerals and metallic minerals. In SEEA-Energy, mineral and energy resources are restricted to those resources that can become energy products.

2.47. An asset account is generally structured as shown in table 2.3. It begins 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 either as additions to, or as reductions in, the stock. Wherever possible, the nature of the addition or reduction is recorded. The same entries are made in monetary terms, although an additional entry recording revaluations of resource stocks is included. This entry accounts for changes in the value of assets over an accounting period due to movements in the price of the resources.

Table 2.3
Basic form of an asset account

Opening stock of resources
Additions to the stock of resources
Growth in stock
Discoveries of new stock
Upward reappraisals
Reclassifications
Total additions to stock
Reductions in the stock of resources
Extractions
Normal loss of stock
Catastrophic losses
Downward reappraisals
Reclassifications
Total reductions in stock
Revaluation of the stock of resources[a]
Closing stock of resources

[a] Applicable only for asset accounts in monetary terms.

2.48. Other changes in environmental assets are caused by natural phenomena. For example, an earthquake may cause the collapse and abandonment of a coal mine, which results in its assignment to a different class (see chap. V for further details). Some changes between the opening and closing stock are purely accounting-related, and reflect changes arising from improved measurement (reappraisals) or 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. A reclassification is 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, there may be interest in aggregating the values of all mineral and energy resources in monetary terms at the beginning and the end of the accounting period. This allows for the presentation of such aggregations in balance sheets alongside the value of a variety of other assets (e.g., produced and financial assets).

2.50. Energy from renewable sources represents a special case, inasmuch as renewable sources used in the generation of energy are different from non-renewable natural inputs, such as oil, as regards the manner in which they are exhausted. In the SEEA-Central Framework, the value of the renewable source (solar, wind, wave and tidal, and geothermal) is generally included as part of the value of the associated land or water (in the case of hydro).

2.51. A fundamental attribute of SEEA-Energy is its capacity to account for levels of mineral and energy resources and changes in those levels. However, many conceptual and practical measurement challenges do arise, which are often unique to particular energy assets. These measurement issues are discussed in detail in chapters V and VI.

Connections between supply and use tables and asset accounts

2.52. The physical supply and use tables and the asset accounts differ in terms of (a) the purposes for which they are compiled and (b) the aspects of the relationship between the economy and the environment with regard to energy that they highlight. At the same time, the supply and use tables and the asset accounts are closely linked through, for example, the inclusion of flows of energy from natural inputs in both accounts.

2.53. As already noted, the opening and closing stocks for a given period appear in the asset accounts. While certain components of the changes in stocks (for example, extraction of energy from natural inputs) appear in both the asset accounts and the supply and use tables, other components of the changes in stocks are not recorded in the supply and use tables. 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 asset accounts, changes in the values of mineral and energy resources due to price changes.

2.3.4. Specific-purpose accounts

2.54. While national accounts data can be utilized to organize and present certain types of energy-related transactions that are of particular relevance to the environment, inclusion of such transactions within those tables usually requires additional disaggregation, as the conventional industry and product classifications do not necessarily highlight environmental activities or products.

2.55. Information on the economic response to environmental issues can be provided by the highlighting of energy-related activities and products. Particular items of interest in this regard could include energy-related subsidies and taxes; transactions related to tradable permits to emit carbon; and expenditures on the decommissioning of nuclear power plants.

2.56. The construction of specific-purpose accounts including associated information is discussed further in chapter IV.

2.4. Economic units

2.4.1. Introduction

2.57. The key component in accounting related to the interaction between the economy and the environment encompasses the definition not only of the various stocks and flows but also of the units involved.

2.58. For SEEA-Energy, these are economic units that interact and that are able to make decisions regarding the production, consumption and accumulation of goods and services. How they are classified depends on the type of analysis undertaken. The focus of the present section is on describing such economic units. The section also provides a discussion on reporting units used for statistical purposes. Within this context, both economic units and "units of the environment"—for example, mineral and energy deposits—are relevant concepts.

2.4.2. Enterprises, establishments and industries

2.59. An enterprise is the view of an institutional unit as a producer of goods and services (2008 SNA, para. 5.1; SEEA Central Framework, para. 2.114). Enterprises undertake production in a range of 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.

2.60. An enterprise may comprise one or more establishments and hence may be situated across multiple locations within a single economy. An establishment is a unit situated in a single location at which either a single type of productive activity is carried out, or a single productive activity (the primary activity) accounts for the majority of the value added (2008 SNA, para. 5.24; SEEA Central Framework, para. 2.114). If more than one productive activity is carried out by an establishment, activities other than the primary activity are considered secondary activities.

2.61. An enterprise may also undertake ancillary production. This generally involves the production of supporting services (such as accounting, employment, cleaning and transport services) which could be purchased from other enterprises but are produced in-house to support the production of primary and secondary products. SNA recommends that only in cases where ancillary production is significant should distinct measures of output for the production of these different services be recorded. In those cases, separate establishments should be created that are treated as undertaking the ancillary production. However, in most cases, the production of these services is not recorded as a separate set of outputs; rather, the relevant inputs are recorded as constituting part of the overall inputs to the production of the enterprise's primary and secondary products.

2.62. The ability to define and observe establishments and enterprises, and determine the types of goods and services that 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.

2.63. In SEEA-Energy, as in the SEEA Central Framework (para. 2.116) and SNA (para. 5.2), the groupings of establishments that undertake similar types of productive activity are referred to as industries. Within SEEA-Energy, establishments are classified within industries using ISIC. Industries cover, broadly, agriculture, mining, manufacturing, construction and services, which include electricity, gas, steam and air conditioning supply services. Ideally, an industry comprises establishments that undertake the same activity and only that activity, that is to say, the grouping should be homogeneous. In practice, many establishments undertake a variety of activities but have a primary activity that can be used to assign that establishment to a specific industry class.

2.64. In both physical and monetary terms, the production and use of goods and services within establishments are referred to as "own-account" activities. In SNA, own-account activity covers activities related either to final consumption or to investment undertaken by the economic unit (own-account final use). While SNA does allow for the possibility of recording separately some own-account intermediate use activity, referred to as ancillary activity, this is limited to a specific set of activities.[14]

[14] 2008 SNA, chap. 5.

2.65. In SEEA-Energy, own-account activities also include intra-establishment intermediate production and consumption of energy products. For some purposes of environmental-economic accounting, it may be relevant to identify activities undertaken within an establishment but whose output is not sold to other units. This is particularly the case in respect to 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 undertaken only 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.

2.66. An establishment may undertake production of a significant quantity of fuel that is then consumed by the same establishment in the production of market output. Difficulties might arise when recording the establishment's production of this energy that is not sold outside of the establishment. For example, an establishment may extract coal for use in electricity generation or extract natural gas in order to manufacture liquefied natural gas. In both cases, it is important that own-account use of energy form part of the physical supply and use of energy within the economy—even if the fuel never enters the market. This ensures a full recording of physical energy flows related to economic activity and the provision of a consistent recording of stock and flow information. These two cases illustrate the importance of separately reporting own use of energy, wherever possible.

2.67. In the compilation of functional accounts, it may be important to identify establishments' secondary and other activities that are being undertaken for environmental purposes so as to ensure that a complete description of the relevant activities can be made. One such activity would be the use of equipment designed to remove SO_2 from coal. With respect to the compilation of functional accounts on energy-related activities and flows, the aim of SEEA-Energy is to separately identify these types of activities and flows.

2.68. The activities of households are of potential interest in SEEA-Energy, for example, by virtue of the information they provide on household use of energy from a certain natural input (e.g., collected fuelwood) or on the use of solar panels situated atop houses. The energy produced by households is either consumed on own account or sold on the market (e.g., electricity by way of the grid). As in the SEEA Central Framework, such activity is recorded together with that of industrial units undertaking the same activity.

2.4.3. Reporting units used for statistical purposes

2.69. The discussion of economic units in this section has focused on their ability to operate within an economy as active participants. In statistical terms, these units are also often the focus of measurement as units of observation or as reporting units. Depending on the structure of information systems within a country, economic data are likely to be available for most types of economic units, particularly enterprises and, in some cases, 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 a straightforward undertaking.

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

2.71. At the same time, the collection of information about the environment, particularly with regard to environmental assets, requires consideration of the appropriate environmental reporting units for statistical purposes. These reporting units reflect the components of the environment for which statistics may be collected and presented, such as 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. As the SEEA-Energy framework covers a range of disciplines, it necessarily utilizes several classification systems ranging from systems with an essentially physical focus to those typically used for economic accounts. The defining characteristic of SEEA-Energy, as a subsystem of the SEEA Central Framework, is its specific focus on energy-related stocks and flows, in both physical and monetary terms. How SEEA-Energy defines and classifies the various stocks and flows included within its framework is therefore of paramount significance.

2.73. Of particular importance is the building of knowledge regarding those industries that extract mineral and energy resources, produce and use energy products and undertake energy-related transactions. Hence, the classification of industries is important. The present section begins with a description of the basic structure of ISIC and goes on to establish a more detailed correlation between various mineral and energy resources and the industries that typically engage in the extraction of those resources.

2.74. This section also introduces the subject of classification of energy from natural inputs (discussed more fully in chapter III), which are closely related to the energy products derived from them. How energy products are defined and classified is of fundamental importance for SEEA-Energy, as it essentially determines the scope of the framework. SEEA-Energy and IRES use identical concepts and classifications of energy products, as set out in SIEC. There is great interest from an analytical perspective in determining whether energy products are primary or secondary in character, as well as considerable interest in determining whether those sources are renewable or non-renewable. A discussion of primary versus secondary and renewable versus non-renewable energy products is therefore presented below.

2.5.2. Classification of industries

Industries

2.75. Industries are groupings of establishments engaged in the same, or similar, activities. An establishment is assigned to an industry according to its principal activity, that is, 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. For example, a steelworks may engage in producing steam from surplus heat as a secondary activity or a manufacturing company may engage in producing electricity for own use as an ancillary activity.

2.76. The classification of industries in SEEA-Energy, including the following description, is based on ISIC Rev.4.[15]

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

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

2.78. Establishments engaged in extracting mineral and energy resources as a *principal activity* are included in ISIC section B, Mining and quarrying, which is broken down into the following divisions:

- Division 05—Mining of coal and lignite;[16]
- Division 06—Extraction of crude petroleum and natural gas;
- Division 07—Mining of metal ores;
- Division 08—Other mining and quarrying;
- Division 09—Mining support service activities.

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

2.80. ISIC divisions 05 and 06 encompass mining and quarrying of fossil fuels (coal, lignite, petroleum and gas), while divisions 07 and 08 cover metal ores and various minerals and quarry products.

2.81. Some of the technical operations associated with mining and quarrying, particularly as related to the extraction of hydrocarbons, may also be carried out for third parties by specialized units as an industrial service. Such specialized support services incidental to mining provided on a fee or contract basis are classified in division 09, including exploration services through traditional prospecting methods as

[15] Statistical Papers, Series M, No. 4, Rev. 4 (United Nations publication, Sales No. E.08.XVII.25). Available at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27&Lg=1.

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

well as drilling. Other typical services cover, inter alia, construction of oil and gas well foundations, cementing oil and gas well casings, draining and pumping mines, and overburden removal services at mines.

2.82. Section B excludes the processing of the extracted materials (included in section C (Manufacturing)), separate site preparation activities for mining (included in class 4312) and geophysical, geologic and seismic surveying activities (included in class 7110).

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 categories covering the extraction activities for these specific resources.

Table 2.4
Linkage of mineral and energy resources to the ISIC category covering their extraction

Type of mineral or energy resources[a]	Division, group or class within ISIC section B
Oil resources	Group 061—Extraction of crude petroleum
Natural gas resources	Group 062—Extraction of natural gas
Coal and peat resources	Division 05—Mining of coal and lignite Class 0892—Extraction of peat
Uranium and thorium ores	Class 0721—Mining of uranium and thorium ores

[a] See table 2.5.

Industries that capture energy from renewable sources

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

2.85. The principal activities associated with capturing heat and electricity from renewable sources, that is, 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) includes the operation of generation facilities that produce electricity, including thermal energy, while class 3530 (Steam and air conditioning supply) includes 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 section C, division 19 (Manufacture of coke and refined petroleum products) is of specific relevance to the production of energy products. It is subdivided into:

- Group 191—Manufacture of coke oven products;
- 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 use or sale, of products such as butane, coke, fuel oil, kerosene, petrol and propane. Processing services provided (e.g., custom refining) are also included. Petroleum refineries may also produce petroleum-based gases such as butane, ethane and propane.

2.88. The enrichment of uranium and production of elements to allow the use of uranium in nuclear reactors is covered by ISIC class 2011 (Manufacture of basic chemicals).

2.89. ISIC section D (Electricity, gas, steam and air conditioning supply) includes the following three groups:

- Group 351—Electric power generation, transmission and distribution;
- Group 352—Manufacture of gas; distribution of gaseous fuels through mains;
- 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 and hot water in industrial parks and residential buildings, as well as the operation of electric and gas utilities, which generate, control and distribute electricity, gas and steam.

2.91. These industries produce not only secondary energy by converting other energy products, but also primary energy (as described above) by capturing, for example, energy from sun and wind, and using it to generate electricity and heat.

2.92. As regards units that generate combined heat and power, separate ISIC classifications for electric power (group 351) and steam (group 353) become artificial. The output of electricity and heat can be measured separately, but for the inputs of energy products for the combined heat and power process to be so measured, certain assumptions are required. As a default option, those inputs may be separated 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 above-mentioned industries, other industries may in principle be involved in the capture of energy from natural inputs. Moreover, it is not unusual for other industries to be involved in the production of energy products (such as electricity or heat) as a secondary or ancillary activity.

2.94. The recording of such activities should begin with their assignment to the industries that actually carry them out. For instance, production of electricity and heat as the result of the incineration of waste should be recorded as the result of activities included in ISIC class 3821 (Treatment and disposal of non-hazardous waste). Nevertheless, it should be observed that, in practice, a reallocation of activities to such industries as agriculture, construction, energy supply and trade often occurs when the national accounts are being compiled. That requires that data from basic statistics regarding secondary activities in industries be transferred to the relevant primary industries, at the time when those data are entered into the supply and use tables.

2.95. Therefore, it may be necessary to carry out a similar reallocation of the flows of energy products in order to ensure consistency with the national accounts. Such a reallocation will give rise to a sparse supply table. That stems from the fact that while all industries must be shown, most flows will be concentrated within the small number of columns representing the industries described above.

2.96. In addition to the core activities of extracting and producing energy products, as carried out by the above-mentioned industries, there are supplementary activities that are carried out by other industries. Covered by ISIC section H (Transportation and storage), these include activities such as long-distance transport of gas through pipelines and transport of energy products by ships, trains and trucks.

2.5.3. Classification of energy from natural inputs

2.97. The supply and use tables utilize the classification of energy from natural inputs by type (see table 2.5) to specify the flows of energy from various types of natural inputs to the economy. The classification is also used in the asset accounts to specify 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, to present a full correspondence between the recording of energy-related flows and the recording of energy-related stocks.

Table 2.5
Energy from natural inputs by type

Energy natural resource inputs
Mineral and energy resources
Oil resources
Natural gas resources
Coal and peat resources
Uranium and other nuclear fuels
Natural timber resources
Inputs of energy from renewable sources
Solar
Hydro
Wind
Wave and tidal
Geothermal
Other electricity 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. As presented in table 2.5, the three types of energy from natural inputs are energy natural resource inputs, inputs of energy from renewable sources and other natural inputs. In order to assess whether mineral and energy resources are also economic assets, it is necessary to assess various “quality”- and “knowledge”-related aspects of these resources. In this regard, the classification of mineral and energy resources and the closely related determination of whether they are “economic” are discussed more fully in chapter V.

2.99. When energy from natural inputs is removed or extracted from the environment and subjected to production processes, the resultant output typically takes the form of an energy product (see also sect. 3.3.2).

2.5.4. Classification of energy products

Energy products

2.100. In IRES, it is recommended, as a general guideline, that the term *energy products* refer to products exclusively or mainly used as a source of energy. Such products include energy suitable for direct use (e.g., electricity and heat) and energy products that release energy while undergoing some chemical or other process (including combustion). By convention, energy products also include peat, biomass and waste when and only when they are used for energy purposes.[17]

[17] IRES 2018, chap. II.B, para. 2.9.

2.101. This definition emphasizes the energy product's use rather than its physical characteristics. At the same time, the use of the qualifying term mainly should be noted, signifying as it does that an energy product might still be used for non-energy purposes. And conversely, many products that are not normally considered energy products might still be used, to a certain extent, as a source of energy. The scope of the SEEA-Energy framework is such that products are determined to be energy products based on their purpose in a particular context.

2.102. With regard to a product such as crude oil, for the full amount of its use, it is normally described as an energy product in SEEA-Energy. This is because it is used mainly for energy purposes, despite the fact that it may be used for non-energy purposes such as the production of plastics. In the SEEA-Energy accounts, a distinction is therefore made between use of energy products for energy purposes and their use for non-energy purposes.

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

2.104. As a further example, corncobs can be burned to produce heat, used in the production of ethanol-based biofuels or consumed as food. It might be argued that corncobs used in the production of biofuels should be regarded as an energy source; however, according to IRES, they should not be included as energy products. Rather, it is the resulting biofuel that is to be considered the energy product. Only those corncobs that are combusted directly are included as energy products (IRES 2018, para. 2.11). This conclusion reposes on the distinction between primary and secondary energy products—a distinction that is important for analytical purposes—which is discussed more fully below.

Primary and secondary energy products

2.105. Primary energy products result from the removal or capture of energy from natural inputs from the environment. When removed from environment, energy typically becomes an energy product that is delivered from extracting industries to other parts of the economy. Biofuels, heat and energy produced through the capture of energy from renewable sources from the environment are considered primary energy products.

2.106. 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 fuelwood.

2.107. It should be noted that electricity and heat may be produced either as primary or as secondary products. If heat is captured directly from the environment by 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.

2.108. Corncobs used for combustion are regarded as primary energy products, while the heat or electricity generated by this combustion is classified as a secondary energy product. Biofuels made from corncobs, however, are characterized as primary energy products. Therefore, all inputs used in the production of such biofuels fall outside the scope of the energy product category.

Renewable and non-renewable energy from natural inputs

2.109. Energy products can be derived from both renewable (e.g., solar and biomass) and non-renewable (e.g., coal and crude oil) energy from natural inputs. It is important, both for energy planning and from an environmental perspective, to distinguish between renewable and non-renewable energy from natural inputs and between non-depletable renewable inputs (e.g., solar) and depletable renewable inputs (e.g., biomass).

2.110. Replenishment of energy from natural inputs for an indefinite time period is the basis for the concept of renewability. Most forms of energy from renewable sources—including solar, wind, hydropower and biofuels—are derived directly or indirectly from the sun.

2.111. Discussion of renewable energy inputs might also include the requirement that the energy from natural inputs should be replenished at a rate comparable to, or faster than, its rate of extraction. Related to this requirement is the question whether the input from which the energy product is derived is a non-depletable (e.g., wind or solar energy) or a cyclical renewable input (e.g., forest).

2.112. Time and appropriate management have a role to play in the replenishment of cyclical renewable inputs, whose regrowth and reproduction take time. A renewable energy input that is used up too rapidly—for example, a forest (a potentially renewable input) that is harvested more rapidly than it regrows—clearly cannot provide energy for an indefinite period of time. Hence, proper management of that forest could be considered necessary to uphold the "renewability status" of this 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. Changes to the surrounding area (for example, blockage, by a newly built structure, of installed solar panels' access to the sun) might in some cases impact that energy production.

2.114. Although sustainable management is a reasonable requirement for ensuring the renewability of the cyclical renewable energy input, it would seem appropriate for statistical and accounting purposes, when the information on supply and use of energy products is collected and recorded in the accounts, not to include the management dimension, as it encompasses factors that cannot be observed directly.

Standard International Energy Product Classification

2.115. In its chapter 3 on SIEC, IRES provides a list of the internationally agreed definitions of energy products. Table 2.6 presents the classification of these products at the broadest (section) level.

2.116. In SEEA-Energy, the monetary flow accounts, in contrast to the physical flow accounts, utilize the Central Product Classification. The direct comparison of monetary and physical flow accounts for SEEA-Energy therefore requires a working correspondence between the SIEC and Central Product Classification classifications.

2.117. Within SIEC, the distinctions both between primary and secondary energy products, and between renewable and non-renewable energy inputs, do not constitute explicit classification criteria, although in many cases, an entire SIEC category can clearly be assigned to primary or secondary products, and also to products coming from renewable sources of energy or products coming from non-renewable sources of energy.

Table 2.6
Sections for energy products in SIEC

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 not elsewhere classified

Source: IRES 2018, table 3.1.

2.118. IRES, in chapter 3 and annex A, provides a discussion not only on SIEC and the definitions of energy products but also on the distinctions between primary and secondary energy products, and energy products derived from renewable and non-renewable sources. IRES also sets out the correspondences between SIEC and other international product classifications, such as the Harmonized Commodity Description and Coding System and Central Product Classification.

Main producers and autoproducers of electricity and/or heat

2.119. Within the framework of energy statistics and energy balances, an enterprise that produces electricity or heat as its principal activity is called a main activity producer. An enterprise that produces electricity for sale or own use where such activity is not its principal activity is referred to as an autoproducer (electricity). The production of electricity by an autoproducer can be classified as an ancillary activity when the electricity is used by the producer or a secondary activity when sold. Similarly, an enterprise that produces heat for sale where such activity is not its principal activity is called an autoproducer (heat).[18] The production of heat by an autoproducer is a secondary activity.

2.120. While information on the status of main activity producer and autoproducer could be reflected in tables to support specific analytical applications, such information has not been provided in the standard tables of SEEA-Energy.

[18] IRES 2018, para. 5.45. Available at https://unstats.un.org/unsd/energy/ires/IRES-web.pdf.

2.6. Accounting rules and principles

2.6.1. Introduction

2.121. The compilation of accounts requires the use of a set of consistent accounting rules and principles. Without such a set, related transactions and flows may be recorded on different bases, at different times or with different values, thereby rendering accounting far less useful and reconciliation difficult.

2.122. SEEA-Energy uses accounting rules and principles that are consistent with those of the SEEA Central Framework and SNA. The present section introduces the rules and principles that are of most relevance to SEEA-Energy. Readers are encouraged to refer to chapter 3 of 2008 SNA for further details.

2.6.2. Recording rules and principles

Time of recording

2.123. One requirement under the accounting principles of both SEEA-Energy and the SEEA Central Framework 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 that arise are either transformed or cancelled. Transactions internal to one unit are recorded when economic value is created, transformed or extinguished. This approach to the timing of recording is carried out on what is known as an accrual basis.

2.125. When conducted on an accrual basis, the timing of transactions may not align with 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 upon which 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 monetary value of the actual transactions taking place, but in other cases the amounts entered are estimated by reference to equivalent monetary values (for own-account use) or valued at the cost of production (for non-market output).

2.128. For accounts compiled in physical terms, the unit of measurement should 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 units are kilograms or metric tons for solid fuels; barrels, litres or tons for oil; and cubic metres for gases. The actual units used vary according to country and local conditions and reflect historical practice within the country (see IRES 2018, para. 4.9).

2.129. For statistical and accounting purposes and for many types of analyses—for example, the comparison of quantities of different energy products and the estimation of efficiencies—it is useful to convert the original units to a common unit. The conversion of different units to a common unit requires conversion factors for each product. While within the International System of Units (*Système International d’Unités* (SI)),[19] the joule is the common unit used for energy, other common energy units are also utilized in practice, such as the ton of oil equivalent (toe), the gigawatt-hour (GWh), the British thermal unit (Btu) and the calorie. The use of the joule as a common unit is recommended by SEEA-Energy and IRES (para. 4.27).

2.130. Only one unit of measurement should be used within each physical energy account so as to ensure that aggregation and reconciliation are 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.

2.131. Further information on units of measurement and the conversion of one unit to another is provided in IRES and in Annex A1.

[19] The SI brochure is available at the website of the Bureau International des Poids et Mesures (International Bureau of Weights and Measures) (BIPM), www.bipm.org/en/si/.

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. This 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 of physical and monetary accounts and statistics, it is logical to use those 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 nevertheless presented following common classifications and definitions; 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 under 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 that need to be resolved.

2.135. Compiling and contrasting monetary and physical data in meaningful ways remain at the heart of SEEA-Energy, even if no standard structure can be prescribed. The present section serves as a general introduction to combined physical and monetary presentations. Chapter IV discusses the compilation of these presentations. More detailed structures entailing presentations that cover a particular theme or topic, for example, the decoupling of energy use and economic growth, are considered in chapter VII.

2.7.2. Conceptual basis for combining physical and monetary data

2.136. At the core of combining physical and monetary data is the logic inherent in recording physical flows in a manner that is compatible with economic transactions as presented in SNA. These data can be used, for example, to compile energy accounts enabling linkages to be made that guarantee a consistent comparison of environmental burdens with economic benefits, or environmental benefits with economic costs. These 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 to specific industries, or for the purpose of examining the flows associated with the extraction of a particular natural resource and/or the flows associated with certain energy products.

2.137. Such presentations combine (a) physical data that may be of more immediate use to scientists who have greater familiarity with environmental issues and (b) monetary data with which economists are more familiar. They therefore have the potential to create a bridge between the perspectives and concerns of these two groups.

2.138. Combined physical and monetary presentations may usefully—and legitimately—include only a limited set of variables, depending on the most relevant and pressing environmental concerns to be taken into consideration. In other words, 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 the economy and the environment and, given the importance of that interaction for so many environmental issues, thereby provides a powerful basis for the analyses required to tailor appropriate policy responses. Because combined physical and monetary presentations provide consistent environmental and economic indicators, they enable the observation and analysis of the trade-offs, in environmental (and economic) terms, between alternative environmental and economic strategies, particularly within the context of time series.

2.7.3. Building blocks of combined presentations

2.140. SEEA-Energy affords compilers considerable flexibility with regard to how they choose to present combined physical and monetary data related to energy. Generally, however, there are certain typical areas that will be covered by combined presentations. At a broad level, these areas encompass the entire content of SEEA-Energy. That content serves as the basis for those presentations, which include the variables and aggregates that best inform the topic or theme that is of interest.

2.141. In chapter IV, SEEA-Energy presents several combined monetary and physical presentations in the form of supply and use tables. These tables, in which physical and monetary flows are combined, are useful in (a) providing a basis for analysis of the links between those monetary and physical flows and (b) 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 in response to policy needs and to the extent that data and information requirements allow. SEEA-Energy is able to provide a relatively comprehensive set of indicators on 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 VII.

Chapter III
Physical flow accounts

3.1. Introduction

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

3.2. Organization of the physical flows of energy in SEEA-Energy entails their division into three broad groups, namely, energy from natural inputs, energy products and energy residuals, according to whether those flows represent a supply of energy or a use of energy. Energy is supplied when it becomes a product through direct extraction (e.g., of natural gas) from the environment or capture (e.g., by solar panels) or through transformation of another energy product (e.g., of coal into electricity). Energy (e.g., crude oil) may also be imported.

3.3. The supply and use of energy are presented in supply and use tables that, conceptually and in terms of organization, closely resemble supply and use tables as described in 2008 SNA; and they are also similar to energy balances. However, the SEEA-Energy supply and use tables have several important distinguishing features. These features, such as the use of the residence principle and of classifications consistent with economic accounts, allow for direct comparison with key economic aggregates such as GDP, 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 organization and combined presentation of energy-related flows in both physical and monetary terms are discussed in chapter IV.

3.5. The framework for measuring physical energy flows is also aligned with the monetary energy flow accounts (chap. IV) and mineral and energy asset. This alignment of the physical flow accounts and the asset accounts enables 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 table.

3.6. Section 3.2 describes several principles that are of fundamental importance for understanding and recording physical energy flows in SEEA-Energy and, in particular, examines the treatment of international flows and the related accounting of goods sent abroad for processing. Also described, in general terms, is 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. As the supply and use tables for energy contain a range of industry detail, the section provides appropriate guidance on the types of energy flows and specific treatments to be considered for each industry. The various tables that make up the SEEA-Energy physical flow accounts are described, and the function and purpose of each table are elucidated. Several tables closely related to the supply and use tables—including on supply of primary energy products and imports, transformation of energy, end use of energy and energy use by purpose—are presented.

3.8. Finally, section 3.4 examines interrelationships among energy statistics, energy balances and energy accounts. While these three bodies of energy-related information clearly share much common ground, this section focuses on the key differences between energy accounts and energy balances. It concludes with a discussion on how bridge tables can be used to reconcile the data contained within energy accounts with those in 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 II requires the adoption of a range of accounting principles and conventions, several of which, including units of measurement, and the definitions of economic units and industries, are examined in chapter II.

3.10. The present section describes in detail some recording principles specific to physical flow accounting, namely, 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, at the time of the flow of energy, the flows are attributed to the country of residence of the producing or consuming unit, in accordance with the residence principle as opposed to the territory principle of recording. The latter is applied in several statistical frameworks, including IRES.

3.12. Treatment according to the residence principle is consistent with the SEEA Central Framework and SNA.[20] While in most cases, energy flows would be assigned to the same country regardless of whether the resident or territory principle was applied, there are important activities, in particular international transport and tourism, which need to be considered separately so that the appropriate treatment can be determined. Within this context, the present subsection examines the key areas of international transport, tourist activity, imports and exports, ownership of timber resources and mineral and energy resources, and flows from jointly owned assets.

[20] 2008 SNA, paras. 4.10–4.15.

International transport

3.13. As many countries engage in significant international transport activity, the appropriate and consistent attribution of physical flows related to international transport to individual countries is therefore a vital component of SEEA-Energy. It is important that information on the use of energy and the associated release of emissions for this activity be properly recorded.

3.14. Following the pattern for treatment of all other activities within the 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 operator's headquarters. 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 conducted between two locations that are not within the resident country, inputs (including fuel, wherever purchased) and emissions are attributed to the operator's country of residence.

3.15. Following the determination of the residence of the operator of international transport equipment, under standard SNA and the *Balance of Payments and International Investment Position Manual* principles, the appropriate accounting procedure can be carried out, as illustrated by the examples in table 3.1 below.

Table 3.1
Attribution of physical flows related to international transport

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 by 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 must be taken of the bunkering of fuel, primarily as it relates to ships and aircraft. Special arrangements may be entered into whereby a unit resident in a country stores fuel in another country while retaining ownership of the fuel itself. Following the principles of SNA and the *Balance of Payments and International Investment Position Manual*, the physical location of the fuel is not the primary consideration: the 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, not all the fuel stored in country B is necessarily attributable to country B. As this treatment is likely to differ from the recording in international trade statistics, alignment to the treatment may require adjustments to source data.

Tourist activity

3.17. Tourist activity, like international transport, is recorded using the residence principle. Tourists encompass all those travelling outside their country of residence including short-term students (students abroad for 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 tourist's location when the energy was 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 by the tourist's country of residence.

3.18. Energy use and the resulting 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, energy use and the resulting emissions from aircraft and other long-distance transport equipment are attributed to the country of residence of the operator. The energy used and the resulting emissions are not attributed to the tourist in the case of either aircraft or other long-distance transport equipment.

3.19. Energy use and the resulting 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 is being hired from a car rental company. Energy use and the resulting emissions (e.g., from taxis and local minibuses) are also attributed to the driver or relevant business rather than to the passenger.

Imports and exports

3.20. Table 3.2 on the imports and exports of energy products sets out the key adjustments needed in order for foreign trade statistics to reflect the residence principle-based import and export concepts used in SEEA-Energy. The imports and exports of energy products need to be adjusted for purchases by residents abroad and 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:
Domestic ships' and fishing vessels' bunkering of oil abroad
Domestic aeroplanes' bunkering of jet fuel and kerosene abroad
Domestic vehicles' refueling of gasoline and diesel abroad
Tourists' and business travelers' 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 (SEEA)
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 aeroplanes' bunkering of jet fuel and kerosene on territory
Foreign vehicles' refueling of gasoline and diesel on territory
Foreign tourists' and business travelers' 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 (SEEA)

Ownership of timber resources and mineral and energy resources

3.21. The term *energy from natural inputs* denotes physical flows from the environment to the economy that are derived principally 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 situated. 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, occur within a country's economic territory, carried out by economic units that are resident in that country.

Flows from jointly owned assets

3.22. Flows of mineral and energy resources can also come from assets that are owned jointly by countries (e.g., joint oil territories). In general, there will be an agreement between the countries that details how the jointly owned asset should be managed and how the mineral and energy resource flows are to be split between the different owners, which can in turn be used to determine how flows should be assigned. In the event that such an agreement is not readily available, it is recommended that flows from jointly owned assets be assigned to each country based on other available information, such as revenues earned from the relevant flows by each country.

3.2.3. Treatment of goods for processing

3.23. 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.

3.24. 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 such circumstances, typically no change of ownership takes place. For example, crude oil that is sent to another country to be refined is excluded from measures of exports and, conversely, the refined products that are returned are excluded from imports to the country. On the other hand, the import of a service corresponding to the value of the processing undertaken abroad is recorded.[21]

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

3.25. Nevertheless, within SEEA-Energy, it is considered appropriate to record the physical flows as they occur. 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—for example, from emissions to air—of the processing activity in the country in which the processing is being undertaken.

3.26. 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 consequently to apply a treatment in monetary terms that is different from that applied to international trade data.

3.3. Physical flow accounts for energy

3.3.1. Introduction

3.27. The present section describes the full sequence of physical flow accounts for energy. These accounts record energy flows in physical units (i.e., joules) from the initial extraction (i.e., the capture of energy from natural inputs from the environment) into the economy, 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). Details are provided 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.

3.28. The purpose of compiling physical flow accounts for energy is to support a consistent monitoring of supply and use of energy by flow type and industry. Indicators of energy intensity, efficiency and productivity can be derived through the combining of these physical flows with corresponding monetary information on supply and use of energy products.

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

3.3.2. Energy from natural inputs

3.30. The flow of energy from natural inputs encompasses the extraction or capture of energy from the environment by resident economic units. Such flows include energy from natural resource inputs (e.g., oil, natural gas, uranium, coal and peat, and natural timber resources), inputs from renewable energy sources (e.g., solar, wind, hydro and geothermal) and other natural inputs (e.g., energy inputs to cultivated biomass).

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

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

3.33. Energy from cultivated biomass, including from cultivated timber resources, is treated as being produced within the economy and hence is first recorded as a flow of an energy product. However, to ensure a complete balance of energy flows in the physical supply and use tables (tables 3.4 and 3.5), 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” section of the use table (table 3.5), the value for energy inputs to cultivated biomass is generally split among several industries, corresponding to end use among them.

3.34. Solid waste incinerated for energy purposes is also treated as being produced within 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

3.35. Energy from natural inputs comprises the flows of energy that result from its removal and capture from the environment by resident economic units. Table 3.3[22] illustrates the types of flows encompassed by energy from natural inputs.

[22] Note that table 3.3 is the same as table 2.5 and is reproduced here for ease of reference.

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 fuels
Natural timber resources
Inputs of energy from renewable sources
Solar
Hydro
Wind
Wave and tidal
Geothermal
Other electricity and heat
Other natural inputs
Energy inputs to cultivated biomass

3.36. In many cases, energy from natural inputs will change little in form as it is extracted from the environment for use in the economy. For example, coal, peat, oil and natural gas do not undergo fundamental physical transformations upon entry into the economy. Consequently, the description of the characteristics and the classification of coal, peat, oil and natural gas apply equally well to the flows related to their extraction from the environment for use in the economy and to those related to their subsequent use as energy products within the economy.

3.37. In other cases, the energy extracted from the environment is very different from the resulting energy product subsequently used within the economy. Described directly below are those types of energy from natural inputs that undergo a fundamental physical transformation as they enter the economy.

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

3.39. 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 these natural inputs are used in the production of electricity or heat. It is essential that natural inputs used in the generation of electricity be recorded so as to ensure a complete balance of flows of energy between the environment and the economy. The amount of electricity or heat produced from renewable 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 are energy inputs from cultivated timber resources, from other cultivated biomass or from solid waste (see also para. 3.87).

3.40. "Energy inputs to cultivated biomass" gives rise to cultivated biomass, which in turn becomes an input to energy products such as ethanol and other biofuels. That is to say, biofuels are produced "within the economy" through the use of energy inputs from the environment. These inputs, like energy inputs from renewable sources, must be shown in the physical supply and use tables for energy (tables 3.4 and 3.5) in order to preserve the input-output identity for energy flows.

3.3.3. Energy products (flows)

3.41. 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.

3.42. 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 directed towards producing other energy or non-energy products. Energy products, which are also used by households as part of household consumption or by the rest of the world as exports, can be stored in the form of inventories.

3.43. Energy-supplying industries and other industries typically carry inventories of energy products. Changes in inventories are recorded net in the “accumulation” column of the use table.

3.44. Energy products are classified based on the SIEC. At the first level, energy products are classified into 10 sections that are described below.

Description of energy products[23]

[23] See IRES 2018, chap. III, and, in particular, table 3.1.

3.45. Chapter II covers the broad categorization of energy flows: energy from natural inputs from the environment to the economy; energy products produced and used within the economy; and various residual flows from the economy back to the environment. The present section provides a descriptive overview of the energy products used in the SEEA-Energy physical flow accounts. The descriptions, as well as the classification of energy from natural inputs, draw heavily from SIEC.

3.46. The following descriptions reflect the highest level of product detail as presented in SIEC, that is, the one-digit (section) level. While it is recommended that compilers attempt to produce data at the SIEC two-digit (division) level so as to deliver a much richer data set for data users, the level of product detail ultimately used in the physical flow accounts for energy will depend on the requirements of data users, as well as on data availability. Compilers will therefore need to adapt the level of product detail used in their physical flow accounts to existing circumstances.

3.47. 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.

3.48. Peat and peat products are composed of a solid formed through 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.

3.49. Oil shale/oil sands constitutes a sedimentary rock that contains organic matter in the form of kerogen (IRES 2018, chap. III, sect. D, p. 30). Kerogen is a waxy, hydrocarbon-rich material that is regarded as a precursor of petroleum.

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

3.51. Oil is made up of liquid hydrocarbons of fossil fuel origin comprising (a) crude oil, (b) liquids extracted from natural gas, (c) fully or partly processed products derived from the refining of crude oil, and (d) hydrocarbons and organic chemicals of vegetal or animal origin that are functionally similar to liquid hydrocarbons of fossil fuel origin.

3.52. Biofuels derive directly or indirectly from biomass (fuels produced from animal fats, by-products and residues that obtain their calorific value indirectly from the plants consumed by those animals).

3.53. Waste is made up of materials voluntarily discarded by their owner. In cases where the owner of the waste receives payment for passing on the waste to another party, the waste is considered a product. In cases where no payment is received by the discarding unit, the waste is considered a residual.

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

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

3.56. The category of nuclear fuels and other fuels not elsewhere classified includes uranium, plutonium and derived products that can be used in nuclear reactors as a source of electricity and/or heat.

3.3.4. Residuals

3.57. 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 the SEEA Central Framework (sect. 3.2.4).

Energy residuals

3.58. Energy residuals, which are flows of energy from the economy to the environment, comprise energy losses as well as other energy residuals (primarily dissipative heat generated through end use of energy products for energy-related purposes, for example, fuel combustion and electricity-powered operation of an appliance). Energy losses are grouped into four categories: losses during extraction, losses during distribution, losses during storage and losses during transformation. Particular cases are discussed below.

3.59. The wreckage of an oil tanker at sea may result in the loss of cargo. This should be recorded as a *loss during distribution* flowing from the economy to the environment.

3.60. Efforts may be made to recover residuals (including natural resource residuals) from the environment and to reintroduce them into the economy either for treatment or for disposal at a landfill site. This represents the only case where flows of residuals from the environment to the economy should be recorded. While the numerical amount involved may be small, in particular cases (such as that of the wreckage of an oil tanker near a protected coast), the cause for concern may be large enough to warrant the explicit identification of those flows.

3.61. 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

3.62. Controlled and managed landfill sites, emission capture and storage facilities, treatment plants and other waste disposal sites are considered to be within the economy. Flows of residuals into those facilities are therefore regarded as flows within the economy rather than as 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-related purposes, in which case it is recorded separately as energy from solid waste within other residual flows.

3.63. Other residual flows include "residuals from end use for non-energy purposes", which accounts for the energy embodied in energy products that is used for non-energy purposes such as oil used for production of lubricants.

3.3.5. Industry reporting

3.64. The fact that the SEEA-Energy physical flow accounts are compiled using the ISIC industry classification makes 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 displayed in tables 3.4 to 3.9 as a means of supporting internationally comparable data. Provided directly below is a descriptive guide to energy supply and use for those industries presented in the SEEA-Energy tables contained in this chapter.

3.65. Agriculture, forestry and fishing would, generally, not be expected to constitute a significant supplier of energy, although forestry operations may supply fuelwood and charcoal. These are energy products (biofuels) produced by forestry operations that utilize 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.

3.66. Agriculture may support biofuel production through, for example, the supply of corn and/or sugar cane for bioethanol. In this case, the corn or sugar cane is not an energy product, but, rather, energy from natural inputs which is required for the production of biofuel, as embodied in the corn and sugar cane.

3.67. Mining and quarrying is often the most significant domestic supplier of primary 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 (although where energy is lost during extraction, the quantity of energy from natural inputs will exceed the corresponding quantity of energy products supplied by mining and quarrying).

3.68. The manufacturing industry plays an important role in the production of energy products, as it is responsible for converting a range of primary energy products into a usable form, as secondary energy products. For example, the environment supplies energy from natural inputs, such as oil resources, to the economy, where the mining industry extracts these inputs as crude oil, which is then supplied as an energy product to the manufacturing sector for refining. The manufacturing sector in turn supplies others with the refined oil product.

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

3.70. The electricity, gas, steam and air conditioning supply industry supplies energy in a number of forms and under various arrangements. Enterprises in this industry frequently receive energy products from other enterprises and transform those products into secondary energy products. This is the case for the 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, solar, hydro, wind, wave and tidal and geothermal inputs.

3.71. The supply of electricity includes the activity of distributing electricity to the final consumer. While the supply of gas through a system of mains is also included in this ISIC division, the activity of transporting gas through pipelines over long distances is considered to be a transport activity. Thus, in the supply portion of physical supply and use table, 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 transportation industry, depending on where the losses occur.

3.72. Natural gas supply includes both distribution of gas through mains and the extraction of certain gases. Distributed and extracted natural gas are recorded in separate rows of the physical supply and use table (see also para. 3.92). 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 as directly used for intermediate consumption by industries or final consumption by households in the use table.

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

3.74. There is no attempt to link waste flows back to energy from natural inputs. This is in contrast to crops (for example) purpose-produced for biofuel production. Since the growth of most (if not all) of those crops occurs within the accounting period of reference, the link to energy from natural inputs is much more direct.

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

3.76. Transport is an important energy-consuming activity. It should be noted, however, that the use of a fuel such as oil or gas in a car, truck, ship or aeroplane for example, does not automatically constitute a transport industry use: what is critical is the prevailing activity of the unit using the fuel. For example, if a business is engaged predominantly in mining activity, then energy used by this business is attributed to the mining industry regardless of 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 household is attributed to households and not the transportation and storage industry. The treatment of fuel in relation to transport activity within SEEA-Energy contrasts with its treatment within energy balances and the IRES, where all fuel used in motor vehicles, ships, etc. is allocated to transportation activities.[24]

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

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

3.78. 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 transportation and storage industry.

3.79. Other industries will appear in the physical supply and use table for energy primarily as users of energy products.

3.80. Where households generate energy products, this supply should be attributed generally to the industry that would typically supply such a product. For example, if households produce electricity through the use of solar photovoltaic panels, the supply table of the physical supply and use table should show a flow of inputs of energy from renewable sources from the environment to the electricity, gas, steam and air conditioning supply industry. The resulting supply of electricity is then used by households unless households have generated electricity and routed this back to 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 guidance on this allocation, it should be carried out on the basis of general patterns of electricity use observed for the various users of electricity. It should be noted that household production of energy products, including the use of animal waste and wood for heating purposes, might be of analytical interest as well; such analyses could be provided in addition to the information included in the accounts.

3.3.6. Physical supply and use tables for energy

3.81. 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).

3.82. Tables 3.4 (supply table for energy) and 3.5 (use table for energy) represent the standard physical supply and use tables for energy flows. These tables cover flows of all energy from natural inputs and energy products, including those energy products that are transformed into other energy products. The energy content of some products is therefore counted more than once. For example, as coal serves as an input into a transformation process for obtaining electricity and heat, the accounts record the energy content of both the coal and the resulting electricity and heat.

3.83. 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. There are no restrictions, however, as regards 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 physical supply and use table for energy

3.84. The key components of the physical supply and use table for energy cover (a) supply and use of energy from natural inputs, (b) supply and use of energy products, including imports and exports, (c) supply and use of energy residuals, and (d) other residual flows. Discussions in the remainder of the present section focus on these four areas.

Supply and use of energy from natural inputs

3.85. The first parts of tables 3.4 and 3.5 record flows of energy from natural inputs. In table 3.4, the energy from natural inputs is shown as being supplied by the environment. In table 3.5, the energy from natural inputs is shown as being used by the extracting industries. Across these two tables, the total supply for each row of the section "energy from natural inputs" must equal total use.

3.86. The level of detail displayed in the presentation of flows of energy from natural inputs can vary within a country: the highest level of detail may be associated with those inputs that are of the most relevance and the greatest analytical interest.

3.87. In principle, the inputs of energy from renewable sources should reflect the amount of energy that can be generated based on the technology put in place. In practice, inputs of energy from renewable sources are recorded in terms of the amounts of heat and electricity produced through 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 physical supply and use table. Energy from hydroelectric schemes is recorded here also in terms of electricity produced.

3.88. For inputs of mineral and energy resources, losses of energy during extraction are included in the total quantity 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 section of the supply and use tables concerning energy residuals.

3.89. In principle, the inputs of uranium and other nuclear fuel used for energy production should reflect the energy content of the resource extracted from the environment. However, since in practice, it is difficult to measure such a quantity in a meaningful manner, an estimate is made based on the amount of nuclear electricity generated by the use of this natural input.[25] Thus, if information is available on the amount of nuclear electricity generated from uranium extracted in the territory of reference and from imported uranium and other nuclear fuel, this could be the basis for the estimation of the inputs of uranium and other nuclear fuel as well as the estimation of the imports of uranium and other nuclear fuel (see discussion below). The extracted uranium is recorded in the use table under the "mining and quarrying" column heading (ISIC, sect. B).

Supply and use of energy products, including imports and exports

3.90. All energy products supplied by one unit to another (including 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 transaction, or provided free of charge.

3.91. Energy products are produced mainly by establishments classified to ISIC section B, mining and quarrying; section C, manufacturing; and section D, electricity, gas, steam and air conditioning supply. For many countries, energy products are supplied mainly by imports from the rest of the world.

3.92. Extracted natural gas and distributed natural gas are recorded separately as a means of distinguishing between natural gas that is taken out of the environment and natural gas that is processed and ready for consumption. In principle, this is a single commodity; however, in the case of some countries, natural gas is shown as being supplied by the oil and gas extraction industry, while in other cases, it is recorded as being supplied by the gas distribution industry.[26] The difference between extracted and distributed natural gas is accounted for by losses during distribution, storage and transformation. A similar approach may be taken for all energy products; for example,

[25] This follows the convention used in the energy balances, whereby for nuclear electricity, the primary energy form is nuclear heat, which is estimated using an efficiency of 33 per cent (IRES, para. 8.9 (j), third para.). For heat generated from nuclear fuel, the estimate is based on an efficiency of 33 per cent (OECD, International Energy Agency and Eurostat, *Energy Statistics Manual* (Paris, 2005), p. 138).

[26] The two rows can be collapsed into one if care is taken to ensure that the quantity of gas supplied by the oil and gas industry is not also shown as being supplied by the gas distribution industry, as this would lead to double-counting the supply. If there is a need to display the physical flow from the extraction industry to the distribution industry, then the two distinct rows should be retained to prevent double-counting.

coal products may be divided into extracted coal products (hard coal, sub-bituminous coal and lignite) and distributed coal products.[27]

3.93. Production of energy products is a secondary activity within many establishments and, in some cases, it constitutes own-account production for use within an establishment. Where it is possible to quantify own-account, intra-establishment production and use of energy products, these flows should be recorded separately in the accounts as flows of energy for own use. Own-account production and use for each energy product should be recorded in the "*of which for own use*" rows of the supply and use tables.[28]

3.94. Within table 3.4, imports of energy products are recorded as items in a separate column, with each item being among the components making up the total supply of energy. Similarly, table 3.5 records exports of energy products as items in a separate column, with each item being among the components making up the total supply of energy.

3.95. In general, imports and exports of energy products should be recorded when a change of ownership of the product involving a resident and a non-resident unit occurs.[29]

3.96. 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, with all outgoing flows recorded as exports. Energy products sent abroad for processing should be treated in accordance with the treatment of goods for processing described in section 3.2.3.

3.97. Imports of "nuclear fuels and other fuels not elsewhere classified", like natural inputs of "uranium and other nuclear fuels", are difficult to measure in a meaningful manner. Their estimation is therefore based on the amount of nuclear electricity produced from imported nuclear fuel, if available, using an efficiency of 33 per cent. By convention, that value is included as part of the use table, in the "transformation of energy products" section, under the column for the electricity sector (ISIC, sect. D). Nuclear fuels that are extracted from the territory of reference and are used for energy purposes are also included in the "transformation of energy products" section of the use table, in the column for the electricity sector (ISIC, sect. D).

3.98. 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 use by the industries earning the value added from those activities or as use by the households operating the transport equipment. Conversely, all energy use by non-resident entities within the national boundary (ships, aeroplanes, trucks and tourists) should be excluded (see also sect. 3.2.2).

3.99. The use of energy products is divided 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 supply coal to the electricity supply industry for use by the latter in the production of electricity. This would be recorded in the supply table under the mining and quarrying industry. The use of coal to produce electricity would be shown in the "transformation of energy products" section of the use table as the use of coal by the electricity supply industry.

27 For presentation-related reasons, such a breakdown is not shown explicitly in the table.

28 It may be noted that the "*of which for own use*" rows of the supply table are identical to those in the use table. They are included in both tables for completeness.

29 Imports and exports can be recorded according to either the general trade or the special trade systems. 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., when they enter into free circulation).

3.100. The second section, entitled "end use of energy products", records the use of energy products to produce goods and services that are not energy products. These energy products 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 be associated with 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 energy products used were produced for own use or for sale.

3.101. While the structure of the "energy products" section of the supply table is different from that of the use table, care should be taken to ensure that the supply-and-use identity is maintained. For example, the total supply of the energy product coal (table 3.4) should equal the sum (up to rounding error) of the total use of coal in the "transformation of energy products by SIEC class" and "end use of energy products by SIEC class" sections of the use table.

3.102. The "*of which for own use*" rows are included only in the "end use of energy products by SIEC class" section of table 3.5. By definition, own use of energy products implies that the energy product has been used to produce goods and services that are not energy products. For the same reason, the supply and use tables do not include an "*of which for own use*" row for natural gas (extracted) and oil (e.g., conventional crude oil).

3.103. In total, intermediate consumption includes the use of all energy products by industries as inputs into the production process, regardless of the nature of the production process, that is, regardless of whether it is a process that converts an energy product into another energy product for further use in the economy (transformation), or a process that 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.

3.104. During the extraction process, businesses may undertake reinjection—as well as flaring and venting—of natural gas. These flows are recorded not as part of the intermediate consumption of energy products, but rather as flows of residuals, as described below. Losses should be attributed to the owner of the energy product when the losses occur. For example, if a product is lost after it has been handed over from the producer to the final user of the product, the loss is attributed to the final user and should not be recorded as part of the intermediate consumption of the energy producer.

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

3.106. Household consumption entails the consumption by households of energy products purchased or otherwise obtained from energy suppliers. Such consumption exemplifies the end use of energy. Final consumption includes use of energy products by households that they themselves produced,[30] for example, electricity generated by windmills owned by households. These "other energy residuals" correspond to what the national accounts 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 in terms of 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 the energy needs of the energy industry (IRES 2018, para. 8.33). In SEEA-Energy, this is characterized as exemplifying the concept of "end use" of energy.

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

Table 3.4
Supply table for energy (terajoules)

	Production (including household production on own-account); generation of residuals								Flows from the rest of the world		
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries	Households			Flows from the environment	Total supply
	ISIC–A	ISIC–B	ISIC–C	ISIC–D	ISIC–H			Accumulation	Imports		
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										2.0	2.0
Total energy from natural inputs										1 292.0	1 292.0
Energy products											
Production of energy products by SIEC class											
Coal									225.0		225.0
of which for own use											
Peat and peat products											
of which for own use											

Oil shale/oil sands											
of which for own use											
Natural gas (extracted)		395.0									395.0
Natural gas (distributed)				369.1							369.1
of which for own use											
Oil (e.g. conventional crude oil)		721.0									721.0
Oil (oil products)			347.0						930.0		1 277.0
of which for own use											
Biofuels	5.3		0.2	1.5							7.0
of which for own use											
Waste	39.0		54.5						16.9		110.4
of which for own use											
Electricity				212.0					22.0		234.0
of which for own use											
Heat				78.5							78.5
of which for own use											
Nuclear fuels and other fuels not elsewhere classified											
of which for own use											
Total energy products	44.3	1 116.0	401.7	661.1					1 193.9		3 417.0
of which for own use											
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 purposes			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**

Note: Dark grey cells are null by definition.

Table 3.5
Use table for energy (terajoules)

	Intermediate consumption; use of energy resources; receipt of energy losses						Final consumption		Flows to the rest of the world		
	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	Flows to the environment	Total use
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 not elsewhere classified.											
Total transformation of energy products			360.0	752.0							1 112.0
End use of energy products by SIEC class											
Coal	2.0	0.1	17.0				1.0	- 21.0	1.9		1.0
of which for own use											
Peat and peat products											
of which for own use											
Oil shale/oil sands											
of which for own use											
Natural gas (extracted)											
Natural gas (distributed)	2.0		39.0	0.1		12.0	26.0	2.0	201.0		282.1
of which for own use											
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
of which for own use											
Biofuels	0.3		0.2	1.5			5.0				7.0
of which for own use											
Waste	3.0	0.1	4.0	37.0		1.0	33.0	0.3	1.0		79.4
of which for own use											
Electricity	7.0	1.0	22.0	50.0	10.0	15.0	29.0		100.0		234.0
of which for own use											
Heat	2.0		10.5	2.0	1.0	19.0	44.0				78.5
of which for own use											
Nuclear fuels and other fuels not elsewhere classified											0.0
of which for own use											
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
of which for own use											
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**

Note: Dark grey cells are null by definition.

Supply and use of energy residuals

3.107. The following section of tables 3.4 and 3.5 contains entries associated with energy residuals, that is, 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, losses during distribution, losses during storage, losses during transformation, and "other energy residuals". The different types of energy residuals are recorded in the supply table as being supplied by various industries and households and in the use table, as received by the environment.

3.108. More broadly, there are a wide variety of types of residuals that are not usually accounted for as distinct flows belonging to mutually exclusive classes (see also the definition of residuals as contained in para. 3.57 above). Rather, different groups of residuals are analysed on the basis of the physical nature of the flow, or the purpose underlying or the destination of the flow, or simply as a means of presenting the balance of physical flows leaving the economy.

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

3.110. Within this context, four types of losses of energy are identified, according to the stage at which they occur in the production process. It is to be noted that some types of losses may be necessary for maintaining safe operating conditions, as exemplified by some instances of flaring and venting of natural gas.

3.111. Four broad types of losses can be identified:

(a) Losses during extraction;

(b) Losses during distribution or transmission;

(c) Losses during storage;

(d) Losses during transformation or conversion.

3.112. Losses during extraction occur at the time of extraction of mineral and energy resources prior to any further processing, treatment or transportation of the extracted resource. Such losses arise from, for example, the flaring and venting of natural gas during extraction. Some natural gas may also be reinjected into the deposit in order to increase pressure and facilitate further extraction. These flows are not treated as losses since the reinjected gas could be extracted at a later period.

3.113. Losses during extraction are attributed to the economic unit undertaking the extraction. The gross amount extracted (i.e., the amount including the losses) is shown as a flow from the environment to the extracting unit (the supply and use of natural inputs). The portion extracted that is lost during extraction is then recorded as a part of natural resource residuals. These losses, which are included in the supply of residuals attributed to the extracting industry, are "used" by the environment. Assuming that no other losses (or natural resource residuals) are attributable to the extracting industry, the output of products supplied to other economic units by the extracting industry will be equal to the gross extraction less the losses during extraction.

3.114. Losses of energy during distribution or transmission occur between a point of extraction or supply and a point of use. These losses may take any of the following forms (among others): loss of liquid fuels through evaporation and leakages, loss of heat during transportation of steam, loss of gas during distribution or pipeline transport, and loss of electricity through transmission.

3.115. Losses during distribution or transmission are attributed to the economic unit supplying the energy product, based on the assumption that the ownership of the product changes only at the point at which the energy is received by the user. Following the general recording principle, the output of the supplying unit should exclude losses during distribution or transmission and should equal the quantity recorded by the other economic unit (business or household) as consumption. By convention, losses that occur during the production of heat and electricity from uranium and other nuclear fuels are recorded as being supplied by the electricity sector (ISIC, sect. D).

3.116. When losses during distribution are calculated as the difference between the amounts supplied and corresponding amounts received, such calculations may include errors related to meter readings or meter malfunction. These errors in the measurement of flows are commonly referred to as apparent losses, which are recorded under distribution losses.

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

3.118. Losses of energy, such as residual heat during transformation of one energy product into another (e.g., of coal into electricity), are linked to the difference between inputs and outputs of products and in that regard are part of the transforming industry's intermediate consumption. They differ from the other types of losses described here by virtue of being measured only in energy units. In mass terms, this reflects the simple 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.

3.119. Losses during transformation or conversion are attributed to the economic unit that is undertaking the transformation or conversion. The estimate of the intermediate consumption of the energy product that is to be transformed is not affected. Rather, following the general recording principle, the output of the transformed energy products is reduced (and is equal to the amount distributed, assuming no other losses) and a corresponding entry for the supply of energy residuals by the transforming unit is recorded.

3.120. While losses due to evaporation and leakages are often measured in units of volume or weight (e.g., cubic metres or tons), these units should be converted to joules for the purposes of the SEEA-Energy account. Losses of heat are frequently measured in units of energy (e.g., terajoules, or kilowatt-hours).

3.121. From the perspective of suppliers of products, the quantities 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, these are not considered losses in SEEA-Energy. Nonetheless, there may be interest in compiling data concerning theft as a subset under overall use of energy. It should be noted, however, that losses due to theft may be difficult to measure in practice and may be included under losses during distribution.

3.122. Other energy residuals are most often generated from the end use of energy products (e.g., of fuel for vehicles or electricity for heating).[31] The flow of residual heat is recorded as equal to the energy input in order to satisfy the law of the conservation of energy.

[31] Energy can also be dissipated in the form of light or noise.

3.123. By convention, household consumption of all energy products is considered end use and therefore recorded under "other energy residuals". For example, use by households of fuelwood or gas for heating is considered end use.

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

Other residual flows

3.125. For other residual flows, the energy embodied in energy products used for non-energy purposes is shown as supplied by various industries and is, by convention, recorded in the "accumulation" column of the use table as being retained within the economy.

3.126. Energy derived from the incineration of solid waste is recorded separately in the supply and use tables. Solid waste encompasses materials that have been discarded because they are no longer required by the owner or user. By convention, energy from solid waste is shown in the "accumulation" column as being supplied from within the economy 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

3.127. The information contained in the supply and use tables can be used to derive several other tables that highlight specific facets of the supply and use of energy, for example, supply of primary energy products (including residuals) and imports (see table 3.6), transformation of primary energy and imports into energy available for end use (table 3.7) and end use of energy (see table 3.8). While these tables are very similar in concept and presentation to energy balances (see, for example, OECD, International Energy Agency and Eurostat, *Energy Statistics Manual* (Paris, 2005, chap. 7), there are some differences in terms of classifications and terminology.

3.128. Table 3.6, which presents the total inflow of energy to the economy from the environment and the rest of the world,[32] 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, as opposed to figures of energy from natural inputs for the flows from the environment to the extracting industries. All types of energy—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.

3.129. The aggregation level of the energy products presented in the rows of table 3.6 differs from that shown in the preceding tables because the focus of table 3.6 is on presenting 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 before the nuclear fuel has been processed and used in electricity production. Therefore, for nuclear fuels, only the resultant electricity should be recorded in the table.

3.130. For each industry, the column sum shows the amount of primary energy products supplied. The figure in the cell at the intersection of the last row and last column of table 3.6 is equal to the total domestic supply of primary energy products and imports of primary and secondary energy products.

[32] The "imports" column includes primary and secondary products. In contrast, only primary products are included in the "production" columns. For example, only hard coal, sub-bituminous coal and lignite are included in the "coal" row under the heading "production", since they are the only primary coal products.

Table 3.6
Supply of primary energy products (including residuals) and imports (terajoules)

	Production						Flows from the rest of the world	Flows from the environment	Total primary energy supply and imports
	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									
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 not elsewhere classified									
Total energy products	**44.3**	**1 116.0**	**54.7**	**125.5**			**1 193.9**		**2 534.4**

Note: Dark grey cells are null by definition.

3.3.8. Transformation and end use of energy products

3.131. The use of energy products is recorded in table 3.7, entitled "Transformation of energy", which displays the transformation of energy products into other energy products, and table 3.8, entitled "End use of energy", which displays the use of energy products in producing goods and services that are not energy products.

3.132. Table 3.7 shows how energy products that enter 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 shows 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.

3.133. 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 products (e.g., the electricity produced from coal).

3.134. Inspection of a column within table 3.7 yields information on the amounts and types of energy used by an industry as intermediate inputs for transformation (as represented by negative numbers) and on how much of each secondary energy product is produced by the same industry as a result of the transformation (as represented by a 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 industry's transformation processes is shown in the bottom row of the table.

Table 3.7
Transformation of energy (terajoules)

	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 indus-tries	Net	Avail-able 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 (extracted)	395.0				- 395.0			- 395.0	
Natural gas (distributed)					282.1			282.1	282.1
Oil (e.g. conventional crude oil)	721.0			- 360.0				- 360.0	361.0
Oil (oil products)	930.0			347.0	- 16.0			331.0	1 261.0
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 not elsewhere classified									
Total energy products	**2 534.4**								**2 305.0**
								Total losses	
Losses				**13**	**216.4**			**229.4**	

3.135. The rows of table 3.7 show how much of each type of energy is produced as a result of the energy transformation processes (represented by positive numbers) or used as inputs for energy transformation processes (represented by negative numbers).

3.136. The "losses" row includes losses due to distribution, storage and transformation. Losses during extraction are already accounted for in the "total" column entry for a specific product. This column indicates the total supply of each product and thus already accounts for losses incurred during extraction.

3.137. The amount of energy available for end use (shown in the rightmost column of table 3.7) is obtained by adding (a) the net output from the transformation and (b) the domestic supply of primary energy and imports of primary and secondary energy products (shown in the "total" column). Subtracting total losses from total supply of primary energy and imports yields the total amount of energy available for end use.

3.138. Table 3.8 records the use of energy products for purposes other than transformation into other energy products. For a specific energy product, "end use" signifies what is available after the energy transformation processes are complete. These energy products may be used for intermediate consumption, for household consumption, as a change in inventories of energy products, or for export. Some end use entails non-energy uses of energy products, for example, the use of oil-based products as lubricants or in the production of plastics.

3.139. In total, intermediate consumption includes the use of all energy products by industries as inputs into a production process, regardless of the nature of that process, that is, regardless of whether it is (a) a process of conversion of one energy product into another energy product for further use in the economy (transformation); (b) a process of use of the energy content of the energy product that results in no possible further use of that energy (end use); or (c) a process that allows for the possibility of further use of the energy content at a later point, in some cases, through incorporation of the energy into a non-energy product (e.g., plastics). Tables 3.7 and 3.8 can be used to calculate intermediate consumption of energy products.

Table 3.8
End use of energy (terajoules)

	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	Sum of row
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 not elsewhere classified										**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**
End use of energy products for non-energy purposes			51.0							**51.0**
Total use										**2 305.0**

3.140. Some energy products may be stored by industries for later transformation or end use. For each relevant energy product, the net changes in the quantities stored are recorded as changes in inventories in the "accumulation" column.

3.141. Household consumption entails 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 fuelwood or animal waste gathered by households and electricity generated by windmills for own use by households.

3.142. For each type of energy product, table 3.8 displays the end use of energy by industries and households, as well as by other use categories. A range of energy products is typically used by industries.

3.143. The value for each energy product in the final column of table 3.7 ("available for end use") is equal to that for the same product in the final column of table 3.8, up to rounding error, after accounting for end use of energy products for non-energy purposes. In the present example, oil accounts for the major part of end use of energy products for non-energy purposes.

3.3.9. Use of energy by purpose

3.144. The range of tables presented above do not include specific information on the purpose for which energy is used. However, for some types of analysis, it is useful to possess that information, that is, to know whether the energy is used for, say, transport or heating or for non-energy purposes. The present section presents a physical use table (table 3.9, entitled "Energy use by purpose") that displays such information. The compilation of an "energy use by purpose" table requires additional data sources (as shown in table 3.9). Depending on policy needs, countries might wish to have a more detailed energy product presentation for each purpose.

3.145. According to IRES, energy products can be used for (a) energy purposes; (b) non-energy purposes; and (c) transformation (IRES 2018, para. 5.83). Further, an energy product is classified as being used for energy purposes if it is used for heat raising, transportation and electrical services (IRES 2018, para. 5.79).

Table 3.9
Energy use by purpose (terajoules)

	Agriculture, forestry and fishing ISIC–A	Mining and quarrying ISIC–B	Manufac-turing ISIC–C	Electricity, gas, steam and air conditioning supply ISIC–D	Transportation and storage ISIC–H	Other industries	House-holds	Accumu-lation	Exports	Total
Energy purposes encompassing transportation, heating and other energy purposes										
Transportation										
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**

3.146. According to SEEA-Energy, energy products can be used for (a) energy purposes and (b) non-energy purposes. Energy purposes are broken down into heating, transportation and "other" energy purposes, which include electrical services and transformation.

3.147. Electricity, an energy product, can be used, for example, in the transformation of crude oil into gasoline and can be included in the category "other energy purposes". The category of energy use for heating includes energy use for cooking, lighting and household appliances. Other energy purposes include industrial applications involving stationary machinery.

3.148. In some cases, determining the purpose for which an energy product is used is straightforward. Energy products bought by private households, for instance, are most likely to be used for energy purposes. In other cases, however—when, for example, the chemical industry buys oil products—determining the purpose of the product's use will require that information be obtained from the relevant business units.

3.149. Non-energy use consists of the use of energy products as raw materials for the manufacture of products outside the scope of SIEC, as well as for direct uses that do not involve using the products as a source of energy, or as a transformation input. Examples are lubrication, sealing, preservation, road surfacing and use as a solvent. (IRES 2018, para. 5.21).

3.150. Almost all consumption of electricity is for power, heat and electronic use that results in the dissipation of the electricity (as heat). While use of electricity for electrolysis does occur in some industries, statistics that distinguish this type of use from other uses in enterprises are not usually available (OECD, IEA and Eurostat, *Energy Statistics Manual*, p. 30).

3.151. In SEEA-Energy, even if energy products that are exported or placed in inventory for future use may ultimately be used for energy purposes, they are always classified under non-energy purposes, since that ultimate use is usually unknown. Similarly, products that are lost during distribution (distribution losses) are included under the category "non-energy purposes".

3.4. Energy statistics, energy accounts and energy balances

3.4.1. Introduction

3.152. Energy statistics, energy accounts and energy balances all present information on energy supply and use. The present section describes these broad approaches to provision of information on energy, including how they are related and the key differences among them. Bridge tables, which formally articulate these differences, are presented as well.

3.153. Energy statistics are generated through the collection and compilation of information on production, imports, exports and domestic use of energy products based on specific surveys and the use, inter alia, of business statistics and foreign trade statistics. Energy balances reorganize these basic energy statistics by focusing on and consolidating the supply and use components, and highlighting the transformation of energy within the economy. Along the same lines, energy accounts, which primarily use national accounts classifications and definitions, represent both a re-organization and a broadening of the scope of energy statistics. While both energy balances and energy accounts apply the principle that supply equals use, these two systems define "total supply" and "total use" somewhat differently in order to meet their different needs.

3.154. The main differences between energy balances and energy accounts are related to what activities are considered to be in scope and how those activities are classified. The energy accounts use the residence principle to determine whether a specific energy flow should be included (for instance, as imports) and whether it is to be included as part of energy use or not. The boundary of the energy balances is defined in accordance with the territory principle, which is usually the case for basic energy statistics as well.

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

3.156. The following sections examine the main differences between energy balances and energy accounts. As mentioned above, one such key difference lies in the fact that in defining the national boundary, energy accounts use the residence principle and energy balances apply the territory principle. This topic has been considered comprehensively in section 3.2.2 on the treatment of international flows (although sect. 3.4.4 is also relevant) and is not further discussed here. The discussion below corresponds in large part to the descriptions contained in chapter XI, entitled "Uses of basic energy statistics and balances", of IRES 2018).

3.4.2. Energy balances: products

3.157. In SEEA-Energy, as in the SEEA Central Framework and SNA, a physical energy unit is generally regarded as a "product" when it has a positive monetary value. This ensures coherence between the physical and monetary flows of energy products (see chap. IV below for a discussion of monetary flow accounts). It is to be noted that energy produced for own use is included in the energy accounts as an energy product.

3.158. In energy balances, production is defined as the capture, extraction or manufacture of fuels or energy in forms that are ready for general use. The only significant deviation from the SEEA-Energy concept of product is the inclusion in the energy balances of quantities lost through venting and flaring during and after the production of secondary products (IRES 2018, para. 5.10). Therefore in order for information contained in energy balances to be compared with that in energy accounts, the relevant categories of energy products and energy losses within the energy accounts should first be combined.

3.4.3. Energy balances: industries

3.159. SEEA-Energy accounts use an industry classification scheme that is consistent with the national accounts in that it follows the principles of classification and the structure of the ISIC Rev.4. Thus, information on any specific enterprise/establishment (on either the production or the consumption side) is, as a general rule, presented under the ISIC division/group/class of the principal activity of the unit involved.

3.160. While ISIC is used by both the energy accounts and the energy balances, in some cases, they include different activities. The clearest example of this difference is provided by own-account transportation undertaken by enterprises. Within the energy accounts, consumption of fuels for own-account transportation activity is allocated to the ISIC categories based on the principal activity of the enterprise in question, in accordance with ISIC principles. In the energy balances, however, this activity is simply allocated to the transportation sector, regardless of what the predominant activity of the enterprise might be.

3.161. A similar treatment applies to the generation of electricity and heat for sale where such activity does not occur within any of the energy-producing industries of ISIC. In the energy accounts, this is regarded as a secondary activity leading to the output of energy products from the specific industries involved. The production of electricity and heat from the incineration of waste, for example, 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 be allocated to an energy-producing industry only if it is that industry's main activity.

Energy industries and the energy transformation sector

3.162. More generally, the energy balances provide a description of the transformation of energy broken down by type of 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 and coal liquefaction plants.

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

3.164. Within the energy balances, all production of energy, including industries' own generation of electricity and heat for sale, is allocated to primary production and transformation. On the use side, the energy industries' own use of energy is included in the energy balances as a separate category.

3.165. The concept of energy industries' own use as defined in IRES is different from the concept of own use used in SNA and SEEA-Energy. In SNA and SEEA-Energy, own use refers to intra-establishment production and use of energy products. 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. Further, the IRES 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.

3.166. SEEA-Energy accounts include the following ISIC categories for 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.

3.167. It is to be noted that the distinction between heat and electricity is irrelevant in the tables presented when the production of heat and electricity in combination is being recorded. The energy balances include heat and power generation as a combined activity when heat and power are generated from combined heat and power plants.

3.4.4. Energy balances: transport activity and industry statistics

3.168. In the energy balances, energy use related to road, rail, air, sea and pipeline transport are placed under the separate aggregate item "transport". Fuels delivered to fishing vessels are included under "fishing" (IRES 2018, para. 5.94); and energy use for tractors and other off-road vehicles is not regarded as transport (ibid., para. 8.41).

3.169. In contrast, the energy accounts attribute the consumption of fuels by transport activities to the industries actually using these fuels. In cases 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 (Transportation and storage). However, where an establishment operates its own transport activity for own use, any fuel use associated with that activity is allocated to the industry to which the establishment belongs, that is, this use of fuel is recorded in exactly the same way as other energy use undertaken by the establishment is recorded. The use of fuels for private cars, boats, aeroplanes and so on is allocated to households' private consumption.

3.170. Energy use for transport could be separated from the total energy use of industries and households, and shown as a memorandum item, which would then constitute a supplement to the SEEA-Energy standard tables. Such a memorandum item should not, however, include the fuels used, e.g., for off-roaders and lawnmowers.

3.4.5. Energy balances: supply, use and stock concepts

3.171. In the aggregated energy balances, the term *supply* refers to energy entering the national territory for the first time, less energy exiting from the national territory (through exports or international bunkering) and stockchanges (IRES 2018, para. 11.13). This is illustrated by the following equation:

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

3.172. For individual energy products, *supply* is defined as follows in the "commodity balances":

Supply = + production
+/- transfers between commodities
+ imports
- exports
- international (aviation and marine) bunkers (as applicable)
- stock (inventory) changes

3.173. The latter definition characterizes supply as *supply for use within the national territory.*

3.174. Transfers entail product reclassification (renaming) (IRES 2018, para. 5.17).

3.175. One consequence of such a definition of supply in the energy balances and of supply's being always equal to use is the exclusion of exports and fuel purchased abroad by domestic ships and aircraft that are undertaking international voyages.

3.176. In contrast, the SEEA-Energy definition of supply is consistent with the conventions of the national accounts, as illustrated by the following equation:

Supply (SEEA-Energy) = production (output)
+ imports (according to the residence principle)

3.177. The SEEA-Energy definition of supply is therefore broader than that of the energy balances, since it includes all energy made available for use, including fuel made available through international bunkering.

3.178. The concept of *use* formulated by 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 refuelling and bunkering by resident aeroplanes and ships abroad is also included in the supply and use tables of the energy accounts.

3.179. The term *final consumption* within the energy balances excludes the use of energy products as input into transformation and energy industry own use by energy industries and other energy producers. In the national accounts, the term denotes the use of goods and services by individual households or the government to satisfy individual or collective needs or wants. As indicated above, the term *final consumption* is not used in SEEA-Energy so as to prevent confusion with the different use of the term within the energy balances. Explicit reference is made instead to household consumption, changes in inventories, exports and so forth. The term *end use* as used in SEEA-Energy denotes use of energy that excludes its use for transformation processes.

3.180. 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 2008 SNA, as well as in commercial accounting). Energy balances include stock changes (inventory changes) as part of supply, so that an increase of inventory is seen as decreasing the supply of the product, while a decrease in inventory is seen as increasing the supply. In SEEA-Energy, changes in inventories are accounted for in the "accumulation" column. It should be also noted that in energy balances, inventories are recorded using the territory principle.

3.181. By SNA convention, inventory changes in SEEA-Energy are recorded as a use or a loss during storage that is, an increase of inventory is recorded as a use, while a decrease in inventory is recorded as a negative use (since it leads to availability of a greater quantity of the product for other uses) or loss during storage.

3.4.6. Energy balances: statistical difference

3.182. Conceptually, the supply of energy products equals the use of those products. In practice, however, there are usually differences between the measures of supply and use, due in general to the utilization of different data sources and different factors for conversion from mass to energy units. Energy balances will therefore explicitly include an item for *statistical difference*, which, as calculated in the balances, can be positive or negative depending on whether the calculated supply is higher or lower, respectively, than the calculated use.

3.183. SEEA-Energy accounts do not include an item for statistical difference, as this is a matter 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. If the initial discrepancies are large, then the compiler should ensure that they are not due to errors in the basic data or should try to determine whether it is possible to obtain the additional information needed to clarify the reason for those discrepancies. When the discrepancies are of a lesser magnitude, different methods can be applied to eliminate them from the accounts. One method often used in national accounts practice entails carrying out a proportional distribution. If, for example, there is a 3 per cent surplus of supply over use, the energy surplus can be allocated to users (intermediate consumption, private consumption, inventories) in proportion to the already allocated energy use.

3.184. Another method is to adjust only the energy product inventories so as to record the statistical discrepancies as part of the inventory changes. Since information on energy stocks is important for national security and the national supply of energy and, in addition, includes market-sensitive material, a decision to use such artificial stock adjustments should be weighed carefully, and significant adjustments should always be identified in a note to the accounts.

3.4.7. Bridge tables linking energy balances and energy accounts

3.185. When a country introduces SEEA-Energy accounts, energy statistics and energy balances are likely to provide the vast bulk of the required basic data. Under these circumstances, the most economical way to compile energy accounts is to make adjustments to existing energy statistics and energy balances. In practice, this means that adjustments and additions must be made to the data presented by energy statistics and energy balances.

3.186. Further, in order to display 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. The bridge tables indicate the additions and subtractions needed to reconcile the bases used in the energy accounts and energy balances. Tables 3.10 and 3.11 present bridge tables for supply and use, respectively.

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

3.188. Table 3.11 opens with final consumption of energy as presented (and defined) within the energy balances. Through addition of international marine bunkers, exports, inventory changes and purchases by residents abroad, end use as recorded in SEEA-Energy is obtained.

3.189. For both tables, the bridging is carried out with respect to energy product details, which are based on SIEC in both the energy accounts and the energy balances.

3.190. The main adjustments to energy statistics and energy balances needed to derive the energy accounts are summarized directly below. The information is derived from IRES (chap. XI, sect. B.2).

3.191. *Adjustments to imports/exports*. In order for imports and exports from the energy balances to be included in the energy accounts, adjustments are needed to relate them to transactions between resident and non-resident units, such as the inclusion of fuel purchases by residents abroad as imports.

3.192. *Other adjustments for geographical coverage*. Other examples relate to the case for international marine and aviation bunkering and for items in the bottom block of the balances (IRES 2018, paras. 8.33–8.34 and table 8.1). In addition, the different uses of energy products of energy balances need to be disaggregated so that they can be recorded as intermediate/final consumption when the unit is resident or exports when the unit is non-resident, and complemented by the use by resident units abroad. This case is similar to that of international bunkering.

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

3.194. *Reallocation/regrouping of data to the relevant ISIC division/group/class.* In order for the energy accounts to be compiled, information has to be regrouped according to the different ISIC categories. In order for information to be presented based on a purely ISIC-based tabulation, such as that used in SEEA-Energy, information on "transformation", "transport", "non-energy use", "energy industries own use" and "primary production", for example, need to be reallocated.

Additional data items necessary for the compilation of energy accounts

3.195. In order for energy accounts to be compiled, it is important to have information that allows for the adjustments presented. Such information includes, for example, the breakdown of 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.

3.196. In view of the above-mentioned 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 energy accounts.

Table 3.10

Bridge table for domestic supply and total supply (terajoules)

	Supply (energy balances)	+Losses during generation of secondary production	+International marine bunkers	Exports	Accumulation	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 not elsewhere classified							

Note: Exports are removed before the calculation of net supply or availability in the energy balances and therefore need to be added back in.

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

	Final consumption (energy balances)	+International marine bunkers	Exports	Accumulation	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 not elsewhere classified							

Chapter IV
Monetary flow accounts

4.1. Introduction

4.1. The production and use of energy are important for the economy, the environment and society at large. While energy production is itself a significant economic activity, energy is also required for virtually all forms of economic production. Determining how energy products are produced, distributed and used, and by whom they are used, is therefore of socioeconomic importance. Moreover, the choices involved have profound implications for the state of the environment and society.

4.2. SEEA-Energy provides a methodological approach for collating 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 on the physical environment and to thereby support powerful analyses of economic and environmental facets of energy supply and use.

4.3. Particularly relevant to energy are the economic instruments that are being used to achieve environmental outcomes. Many of these instruments are designed to influence the type and amount of energy used—to control, for example, the amount and type of emissions arising from energy production and use. It is instructive to identify environmental transactions within the key aggregates of SNA and to combine this material 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 its capacity to deliver benefits are being used effectively. This information also supports a comparative assessment of various possible policies.

4.4. The present chapter is structured as follows: a general description of monetary supply and use tables, including a presentation of monetary supply and use tables for energy, is followed by a discussion of the characteristics and uses of combined presentations. The chapter concludes with an examination of other environment-related transactions for energy and analyses several tables that display a range of important energy-related transactions. To a large extent, chapter IV summarizes the discussion in the 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. The present section describes valuation based on market prices, which is the starting point from which transactions are valued within SEEA-Energy. As in many cases, the prices received by producers differ from those paid by purchasers. This section provides a general description of (a) the various types of prices used in SEEA-Energy and their application within the monetary supply and use tables, and (b) the impact on these prices both of the recommended treatment of taxes and subsidies on products, and of 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 SNA, values recorded in the accounts are, in principle, the current transaction values or market prices for energy and energy-related transactions. Market prices, which are defined as the amount of money that willing buyers pay to acquire something from willing sellers, entail an exchange between independent parties on the basis of commercial considerations only, which is sometimes referred to as an “at arm’s length” transaction.

4.7. For more details on valuation at market prices, see the SEEA Central Framework, section 2.7.3.[33]

[33] Applying the market price principle to the valuation of mineral and energy assets is a challenge, since market prices are generally not observable. A number of techniques are suggested in 2008 SNA (see chaps. 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, and, in particular, a discussion on the use of net present value approaches, is contained in chap. VI.

Basic, producers’ and purchasers’ 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. This difference could be due to any of several factors, such as taxes, transport costs, wholesale and retail margins and subsidies. The definitions of three different types of prices, reflecting both supply and use perspectives, have been formulated to take these various factors into account. The relationship among these three types of prices is illustrated in table 4.1. A more detailed description of prices is presented in section 2.7.3 of the SEEA Central Framework.

4.9. The basic price measures the amount retained by the producer and is therefore the price most relevant to 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 and is the price most relevant for the purchaser.

Table 4.1
Basic, producers’ and purchasers’ prices

Basic prices *plus*
Taxes on products excluding invoiced value added taxes *less*
Subsidies on products *equals*
Producers’ prices *plus*
Value added taxes not deductible by the purchaser *plus*
Separately invoiced transport charges *plus*
Wholesalers’ and retailers’ margins *equals*
Purchasers’ prices

4.10. Given the importance of imports and exports of energy products for the energy accounts, it should be noted that the price of import cost, insurance and freight is the price at the point of entry into the importing country that includes costs, insurance and freight incurred between the exporter’s and importer’s borders. For imported products, cost, insurance and freight 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 (a) value added-type taxes and (b) other taxes on products, which include taxes named for their tax base, for example, petrol taxes, as well as CO_2 taxes, where the tax base is the unit of energy associated with the transaction. However, if an emissions tax is levied on the emissions rather than on the use of energy, the tax is categorized not as a tax on products, but, instead, as belonging to the "other taxes on production" category (2008 SNA, para. 7.97).

4.12. Taxes and subsidies on products are often a subject of intense focus in the area of energy policy. Taxes are compulsory, unrequited payments in cash or in kind made by institutional units to government units.[34] 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, for example, when a good is exported, transferred, delivered or used for own consumption (2008 SNA, para. 7.88). Examples of taxes on products include value added taxes, taxes on exports and taxes on imports.[35]

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 those enterprises produce, sell or import (2008 SNA, para. 7.98). As in the SEEA Central Framework, SEEA-Energy records only those subsidies for which an actual transaction occurs between institutional units. Hence, for implicit subsidies, such as preferential tax rates for enterprises producing energy from renewable sources, no estimates of the values of those subsidies are included in SEEA-Energy.

4.2.4. Trade and transport margins

4.14. When energy products are sold through wholesalers and retailers, such activities are allocated to ISIC section G (Wholesale and retail trade; repair of motor vehicles and motorcycles), and the trade margins are recorded as output of this industry. The trade margin forms part of the difference between the basic price realized 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, which 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 third party contracted by the producer that undertakes those activities, then 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 the producer, then the transport margins are not recorded.

4.2.5. Classifications

4.17. While monetary flow data on products (including energy products) are usually collected based on the Central Product Classification, for energy statistics, energy

[34] For details on the definitions of the different types of taxes, 2008 SNA, paras. 7.71–7.97, 8.52–8.64 and 10.207.

[35] It is to be noted that the compilation of accounts on environmental taxes excludes value added taxes. Environmental taxes comprise energy taxes, transport taxes, pollution taxes and resource taxes. For further details on environmental taxes, see chap. IV of the SEEA Central Framework.

balances and physical flow accounts in SEEA-Energy, the SIEC is used. In principle, there needs to be an alignment between the SIEC and Central Product Classification in order for combined presentations of physical and monetary data to be compiled. As regards the examples provided in this chapter, the SIEC classification is used for both the physical and monetary data, since it is assumed that such an alignment is possible.

4.3. Monetary supply and use tables

4.3.1. Introduction

4.18. Monetary supply and use tables are closely related to the physical supply and use tables described above. In the present section, a description of the form of a monetary supply and use table is followed by a more detailed discussion of the workings of the monetary supply and use table for energy products.

4.3.2. Monetary supply and use tables

4.19. Monetary supply and use tables in SEEA-Energy encompass 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 that sector, as well as information on the types of entities within the economy that are supplying and using those energy products. Many of the flows of products recorded in monetary terms are associated with the use of energy from natural inputs extracted from the environment, for example, in the manufacture of petroleum products.

4.20. In SEEA-Energy, the recording of product flows within the economy is consistent with the principles used in SNA in recording these flows. Products are "supplied" within the economy when they are either:

(a) Produced by industries in the national economy (output);

(b) Brought in from the rest of the world (imports).

4.21. The supply-use identity requires that all supplied products be recorded as being "used". Use can occur under any of several scenarios, for example, the products can be:

(a) Used by other industries to produce different products (intermediate consumption);

(b) Consumed by households (household final consumption);

(c) Consumed by governments (government final consumption);

(d) Sold to the rest of the world (exports);

(e) Held as inventories for later use.[36]

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

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

4.3.3. Monetary supply table for energy

4.23. The monetary supply table for energy products represented in table 4.2 displays the value of domestic production for various energy products and the value of imports at basic prices; and presents, for each type of energy product, the amount of taxes and subsidies, and the sum of trade and transport margins.

4.24. Following typical national accounts practice, amounts of taxes and subsidies are presented as taxes less subsidies (taxes, net) in table 4.2. If the information is available, it is also possible to show the taxes and subsidies separately.

Table 4.2
Monetary supply table for energy products (currency units)

	Supply										
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries	Flows from the rest of the world	Total supply at basic prices	Taxes (net)	Trade and transport margins	Total supply at purchasers' prices
	ISIC–A	ISIC–B	ISIC–C	ISIC–D	ISIC–H		Imports				
Energy products											
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 not elsewhere classified											
Total	**873**	**60 744**	**27 085**	**56 794**			**59 250**	**204 746**	**54 592**	**8 798**	**268 136**

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

	Intermediate consumption							Private consumption and other				
	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	Total use
Energy products (currency 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**
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**

4.3.4. Monetary use table for energy

4.25. The monetary use table for energy is presented in several stages. The top part of table 4.3, which displays the monetary use table for energy in purchasers' prices, records the amounts paid by users for the various energy products used. As in the physical use table for energy (table 3.5), 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, residuals, for example, do not appear in the monetary use table for energy.

4.26. 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 monetary energy flows:

Total supply at purchasers' prices = domestic production at basic prices
+ import cost, insurance and freight + taxes less subsidies on products
+ trade and transport margins
equals
Total use at purchasers' prices = intermediate consumption
+ private consumption + inventory changes + exports

4.27. Since all energy used by the government is recorded as inputs to intermediate consumption, 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 "accumulation" column.

4.28. The remaining part of table 4.3 presents a breakdown of the use of energy products at purchasers' prices into: taxes less subsidies, trade and transport margins, and use at basic prices.

4.29. The taxes less subsidies paid in relation to each energy product are allocated to the users of the energy products. The assumption is that it is the users of the energy products who ultimately pay taxes and receive subsidies on products, as taxes and subsidies affect the purchasers' price of energy. However, those taxes and subsidies are normally 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 provided in table 4.3 corresponds to the total of taxes less subsidies in table 4.2 (the monetary supply table).

4.30. The tax information is useful for analysing the net tax burden related to the use of energy products. The information can be broken down further by specific taxes and subsidies: for example, tables can be put together for value added taxes, CO_2 taxes and other energy taxes.

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

4.32. Presenting the allocation of taxes less subsidies on products and transport margins by users may be a challenging task in practice, yet there is a specific gain: the resulting tables are useful for analysis. In addition, setting up supply and use tables that make use of the same concept of price is instructive for the compiler, since it ensures the consistency of data and provides a basis for estimating missing data, that is to say, through use of the available information to make a judgment, the compiler can reach a balance by adjusting the components as necessary (2008 SNA, para. 14.6).

4.33. 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 carried out within separate tables for use of domestically produced energy products and imported energy products through use of information and assumptions regarding, for example, market shares.

4.34. The accounting identity according to which total supply at basic prices (table 4.2) is equal to total use at basic prices (table 4.3) for each energy product holds:

Total supply at basic prices = import cost, insurance and freight
+ domestic production at basic prices
equals
Total use at basic prices = intermediate use at basic prices
+ private consumption at basic prices + inventory changes at basic prices
+ exports at basic prices

4.4. Combined presentations for energy

4.4.1. Introduction

4.35. 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 present a wide range of information across various energy-related themes and to derive indicators that combine physical and monetary information.

4.36. The integrated accounting structures utilized by SEEA-Energy within its physical and monetary tables, together with the common underlying accounting rules and principles applied throughout the physical and monetary accounts, provide 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 tons of CO_2. While the units are different, the data sets are presented using consistent classifications and definitions, which explains why these presentations are referred to as combined physical and monetary presentations.

4.37. Different forms of combined physical and monetary presentations are possible and, indeed, there is no standard form for these presentations. Often, data on physical flows 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 depend on the available data and the type of information being sought.

4.38. Energy-related combined presentations could identify: 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 the emissions associated with use of energy products by various users of such products. The combining of monetary and physical information related to energy can also support an informed assessment of policy trade-offs. For example, when the introduction of a tax on carbon emissions is being considered, a combined presentation could be used to provide information regarding potential impacts on energy prices paid by various energy users, profits of energy suppliers and total costs for energy users.

4.39. The present section provides general guidance on the compilation of combined physical and monetary presentations, including an example of a combined monetary and physical supply and use presentation for energy, and offers suggestions regarding other possible combined presentations for energy.

4.4.2. General principles applied in combined presentations

4.40. 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 hinges on the application of a range of practices and principles.

4.41. The overarching principle applied to the combining of energy-related monetary and physical information asserts that physical flows have to be recorded in a manner consistent with economic transactions as presented in SNA. That is, the combining of different types of information must entail the use of similar definitions and classifications of energy products and energy flows, and industries and institutional sectors. The time frame and recording principles (including consistent use of the 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.

4.42. It is important that the compilers be aware of any differences in the principles applied in the underlying statistics when putting together combined presentations. Steps must be taken to eliminate or adjust for such differences so as to ensure that the combined presentations are not marked by any inconsistencies.

4.4.3. Combined supply and use presentations for energy

4.43. A combined presentation for energy entails the juxtaposition 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 confined to energy products that are supplied and used. In consequence, it is possible to juxtapose monetary and physical supply and use flows for energy only for the supply and use of energy products.

4.44. Energy consumed through own use and energy lost during transformation are both included in the physical supply table. These flows correspond to the block within the physical supply and use table related to “energy products”. In contrast, the monetary supply and use tables contain only those flows associated with an economic transaction.

4.45. The supply or use of energy may provide the basis for a tax (or subsidy) even where no monetary transaction occurs. 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.

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

Table 4.4
Combined physical and monetary supply table for energy products

Energy products (currency units)	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	Total output at basic prices	Flows from the rest of the world: Imports	Total supply	Taxes	Subsidies	Taxes (net)	Trade and transport margins	Total supply at purchasers' prices
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 not elsewhere classified														
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 (terajoules)														
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 not elsewhere classified														
Total energy products	**44**	**1 116**	**402**	**661**			**2 223**	**1 194**	**3 629**					

Combined physical and monetary supply table for energy

4.47. Table 4.4 exhibits the form of a standard combined physical and monetary supply table for energy and has two halves. The top half, which displays the monetary supply of energy products in monetary units, is organized in accordance with the discussion in section 4.3 on monetary supply and use tables. Information on those products appears in the rows of the table, while information on the industries that supply energy products is set out in the columns. Details on the supply of other products and the total supply of products in monetary terms are also shown so as to enable a better assessment of the role of the energy sector within the economy. In the bottom half of table 4.4 (organized in accordance with section 3.3), which presents the physical supply of energy products in joules, energy product details again appear in the rows of the table and details on the supplying industries appear in the columns. Since there is no monetary transaction for own-account production, own use is not accounted for in the monetary account. As a consequence, in the combined presentation of table 4.4, own-account production is also excluded from the bottom half (physical supply) of the table.

Combined physical and monetary use table for energy

4.48. Table 4.5 exhibits the form of a standard combined physical and monetary use table for energy products. Table 4.5, like table 4.4, is divided into two halves. The top half, which provides information in monetary terms on the use of energy products, is organized according to the principles of monetary supply and use tables, as examined in section 4.2. Energy product details appear in the rows of the table, while information on industry use of energy products and other uses of energy products is presented in the columns. In the bottom half of table 4.5 (organized according to the principles set out in sect. 3.2), which presents the use of energy products in physical terms (joules), energy product-related details again appear in the rows of the table and industry use-related details appear in the columns, along with details on other types of energy use. The part of the table relating to use of energy in physical terms conforms to the principles and structure of the physical use table for energy as described in chapters II and III.

4.49. The uses of energy products displayed in the columns of table 4.5 include intermediate consumption by industries, household consumption, exports and inventory changes.

4.4.4. Other combined presentations for energy

4.50. It is not necessary to put together 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 a limited number of data variables. In some cases, only a limited range of data may be available, but often, only a limited range of data are needed. In other cases, information on stocks of mineral and energy resources in physical and monetary terms as well as other socioeconomic variables such as employment can be included in the combined presentation. What is important is that the data used in the combined presentation appropriately address the environmental-economic-related concerns of policymakers.

4.51. For example, the introduction of a price on carbon emissions, through either a tax on such emissions or the introduction of a scheme requiring the use of tradable permits for carbon emissions, is typically motivated by the desire to improve the quality of the environment by reducing the level of those emissions entering the

Table 4.5
Combined physical and monetary use table for energy products

Energy products	Intermediate consumption							Private consumption and other changes				
	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	Total use
Energy products by SIEC class: use table at puchasers' prices (currency units)												
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 not elsewhere classified												
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 (terajoules)												
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 not elsewhere classified												
Total end use for energy purposes	**50**	**3**	**419**	**91**	**632**	**96**	**1 291**	**240**	**- 22**	**745**	**963**	**2 359**

air. Nevertheless, the use of these policy tools will usually have significant implications for the economy. There may be concerns, for example, regarding the cost imposed by such schemes on the businesses that supply energy products, as well as on businesses and households that use those products. Governments will be acutely interested in the potential generation of revenue from carbon taxes and carbon emissions trading schemes, and in the related possibility and cost of monetary compensation awarded to affected householders and businesses within the economy.

4.52. Coherent and relatable monetary and physical data are needed to assess the possible impacts of introducing a charge (e.g., a tax) on carbon emissions. Physical data on carbon emissions related to various energy products, and the various users and uses of these products, are required to assess whether carbon emissions targets are being achieved. And a range of monetary data are required to assess the impact of such a scheme on prices, profits, household and business expenditure and saving, and government revenue and spending. What is needed, in short, is a combined presentation of data that utilizes information based on the principles of integrated environmental-economic accounting, as described in SEEA-Energy and in the SEEA Central Framework. The use of combined presentations to inform this (and other) issues is further examined in chapter VII.

4.53. Combined presentations are also useful for the derivation of many energy-related indicators. Through the proper juxtaposition of information, indicators can be derived on, inter alia, energy efficiency, energy expenditures by different industries and households, and energy intensity, as shown in table 4.6.

Table 4.6
Partial combined presentation used for calculating energy intensity of industries

	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries
	ISIC A	ISIC B	ISIC C	ISIC D	ISIC H	
(1) Gross value added (currency units)	15	2	505	350	400	55
(2) End use of energy products (terajoules)	50	3	419	632	632	96
(2)/(1)Energy intensity	3.4	1.6	0.8	1.8	1.6	1.7

4.5. Environment-related activities and expenditures

4.54. In chapter IV of the SEEA Central Framework, the subjects of environmental protection, resource management and the environmental goods and services sector are described in detail. Within the context of SEEA-Energy, relevant environmental protection expenditures include those for energy-related pollution abatement. In this regard, it could be highly informative to combine, for example, time-series information on expenditures linked to energy-related sulfur dioxide (SO_2) abatement with corresponding data on energy-related SO_2 emissions as well as with data on production levels of those activities closely associated with SO_2 emissions.

4.55. Another example related to the content of chapter IV of the SEEA Central Framework is associated with the energy-related component of environmental goods and services sector statistics that includes data on renewable energy production and production of energy-saving products. This information can have a high degree of relevance to policy, especially when considered in conjunction with other physical and monetary data in the SEEA-Energy accounts.

4.5.1. Environmental protection activities and related accounts

4.56. As defined in the SEEA Central Framework, environmental protection activities are those activities whose primary purpose is the prevention, reduction and elimination of pollution and other forms of degradation of the environment (para. 4.12). Extractions of mineral and energy resources are not part of environmental protection according to this definition, since it does not include activities related to natural resource use. Yet, such activities might be of interest owing to their potential impacts on the environment.

4.57. Within the environmental protection group of the Classification of Environmental Activities (see SEEA Central Framework, table 4.1 and annex I, sect. A), most environmental protection activities for the energy sector are related to class 1: Protection of ambient air and climate (e.g., investment in cleaner technologies for coal combustion) and class 3: Waste management (e.g., investments in technologies that result in lower levels of the waste arising from energy transformation processes).

4.58. Energy-related environmental protection activities are not limited to the energy sector. For example, expenditures for the purchase of catalytic converters for vehicles can also be an important contributor to overall environmental protection expenditures.

4.59. The SEEA Central Framework provides more details on the compilation of environmental activity accounts and statistics.

4.5.2. Resource management activities and related accounts

4.60. Resource management activities are activities whose primary purpose is preserving and maintaining the stock of natural resources and hence safeguarding against depletion (SEEA Central Framework, para. 4.13). Those activities constitute group II under the Classification of Environmental Activities. Among the classes of that group, it is class 10: Management of mineral and energy resources, which is the most relevant to SEEA-Energy.

4.61. Included in class 10 are activities and actions aimed at minimizing the intake of mineral and energy resources through (a) in-process modifications (e.g., adjustment of production processes with the aim of reducing inputs of mineral and energy resources needed to produce energy); (b) the recovery, reuse, recycling, savings and use of substitute mineral resources (e.g., through adjusting production processes with the aim of reducing losses); and (c) the production of energy from renewable sources. Activities and actions concerning measurement, control, laboratories and the like are also included in class 10, as well as education, training and information, and administration and regulation activities.

4.62. While accounts for resource management activities are not widely developed, a similar approach to that taken for accounts for environmental protection activities can be applied in developing accounts for resource management activities.

4.5.3. Treatment of activities associated with production of energy from renewable sources and energy saving

4.63. One specific boundary issue concerns the treatment of activities associated with the production of energy from renewable sources and the treatment of activities associated with energy saving. To a large extent, the treatment is likely to depend on the structure of the energy supply in each country. The treatment should be determined on the basis of the primary purpose of the activity, that is, whether it is for environmental protection, for resource management or for the general production of energy.

4.64. Where activity related to energy saving and renewable energy sources is of considerable importance, the allocation of this activity to different classes in different situations may impact the comparability of aggregates related to environmental protection and resource management over time and across countries. Countries should apply the principle of allocation of these activities based on primary purpose. However, in some cases, there may be interest from an analytical perspective in classifying all such activities under resource management, regardless of the primary purpose, in order to facilitate international comparisons.

4.6. Other transactions related to energy

4.6.1. Introduction

4.65. The national accounts contain a wide range of transactions related to energy. The present section focuses on other transactions in the core national accounts framework that may be of interest within the context of the analysis of the economic facets of energy. Some of these transactions may be identified as having an environmental purpose as well, in which case they are considered environmental transactions. When the transactions are related to the environment, they are within scope of the SEEA Central Framework.

4.6.2. Presentation of certain transactions for energy

4.66. Table 4.7 presents taxes on production and subsidies as related to energy production and use. Energy-related property income, income taxes, social transfers and capital transfers are recorded in table 4.8.

4.67. In table 4.7, the placement of the entries in the columns related to industries, households, government and the rest of the world (exports) indicates whether the tax or subsidy is payable or receivable. While taxes are paid by various industries, households and the rest of the world (exports) and received by government, subsidies are paid by 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 the total amounts receivable.

4.68. "Taxes on energy products" is one of the four broad categories of environmental taxes. An environmental tax is defined as a tax whose tax base is a physical unit (or a proxy thereof) of some item that has a proved, specific, negative impact on the environment (SEEA Central Framework, para. 4.150). Energy taxes include taxes on energy products used for stationary processes (including fuel oils, natural gas, coal and electricity or transport). Taxes on fuel used for transport purposes should be displayed as a separate subcategory of energy taxes. Taxes on carbon are included under energy taxes as well. If they are identifiable, carbon taxes should be reported under a separate subcategory of energy taxes.

4.69. Carbon taxes could also take the form of payments for tradable emission permits. Such taxes are treated as environmental taxes and categorized as energy taxes when the permits relate to carbon emissions. Wherever possible, these taxes should be separately identified within energy taxes.

4.70. It should be noted that value added taxes are generally not categorized as energy taxes, since they are charged on a broad range of products regardless of those products' environmental impacts.[37]

[37] See SEEA Central Framework, para. 4.158, for a brief discussion on one minor exception.

Table 4.7

Taxes on production and subsidies related to energy production and use (currency units)

	ISIC sect. B division				ISIC sect. C division		ISIC sect. D group															
	05—Mining of coal and lignite		06—Extraction of crude petroleum and natural gas		19—Manufacture of coke and refined petroleum products		351—Electric power generation, etc.		352—Manufacture of gas; distribution, etc.		353—Steam and air conditioning supply		Other industries		Households		Government		Rest of the world		Total	
	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable	Payable	Receivable
	Currency units																					
Taxes on production and imports																						
Taxes on products																						
Energy products			0		0		0		0		0		17		42			63	3		63	63
Carbon taxes													10					13	3		13	13
Taxes on fuel used for transport													7		42			49			49	49
Taxes on permits																						
Other energy taxes																						
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**	**7**	**253**	**569**	**3**	**1**	**822**	**822**

Note: ISIC sections: B (Mining and quarrying), C (Manufacturing), D (Electricity, gas, steam and air conditioning supply
ISIC divisions: 05 (Mining of coal and lignite), 06 (Extraction of crude petroleum and natural gas), 19 (Manufacture of coke and refined petroleum products)
ISIC groups: 351 Electric power generation, transmission and distribution), 352 (Manufacture of gas; distribution of gaseous fuels through mains), 353 (Steam and air conditioning supply).

Table 4.8
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**

Note: Dark grey cells are null by definition.

4.71. The payment of rents is presented in table 4.8, by institutional sector; the rent paid by non-financial corporations is received by government. In principle, other institutional units may also receive such payments. Further details on rent are provided in chapter VI.

4.72. In table 4.8, specific taxes on income, wealth, etc. as related to mining activities are 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 similarly highlighted within table 4.8.

4.73. 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 had received monetary transfers that are then immediately used to purchase the products concerned (2008 SNA, para. 3.82). In the example presented in table 4.8, the payments are entered as received by households from government.

4.74. Other current transfers related to international cooperation are presented in table 4.8 in the form of a payment from the government to the rest of the world. Capital tax payments related to fixed capital used by energy producing corporations are entered as paid by non-financial corporations to government; investment grants are shown as being transferred from the government to non-financial corporations; and other capital transfer payments are recorded as going from government to the rest of the world.

4.75. The last row of table 4.8 includes, for each institutional sector, the total amount of property income, income taxes, and social, capital and other transfers received or paid in relation to energy.

Chapter V
Physical asset accounts for mineral and energy resources and for energy product inventories

5.1. Introduction

5.1. Assets are items that are 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. There has been increasing awareness of the value inherent in the components of the environment and the inputs provided by the environment 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 organize relevant information, including the levels and values of stocks of natural inputs and the changes in these stocks over time. Flows of extraction, depletion and discoveries are central to the asset accounts, providing valuable information on those mineral and energy resources upon which an economy relies.

5.3. Mineral and energy resources, such as coal and oil, are unique: they can be extracted and used through economic activity but cannot be renewed on any human time scale. It is therefore important for knowledge to be available on the levels of the resources that are being held, and the type and extent of the changes in those levels, over time. That knowledge can be used by policymakers to determine, for example, the likely operating life of existing mineral and energy resources, which could provide an indication of future requirements for energy imports and threats to national energy security.

5.4. The present chapter, in focusing on mineral and energy resources, undertakes the appropriate categorization of these inputs according to their physical characteristics and the criteria associated with their extraction. The presentation and analysis of several basic physical asset accounts for energy also includes the measurement of physical depletion of energy natural resource inputs. Inventories of energy products are defined and discussed, and, in this context, a table is presented that records, in physical terms, inventories of energy products, including a decomposition of changes in inventories for a range of those 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 categorized along two dimensions: first, according to their physical characteristics; and second, according to their viability and feasibility and the geologic knowledge of the resources. The present section defines those resources and, given the lack of a standard international classification in this area, offers some practical guidance to complement this definition. An important exercise in this regard is the categorization of mineral and energy resources as either "known deposits" or "potential deposits"—as the latter are not included in SEEA-Energy. The section concludes with a description encompassing certain recording principles and the units used in physical asset accounts for energy.

5.2.2. Definition and categorization of mineral and energy resources

Definition and classification of mineral and energy resources

5.6. As defined in chapter III, energy natural resource inputs include mineral and energy resources, which for the purposes of SEEA-Energy comprise deposits of oil resources, natural gas resources, coal and peat resources, and uranium and thorium resources. It should be noted that the definition of mineral and energy resources in SEEA-Energy, which includes only those resources related to energy, is necessarily narrower than the corresponding definition in the SEEA-Central Framework, which includes not only non-metallic minerals but other metallic minerals, such as gold, which are not used for energy purposes. As there is no internationally agreed detailed classification of mineral and energy resources suitable for statistical purposes, defining mineral and energy sources within SEEA-Energy requires that several points be clarified.

5.7. While firewood in forests and other stocks of biomass in nature can be used for energy purposes and are included among energy natural resource inputs, asset accounts are not compiled for them because, overall, these assets are not used primarily for energy purposes. They are recorded instead as biological resources within the asset accounts of the SEEA Central Framework.

5.8. In SEEA-Energy, renewable sources of energy such as wind, solar and hydropower are not considered physical assets. With the exception of energy sources from biomass, other renewable sources of energy, in contrast to mineral and energy resources, cannot be exhausted. Thus, from an accounting perspective, there is no physical stock of these types of renewable sources of energy that can be used up or sold. Nevertheless, as physical flows of energy do arise from renewable sources of energy, those flows are discussed in chapters III and IV.

Categorization of mineral and energy resources

5.9. Since mineral and energy resources are found generally below ground, it is often impossible to determine, with complete precision, the quantity of those resources that it would be reasonable to expect might be extracted. Consequently, the quality and quantity of the mineral and energy resources in the deposit become a key determinant in the measurement of those resources, given that this will influence the likelihood and cost of extraction and the degree of confidence regarding the quantity that could be extracted in the future.

5.10. The material in the following discussion is also covered by the SEEA Central Framework (see sect. 5.5 and annex A5.3 for further details).

5.11. The framework used to establish the scope of known deposits is UNFC-2009. More specifically, it is a generic and flexible scheme for classifying and evaluating quantities of fossil energy and mineral resources.

5.12. UNFC-2009 categorizes mineral and energy resources according to whether, or to what extent, projects for the extraction or exploration of those resources have been planned, confirmed or developed. Quantities of those resources are classified according to three extraction-related criteria:

- Economic and social viability (E);
- Field project status and feasibility (F);
- Geologic knowledge (G).

5.13. Criterion E designates the degree of favourability of economic and social conditions in establishing the commercial viability of the project. Criterion F designates the maturity of studies and commitments necessary to implement mining plans or development projects. These extend from early exploration efforts before the existence of a deposit or accumulation has been confirmed through to a project entailing extraction and sale of a product. Criterion G designates the level of certainty in the geologic knowledge and potential recoverability of the quantities of fossil energy and mineral reserves and resources.

5.14. Known deposits are categorized within three classes, each defined according to combinations of the above-mentioned UNFC-2009 criteria (see table 5.1).

(a) *Class A: Commercially recoverable resources*. This class includes deposits for projects that fall in categories E1 and F1, and where the level of confidence in the geologic knowledge is either high (G1), moderate (G2) or low (G3);

(b) *Class B: Potentially commercially recoverable resources*. This class includes deposits for those projects that fall in category E2 (or, eventually, E1) and at the same time in category F2.1 or F2.2, and where the level of confidence in the geologic knowledge is either high (G1), moderate (G2) or low (G3);

(c) *Class C: Non-commercial and other known deposits*. This class includes resources for those projects that fall into category E3, and for which the feasibility is categorized as either F2.2, F2.3 or F4, and the level of confidence in the geologic knowledge is either high (G1), moderate (G2) or low (G3).

Table 5.1
Categorization of mineral and energy resources

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

Source: UNFC-2009, figures 2 and 3.

[a] Includes on-production projects, projects approved for development and projects justified for development.

[b] Includes economic and marginal development projects pending and development projects on hold.

[c] Potential commercial projects may also satisfy the requirements for E1.

[d] Includes unclarified development projects, non-viable development projects, and additional quantities in place.

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

5.16. The scope of known deposits is broader than the scope of deposits that underpins the measurement of energy resources in SNA. The scope of SNA in this regard is limited to deposits that are commercially exploitable, given current technology and relative prices.[38] The broader scope of known deposits is adopted in the SEEA Central Framework and SEEA-Energy to ensure that as comprehensive 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 VI.

[38] 2008 SNA, para. 10.179.

5.2.3. Units and recording principles

Units

5.17. The physical asset accounts for energy use a variety of units, such as tons, cubic metres, oil equivalents and petajoules (PJ). The unit chosen is the one regarded as being the most appropriate for a given resource. The same unit should be used throughout the account for a specific mineral and energy resource in order to ensure consistency in accounting throughout the presentation. Adding and subtracting the various changes to the opening stock allow for derivation of the closing stock. By applying conversion factors, it is possible to convert the accounts from one unit to another (e.g., from tons to petajoules). Annex A1 includes general conversion factors for use in such calculations.

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 displaying opening and closing stocks and changes within the period for all energy stocks.

Quantification

5.19. When natural gas assets are being quantified based on potential future extraction, care should be taken not to double-count quantities that are extracted and then reinjected into the same or other geologic deposits. These quantities of gas should be included in the output only when they are extracted for use within the economy. Another operational arrangement entails placement of quantities of natural gas in controlled storage in readiness for further distribution to consumers. Under these circumstances, the natural gas should be considered a product, and the stocks of gas in controlled storage should be 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 the flow accounts for energy, for example, consistent treatment of flaring of natural gas, own use of energy and extraction losses.

5.21. In practice, the implementation of asset accounts for mineral and energy resources relies heavily on basic quantity estimates. As those estimates, which are published by private companies, geologic surveys, etc., may reflect a range of diverse recording principles, it is important that the basis upon which such fundamental input data are recorded be well researched and that, where necessary and possible, those data be adjusted accordingly. For example, it is stated in the document on the Petroleum Resources Management System, developed by the Society of Petroleum Engineers, that, in general, resource estimates should be based on sales quantities. According to the Petroleum Resources Management System document, "non-sale quantities include petroleum consumed as fuels, flared or lost in processing, plus hydrocarbons that must be removed prior to sale" (SPE-2007, p. 15, sect. 3.2.1). Where data are recorded on this basis, it is necessary to adjust the quantity estimates based on additional information from companies, geologic surveys, etc. on petroleum consumed as fuel, flaring and losses in processing, where that information is available.

5.3. Physical asset accounts for mineral and energy resources

5.3.1. Introduction

5.22. The present section discusses physical asset accounts for mineral and energy resources. Table 5.2 reports on stocks of those resources (in physical units) at a point in time, on the basis of whether the stocks belong to the class of commercially recoverable resources, of potentially commercially recoverable resources, or of non-commercial and other known deposits. Table 5.3 reports on opening and closing stocks of various mineral and energy resources, and the changes in stock positions over the accounting period. This section also defines and describes the various categories of change in those stocks.

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 should include estimates of the opening and closing stock of each 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 categorized by resource class, that is, belonging to class A: Commercially recoverable resources; class B: Potentially commercially recoverable resources; or class C: Non-commercial and other known deposits, according to 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 the likelihood of extraction differs from class to class, simple summation of the available quantities of 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)

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

5.26. Within this framework, it is important to clearly distinguish 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. Table 5.3 displays a basic physical asset account for mineral and energy resources. Described below are the various categories of additions and reductions to stocks.

Table 5.3
Mineral and energy resources account (physical units)

	Type of mineral and energy resource (Class A: Commercially recoverable resources)			
	Oil resources (thousands of barrels)	Natural gas resources (cubic metres)	Coal and peat resources (thousands of tons)	Uranium and other nuclear fuels (tons)
Opening stock of mineral and energy resources	**800**	**1 200**	**600**	
Additions to stock				
Discoveries				
Upward reappraisals		200		
Reclassifications				
Total additions to stock		*200*		
Reductions in stock				
Extractions	40	50	60	
Catastrophic losses				
Downward 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. Changes in stock in physical terms should encompass the following types of changes:

(a) *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, that is, it must belong in class A, B or C. In situations where a quantity of potential deposits becomes known to a higher degree of confidence, such increases should be treated as discoveries. Discoveries should be recorded by type and category of resource;

(b) *Reappraisals*. Reappraisals, which may be upward or downward, should apply only to known deposits. In general, reappraisals will entail either additions or reductions in the estimated available stock of a specific deposit, or changes in the categorization of specific deposits within class A, B or C, based on changes in geologic information, technology, resource price or a combination of these factors.

(c) *Extraction*. Estimates of extraction should reflect the quantity of the resource physically removed from the deposit, while excluding mining overburden, that is, the quantity of soil and other material moved so that the resource could be extracted. 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 the amounts involved reduce the availability of the resource. The following is to be noted:

For natural gas, it may be more difficult to measure the quantity extracted owing to the nature of the extraction process for certain 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 put to direct use, and some may be reinjected—especially after extraction has continued for some time—to increase the pressure on the remaining oil and thereby 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 reinjection;

(d) *Catastrophic losses.* Catastrophic losses are rare for most energy resources. While flooding and collapsing of mines do occur, the deposits continue to exist and can, in principle, be recovered. The issue in this case is one of economic viability of extraction rather than of 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, resulting in significant losses of oil resources. Losses of oil and related resources in this situation should be treated as catastrophic losses;

(e) *Reclassifications*. Reclassifications may occur if certain deposits are opened or closed to mining operations owing 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. The measurement of depletion is often a particular focus in the compilation of asset accounts. In the SEEA Central Framework (para. 5.76), 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. In physical terms, the depletion of mineral and energy resources is equal to the quantity of the resource that is extracted, as a given stock of resources at the beginning of a period cannot regenerate itself on human time scales.

5.30. In general, extractions will not usually fully account for the entire value of depletion in physical terms of the stock of an asset over an accounting period. For example, the depletion of natural timber resources, in physical terms, is equal to removals less sustainable yield. As mentioned earlier, SEEA-Energy does not include asset accounts for natural inputs such as timber, which are not used primarily for energy purposes. Timber resources are, however, part of the asset accounts discussed in section 5.8.3 of the SEEA Central Framework.

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 and energy resources, that is, naturally occurring resources before they become products through extraction. The present section discusses accounts in physical terms for accumulated quantities of energy products. It presents an account for inventories of energy products and suggests a decomposition of changes in inventories. While inventories of energy products are not part of the asset accounts for mineral and energy resources, information on inventories is necessary for provision of a better understanding of the available energy products in a country.

5.4.2. Inventories of energy products

Classification of energy products

5.32. The SIEC is a classification of energy products used in the physical supply and use tables, as shown in chapter III. The same classification should be used for the asset accounts for inventories of energy products in order to ensure consistency between the supply and use tables and the asset accounts for inventories.

Physical asset accounts for inventories

5.33. In addition to accumulated quantities of mineral and energy resources, governments and enterprises within a country will often hold accumulated quantities of coal, oil and other energy products, for reasons related to national security, or the need for self-sufficiency, or for purely commercial reasons.

5.34. Those accumulations of energy products correspond to what are often called stocks within energy statistics. The IRES defines stocks as quantities of energy products that can be held and used to (a) maintain service under conditions where supply and demand are variable in their timing or amount owing to normal market fluctuations or (b) supplement supply in the case of a supply disruption. IRES defines stock *changes* as the increase (stock build) or decrease (stock draw) in the quantity of stock over a reporting period (IRES 2018, para. 5.16).

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

5.36. The range of energy products included under the SEEA-Energy item entitled "inventories" encompasses primary energy products that are being accumulated after extraction and before processing (e.g., coal, crude oil and natural gas) and secondary energy products, which are derived from further processing (e.g., town gas, fuel oil, gasoline and diesel).

5.37. Besides being of analytical interest in their own right, full asset accounts for inventories of energy products can facilitate the corroboration of the data within the physical supply and use tables for those products.

5.38. Table 5.4 presents a physical asset account for inventories of energy products. In line with a physical asset account for mineral and energy resources (table 5.3), this account displays opening and closing level of inventories and changes during the accounting period. However, the change items in the asset account for inventories are different from those in the asset account for mineral and energy resources, since the recording of discoveries and extraction is not applicable to the inventories of energy products.

5.39. An asset account for inventories should be set up for each important energy product. In table 5.4, the names of the various energy products serve as column headings. As mentioned in the previous section, it is important that the same classification of energy products be used as that used in the general supply and use tables.

5.40. Owing to the non-material characteristics of electricity and heat, it is not possible to include these energy products in inventories. Asset accounts are therefore not applicable to electricity and heat. In practice, inventories of certain other energy products may not exist, or (like inventories of waste) may not be relevant.

Table 5.4
Physical asset account for inventories of energy products

	Coal	Peat and peat products	Oil	Natural gas (thousands of cubic metres)	Biofuels	Waste	Nuclear and others
	(thousand tons)						
Opening level of inventories	1 899		5 336	2 004			
Changes due to transactions							
Additions	100		505	55			
Withdrawls	- 800		- 500				
Recurrent losses	- 96		- 64	- 2			
Total changes due to transactions	- 796		53	- 59			
Other changes							
Catastrophic losses							
Uncompensated seizures							
Changes in classification							
Other changes in inventories not elsewhere classifie	99		- 14				
Closing level of inventories	1 202		5 263	2 057			

Note: Units for products under “biofuels”, “waste” and “nuclear and other” vary by subcategory.

5.41. While the column headings of table 5.4 refer only to aggregated groups of energy products, it is more appropriate, in practice, to present the physical asset accounts for inventories at a much more detailed level, for example, through distinguishing the various types of oil and oil products.

5.42. The units used in the asset accounts for inventories can be specific to the various energy products, as in table 5.4, or converted to a common physical unit, such as tons, or to a common calorific values, such as joules.

5.43. In most cases, it is only the opening and closing stocks, and the total change in inventories, that are relevant enough to be recorded. The various accounting items presented in the table are discussed below.

Opening level of inventories is the level of the inventories at the beginning of the accounting period, which is equal to the closing level of inventories of the previous accounting period.

Changes due to transactions is equal to 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 for intermediate consumption or otherwise relinquished. Also included are recurrent losses, which entail such losses in inventories as should be expected because they occur normally. Even large losses, if they occur regularly, should be taken into account when the change in inventories are calculated. Changes in inventories are also recorded in the physical supply and use tables presented in chapter III.

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

Changes in classification entail no change in the volume of the inventories: they are related mainly to the transfer of a unit from one institutional sector to another (e.g., the movement of the inventories' owner from the household sector to the non-financial corporations sector). This item is relevant only if the asset account is set up for individual institutional units, rather than for the total economy. Changes from work in progress to finished good may be recorded here, if such an inventories-related distinction between products is made in the accounts.

Other changes in inventories not elsewhere classified When the assumption underlying the calculation of the rate of current shrinkage of inventories is revised (in relation to changes in inventories, as discussed above), this should be reflected as other changes in inventories (see 2008 SNA, para. 12.50).

Closing level of inventories is the level of the inventories at the end of the year, which is equal to the opening stock of the subsequent year.

Chapter VI
Monetary asset accounts for mineral and energy resources and for energy product inventories

6.1. Introduction

6.1. Monetary asset accounts for mineral and energy resources provide a market-based valuation of physical stocks of those 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 V, and the asset accounts and national balance sheet of 2008 SNA. The scope of SNA asset accounts and balance sheets includes all economic assets.

6.2. As mineral and energy resources are a critically important input to almost all types of economic activity, the value of those resources may be relevant to the measurement of a country's total wealth, 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 monetary values are 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 with those achieved for other types of assets that are being used within the economy. Those values may also serve as a source of information on several flows related to the use of mineral and energy resources, such as rent payments for those resources and payments related to using them to protect and repair the environment.

6.4. The production of monetary asset accounts for mineral and energy resources allows for the development of estimates of the value of the depletion of those resources. Such estimates are vitally important because they enable the calculation of depletion-adjusted economic aggregates such as depletion-adjusted value added for extractive industries and depletion-adjusted GDP. These measures provide additional information on the sustainability of the use of mineral and energy resources because they treat the depletion of those resources as a cost to the extractive industries and to the economy. In contrast, 2008 SNA, while treating the using up (or consumption) of fixed capital as a cost to industries, does not extend this treatment to non-produced (natural) assets such as mineral and energy resources.

6.5. The present chapter is organized as follows: those mineral and energy resources considered to be in scope of the SEEA-Energy monetary asset accounts are the focus of section 6.2; the conceptual form of the monetary asset account for those resources is highlighted in section 6.3; section 6.4 offers a discussion of the monetary valuation of mineral and energy resources and section 6.5 provides an example of the derivation of asset values and depletion using the net present value approach.

6.6. Monetary asset accounts record not only energy resources but also inventories of energy products, which are described in section 6.6. The measurement of energy resources in volume terms is examined in section 6.7. The chapter concludes with a discussion in section 6.8 of the possible inclusion of monetary asset accounts for other relevant assets—those owned and used by extractive industries, for example, extractive equipment, gas pipelines and transport equipment.

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 those resources can be observed and quantified, these values should be used in the accounts. However, in practice, many deposits of mineral and energy resources are seldom, if ever, exchanged on a market; therefore, even if the resources have market values, those values cannot be observed. Consequently, under these circumstances, a market valuation of mineral and energy resources must be based on assumptions regarding what the market prices would have been if the resources had been traded in a market.

6.8. An estimate of a market value can be based on the assumption that this value reflects the future income that an investor would be expected to 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, as well as the economic surplus that each physical unit will bring to the owner or extractor.

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

6.10. As discussed in chapter V, mineral and energy resources are divided into three groups:

Class A: Commercially recoverable resources, which includes resources whose extraction is currently taking place 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 realistic assumptions regarding future market conditions.

Class B: Potential commercially recoverable resources, which includes resources that may be extracted in the future. However, since the feasibility of extraction is subject to further evaluation, and extraction and sale have not yet been confirmed to be economic, there is a significantly high level of uncertainty regarding whether future extraction will occur.

Class C: Non-commercial and other known deposits, which includes resources for which the level of uncertainty regarding future extraction is even higher than that for the resources included in class B.

6.11. Like the SEEA Central Framework (para. 5.193) and SNA (chap. 13), SEEA-Energy recommends that only the valuations of deposits in class A be included in the monetary asset accounts. Classes B and C are not included in the SEEA-Energy monetary asset accounts owing to the degree of uncertainty regarding expected extraction profiles and incomes.

6.12. Countries might find it policy relevant to value the deposits of mineral and energy resources in classes B and C as a means of, for example, gauging future potential flows of income to the government. In such cases, a clear distinction should be made between the valuations of deposits in class B and in class C.

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 displayed in table 6.1. All entries should be recorded in the same currency unit and at current prices. Such an account may be set up for any individual mineral and energy resource of interest (e.g., crude oil, natural gas or coal). If asset accounts have been set up for individual resources, these may be combined into an overarching monetary asset account.

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

	Type of mineral and energy resource
	Class A: Commercially recoverable resources
	(Currency units)
Opening value of stock of resources	
Additions to value of stock	
Discoveries	
Upward reappraisals	
Reclassifications	
Total additions to stock	
Reductions in value of stock	
Extractions	
Catastrophic losses	
Downward 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 definitions for the corresponding physical flows. Thus, the monetary account reflects a valuation of physical flows as recorded in the physical asset account. The only flow recorded in the monetary asset account that is additional to those in the physical asset account concerns revaluations, which are 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 have the ability to affect not only the value of the existing stock of mineral and energy resources but also the proportion of the physical resource considered to have an economic value. These are quantity/volume effects arising from changes in price, and are accounted for not as holding gains and losses but rather as reappraisals under increases in stocks (if prices go up) or decreases (if prices go down).

6.3.2. Linkage to 2008 SNA

6.16. In principle, the scope of SEEA-Energy monetary asset accounts and 2008 SNA asset accounts for mineral and energy resources are identical. However, SEEA-Energy is careful to define the scope of the mineral and energy resources that are to be included in the monetary asset accounts through reference to the UNFC-2009. In contrast, 2008 SNA (para. 10.179), without reference to any specific classification system, simply states that

> "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".

Also in 2008 SNA (para. 12.17), 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".

6.17. Although the terms *economically exploitable reserves* and *proven resources* are not well defined in 2008 SNA, the condition that the resources should be "economically exploitable, given current technology and relative prices", indicates that the scope of 2008 SNA asset accounts for mineral and energy resources, which encompasses class A (Commercially recoverable resources), is the same as the scope of SEEA-Energy.

6.18. The general reference of 2008 SNA to reserves can be assumed to correspond to a broader estimate of the quantities of energy resources that can be extracted (including all three levels of confidence, that is, low, moderate and high (G1+G2+G3), as discussed in chap. V), while the specific reference to proven resources (reserves) corresponds to estimation with a narrow level of confidence (i.e., G1 only). SEEA-Energy recommends that the best estimate (G1+G2+G3) of the commercial recoverable resources be used.

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

6.20. A discussion of the relationship between SEEA asset account entries and those of 2008 SNA can be found in section 5.3.3 of the SEEA Central Framework.

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	
Class A: Commercially recoverable resources	Quantities	Market values assigned to quantities associated with known deposits that can be estimated with high (G1), moderate (G2) or low (G3) levels of confidence in geologic knowledge	Market value assigned, but with some ambiguity about which estimate to use
Class B: Potentially commercially recoverable resources	Quantities	Market value assumed to be zero	Outside asset boundary
Class 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 through the use of a common numeraire. Further, mineral and energy resources can be compared with other assets in order to assess relative returns, national wealth and potential future revenues to the government and carry out similar types of analyses. Since it is commonly the case that governments exercise a high level of ownership of or influence over the extraction of mineral and energy resources, valuation of resources in monetary terms may constitute a useful approach to assessing future streams of income for government, which might include, for example, estimating future government revenue from the extraction of oil and natural gas.

6.22. Since enterprises engaged in extraction make assessments of their future income streams in their business accounts, it is useful to be able to place these individual enterprise-based valuations within a broader, national perspective. Further, market-based mechanisms, such as quotas, which are being used increasingly to allocate access rights to environmental assets, could be linked to aggregate valuations for mineral and energy resources.

6.23. Many mineral and energy resources are not purchased in a marketplace nor is the manner of their production similar to that of buildings and equipment. In consequence, 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. The decision to use such models as tools for the development of meaningful valuations for produced assets has proved to be a sound one overall. Nevertheless, compilers and users should familiarize themselves with certain complexities before applying the models to the valuation of mineral and energy resources in practice.

6.25. In SEEA-Energy, as well as in the SEEA Central Framework, the net present value approach is recommended for estimating asset values. This method 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. Use of the net present value approach generally requires measurement of the returns on the environmental asset (resource rent); estimation of the extraction profile and future resource rents; and selection of the rate of return and discount rate to be used in the estimate of the asset value. A general overview of, and further details on, the net present value approach, including potential uses and limitations, can be found in section 5.4 and annex A5.1 of chapter V of the SEEA Central Framework. Provided below is an empirical example of its application.

6.5. Empirical example of the application of the net present value approach

6.5.1. Introduction

6.26. The present section provides practical guidance on how to apply the approach. The value of a mineral and energy resource can be estimated using this approach by following the steps described below. Much of the data required for the valuation of stocks using the net present value approach can be found in the monetary flow accounts, which are described in chapter IV.

6.5.2. Variable estimates

6.27. In SEEA-Energy, resource rent provides a gross measure of the return on environmental assets. There are several methods for estimating resource rent, the most common being 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 entails estimating gross operating surplus, specific subsidies and taxes on extraction and the user cost of produced assets incurred through extractive activity. Such estimates are generally based on data from the national accounts.

6.28. As defined in table 6.3, *gross operating surplus* is equal to output less operating costs. Operating costs include intermediate consumption, compensation of employees, and other taxes and subsidies on production.

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

6.30. *Intermediate consumption*, which is the value of products used by the extraction industry, is valued at purchasers' prices, that is, including trade margins and all taxes and subsidies on products but excluding 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, including all subsidies on products, excluding taxes on products)
Less operating costs
Intermediate consumption (input costs of goods and services at purchasers' prices, including taxes on products)
Compensation of employees (input costs for labour)
Other taxes on production plus other subsidies on production
Equals gross operating surplus: SNA basis[a]
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[b]

[a] Strictly speaking, the accounting identity "output less operating costs equals gross operating surplus" also includes gross mixed income (the surplus earned by unincorporated enterprises) and should be adjusted for net taxes and subsidies on production. However, these details do not affect the logic of the explanation here.

[b] 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 do play a role in generating the operating surplus. These returns are ignored in the present formulation.

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 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 on the compensation of employees.

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 used by the government to partly appropriate or subsidize, respectively, the operations of the extractive industry. Since intermediate consumption at purchasers' prices includes all taxes and subsidies on products, the resource rent is affected by the specific taxes and subsidies on extraction when intermediate consumption is subtracted from the output. It is therefore necessary to add them back into the resource rent to prevent them from influencing its estimation.

6.35. User cost of produced assets is the sum of consumption of fixed capital and return to produced assets. 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 in the consumption of fixed capital.

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

6.5.3. Estimation of resource rent

6.37. The *resource rent* is that part of an extractor's operating surplus that represents a return on a mineral and energy resource. In practice, the resource rent is calculated by subtracting all extraction costs from the total output of products, that is, 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 do not include secondary activities that have no direct relation to extraction activities.

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

Table 6.4
Calculation of resource rent

	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**
Quantity of resource extracted (millions of cubic metres)	20
Per unit resource rent (currency units per million cubic metres)	**2 148**

6.40. *Quantity of resources extracted* is the quantity of resources extracted in the reference period. The total resource rent for the same reference period is divided by this quantity in order to obtain the per unit resource rent, that is, the price of the commercial mineral and energy resources in ground.

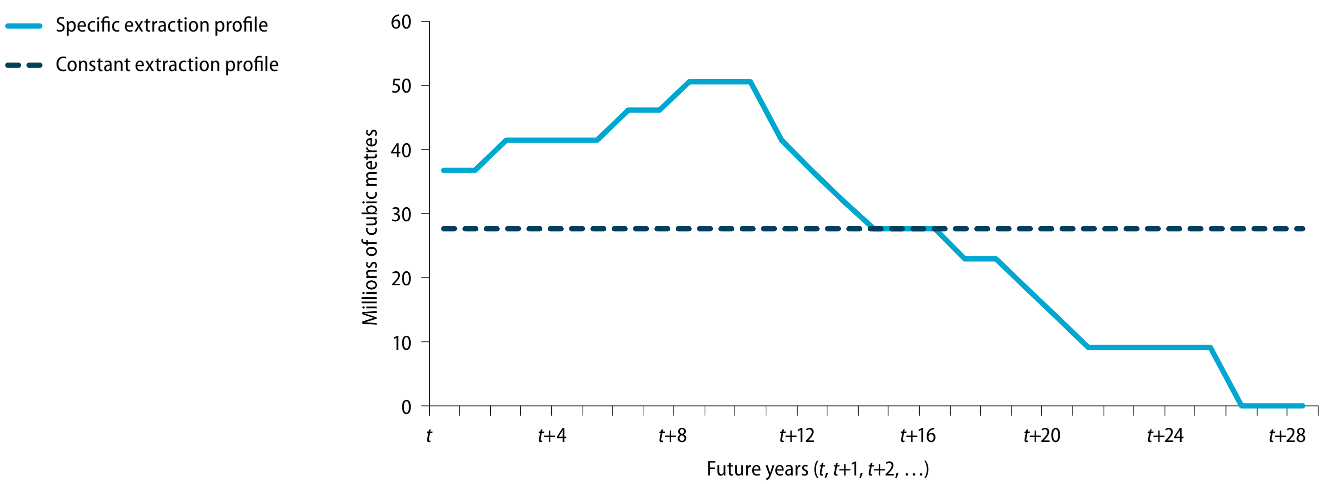
6.5.4. Future extraction profile

6.41. A 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, geologic institutes, etc., those 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 years' extraction should be no greater than the estimate of the quantity of resources in class A, as described in the physical asset account (see chap. V).

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

6.43. Figure 6.1 provides examples of two of the extraction profiles described in paragraph 6.42 above. In both cases, the area under the curve, that is, the total amount of the mineral and energy resource 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. Estimation of 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 regarding 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. As is the case for 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 2,148, while the expected general inflation rate ρ_{t+i} is 3 per cent for all $t+i$.

6.5.6. Net present value 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 in the following year is considered to be worth less than the same amount received in the current year, and the difference in value is reflected by the discount rate. A discount rate at, for example, 6 per cent indicates that $106 next year corresponds to $100 this year.

6.49. The sum of the discounted future resource rents represents a total net present value of future extraction, which is then assumed to correspond to the value of the total quantity of the mineral and energy resource 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:

$$V_t = \sum_{\tau=1}^{n} \frac{RR_{t+\tau}}{(1+r)^\tau} = \frac{(rr_{t+1}e_{t+1})}{(1+r)^1} + \frac{(rr_{t+2}e_{t+2})}{(1+r)^2} + \cdots + \frac{(rr_{t+n}e_{t+n})}{(1+r)^n}$$

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, and

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

6.51. Table 6.5 presents calculations of the value of the mineral and energy resources asset as the sum of present values of future resource rents. The table includes two alternative calculations, one using a specific extraction profile, and the other, a constant extraction profile (as displayed in figure 6.1). In both cases, the per unit resource rent derived in table 6.4 and a discount rate set at 6 per cent per year are used.

6.52. In the fictitious case presented in table 6.5[39] a somewhat lower opening stock value is estimated when the constant extraction profile is used compared with 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 that fall in later years, a higher total present value of resource rents is obtained. The example demonstrates the importance of careful determination of the extraction profile used for the estimation, as realistic extraction profiles increase the accuracy and reliability of the estimates of resource values.

[39] In this example, it is assumed that all the revenue is earned at the last day of the given year.

Table 6.5
Calculation of the asset value of a mineral and energy resource

Year	Specific extraction profile					Constant extraction profile				
	1. Quanity of resource extracted	2. Per unit resource rent	3. Undiscounted resource rent (=1*2)	4. Discount factor (6% per year)	5. Present value of resource rent (=3*4)	1. Quanity of resource extracted	2. Per unit resource rent	3. Undiscounted resource rent (=1*2)	4. Discount factor (6% per year)	5. Present value of resource rent (=3*4)
	Millions of cubic metres	Currency units per millions of cubic metres	Currency units		Currency units	Millions of cubic metres	Currency units per millions of cubic metres	Currency units		Currency units
t	37	2 148	79 007	0.94	74 535	28	2 148	59 255	0.94	55 901
t+1	37	2 212	81 377	0.89	72 425	28	2 212	61 033	0.89	54 319
t+2	41	2 279	94 296	0.84	79 173	28	2 279	62 864	0.84	52 782
t+3	41	2 347	97 125	0.79	76 932	28	2 347	64 750	0.79	51 288
t+4	41	2 418	100 038	0.75	74 754	28	2 418	66 692	0.75	49 836
t+5	41	2 490	103 039	0.70	72 639	28	2 490	68 693	0.70	48 426
t+6	46	2 565	117 923	0.67	78 426	28	2 565	70 754	0.67	47 055
t+7	46	2 642	121 461	0.63	76 206	28	2 642	72 876	0.63	45 724
t+8	51	2 721	137 615	0.59	81 454	28	2 721	75 063	0.59	44 429
t+9	51	2 803	141 743	0.56	79 149	28	2 803	77 315	0.56	43 172
t+10	51	2 887	145 996	0.53	76 909	28	2 887	79 634	0.53	41 950
t+11	41	2 973	123 035	0.50	61 144	28	2 973	82 023	0.50	40 763
t+12	37	3 063	112 645	0.47	52 812	28	3 063	84 484	0.47	39 609
t+13	32	3 154	101 521	0.44	44 903	28	3 154	87 018	0.44	38 488
t+14	28	3 249	89 629	0.42	37 399	28	3 249	89 629	0.42	37 399
t+15	28	3 347	92 318	0.39	36 340	28	3 347	92 318	0.39	36 340
t+16	28	3 447	95 087	0.37	35 312	28	3 447	95 087	0.37	35 312
t+17	23	3 550	81 616	0.35	28 594	28	3 550	97 940	0.35	34 313
t+18	23	3 657	84 065	0.33	27 785	28	3 657	100 878	0.33	33 341
t+19	18	3 767	69 270	0.31	21 599	28	3 767	103 904	0.31	32 398
t+20	14	3 880	53 511	0.29	15 740	28	3 880	107 021	0.29	31 481
t+21	9	3 996	36 744	0.28	10 197	28	3 996	110 232	0.28	30 590
t+22	9	4 116	37 846	0.26	9 908	28	4 116	113 539	0.26	29 724
t+23	9	4 239	38 982	0.25	9 628	28	4 239	116 945	0.25	28 883
t+24	9	4 366	40 151	0.23	9 355	28	4 366	120 454	0.23	28 066
t+25	9	4 497	41 356	0.22	9 090	28	4 497	124 067	0.22	27 271
t+26						28	4 632	127 789	0.21	26 499
t+27						28	4 771	131 623	0.20	25 749
t+28						28	4 914	135 572	0.18	25 021
Total quantity extracted	**800**					**800**				
Total undiscounted value			**2 317 395**					**2 679 451**		
Total discounted value of energy resource (opening stock year *t*)					**1 252 407**					**1 116 130**

6.6. Monetary asset accounts for inventories of energy products

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

6.54. Monetary asset accounts for inventories of energy products display 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 other products
Opening level of inventories	**760**			**5 319**	**15 189**			
Changes due to transactions								
Additions	32			143				
Withdrawals	- 255							
Recurrent losses	- 31			- 5				
Changes in level of inventories	- 254			138	2 279			
Other changes								
Catastrophic losses								
Uncompensated seizures								
Changes in classification								
Other changes in inventories not elsewhere classified	22			207	- 430			
Revaluations	17				516			
Closing level of inventories	**291**			**5 802**	**17 554**			

6.55. The various accounting items are explained below. It is to be noted, however, that in most cases, it is sufficient to record only the opening and closing level of inventories.

Opening level of inventories is 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 of 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, para. 10.118). Recurrent losses include losses that normally occur and should be expected. *Changes in level of inventories* are also recorded in the monetary supply and use tables of SEEA-Energy.

Other changes

Catastrophic losses and uncompensated seizures records the effects on the value of inventories exerted by 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 do not entail any change in the value of the total inventories as such. Such changes are associated mainly with the change of a unit from one institutional sector to another (e.g., the movement of the owner of the inventories from the household sector to the non-financial corporations sector). This is relevant only if the asset accounts are set up for institutional units as well as for the total economy, but not if the accounts are set up only for the total economy. Also, changes from works in progress to finished energy products would be recorded here, if such a distinction between inventories of works in progress and inventories of energy products was made in the accounts.

Other changes in inventories not elsewhere classified If the assumption regarding the value of normal shrinkage or recurrent losses of inventories is revised (see *changes in level of inventories* above), this should be reflected in other changes in inventories (2008 SNA, para. 12.50).

Revaluation is an item specific to the monetary asset accounts for which 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 is 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

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

6.57. 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. Removal of the effect of a price change may be carried out for either of two main purposes: (a) to provide an indicator of the purchasing power of mineral and energy resources, that is, an estimate of the capacity of a set of resources to be used to acquire a given set of goods and services; or (b) to assess whether there has been a change in the underlying aggregate physical stock of several mineral and energy resources. It may be important for both purposes to be considered when an aggregate analysis of the wealth of a country is being undertaken, or when the relative importance of mineral and energy resources compared with other economic and social assets is being assessed. Approaches to calculating volume measures are presented in section 5.4.6 of the SEEA Central Framework.

6.8. Monetary accounts for other assets used by extractive industries

6.8.1. Other assets with the potential for use by extractive industries

6.58. It may be useful to compile the asset accounts not only for mineral and energy resources but also for other assets owned and used by the extraction industry for exploration, evaluation and exploitation of those resources. Equipment used for transportation of energy products (e.g., pipelines for transport of oil from the well head to the point of processing) or sale of land should also be included if owned by the extraction industry.

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

6.60. Asset accounts for these types of assets are included in the accounts of 2008 SNA, although the required level of detail may not be explicitly provided in standard national accounts outputs. In principle, all of the types of non-financial assets (except mineral and energy resources) that are listed by 2008 SNA could be used by the mining and quarrying industry but, in practice, fixed assets such as AN113 (Machinery and equipment) and AN1172 (Mineral exploration and evaluation) are often the most important (see 2008 SNA, annex 2).

6.61. Table 6.7 displays a sample asset account, presented in short form, for other assets used by the extraction industries. Gross fixed capital formation is equal to the acquisitions less disposals of produced assets for the purposes of fixed capital formation. Consumption of fixed capital represents the decline in the current value of the stock of fixed assets owned and used by a producer as a result of normal production activities. Non-produced assets are assets that have come into existence through means other than processes of production. "Other changes in the volume of assets" is an aggregate, which includes the various items within 2008 SNA "Other changes in the volume of assets" account, for example, economic appearance and disappearance of assets and catastrophic losses (see 2008 SNA, annex 2).

Table 6.7
2008 SNA asset account for other assets

	Total	AN11: Fixed assets	*Of which:* AN1172: Mineral exploration and evaluation	Terminal costs (part of AN116)	AN2: Non-produced non-financial assets[a]	*Of which:* AN22: Contracts, leases and licenses
	Currency units					
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			
Acquisition less disposals of non-produced assets (NP)	300	300	300			
Other changes in the volume of assets						
Revaluation						
Closing stock	**80 501**	**66 481**	**47 908**		**14 020**	**14 020**

[a] Excluding commercial energy resources.

6.8.2. Mineral exploration and evaluation

6.62. Mineral exploration and evaluation consists of expenditures on exploration for mineral and energy resources and subsequent evaluation of the discoveries made. Exploration and evaluation activities include (see 2008 SNA, para. 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.

6.63. 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 derived from exploration influences the production activities over a number of years of those who obtain that information. The expenditures incurred from 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, para. 10.107). The values are included in the asset accounts as items under a specific code, namely, AN1172.

6.64. The value of exploration and evaluation as an asset is not measured by the value of new deposits discovered through 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, form part of the value of the expenditures incurred (2008 SNA, para. 10.108).

Chapter VII
Uses of energy accounts

7.1. Introduction

7.1. There are a variety of ways in which energy accounts, as developed through the application of the concepts and methods discussed in the previous chapters, can be utilized to effectively present and summarize the data collected so as to reveal linkages between different variables. Integration of energy accounts with other sources of information can be an important means of providing policymakers, researchers and other users of these accounts with a greater range of insights.

7.2. The present chapter, which showcases potential applications of the energy accounts, offers several examples of what can be accomplished through their use. Its purpose, however, is not to provide an exhaustive examination of every possible use and application of those accounts. This chapter differs from others in both its presentation of the information in those accounts in a concise, easily accessible (and usually graphical) format and its focus on analysing several descriptive statistics, aggregates and indicators. The data set used in the analysis is a fictitious one; therefore, the conclusions drawn from the analysis are relevant only for the data being analysed and should not be generalized.

7.2. SEEA-Energy and the Sustainable Development Goals

7.3. By its resolution 70/1 of 25 September 2015, the General Assembly adopted the 2030 Agenda for Sustainable Development, including the Sustainable Development Goals and targets. Linkages of SEEA-Energy to the targets under Sustainable Development Goal 7 (Ensure access to affordable, reliable, sustainable and modern energy for all) are set out in table 7.1 below.

7.4. There are several targets under the Sustainable Development Goals, besides those under Goal 7, that could be informed by SEEA-Energy, including two targets under Goal 12 (Ensure sustainable consumption and production patterns), namely, targets 12.2 and 12.c.[40] Compiling the various energy accounts makes it possible to inform multiple targets in an integrated fashion.

7.5. The data collected in the energy accounts can also be used in the derivation of many other indicators. Following the general structure, including table 3.1, of *Energy Indicators for Sustainable Development: Guidelines and Methodologies*,[41] energy indicators can be grouped along three dimensions: social, economic and environmental. Table 7.2 below displays 30 indicators and details some of the information, as provided by SEEA-Energy, needed to derive them.

[40] Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources. Target 12.c: Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

[41] International Atomic Energy Agency, United Nations Department of Economic and Social Affairs, International Energy Agency, Eurostat and European Environment Agency, *Energy Indicators for Sustainable Development: Guidelines and Methodolgies* (Vienna, 2005). Available at http://www-pub.iaea.org/MTCD/publications/PDF/Pub1222_web.pdf.

Table 7.1
Relevance of SEEA-Energy accounts to Sustainable Development Goal 7 and its targets

Target under Goal 7	Linkage to SEEA-Energy
7.1 By 2030, ensure universal access to affordable, reliable and modern energy services.	Energy physical supply and use accounts provide contextual information on the magnitude of electricity consumption by households relative to other sectors. Monetary accounts and other SNA accounts contain information on government and private spending on electricity services and associated infrastructure.
7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.	Energy physical supply and use tables provide information on the generation and use of all energy sources, including renewable energy.
7.3 By 2030, double the global rate of improvement in energy efficiency.	Energy physical supply and use tables display the use of energy by economic activity (based on ISIC). This information, easily combined with information on value added derived from applying the approach of SNA (which uses the same classification), can be used to calculate energy use efficiency for the economy as a whole and as disaggregated by economic activity.
7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil fuel technology, and promote investment in energy infrastructure and clean energy technology.	Contextual information can be provided by energy physical supply and use tables, monetary supply and use tables. SEEA Central Framework accounts for the environmental goods and services sector and environmental protection expenditure are also relevant.
7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support.	SEEA-Energy has information on measuring investment activity in the energy sector that can be identified within the national accounts.

Table 7.2
Energy indicators linked to the social, economic and environmental dimensions

Theme	Subtheme	Energy indicator	Components	SEEA-Energy
A. Social dimension				
Equity	Accessibility	Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy	– Households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy – Total number of households or population	
	Affordability	Share of household income spent on fuel and electricity	– Household income spent on fuel and electricity – Household income (total and poorest 20 per cent of population)	Household expenditures on energy are part of the monetary accounts, which can be linked to income groups (see chap. IV)
	Disparities	Household energy use for each income group and corresponding fuel mix	– Energy use per household for each income group (quintiles) – Household income for each income group (quintiles) – Corresponding fuel mix for each income group (quintiles)	Household expenditures on energy are part of the monetary accounts that can be linked to income groups (see chap. IV)
Health	Safety	Accident fatalities per energy produced by fuel chain	– Annual fatalities by fuel chain – Annual energy produced	Energy supply is part of the supply and use table (see chap. III)
B. Economic dimension				
Use and production patterns	Overall use	Energy use per capita	– Energy use (total primary energy supply, total final consumption and electricity use) – Total population	Energy use is part of the supply and use table (see chap. III)
	Overall productivity	Energy use per unit of GDP	– Energy use (total primary energy supply, total final consumption and electricity use) – GDP	Energy use is part of the supply and use table (ee chap. III)
	Supply efficiency	Efficiency of energy conversion and distribution	– Losses in transformation systems, including losses in electricity generation, transmission and distribution	Losses are part of the supply and use table (see chap. III)

Theme	Subtheme	Energy indicator	Components	SEEA-Energy
Use and production patterns	Production	Reserves-to-production ratio	– Proved recoverable reserves – Total energy production	Asset accounts provide data on recoverable reserves (see chap. V)
			– Total estimated resources – Total energy production	Asset accounts provide data on resources available (see chap. V)
	End use	Industrial energy intensities	– Energy use in industrial sector and by manufacturing branch – Corresponding value added	Supply and use tables provide energy use by ISIC sectors, which can be easily linked to value added (see chap. III)
		Agricultural energy intensities	– Energy use in agricultural sector – Corresponding value added	Supply and use tables provide energy use by ISIC sectors, including details on agriculture, which can be easily linked to value added (see chap. III)
		Service/commercial energy intensities	– Energy use in service/ commercial sector – Corresponding value added	Supply and use tables provide energy use by ISIC sectors, which can easily be linked to value added (see chap. III)
		Household energy intensities	– Energy use in households and by key end use – Number of households, floor area, persons per household, appliance ownership	Use tables provide energy use by households (see chap. III)
		Transport energy intensities	– Energy use in passenger travel and freight sectors and by mode – Passenger-kilometre travel and ton-kilometre freight and by mode	Supply and use tables provide energy use by ISIC sectors, which can be easily linked to value added (see chap. III)
	Diversification (fuel mix)	Fuel shares in energy and electricity	– Primary energy supply and final consumption, electricity generation and generating capacity by fuel type – Total primary energy supply, total final consumption, total electricity generation and total generating capacity	Energy use by households is part of the supply and use tables (see chap. III)
		Non-carbon energy share in energy and electricity	– Primary supply, electricity generation and generating capacity by non-carbon energy – Total primary energy supply, total electricity generation and total generating capacity	Supply and use tables and related tables provide data on primary supply of energy products (see chap. III)
		Renewable energy share in energy and electricity	– Primary energy supply, final consumption and electricity generation and generating capacity by renewable energy – Total primary energy supply, total final consumption, total electricity generation and total generating capacity	Supply and use tables provide energy use by ISIC sectors, which can be linked to travel-related data (see chap. III)
	Prices	End-use energy prices by fuel and by sector	– Energy prices (with and without tax/subsidy)	Data available in the monetary supply and use tables (see chap. IV)
Security	Imports	Net energy import dependency	– Energy imports – Total primary energy supply	Data available in physical supply and use tables and related tables (see chap. III)
	Strategic fuel stocks	Stocks of critical fuels per corresponding fuel consumption	– Stocks of critical fuel (e.g., oil, gas) – Critical fuel consumption	Data available in physical supply and use tables and related tables (see chap. III)
C. Environmental dimension				
Atmosphere	Climate change	Greenhouse gas emissions from energy production and use per capita and per unit of GDP	– Greenhouse gas emissions from energy production and use – Population and GDP	Supply and use tables provide energy use by ISIC categories, which plays a key role in determining emissions (see chap. III)
	Air quality	Ambient concentrations of air pollutants in urban areas	– Concentrations of pollutants in air	
		Air pollutant emissions from energy systems	– Air pollutant emissions	Supply and use tables provide energy use by ISIC, which plays a key role in determining emissions (see chap. III)
Water	Water quality	Contaminant discharges in liquid effluents from energy systems including oil discharges	– Contaminant discharges in liquid effluents	

Theme	Subtheme	Energy indicator	Components	SEEA-Energy
Land	Soil quality	Soil area where acidification exceeds critical load	– Affected soil area – Critical load	
	Forest	Rate of deforestation attributed to energy use	– Forest area at two different times – Biomass utilization	
	Solid waste generation and management	Ratio of solid waste generation to units of energy produced	– Amount of solid waste – Energy produced	Data on energy produced available in physical supply and use tables and related tables (see chap. III)
		Ratio of solid waste properly disposed of to total generated solid waste	– Amount of solid waste properly disposed of – Total amount of solid waste	
		Ratio of solid radioactive waste to units of energy produced	– Amount of radioactive waste (cumulative for a selected period of time) – Energy produced	Data on energy produced available in physical supply and use tables and related tables (see chap. III)
		Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste	– Amount of radioactive waste awaiting disposal – Total volume of radioactive waste	

Source: International Atomic Energy Agency, United Nations Department of Economic and Social Affairs, International Energy Agency, Eurostat and European Environment Agency, *Energy Indicators for Sustainable Development: Guidelines and Methodologies* (Vienna, April 2005), table 3.1.

7.6. The social dimension includes several important indicators related to energy access, such as share of households without electricity and share of income spent on fuel and electricity. SEEA-Energy can inform several important elements that are needed for a proper understanding of the policy implications of the information provided by 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.

7.7. All of these seemingly unrelated pieces of information can, once combined, offer insights into not only the current state of energy access but also the best means of structuring policy for the benefit of present and future generations. The details available in the SEEA-Energy accounts have the advantage of enabling users to acquire a better understanding not just of the current state of energy use, but also of why a given aggregate or indicator is situated at a particular level.

7.8. Compilation of all 16 indicators listed in *Energy Indicators for Sustainable Development*: *Guidelines and Methodologies* that are linked to the economic dimension makes direct use of information contained in the energy accounts. Combining the information in the accounts with supplementary demographic and economic information would make it possible, for example, to calculate energy use both per capita and per unit of GDP. A major strength of the SEEA-Energy accounts lies in the presentation of energy use by economic sector, which is necessary for the derivation of several efficiency- and intensity-related indicators.

7.9. Along the environmental dimension, the energy accounts again play a key role not only in filling the gaps in the knowledge required for the derivation of the indicators but also in supplying necessary background and contextual information. For example, energy accounts provide information that aids in the calculation of emissions not just by energy product, but (through use of the ISIC classification) by industry as well, which allows for a more complete understanding of emissions. Such information supports the formulation of strategies and policies that target emitters and in such a way as to focus on the larger ones.

7.10. Analysis can often be carried out on the basis of information obtained from multiple sources. In many cases, whether the starting point is energy statistics, energy balances or energy accounts is not a matter of concern, since the concepts and basic information involved are more or less identical. In other cases, each of these statistical systems will be determined to have its own distinct advantages or disadvantages based on the purpose of the analysis. The use of energy statistics and balances, for example, is often more appropriate when analysis is focused on specific energy technologies. On the other hand, energy accounts serve as a better information system when the focus is on comparing physical data with economic activities or on presenting specific monetary information related to energy issues.

7.11. The SEEA Central Framework (in sect. 3.4.5) defines two energy aggregates that are appropriate for dealing with particular analytical and policy questions: gross energy input and net domestic energy use. Gross energy input is equal to (a) energy from natural inputs plus (b) imports of energy products plus (c) energy from waste. Net domestic energy use is defined as (a) end use of energy products (including changes in inventories of energy products) less (b) exports of energy products plus (c) all losses of energy (losses during extraction, losses during transformation, losses during storage and losses during distribution). Both aggregates can be calculated from the physical supply and use tables presented in chapter III.

7.12. Each example presented in this chapter is preceded by background information on the purpose of the aggregates used and a detailed examination of their composition. Relevant conclusions are drawn from the analysis carried out for each example and the general implications of those analyses are emphasized. A short discussion on the derivation of potential indicators is often included as well.

7.13. The structure of this chapter is, to a large extent, aligned with the social, economic and environmental dimensions discussed above. It should be noted, however, that the analyses do not lead to the derivation of indicators listed in table 7.2 but, rather, provide useful guidance on how the data presented in the energy accounts can be used to inform energy issues within social, economic and/or environmental contexts. As is to be expected, the conclusions that can be drawn from the examples analysed may, in many cases, have an impact on social, economic and environmental policies. The main focus of section 7.3, which presents information on energy supply and use, is the energy sector together with several immediate extensions and applications of energy supply and use that rely and build upon the supply and use data. This is followed in section 7.4 by a discussion of the relationship between the energy sector and the economy. Section 7.5 examines the relationship between energy and other sectors of the economy. The chapter concludes with an examination of how energy accounts can help clarify the relationship between the energy sector and certain components of the environment.

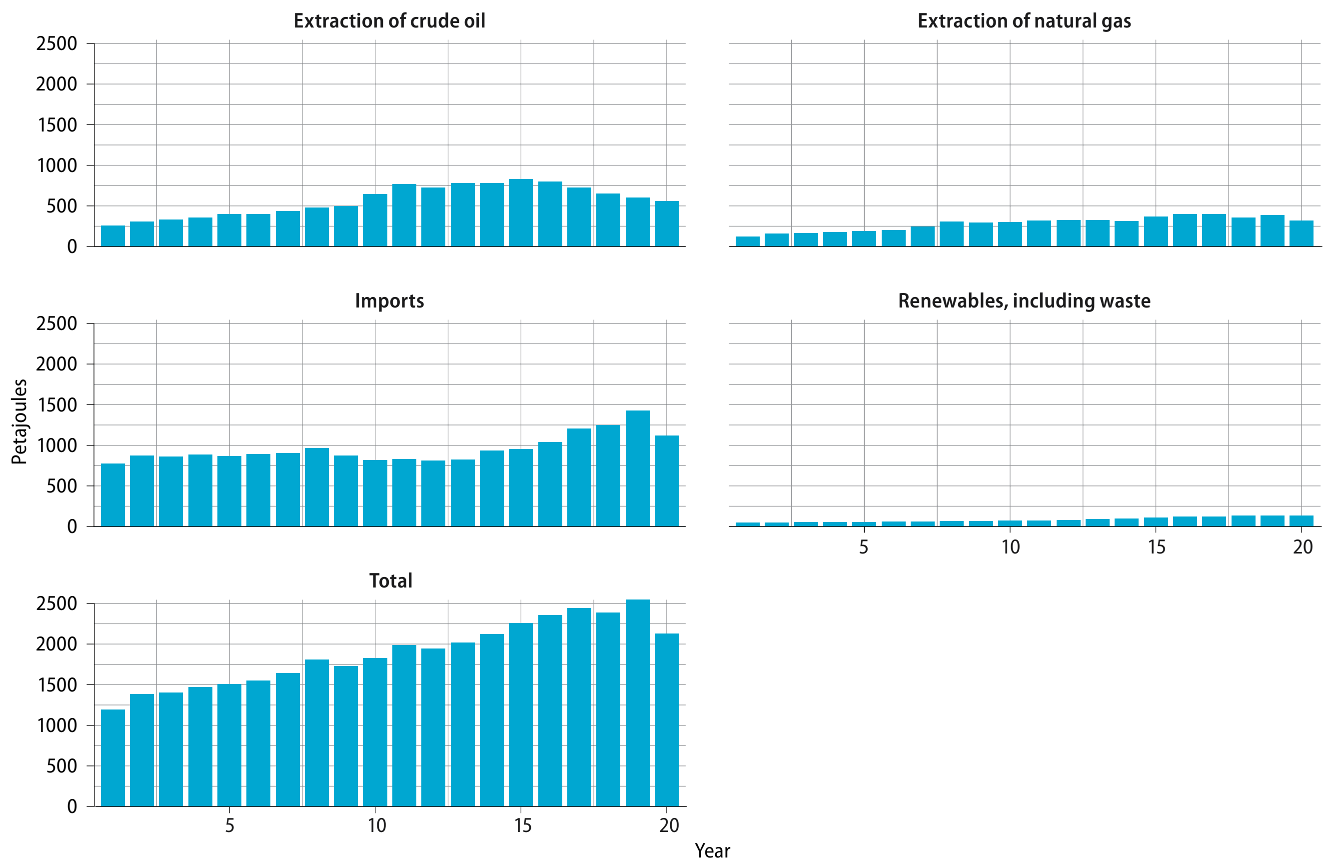
7.3. Energy supply and use

7.14. A logical starting point in the analysis of the energy sector would entail consideration of energy supply and use. A good understanding of supply and use is necessary for the improved management of energy natural resource inputs as well as for future planning. Furthermore, such information is crucial to deriving several indicators. For example, augmenting this data with data on population facilitates the calculation of energy use per capita, an important indicator.

7.3.1. Overall supply and use of energy

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

Figure 7.1
Total primary supply and imports of energy



7.16. Several conclusions can be immediately drawn from figure 7.1 above. Energy supply has generally increased over time, with the exception of the last year. Extraction of fossil fuels (crude oil and natural gas) levelled off or decreased over the last five years of available data, while energy supplied from renewable sources increased. Over half of the energy supply during the last year came from imports. The "net energy import dependency" indicator, as defined in table 7.2, can be derived from the data summarized in figure 7.1.

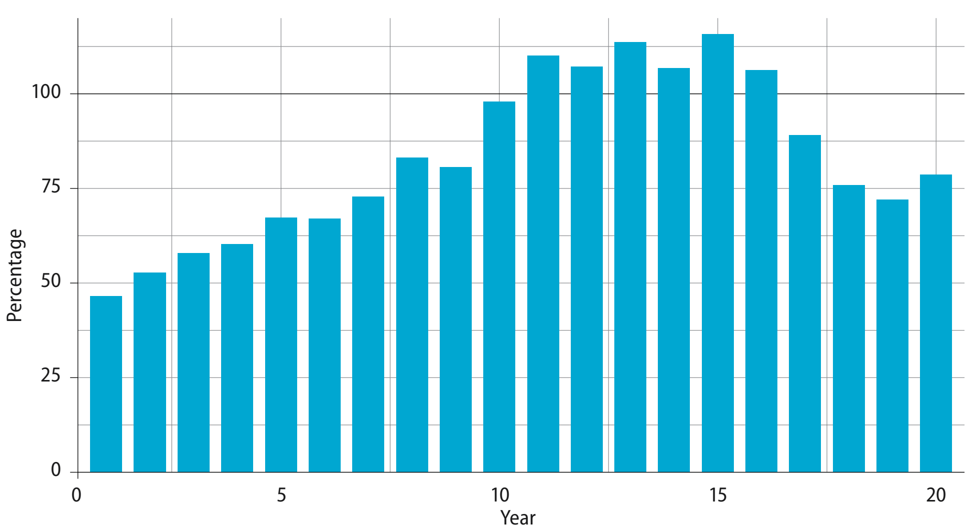
7.17. Figure 7.2 illustrates how the supplied energy is used, indicating the amount exported and the amount used by households and industries. It is shown that household use remained roughly constant over the two decades covered, while exports more than doubled in the same period. Use of energy by industry is shown to have also increased, in general, although not at the same pace as exports.

Figure 7.2
End use of energy, including losses

7.3.2. Degree of energy self-sufficiency

7.18. The ratio of primary energy production to domestic end use is an indicator that can be derived using the data from figures 7.1 and 7.2. Values greater than 100 per cent indicate the ability to meet domestic demand for energy, while values lower than 100 per cent indicate a dependence on foreign sources of energy. Figure 7.3 reveals that the degree of self-sufficiency increased from less than 50 per cent at the beginning of the period to more than 100 per cent in the middle. After a period of full self-sufficiency, during the last four years, the reliance on imports increased again. This development is closely connected with the pattern of extraction of energy resources displayed above.

Figure 7.3
Degree of energy self-sufficiency



7.3.3. Use of energy and expenditures by industries and households

7.19. Figures 7.1 and 7.2 above offer a broad aggregated perspective on energy supply and use. However, responding to more specific questions—for example, what energy products are being used by households and industries, and at what cost—often requires a further breakdown of the data. Figures 7.4 and 7.5 provide the answers to these questions for a particular year with electricity generated from renewable sources separately identified.

Figure 7.4
Physical use of energy by industries and households

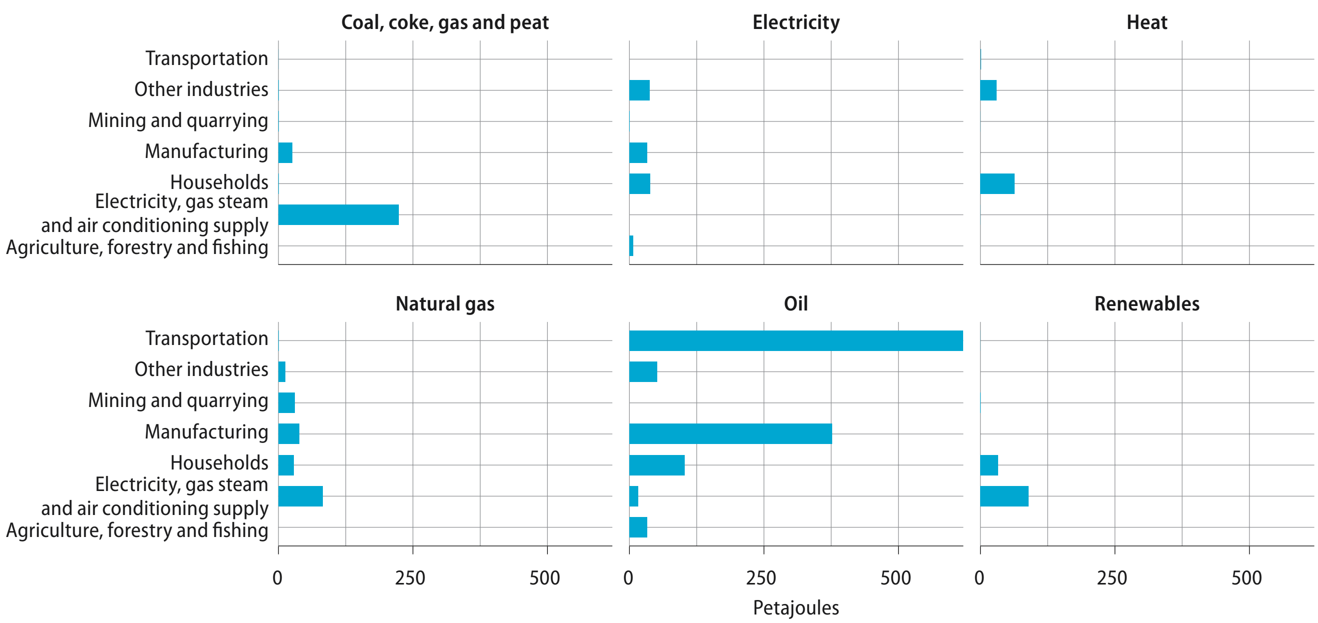
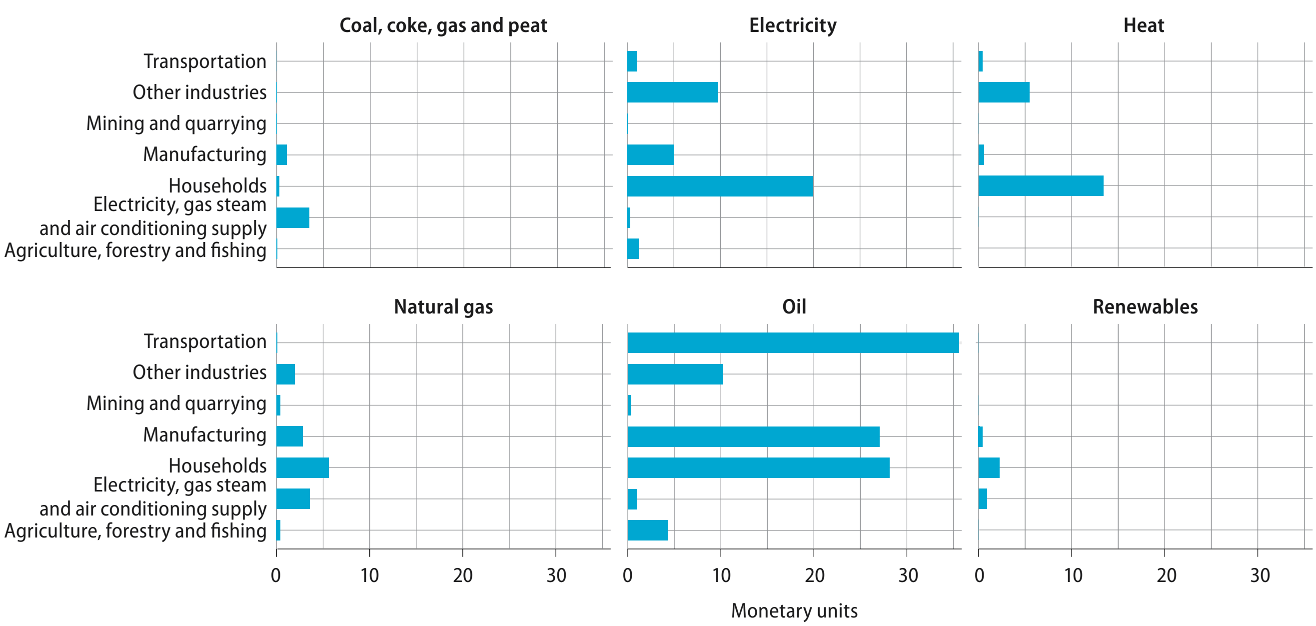


Figure 7.5
Expenditures for energy by industries and households



7.20. Several policy-relevant conclusions can be drawn from examining the figures above and their underlying data. Manufacturing and transportation rely heavily on oil as their main source of energy. While oil is also the largest source of energy for households, other sources, such as electricity and heat, are of importance as well. With use of the above information and depending on relevant circumstances, policymakers can design policies that exert an impact on the demand for certain energy products.

7.21. While the data underlying each of the figures are useful in their own right, more insights can be gained from considering monetary and physical data jointly. For example, household *expenditures* on energy are the highest among the seven groups shown, while in terms of energy *use*, households rank only fourth among them.

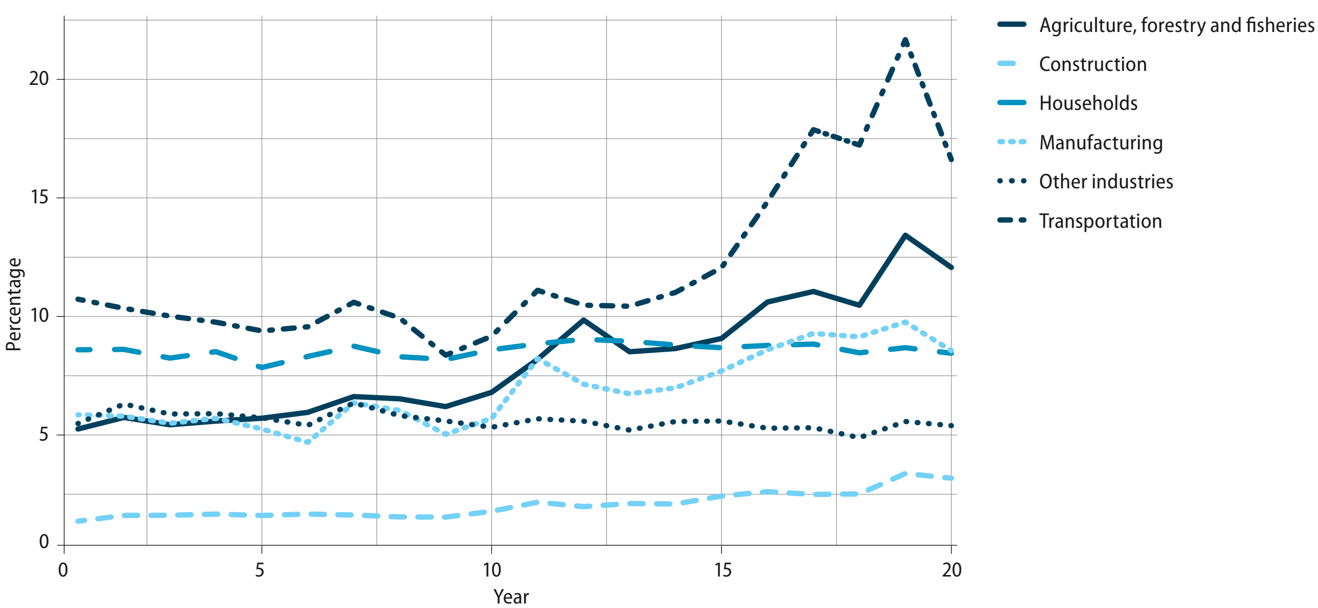
7.22. Moreover, linkage of data on household use of and expenditures on energy products with household income data enables the derivation of several important indicators on affordability of energy (e.g., proportion of income spent on energy by total income deciles) and disparities in energy use (e.g., household energy use by income group and fuel mix).

7.23. The importance to households and enterprises of access to affordable energy is reflected by the fact, inter alia, that higher energy costs could have an adverse effect on households as regards both the cost of other goods and services, and the availability of disposable income for those goods and services. The data in the accounts provide the necessary monetary information on energy expenditures, which can consequently be linked with other national accounts data and trade data to provide a more complete picture of the pricing of goods.

7.24. Several further extensions can be made to the data provided above using the information collected and contained in the accounts. Figure 7.6, which presents the share over time of energy expenditures by households in overall final consumption and by industries in overall intermediate consumption, constitutes one such extension. This information puts the impact of energy expenditures into context.

Figure 7.6

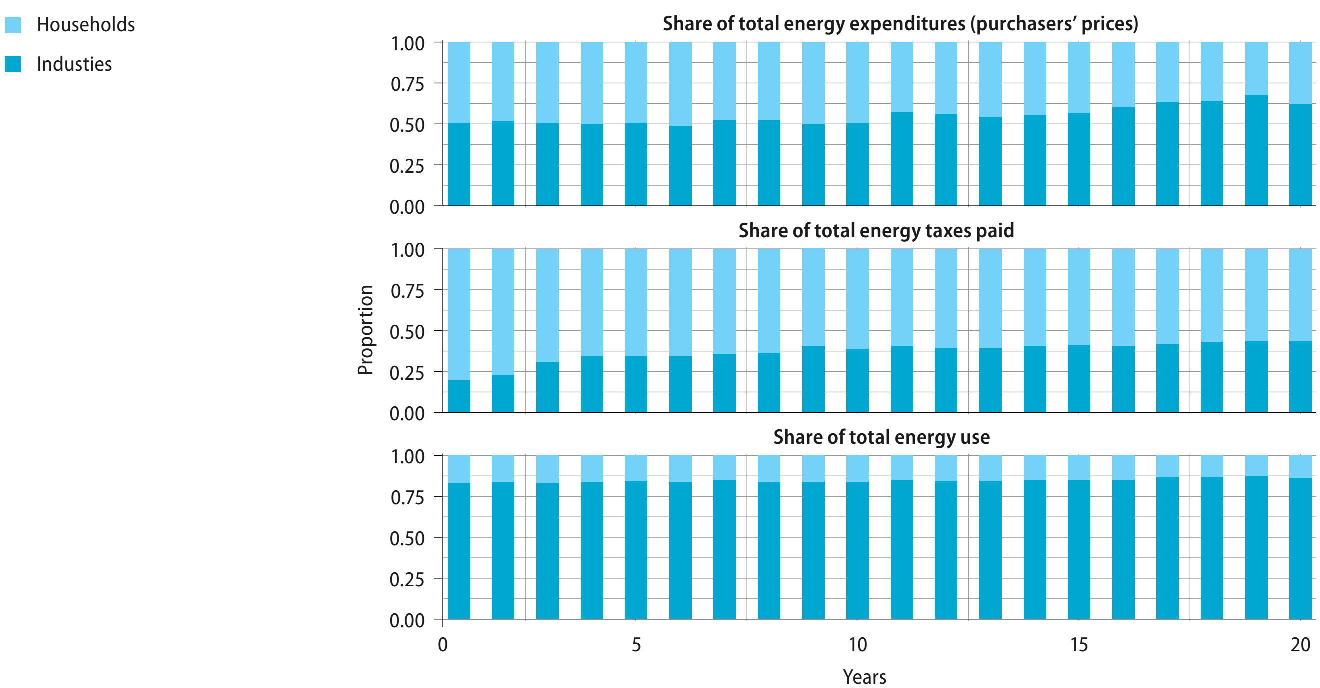
Share over time of energy expenditures by industries in overall intermediate consumption, and by households in overall final consumption



7.25. As can be seen from figure 7.6, household energy expenditures as a proportion of final household consumption was relatively stable over the two decades, fluctuating within the narrow range of 7.8–9.0 per cent. As can be seen from table 7.2, this is an important energy indicator for the social dimensions of sustainable development. Furthermore, energy expenditures as a proportion of intermediate consumption remained fairly stable for all sectors of the economy, except the transportation sector. The overall increase in that sector's share starting in year 10 was likely due to increases in oil costs.

7.26. Another extension, set out in figure 7.7, traces the share, over time, of energy use and expenditures and energy taxes paid by households and industries (which can be further broken down by industries sectors), thereby further enhancing the policy relevance of information collected. Creation of other extensions, such as energy use by resource for different sectors over time, is also possible, depending on the needs of the users and the available data.

Figure 7.7
Share over time of energy use and expenditures and energy-related taxes paid by industries and households



7.27. Juxtaposing data on energy-related taxes with physical and monetary data on energy use generates several observations with policy implications. Most striking is the fact that while households pay by far the largest share of energy-related taxes, that is, about 60 per cent of the total energy-related taxes paid in the last period considered, their share of energy use in physical terms is about 20 per cent and about 40–50 per cent in monetary terms. Over the two decades shown, households' share of total energy-related taxes decreased from about 80 to about 60 per cent. Such a shift could be due to any of several factors, including changes in tax law, energy regulations and increases in levels of extraction activity by domestic producers and the taxation associated with that increase. Clearly, such information could provide policymakers with insights regarding the impacts of different policies.

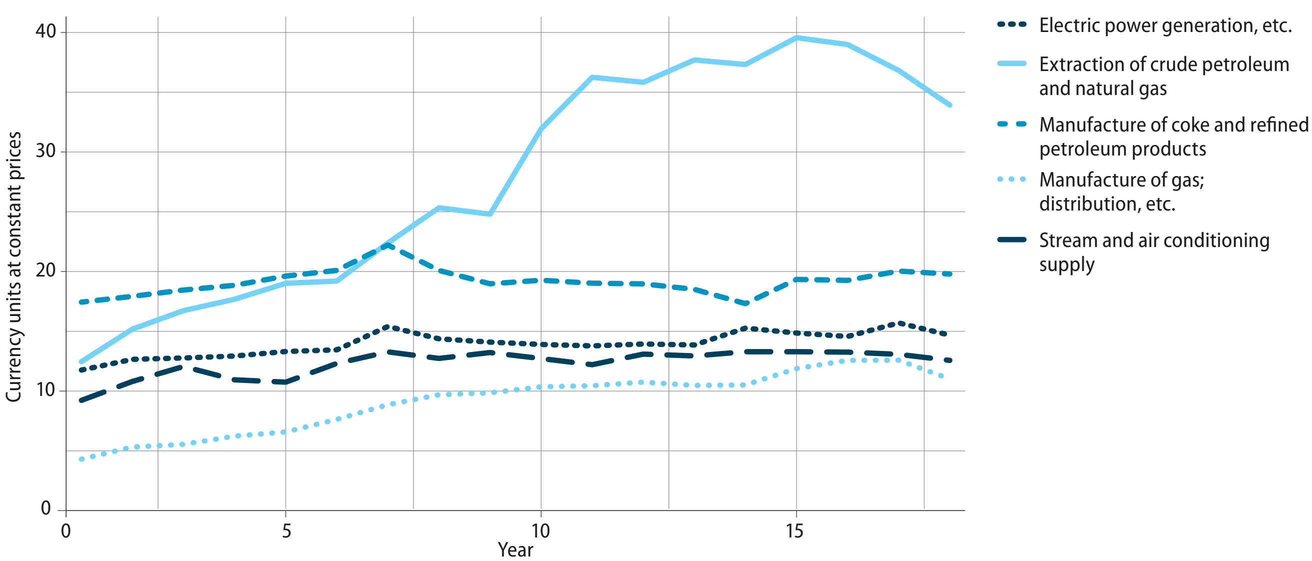
7.4. Energy sector and the economy

7.28. The importance of the energy sector's contribution to the wider economy cannot be overstated. The energy sector is an important player in the economy at large, as all other sectors of the economy depend upon it for necessary inputs into their production processes. Hence, monetary data collected through the energy accounts are invaluable as a tool for achieving a proper understanding of this sector's role within the economy.

7.4.1. Output and value added from the energy sector

7.29. An often useful first step on the path towards comprehending the scale of the energy sector is to focus on its output. Figure 7.8 illustrates that output as measured in constant prices (chained values) over time. The values of crude petroleum and natural gas output increased at the beginning of the period, but have been decreasing in recent years. Despite this decrease, the extraction of crude petroleum and natural gas contributes most to the overall output of the energy sector. While the output from the manufacturing and distribution of gas increased roughly fivefold over the span of two decades, little variation in output was experienced by the other sectors over this period.

Figure 7.8
Energy sector output over time



7.30. While figure 7.8 does illustrate the output of the energy sector, no indication is given of how important this sector is to the national economy. That importance is addressed in table 7.3, where the contributions of the energy-related industries to the overall economy are compared with the contribution of non-energy-related industries. The statistics required for such a comparison are easily accessible in the accounts.

7.31. Table 7.3 presents, in particular, in monetary terms, output, intermediate consumption, gross value added, consumption of fixed capital and net value added for all industries, by ISIC categories, for a given year. The data clearly reveal how important the energy-related industries are to the economy at large, accounting as they do for 5 per cent of output and about 6 per cent of gross and of net value added.

7.32. Within the group of energy industries, it is the extraction of mineral and energy resources that generates the largest value added. The share of intermediate consumption in relation to output is much smaller for the mining industry compared with all other industries, as the resource itself contributes considerably to the value of output. This is related to (a) resource rent, that is, the contribution by the resource itself to net value added, and (b) depletion, that is, the decrease in value of the resource due to extraction. The roles of depletion and resource rent are examined further below, in sections 7.4.2 and 7.4.3, respectively.

Table 7.3
Energy-related and non energy related industries' share of output and value added for a given year

ISIC		Output	Intermediate consumption	Gross value added	Consumption of fixed capital	Net value added
		Thousands of 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
B. 08	Other mining and quarrying	5		5		
C	Manufacturing	611	415	196	31	165
C.19	Manufacture of coke and refined petroleum products	28	27	1	1	
C.32	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	
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, C19, D)	**145**	**63**	**83**	**16**	**67**
	Energy-related industries, percentage of total industries	**5.0**	**4.1**	**5.9**	**6.0**	**5.8**

7.4.2. Operating surplus of energy-related industries and the role of depletion

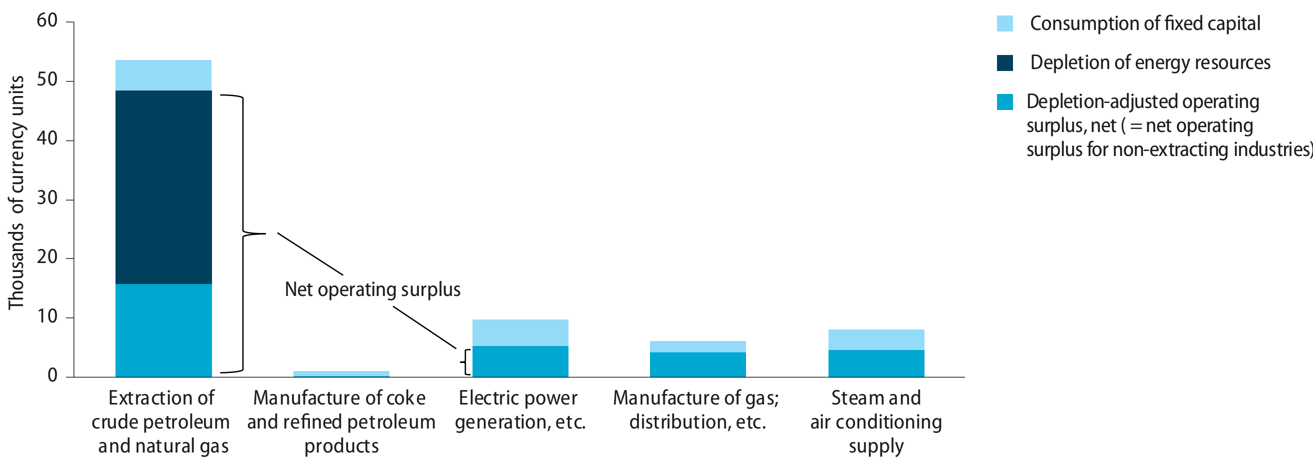
7.33. One significant fact conveyed by the data in table 7.3 is that the major part of net value added for the energy sector is derived from the extraction of crude petroleum and natural gas. Net value added (NV) can be decomposed as follows:

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.

7.34. Once net operating surplus has been isolated, gross operating surplus, as the sum of net operating surplus and consumption of fixed capital, can be calculated. Share of each component of gross operating surplus by energy industry is presented in figure 7.9.

Figure 7.9
Share of each component of gross operating surplus for the energy industries

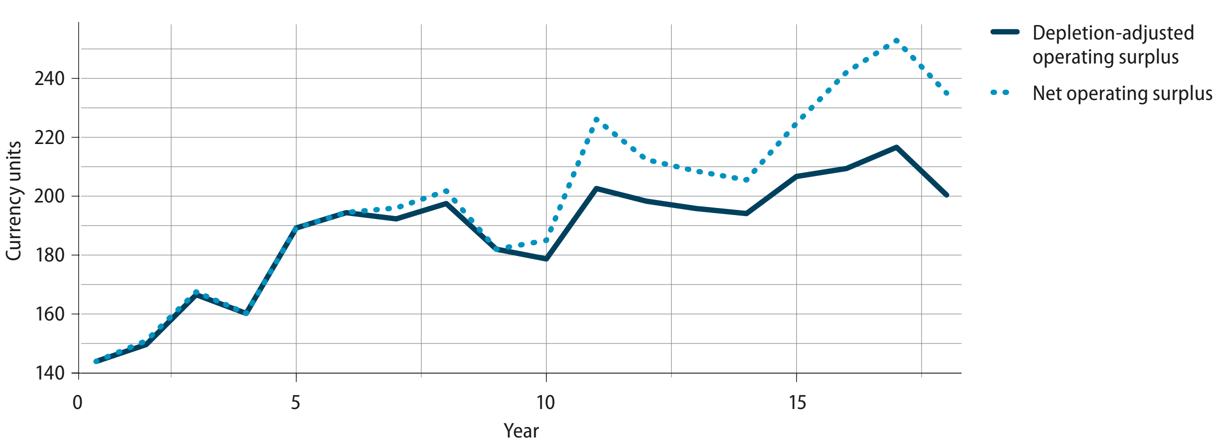


7.35. Depletion, one of the important concepts underpinning the energy accounts, is the largest component of gross operating surplus for extraction by the crude petroleum and natural gas industry. Once depletion has been subtracted from net operating surplus, the contribution of the mining industry to value added becomes considerably smaller, and the differences between the mining industry and other energy industries are shown to be less pronounced.

7.36. The effect of depletion on net operating surplus is greater than that exerted by consumption of fixed capital. However, this characteristic is specific to the mining and quarrying industry: for all other industries, no such adjustments take place.

7.37. The impact of depletion of mineral and energy resources can also be viewed within the context of the operating surplus for the overall economy. The two curves displayed in figure 7.10 represent net operating surplus and depletion-adjusted net operating surplus. The distance between the curves corresponds to a depletion of mineral and energy resources as measured in currency units. Taking depletion into account entails a downward adjustment of the operating surplus by approximately 30 currency units during the last year shown.

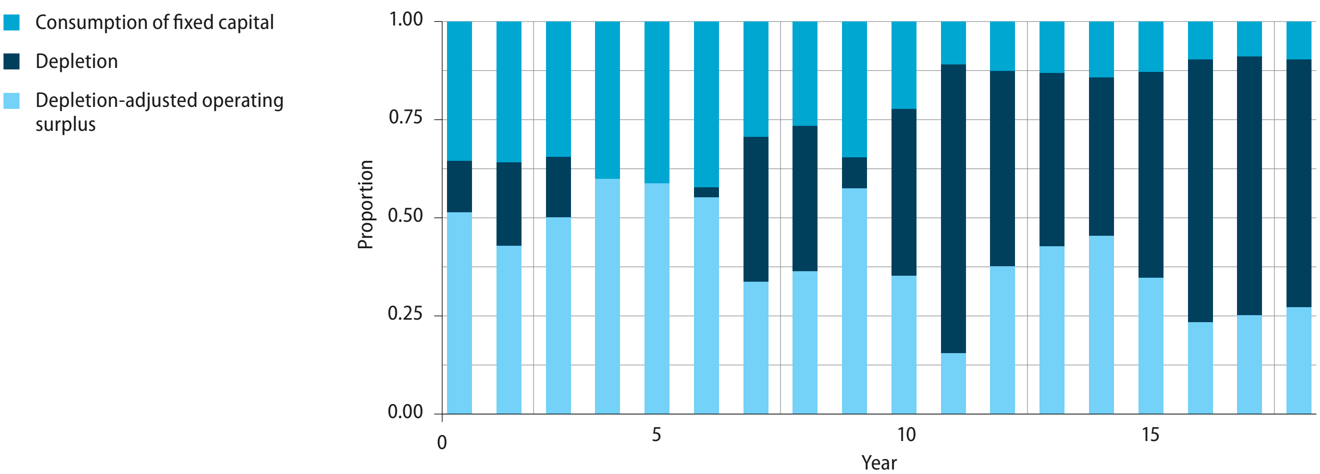
Figure 7.10
Net and depletion-adjusted operating surplus



7.38. Efforts to secure a better understanding of the magnitude of mineral and energy resource depletion benefit from a consideration of what proportion of gross operating surplus is attributed to depletion. As mentioned above, gross operating surplus can be decomposed into three components: consumption of fixed capital, depletion and depletion-adjusted operating surplus. Figure 7.11 displays the relative weight over time of each component of gross operating surplus for extraction by the crude petroleum and natural gas industry.

Figure 7.11

Share of each component of gross operating surplus for extraction by the crude petroleum and natural gas industry



7.39. During the period, the share of depletion of crude petroleum and natural gas in gross operating surplus increased. At the end of the period, depletion accounted for almost two thirds of gross operating surplus. The increase in the share of depletion reflects, in part, an increase in the physical quantities of the mineral and energy resources extracted.

7.40. Figure 7.11 also illustrates that the share of depletion may vary significantly from year to year, even in the absence of significant variation in the level of physical extraction. This can be explained according to the convention that the total value of mineral and energy resources influences the estimate of the depletion. Other things being equal, large increases in the stock of the mineral and energy resources due to new discoveries and revaluations of quantities lead to drastic downward changes in the estimate of the depletion, even if the level of extraction of those resources is the same when measured in physical quantities.

7.41. The relative role of the consumption of fixed capital is seen to decrease over time. This may be due, inter alia, to an increase in productivity, leading in turn to the extraction of a greater quantity of mineral and energy resources through the same input of fixed capital, and/or possibly the decision not to replace production capital as the accompanying natural resource nears full exhaustion. A decreasing share of the consumption of fixed capital can also result from an increase in oil and natural gas prices relative to the prices of the fixed assets used for extraction.

7.42. Subtraction of depletion and consumption of fixed capital from gross operating surplus yields the depletion-adjusted operating surplus. That its share is seen to vary over time reflects the volatility of the estimate of both depletion and gross operating surplus, especially at current prices. This underscores both the importance of establishing a time series for depletion and the depletion-adjusted operating surplus, and the danger of drawing conclusions regarding long-term patterns that are based solely on accounts for a single year or over a short time series.

7.4.3. Energy-related taxes and resource rent

7.43. As discussed in chapter VI, gross operating surplus is the starting point for the calculation of resource rent,[42] which, as is clearly seen in figure 7.12, accounts for a considerable part of the gross value added of extraction by the crude oil and natural gas industry.

7.44. A question of interest from a policy perspective—the type of question that the accounts are perfectly suited to answering—is whether the owner of the resource, for example, the government, has recovered a significant portion of the resource rent through rent payments and energy-related taxes (which include, inter alia, energy taxes as defined in paragraph 4.68 of chap. IV). Figure 7.12 shows that the share of resource rent in value added was relatively low in the first few years when extraction was low but increased once the value of extractions started to increase. While the share of rent payments and taxes was similarly low in the beginning of the period, during recent years, the share has remained high.

7.45. This analysis emphasizes 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.

7.46. The importance of the energy sector to government finances is attested by the share of total government revenues derived from payments related to the extraction of mineral and energy resources and other energy-related taxes (see figure 7.13).

7.47. In recent years, energy-related taxes have made up approximately 10 per cent of total government revenue. Of this, roughly half comes from rent payments and taxes related to the extraction of mineral and energy resources and half from other energy-related taxes, including taxes on CO_2 emissions. Over the years, the contribution of the energy sector to government revenues has increased.

[42] Resource rent = gross operating surplus for derivation of resource rent - consumption of fixed capital - return to fixed capital.

Figure 7.12
Gross value added, resource rent and payments of rent and taxes to the government

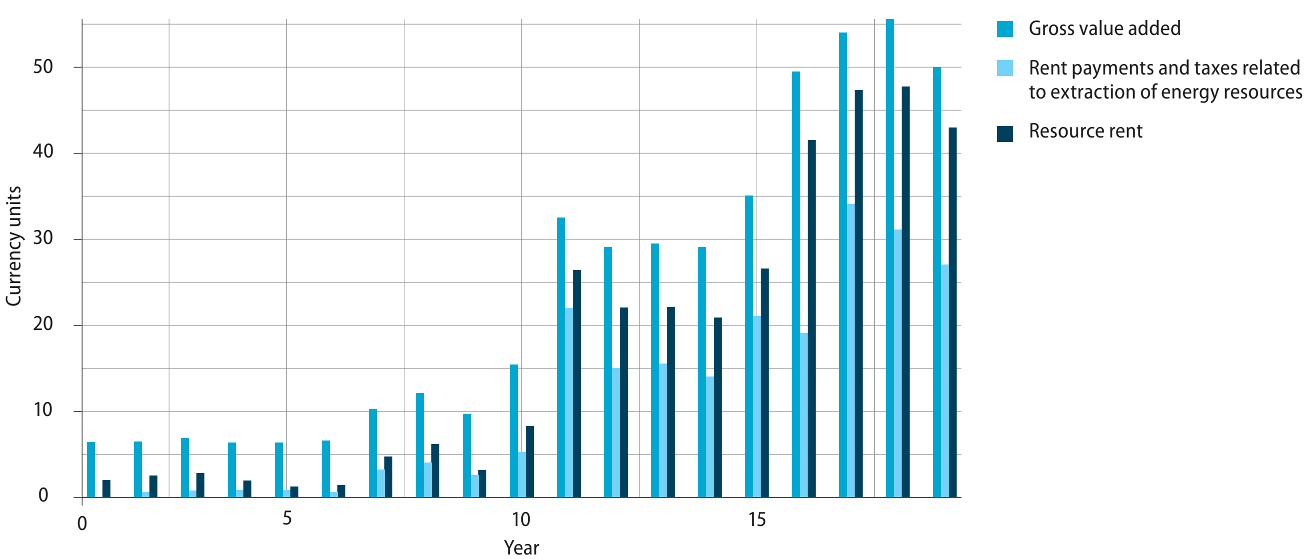
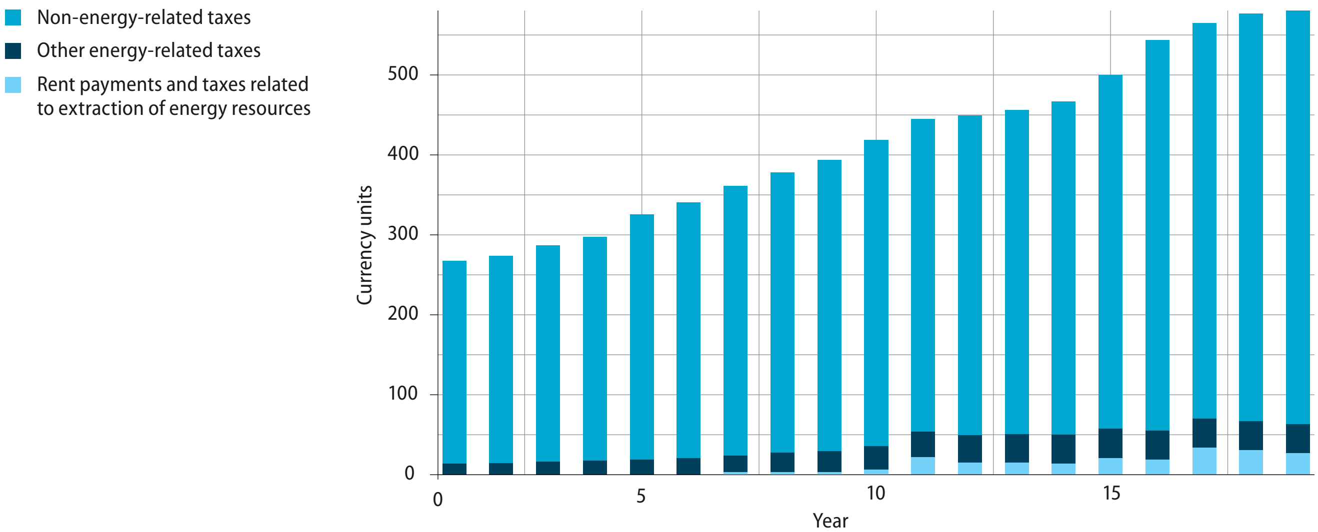


Figure 7.13

Breakdown of taxes for the total economy by non energy related taxes, rent payments and taxes related to extraction of energy resources, and other energy-related taxes



7.4.4. Energy and foreign trade

7.48. An important conclusion arising from the initial supply and use analysis in section 7.3 of this chapter was that imports and exports of energy products are significant components of the overall dynamic of energy supply and use. Furthermore, data on imports and exports are key to understanding energy security, as noted in table 7.2, section B, under the theme "security". In the present section, we examine some of the facets of this relationship with the help of the data available from the accounts.

7.49. Through the data presented in table 7.4, it is demonstrated that, in monetary terms, crude oil is the most important energy product being exported, while processed oil in the form of fuel oil is the main imported energy product. Overall, there is a trade surplus for energy products, owing mainly to the extraction of crude oil and natural gas.

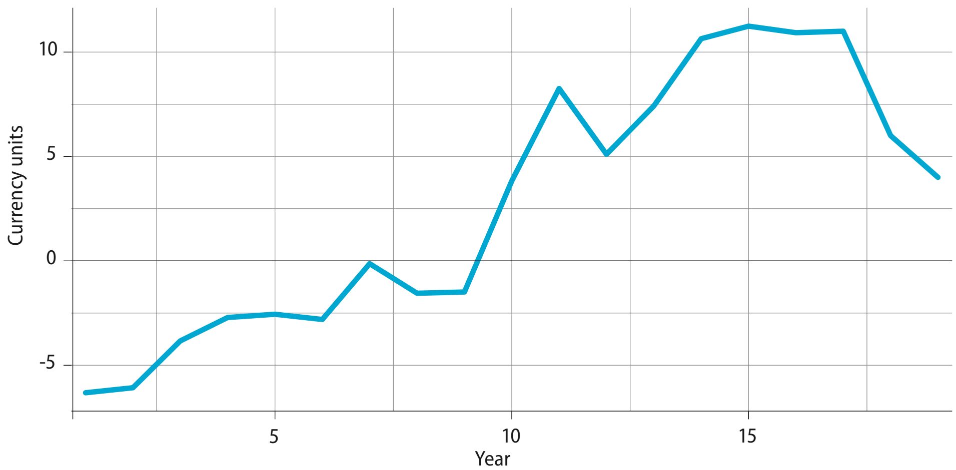
Table 7.4

Imports and exports of energy products

	Imports	Exports	Trade balance (exports minus imports)
	Thousands of currency units		
Crude oil	8	32	24
Natural gas	0	9	9
Electricity	2	4	3
Gasoline and diesel	7	8	1
Other	6	5	- 1
Coal	3	0	- 3
Fuel oil	33	10	- 23
Total, energy products	**59**	**69**	**10**
Total, all products	**520**	**538**	**18**
Energy products' share of all products (percentage)	11	13	53

7.50. The trade balance for energy products over time is shown in figure 7.14, where it can be seen that a trade surplus first occurred during year 9 and increased to year 15. Comparison of figure 7.14 with figure 7.8, which shows the output of the extraction industry, reveals a close connection between 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 over time

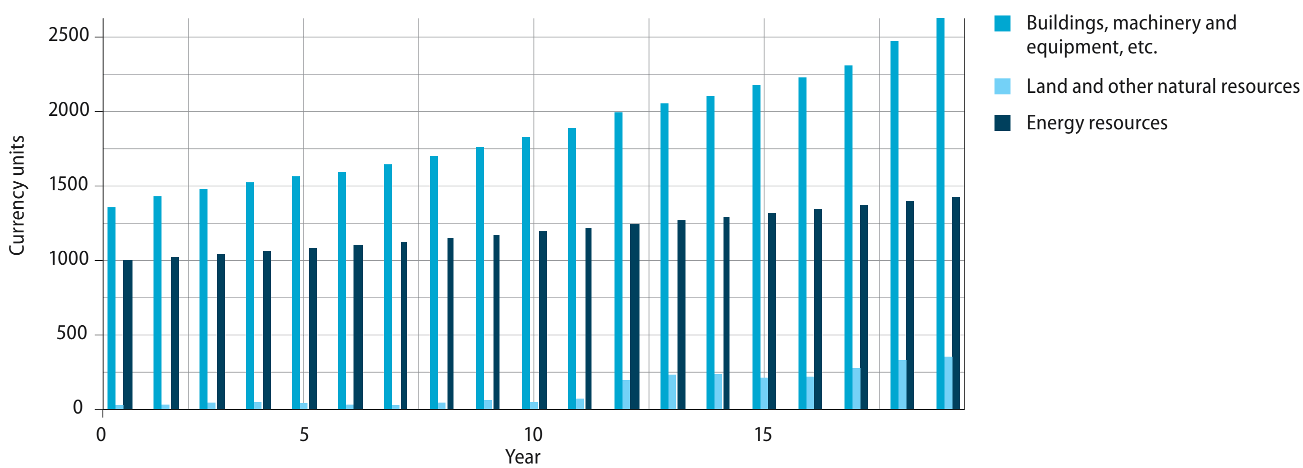


7.4.5. Wealth

7.51. In the present section, the energy sector is viewed within the larger context of national wealth. The value of mineral and energy assets constitutes 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.

7.52. Figure 7.15 presents the market values of human-made and natural capital, while excluding the value of human capital.

Figure 7.15
Contribution to national wealth by fixed assets, mineral and energy assets, and land and other natural resources

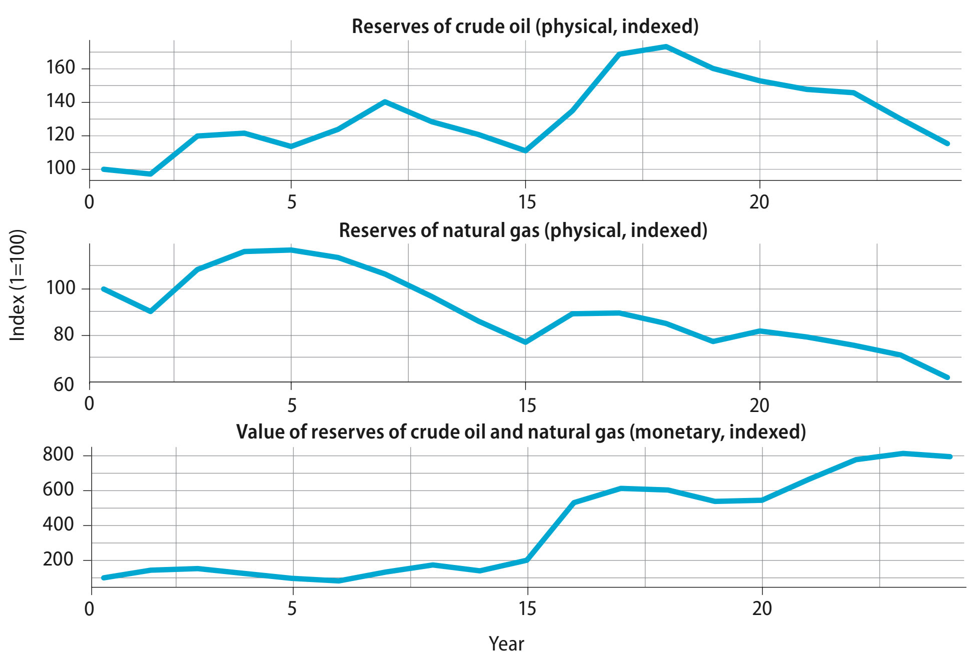


7.53. In this case, fixed assets (buildings, machinery and equipment, etc.) are shown to make up the largest part of the value of assets. Although mineral and energy assets are important for the economy (for the trade balance, for instance), their contribution to total wealth, as measured by the value of the assets, is modest.

7.54. The value of mineral and energy assets is shown to increase over time. This increase can be attributed partly 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 the fact that increases in oil prices affect the value of the mineral and energy assets, and when the oil price increases more than the general price level, the value of the mineral and energy assets will also tend to increase relative to the value of other assets.[43]

7.55. Clearly, the value of mineral and energy assets is tied to the available physical quantity of the asset. Figure 7.16 illustrates how the value of energy natural resource assets changes compared with their physical quantities. The value index is calculated from the current price value as deflated by the GDP deflator.[44] The changes in the index are therefore influenced by the fact that energy prices and the general price level evolve differently. 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



7.56. The physical stock of oil resources was 15 per cent higher at the end of the period compared with the beginning of the period. In contrast, the physical stock of natural gas is almost 40 per cent lower. The GDP-deflated value index was almost eight times higher at the end of the period than at the beginning.

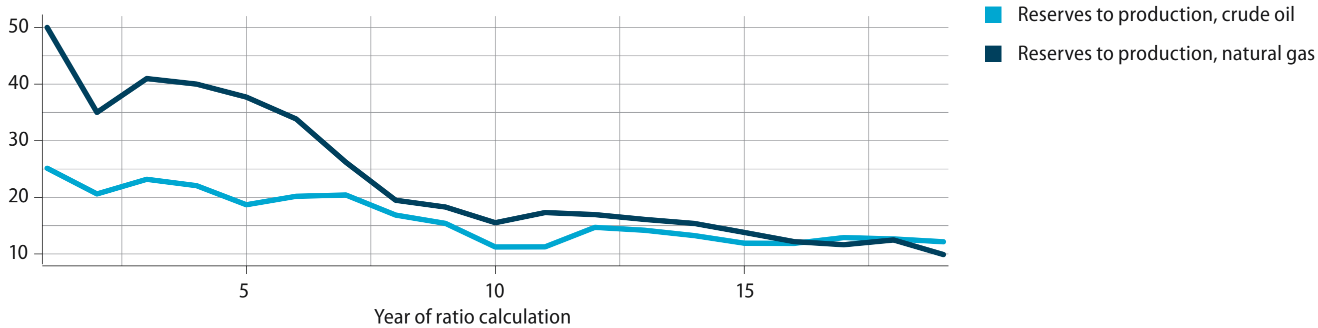
7.57. The reserves-to-production ratio for oil and natural gas resources, as presented in figure 7.17, sheds further light on the size of mineral and energy assets. For a given year, the reserves-to-production ratio (which is one of the indicators listed in table 7.2). is equal to the available stock at the opening of the period divided by the extractions in the given year.

$$\frac{R}{P} = \frac{\text{Stocks}}{\text{Extraction}}$$

[43] Using constant prices is standard practice in this type of analysis because the value of a given asset depends on the period of the valuation.

[44] Recall that the GDP deflator = (GDP current prices)/(GDP constant prices). Others, such as the domestic final demand deflator and the gross national expenditure deflator, could also be used.

Figure 7.17
Reserves-to-production ratios for crude oil and natural gas, assuming continuation of current levels of stocks and extactions



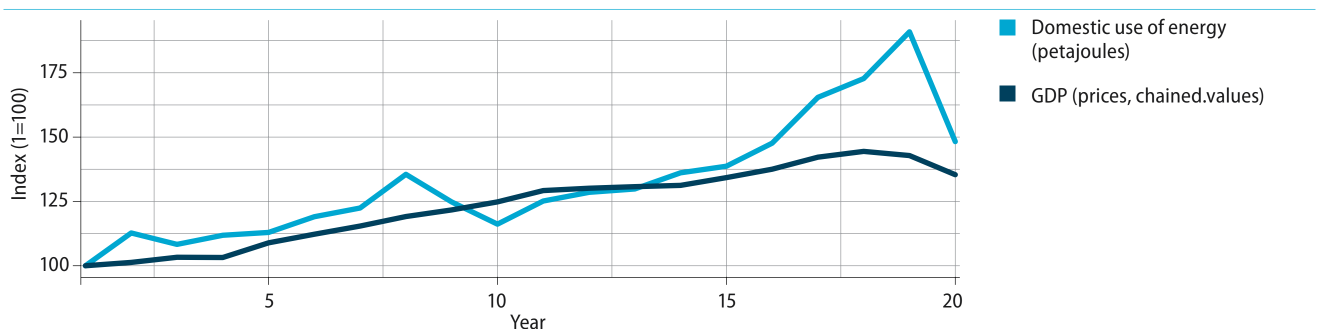
7.58. The ratio represents the number of years of extraction left before the mineral and energy resource is exhausted, assuming that in follow-up periods, there are no additions to the stocks (e.g., discoveries) and no reductions other than the extractions that are assumed to continue at the current level. It is shown in figure 7.17 that for natural gas, 50 years of extraction were left at the beginning of the time series, while little more than 10 years remain 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 reserves-to-production ratio decreases 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 reserves-to-production ratio for oil remains fairly constant, at above 10 years, for the last decade. This stabilization of the ratio, which is often seen, is a result partly of increased exploration and evaluation activities. This makes it possible to carry out extraction from newly discovered deposits as other deposits approach exhaustion.

7.4.6. Economy-wide energy decoupling

7.59. Decoupling of energy use and economic growth is generally seen as necessary to ensure sustainable development. The extent to which such decoupling takes place can be illustrated, as in figure 7.18, by a comparison of changes in GDP with changes in domestic use of energy. The underlying data (the data used to calculate the decoupling indicators) can also be used to calculate energy use per unit of GDP.

7.60. 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, an initial large increase in energy use is followed by a steep decrease. In the last year, indexed energy use and GDP are seen to have roughly the same value.

Figure 7.18
Economic growth and domestic use of energy



7.5. Energy and other sectors of the economy

7.5.1. Energy intensities for selected industries

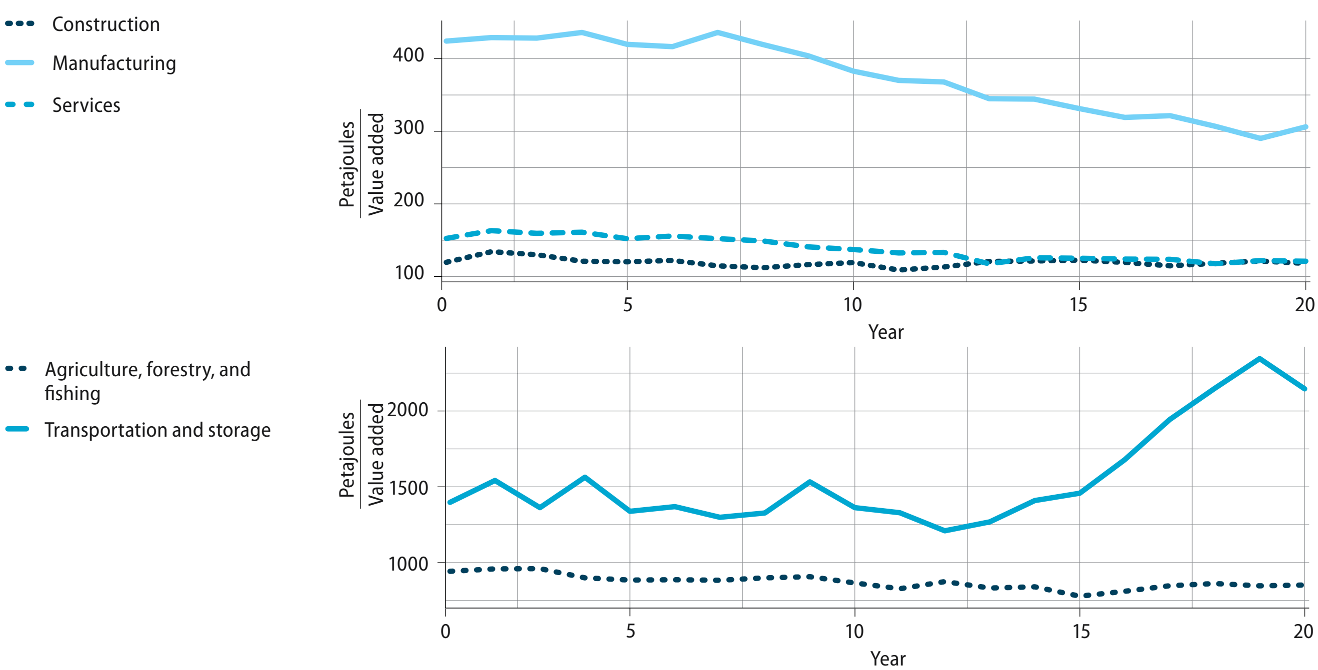
7.61. Increased efficiency in energy use and decreasing energy intensities can contribute to sustainable development. The present section, in its analyses of energy use in relation to economic growth and the energy efficiencies of industries, displays energy intensities for various industries and presents the results of decomposition analysis, a method designed to shed light on changes in energy use. Several energy intensity indicators can be generated using the data in the energy accounts.

7.62. Figure 7.19, which comprises two graphs, distils the development of economic activity and energy use across selected industries based on the calculation of energy intensities for those industries. Energy intensity is defined as the ratio of energy used for a given industry to the value added in constant prices by that industry. The importance of energy intensity type indicators is further reflected by the fact that such indicators constitute the largest subgroup of table 7.2 on energy indicators across the social, economic and environmental dimensions.

7.63. The upper graph illustrates development of industries with relatively low energy intensities. Manufacturing is characterized by decreasing intensities, which indicates a tendency over time to use energy more efficiently and/or to make increased use of energy transformed outside of the manufacturing sector, as opposed to energy that is autoproduced. After a decrease at the beginning of the period shown, energy intensities for construction and services are seen to remain constant, at a low level.

7.64. The lower graph displays the energy intensities of the transportation and storage industry and the agriculture, forestry and fishing industry. Both industries report high energy intensities. While there has been a slight decrease in the intensity for agriculture, forestry and fishing during the period, the intensity for transportation and storage has risen sharply.

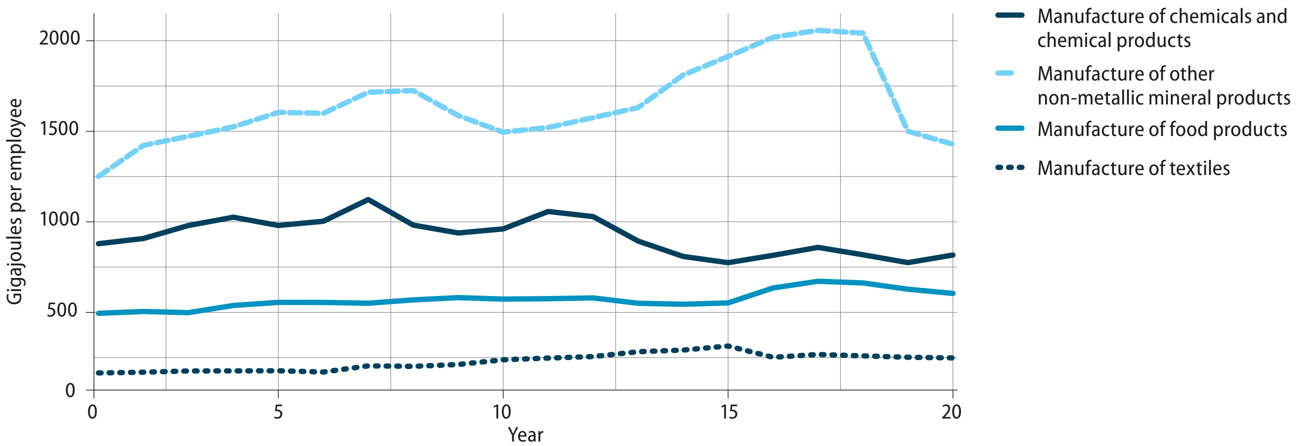
Figure 7.19
Energy intensities for selected industries



7.65. The data in the energy accounts are collected in a manner consistent with SNA, which allows for easy integration of data from these two systems. For example, through integration of energy use data with employment data, the ratio of energy use to number of employees in a particular sector may be obtained.

7.66. Figure 7.20 presents information on energy use per employee for selected manufacturing industries. As energy use per employee varies considerably among the manufacturing industries, no clear conclusion can be reached on the question whether there is decoupling between energy use and employment in those industries.

Figure 7.20
Energy use per employee in selected manufacturing industries



7.5.2. Factors behind changes in energy use

7.67. The application of structural decomposition analysis, based on input-output modelling, can shed light on the factors behind changes in energy use. Structural decomposition analysis is well established, as attested by the large number of articles and reports in the literature that examine the results obtained through its use.

7.68. Figure 7.21 presents the results of such an analysis. The total change in actual energy use by industries (excluding the transportation services industry[45])—which amounted to an increase of about 200 petajoules—is composed of four components: (a) change in the growth of final demand (e.g., private and government consumption, exports and gross fixed capital formation), (b) change in the structure of final demand (i.e., shifts in final demand among different sectors of the economy), (c) change in industry structure and (d) changes in the energy intensities of industries.

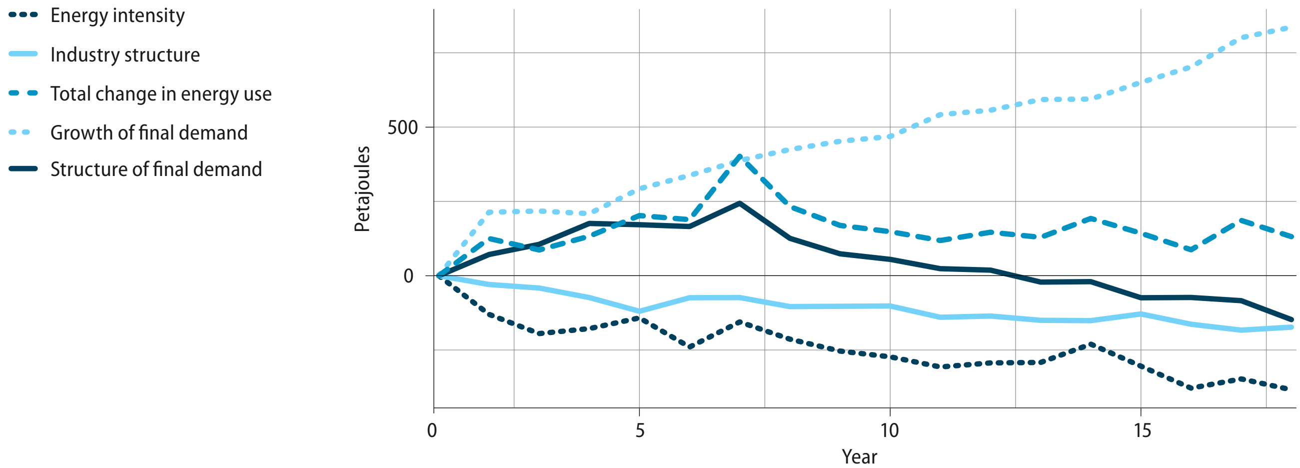
7.69. Growth of final demand increased by over 800 petajoules over 18 years, while growth of the other three components decreased. If growth in energy use had followed the growth in final demand, there would have been an increase in energy use of over 800 petajoules. In fact, the total increase in energy use amounted to about 200 petajoules. The difference is due mainly to a reduction in energy intensity in industries (i.e., a reduction in their use of energy per unit of output), with this factor alone decreasing by about 400 petajoules. Changes in the composition of final demand (i.e., the mix of products purchased) and changes in industry structure (i.e., in the interactions among industries) also contributed to a decrease in energy use over the time series.

7.70. It should be noted that in practice input-output modelling cover a period shorter than many of the other time series used in this chapter, owing to the fact that the publication of input-output tables is normally associated with a greater time lag than is the case for other statistics.

45 The transportation services industry has been excluded from the analysis because the pattern exhibited by this industry differs significantly from that of other industries.

Figure 7.21

Factors behind the changes in industry energy use



7.5.3. Energy use attributed to final use of products

7.71. Increasingly, as regards sustainable production and consumption policies, policymakers and others are focusing on the fact that resource uses and environmental pressures can be seen within the context 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, resource uses and environmental pressures, which occur at the level of production, can in fact be viewed as determined by final use, which initiated the production chain.

7.72. The data in the accounts can be used to facilitate the proper understanding of how final demand drives energy use. In particular, input-output analysis derives the allocation of energy use by final use categories or specific products. Figure 7.22 displays an input-output model-based allocation of total domestic energy use to overall final use categories, which lies behind the production and corresponding energy use in all industries.

7.73. Figure 7.22 shows that the steep increase in energy use between t_0 and t_1 was related mainly to an increase in export activities. In contrast, private and government consumption and gross fixed capital formation were responsible for almost the same level of industries' energy use in t_1 as in t_0.

Figure 7.22

Industries' energy use by final use categories

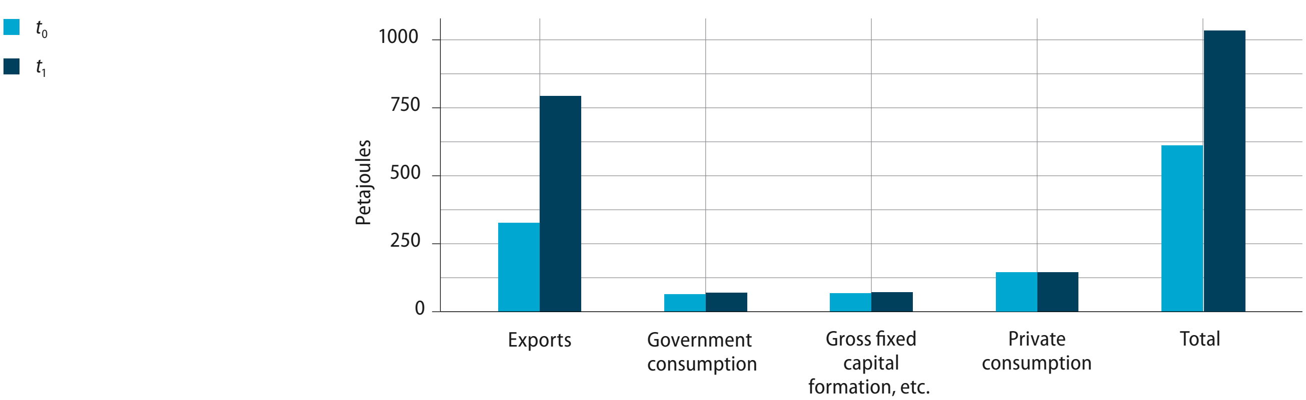
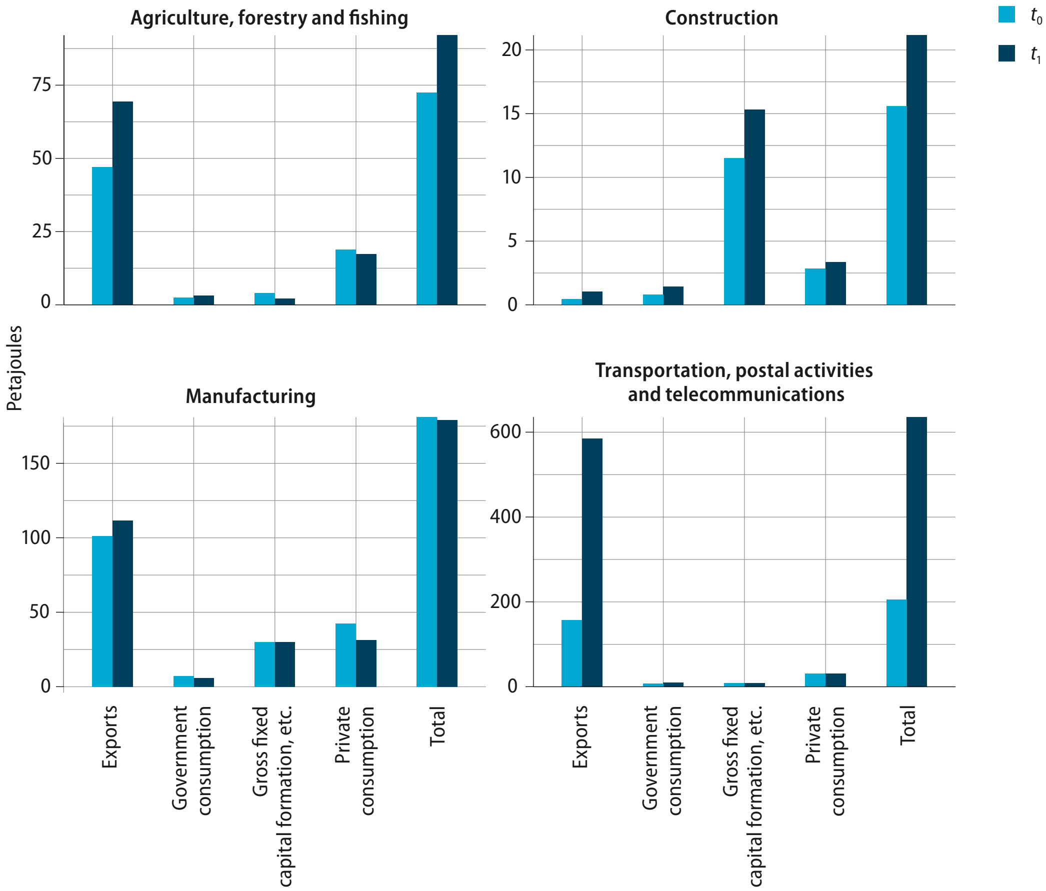


Figure 7.23
Industry groups' energy use by final use categories

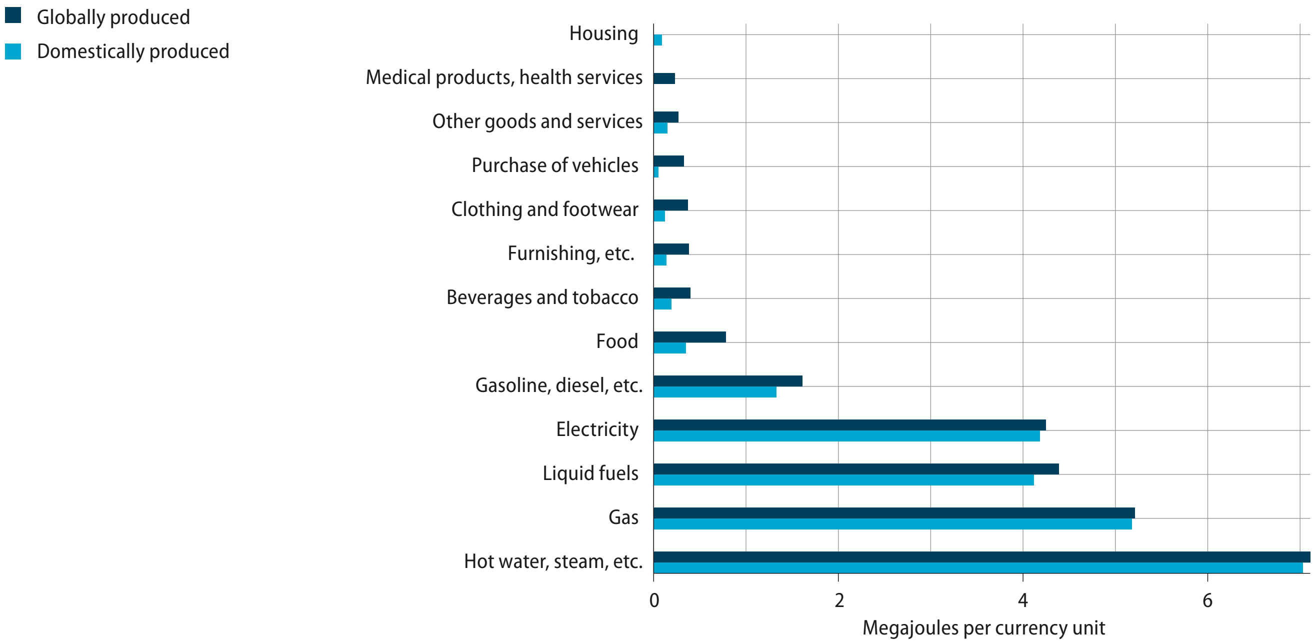


7.74. This type of analysis can also be carried out for particular industry groups. It is clear from figure 7.23 that the activities and energy use of different industries are driven by different final use categories. For example, exports underpin energy use by agriculture, forestry and fishing; manufacturing; and transportation, postal activities and telecommunications. The increase in exports of transportation services accounted for much of the increase in overall energy use in that industry, while gross fixed capital formation was the main driver of energy use in the construction industry.

7.5.4. Domestic and global energy use attributed to household consumption

7.75. For each of the final use categories, energy use in the production chains can be further decomposed by distinguishing among the final uses of different products. In presenting the results of such an analysis for household consumption, figure 7.24 shows how much energy is used directly or indirectly per one currency unit spent on products by households. A distinction is also made between a production process in which energy is used domestically and a production process in which it is used both domestically and abroad. The latter type of production process includes both products that are imported and products that are produced domestically using imported intermediate products.

Figure 7.24
Domestic and global energy intensities as a result of household consumption



7.76. Among energy products, hot water, steam, etc. are the most energy-intensive, while gasoline, diesel, etc. are the least energy-intensive. It should be noted that, as intensities are calculated from purchasers' prices, which include energy taxes, products that are heavily taxed appear to have lower energy intensity per unit of currency. This can be avoided through the use of prices that exclude taxes. It is clear from the figure that among other types of products, food is the most energy-intensive, followed by beverages and tobacco, furnishing, etc. and clothing and footwear.

7.77. 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.

7.78. For other products, there are considerable differences between domestic and global energy use in production. Generally, global energy intensities are twice as large as domestic intensities, which is explained in part by the fact that many of the products used by households are imported. Further, industries in the production chain also use imported products, which require energy use abroad.

7.6. Energy, air emissions and renewable sources

7.79. The present section examines how energy accounts can help clarify the relationship between the energy sector and some components of the environment, focusing on the role of energy-related air emissions (which are important because of their direct impact on the environment) and renewable sources of energy (which help mitigate pressure on the environment). The data presented are necessary for the derivation of several indicators related to sustainable development such as air quality and climate change indicators. As is the case for all of the examples presented in the other sections of this chapter, the examples below incorporate only some of the applications of the accounts.

7.6.1. Energy-related air emissions

7.80. One important application of the physical use table for energy is in the calculation of air emissions. Section 7.6.2 describes how the accounts for energy-related emissions might be set up, and section 7.6.3 presents the results of a modelling exercise based on the energy and emissions accounts. Those results indicate which factors affect energy-related emissions.

7.81. Energy-related air emissions are the main (albeit not the only) contributors to most types of air emissions, because most economic activities are linked to combustion that is needed for energy production. Many production and consumption activities, such as heating of houses and buildings, production of electricity, various industrial processes and transportation, entail combustion processes.

7.82. The SEEA-Energy accounts may be utilized as the basis for establishing energy-related air emissions accounts. Such emissions accounts are compatible with the SEEA Central Framework and the SEEA-Energy physical flow accounts, and, more generally, with the principles of national accounts.

7.83. In preparation for the analysis below, it is worth noting that the term *air emissions accounts* differs from *emission inventories*, a term that is commonly used in reference to data on greenhouse gas emissions and emissions of air pollutants assembled in accordance with certain formats, as agreed under international conventions (e.g., the United Nations Framework Convention on Climate Change[46] and the Convention on Long-Range Transboundary Air Pollution[47]). Emission inventories, which are technology-oriented, may serve appropriately as the basis for focusing on technology-oriented questions and analysis. Air emissions accounts, in contrast, being economically oriented and developed to tackle more economically oriented questions and analyses, assign air emissions to those economic entities that are actually carrying out the activities from which the emissions originate. These two information systems, emission inventories and air emissions accounts—complement each other.[48]

7.84. In addition to being consistent with all of the components of the SEEA-Energy system, including monetary aggregates, energy-related air emissions accounts, as developed below, reflect a continuity and consonance with the physical flow accounts for energy as presented in chapter III.

7.6.2. Use of energy accounts for the estimation of emissions

7.85. Energy accounts can be useful as a tool for estimating emissions from energy use. Table 7.5 constitutes a detailed supply table for CO_2 emissions. Similar tables can be created for all other types of air emissions that are produced primarily through energy use, and in the same way as the CO_2 emissions account.

7.86. Generally, the emissions accounts for energy-related emissions can be established on the basis of the energy use table (table 3.5) by multiplying each of the relevant values recorded in the energy use table by a specific technical emission factor representing the emission per unit of energy use. Formally, the operation can be expressed as:

Emissions (E) = energy use (EU) × emission factor (EF)[49]

7.87. It should be noted that, in practice, the estimations need to be carried out at a more detailed level than that presented in tables 3.5 and 7.5, so as 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, as different products are usually associated with different emission factors. For certain types of air emissions, it may

[46] United Nations, Treaty Series, vol. 1771, vol. 30822.

[47] Ibid., vol. 1302, No. 21623.

[48] See Eurostat, *Manual for Air Emissions Accounts*, 2015 ed., Eurostat Manuals and Guidelines (Luxembourg, Publications Office of the European Union, 2015), sect. 2.3. Available at http://ec.europa.eu/eurostat/documents/3859598/7077248/KS-GQ-15-009-EN-N.pdf/ce75a7d2-4f3a-4f04-a4b1-747a6614eeb3.

[49] Sometimes, emission factors are not expressed in emission per unit of energy but in emission per mass unit or per some other unit. In such cases, caution should be exercised so as to ensure that the proper unit is used in the conversion.

[50] The *Eurostat Manual for Air Emissions Accounts*, 2015 edition, provides further information on how air emissions accounts can be established on the basis of energy accounts.

also be necessary to obtain information and data on the types of technologies utilized within different industries, because the technologies that are chosen exert an influence on the quantity of air emissions per unit of energy used.[50]

7.88. Table 7.5 sets out the quantities of CO_2 emissions generated through the use of the various types of energy products. Thus, the items in the left-hand column of table 7.5 correspond to those items in the energy use table (table 3.5) that are of interest within the context of air emissions.

7.89. The air emissions data related to energy use are allocated to economic activities in a manner consistent with how that energy use is recorded. In other words, if energy use for combustion is recorded for a specific unit (industries and households), then the corresponding emissions are attributed to that unit.

7.90. The use of certain types of energy does not lead to the recording of emissions. This is the case, for example, for the use of electricity and heat by industries and households. Emissions generated when coal and oil are used in the production of electricity and heat are attributed to the producers. Since the main part of production typically occurs within ISIC section D (Electricity, gas, steam and air conditioning supply), it is to section D that the main proportion of these emissions is normally attributed. Other proportions of these emissions are recorded under other industries to the extent that combustion of energy products for electricity and heat generation occurs in those industries for own use or for sale.

7.91. Similarly, emissions related to the use of gasoline and diesel for transportation are attributed to the units carrying out the transportation activities. Thus, only part of the emissions, for example, energy use and emissions associated with public transportation, is attributed to ISIC section H (Transportation and storage). Other parts are attributed to households and industries. For households, transport-related emissions include the use of energy for private cars.

7.92. This analysis of the components of a supply table for energy-related CO_2 emissions is rounded out with a presentation, in the penultimate row of table 7.5, of data on *non-energy-related* CO_2 emissions. The data are based on additional information derived from, inter alia, the emission inventories compiled in compliance with the United Nations Framework Convention on Climate Change.

Table 7.5

Supply table for CO_2 emissions, based on the SEEA-Energy use table

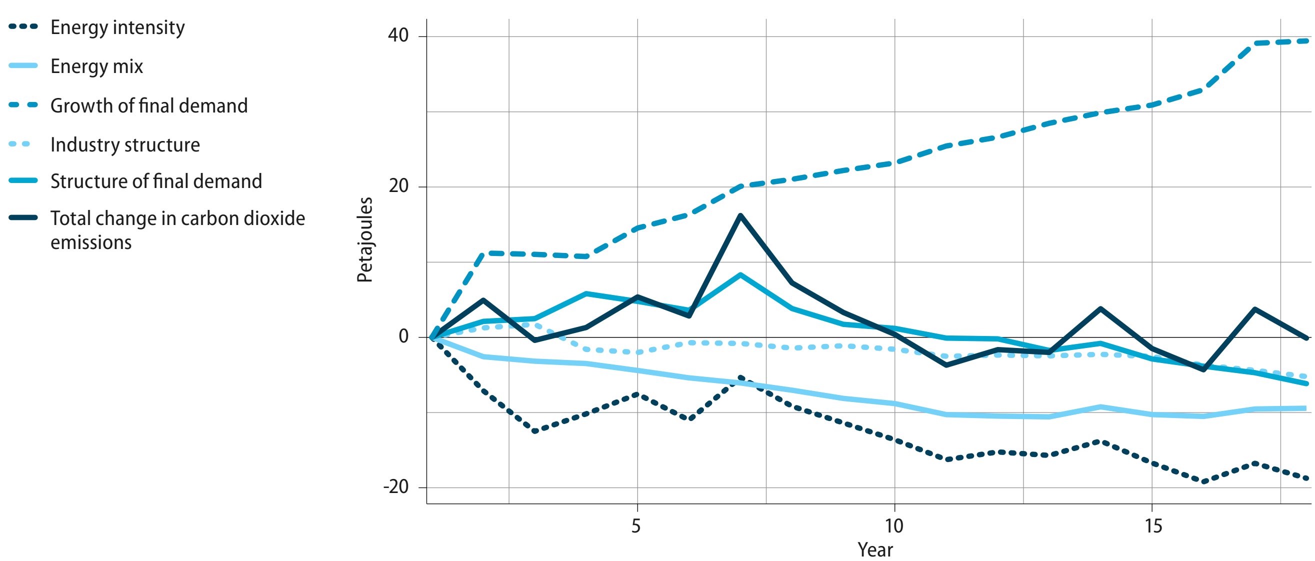
	Industries by ISIC											Households			Total
	A	B	C	D	E	F	G	H	I-U	A-U					
	Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply; etc.	Construction	Wholesale and retail trade; etc.	Transportation and storage	Other industries	Total industries	Of which residents in the rest of the world	Own account transport	Other consumption	Total consumption	Total supply of air emissions by residents
	Thousands of tons														
Energy-related emissions															
Coal	203	14	1 695	21 472			1		1	**23 385**			83	**83.475**	23 468.8
Peat and peat products															
Oil shale/oil sands															
Natural gas	115	1 728	2 211	4 705		21	236	26	433	**9 475**	0		1 606	**1 606.1**	11 081.1
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	**8 453.7**	66 509.8
Biofuels	25		14	126						**165**	0			**0**	164.75
Waste	263	9	396	6 636					85	**7 389**	0		3 391	**3 390.5**	10 780
Electricity															
Heat															
Nuclear fuels and other fuels not elsewhere classified															
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**	**13 533.8**	**112 004**
Non energy-related emissions, total		**425**	**1 465**							**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**

7.6.3. Analysis of energy-related emissions based on the energy accounts

7.93. With the emissions accounts having been established based on the energy accounts, it is possible to extend the analysis to include a consideration of the factors underlying the changes in energy-related emissions. Figure 7.25, which resembles figure 7.21 on factors behind the changes in energy use, illustrates the results of such an analysis. Overall, CO_2 emissions have been fairly constant over the 18-year period. Of the five components shown in figure 7.25, growth in final demand has created substantial upward pressure on CO_2 emissions, while the other components represent factors driving overall CO_2 emissions down.

7.94. Changes in the energy mix imply that industries and household are increasingly using energy products that are less CO_2-intensive. Examples of such a change in the energy mix are substitution of natural gas for coal and of wind energy for fossil-based electricity.

Figure 7.25
Factors behind the changes in industry CO_2 emissions

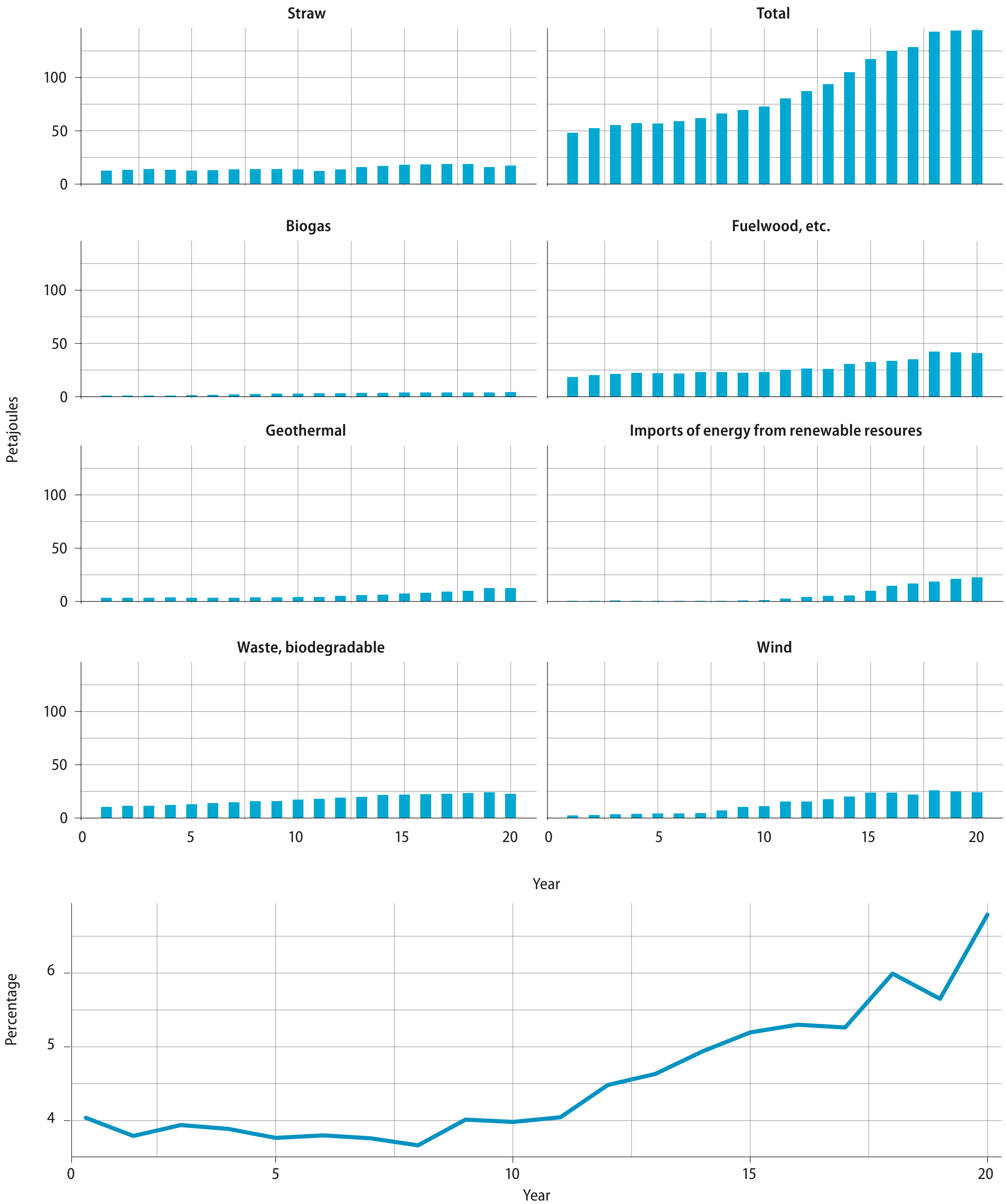


7.6.4. Role of energy from renewable sources and waste

7.95. That the subject of energy from renewable sources is high in the policy agenda in many countries is one reason why it is so important to monitor the development of the production and use of energy from renewable sources and to assess the share of such sources in total energy supply and use. The present section provides a detailed examination of the use of energy from renewable sources and waste and clarifies how much of the total use of energy is accounted for by renewables and waste.

7.96. Figure 7.26 illustrates the development of the supply (production and imports) of energy from various renewable sources, and the share of renewable sources in total primary production and imports of energy products. Production of energy from wind and imports of energy from renewable sources have been increasing, as has the use of fuelwood and biodegradable waste for energy production. Altogether, the share of energy from renewable sources in the total supply increased from 4 to close to 7 per cent during the period covered by the figure.

Figure 7.26
Supply of energy from renewable sources and share of renewable sources in total primary energy production and imports

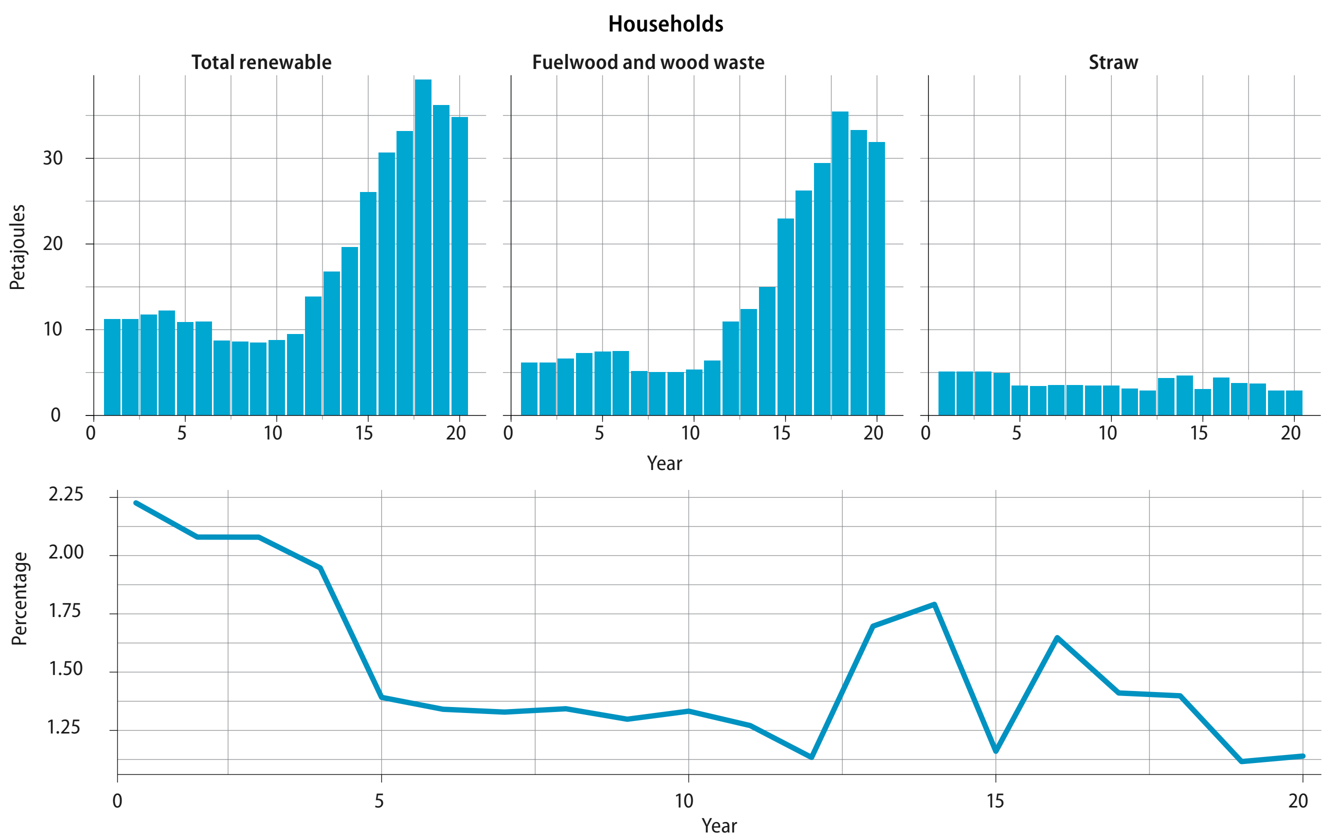


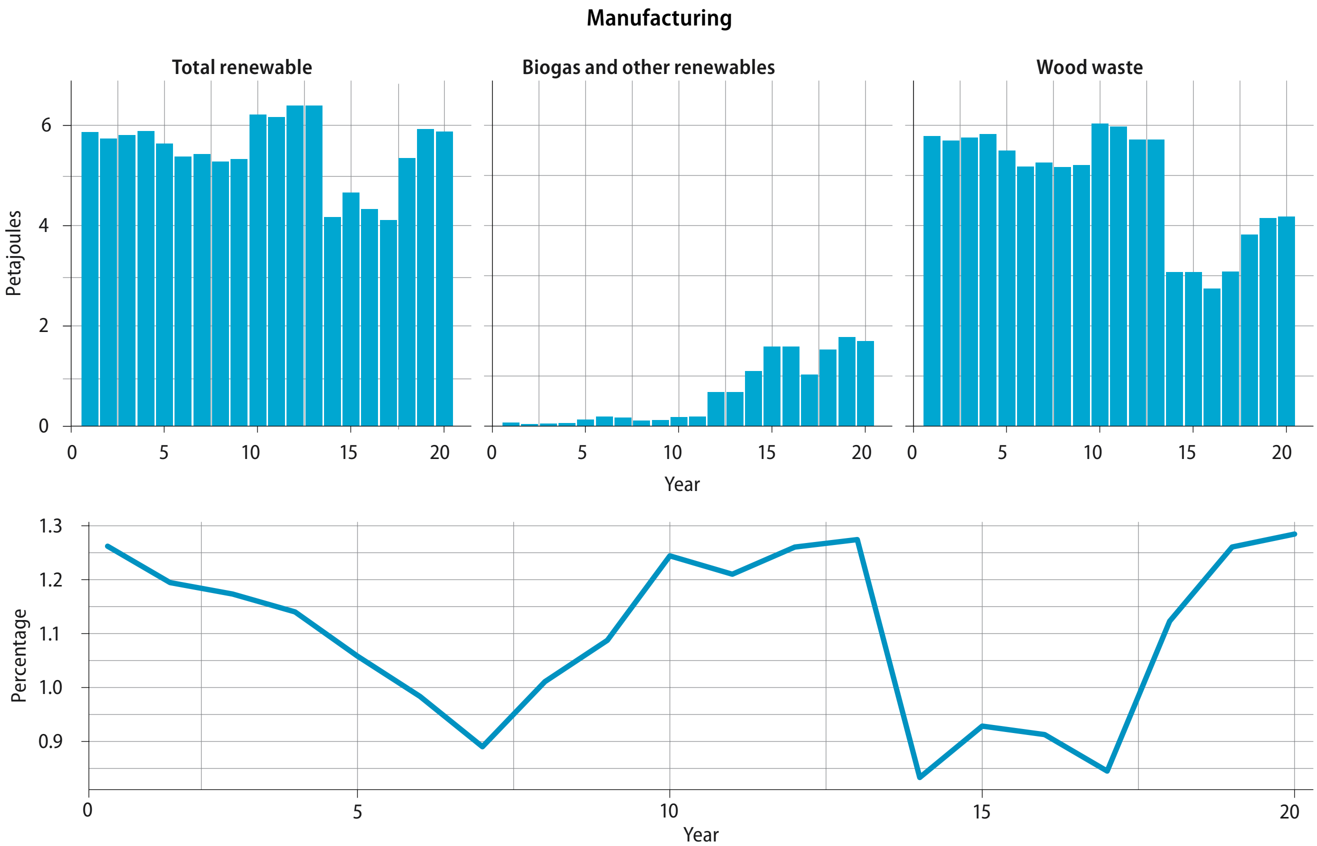
7.97. Energy from renewable sources is used both by households and by industries. Figure 7.27 displays the use of energy from renewable sources in physical terms, by households, by the manufacturing industry and by the electricity, gas, steam and air conditioning supply industry.

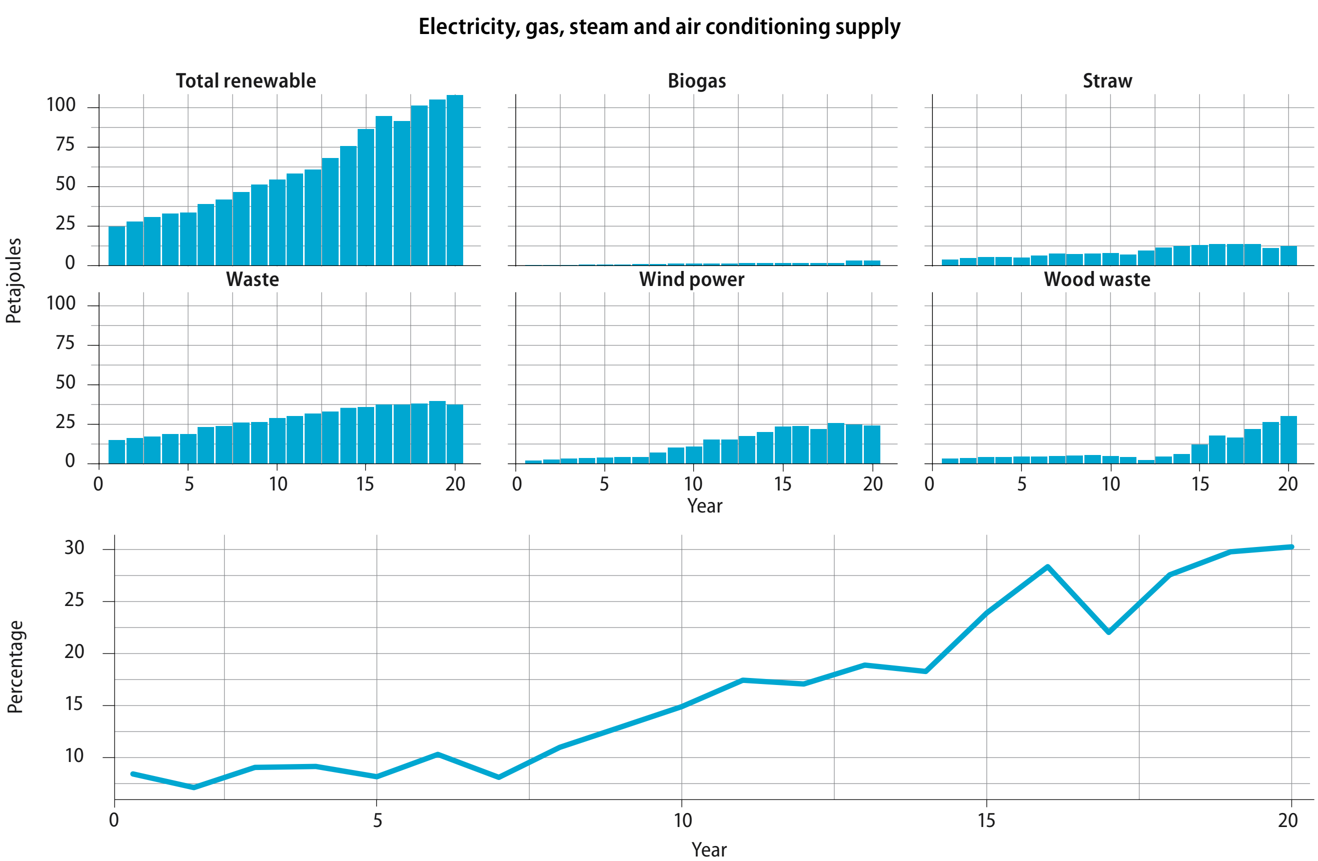
7.98. Notwithstanding the dramatic increase in household use of fuelwood during the period, the share of renewable sources in total energy use by households was reduced by half, from 2 to 1 per cent.

7.99. The use of energy from renewable sources in the manufacturing industries in absolute and relative terms has been fairly constant over the time period. On the other hand, while households increased their use of energy from renewable sources in absolute terms, that growth was lower than the overall growth in household use of energy, that is, households' use of energy from renewable sources decreased from over 2 per cent of household energy use at the beginning of the time period to about 1 per cent at the end. The electricity, gas, steam and air conditioning supply industry witnessed a considerable increase—from 10 to 30 per cent—in use of energy from renewable sources as a share of total energy use. It should be noted that part of this increase was 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




Manufacturing
Total renewable
Biogas and other renewables
Wood waste
Petajoules
0
2
4
6
0
5
10
15
20
Year
Percentage
1.3
1.2
1.1
1.0
0.9
0
5
10
15
20
Year


Electricity, gas, steam and air conditioning supply
Total renewable
Biogas
Straw
Waste
Wind power
Wood waste
Petajoules
100
75
50
25
0
0
5
10
15
20
Year
Percentage
30
25
20
15
10
0
5
10
15
20
Year

Annex A1
Tables on conversion factors, calorific values and measurement units

Note: The present annex is derived from *International Recommendations for Energy Statistics* (IRES 2018), annex B.

Table A1.1
Mass equivalents

FROM \ INTO	Kilograms	Tons	Long tons	Short tons	Pounds
	Multiply by				
Kilograms	1.0	0.001	0.000984	0.001102	2.2046
Tons	1 000	1.0	0.984	1.1023	2 204.6
Long tons	1 016	1.016	1.0	1.120	2 240.0
Short tons	907.2	0.9072	0.893	1.0	2 000.0
Pounds	0.454	0.000454	0.000446	0.0005	1.0

Note: To convert a column-head unit to a row unit, divide the column-head unit by the conversion factor found at the intersection of column and row.

Example: Conversion from tons to long tons: 1 ton ÷ 1.016 = 0.984 long tons.

Table A1.2
Volume equivalents

FROM \ INTO	United States gallons	Imperial gallons	Barrels	Cubic feet	Litres	Cubic metres
	Multiply by					
United States gallons	1.0	0.8327	0.02381	0.1337	3.785	0.0038
Imperial 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: To convert a column-head unit to a row unit, divide the column-head unit by the conversion factor found at the intersection of column and row.

Example: onversion from barrels into cubic metres: 1 barrel ÷ 6.289 = 0.159 cubic metres.

Table A1.3
Conversion equivalents between energy units

FROM \ INTO	Terajoules (TJ)	Millions of British thermal units (Btu)	Gigacalories (GCal)	Gigawatt-hours (GWh)	Kilotons of oil equivalent (ktoe)	Kilotons of coal equivalent (ktce)
	Multiply by					
Terajoules	1	947.8	238.84	0.2777	2.388×10^{-2}	3.411×10^{-2}
Millions of Btu	1.0551×10^{-3}	1	0.252	2.9307×10^{-4}	2.52×10^{-5}	3.6×10^{-5}
Gigacalories	4.1868×10^{-3}	3.968	1	1.163×10^{-3}	10^{-4}	1.429×10^{-4}
Gigawatt-hours (GWh)	3.6	3412	860	1	8.6×10^{-2}	1.229×10^{-1}
Ktoe	41.868	3.968×10^{4}	10^{4}	11.63	1	1.429
Ktce	29.308	2.778×10^{4}	0.7×10^{-4}	8.14	0.7	1

Note: To convert a column-head unit to a row unit, divide the column-head unit by the conversion factor found at the intersection of column and row.

Example: Conversion from gigawatt-hours to terajoules: 1 gigawatt-hour ÷ 0.2777 = 3.6 terajoules.

Table A1.4
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 per cent moisture content)	21–22
Fuelwood (10 per cent moisture content)	11–12
(20 per cent moisture content)	22–23
(30 per cent moisture content)	34–35
(40 per cent moisture content)	45–46

Source: *Energy Statistics: Definitions, Units of Measure and Conversion Factors*, Studies in Methods, Series F, No. 44 (United Nations publication, Sales No. E.86.XVII.21 and corrigendum), table 1.

Table A1.5
Influence of moisture on solid volume and weight of standard fuelwood

	Moisture content of fuelwood (percentage)								
	100	80	60	40	20	15	12	10	0
Solid volume in cubic metres per ton	0.80	0.89	1.00	1.14	1.33	1.39	1.43	1.45	1.60
Weight in tons per cubic metre	1.25	1.12	1.00	0.88	0.75	0.72	0.70	0.69	0.63

Source: *Energy Statistics: Definitions, Units of Measure and Conversion Factors*, Studies in Methods, Series F, No. 44 (United Nations publication, Sales No. E.86.XVII.21 and corrigendum), table 15.

Table A1.6
Fuelwood-to-charcoal conversion table

Influence of parent wood density on charcoal production (weight (kilograms) of charcoal produced per cubic metre of 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

Source: *Energy Statistics: Definitions, Units of Measure and Conversion Factors*, Studies in Methods, Series F, No. 44 (United Nations publication, Sales No. E.86.XVII.21 and corrigendum), table 17.

Table A1.7
Fuelwood requirement for charcoal production by kiln type (Cubic metres of fuelwood per ton of charcoal)

Kiln type	Moisture content of fuelwood (percentage)					
	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: *Energy Statistics: Definitions, Units of Measure and Conversion Factors*, Studies in Methods, Series F, No. 44 (United Nations publication, Sales No. E.86.XVII.21 and corrigendum), table 18, based on Food and Agriculture Organization of the United Nations, *Wood Fuel Surveys* (Rome, 1983).

Table A1.8
Energy value of selected animal and vegetal wastes

Wastes	Average moisture content: dry basis (percentage)	Approximate ash content (percentage)	Net calorific value (megajoules per kilogram)
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 cherries	30	8–10	13.4
Coffee husk cherries	60	8–10	6.7
Corncobs	15	1–2	19.3
Nut hulls	15	1–5	18.0
Rice straw and husk	15	15–20	13.4
Wheat straw and husk	15	8–9	19.1
Municipal garbage	..	..	19.7
Paper	5	1	17.6
Sawdust	50	1	11.7

Source: *Energy Statistics: Definitions, Units of Measure and Conversion Factors*, Studies in Methods, Series F, No. 44 (United Nations publication, Sales No. E.86.XVII.21 and corrigendum), table 20.

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

Glossary

SEEA Energy is a subsystem of the SEEA Central Framework, and, as such, it is fully aligned with it. Many of the relevant accounting terms are fully defined in SEEA Central Framework. They are included here for ease of reference. The first number in parentheses refers to paragraphs in the present publication.

A

Assets are stores of value representing a benefit or series of benefits accruing to an economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another. (5.1, SEEA Central Framework, 5.32)

Autoproducers of electricity are enterprises which produce electricity but for whom the production is not their principal activity. Similarly, autoproducers of heat are enterprises which produce heat but for whom the production is not their principal activity. (2.119)

B

Balancing entry is an accounting construct obtained by subtracting the total value of the entries on one side of an account (resources or changes in liabilities) from the total value of the entries on the other side (uses or changes in assets). (SEEA Central Framework, 2.62, 6.28)

Basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output, minus any tax payable, and plus any subsidy receivable by the producer as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer and any wholesale and retail margins that may be applicable. (4.9, SEEA Central Framework, 2.151)

Biofuels derive directly or indirectly from biomass (fuels produced from animal fats, by-products and residues that obtain their calorific value indirectly from the plants consumed by those animals). (3.52)

Biological resources include timber and aquatic resources and a range of other animal and plant resources (such as livestock, orchards, crops and wild animals), fungi and bacteria. (SEEA Central Framework, 5.24)

C

Capital transfers are unrequited transfers where either the party making the transfer realizes the funds involved by disposing of an asset (other than cash or inventories), relinquishing a financial claim (other than accounts receivable), or the party receiving the transfer is obliged to acquire an asset (other than cash) or both conditions are met. (SEEA Central Framework, 4.138)

Catastrophic losses are reductions in assets due to catastrophic and exceptional events. (5.28 (d), SEEA Central Framework, 5.49)

Changes in inventories are measured by the value of the entries into inventories less the value of withdrawals and less the value of any recurrent losses of goods held in inventories during the accounting period. (SEEA Central Framework, 5.67)

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)

Commercially recoverable resources are resources whose extraction is currently taking place 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 realistic assumptions regarding future market conditions. (6.10)

Compensation of employees is the total remuneration, in cash or in kind, payable by an enterprise to an employee in return for work done by the latter during the accounting period. (6.31, SEEA Central Framework, 5.118)

Consumption of fixed capital is the decline, during the course of the accounting period, in the current value of the stock of fixed assets owned and used by a producer as a result of physical deterioration, normal obsolescence or normal accidental damage. (6.35, SEEA Central Framework, 2.63, 4.198, 5.120)

Current transfers are transactions in which one institutional unit provides a good, service or asset to another unit without receiving from the latter any good, service or asset directly in return as counterpart and does not oblige one or both parties to acquire, or dispose of, an asset. (SEEA Central Framework, 4.138)

D

Decommissioning costs relate to expenditures incurred at the end of the operating life of an asset to restore the surrounding environment. They comprise Terminal costs and Remedial costs. (SEEA Central Framework, 4.194)

Degradation considers changes in the capacity of environmental assets to deliver a broad range of ecosystem services and the extent to which this capacity may be reduced through the action of economic units, including households. (SEEA Central Framework, 5.90)

Depletion, in physical terms, is 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. (5.29, SEEA Central Framework, 5.76)

Discount rate is a rate of interest used to adjust the value of a stream of future flows of revenue, costs or income to account for time preferences and attitudes to risk. (6.48, SEEA Central Framework, 5.145)

Discoveries are additions representing the arrival of new resources to a stock and commonly arise through exploration and evaluation. To be regarded as a discovery, the new deposit must be a known deposit. (5.28, SEEA Central Framework, 5.48)

E

Economic activity comprises the activities of production, consumption and accumulation. (SEEA Central Framework, 2.8)

Economic assets (see Asset).

Economic benefits reflect a gain or positive utility arising from economic production, consumption or accumulation. (SEEA Central Framework, 5.33)

Economic territory is the area under effective control of a single government. It includes the land area of a country, including islands, airspace, territorial waters and territorial enclaves in the rest of the world. Economic territory excludes territorial enclaves of other countries and international organizations located in the reference country. (2.8, SEEA Central Framework, 2.121)

Economic units (see Institutional units).

Emissions are substances released to the environment by establishments and households as a result of production, consumption and accumulation processes. (SEEA Central Framework, 3.88)

Emissions to air are gaseous and particulate substances released to the atmosphere by establishments and households as a result of production, consumption and accumulation processes. (SEEA Central Framework, 3.91)

Energy from natural inputs denotes physical flows from the environment to the economy that are derived principally from stocks of timber and mineral and energy resources. (3.30)

Energy losses include energy losses during extraction, distribution, storage and transformation. (3.58, SEEA Central Framework, 3.150, 3.101)

Energy products refer to products exclusively or mainly used as a source of energy which have a positive monetary value. Such products include energy suitable for direct use (e.g., electricity and heat) and energy products that release energy while undergoing some chemical or other process (including combustion). By convention, energy products also include peat, biomass and waste when and only when they are used for energy purposes. (2.100, 3.157)

Energy residuals are flows of energy from the economy to the environment and comprise energy losses as well as other energy residuals (primarily dissipative heat generated through end use of energy products for energy-related purposes, for example, fuel combustion and electricity-powered operation of an appliance). (3.58) (See also Residuals)

Environmental assets are the naturally occurring living and non-living components of the Earth, together constituting the biophysical environment, which may provide benefits to humanity. (5.1, SEEA Central Framework, 2.17)

Environmental goods and services sector consists of producers of all environmental goods and services, including environmental-specific services, environmental sole-purpose, adapted goods and environmental technologies. (SEEA Central Framework, 4.95–4.102)

Environmental protection activities are those activities whose primary purpose is the prevention, reduction and elimination of pollution and other forms of degradation of the environment. (SEEA Central Framework, 4.12)

Environmental taxes are taxes whose tax base is a physical unit (or a proxy of it) of something that has a proven, specific negative impact on the environment. (SEEA Central Framework, 4.150) (See also Taxes on energy products, and Taxes)

Establishment is an enterprise, or part of an enterprise, that is situated in a single location and in which only a single productive activity is carried out, or in which the principal productive activity accounts for most of the value added. (2.60, SEEA Central Framework, 2.114)

Exclusive economic zone of a country is the area extending up to 200 nautical miles from a country's normal baselines as defined in the United Nations Convention on the Law of the Sea of 10 December 1982. (SEEA Central Framework, 5.248)

Extractions are reductions in stock due to the physical removal or harvest of an environmental asset through a process of production. Estimates of extraction should exclude mining overburden and should include estimates of illegal extraction, either by residents or non-residents. (5.28; SEEA Central Framework, 5.49)

Extraction profile (See Future extraction profile).

F

Financial assets consist of all financial claims, shares or other equity in corporations plus gold bullion held by monetary authorities as a reserve asset. (SEEA Central Framework, 5.37)

Fixed assets are produced assets that are used repeatedly or continuously in production processes for more than one year. (SEEA Central Framework, 4.190, 5.34)

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. (6.41)

G

Gross domestic product (GDP) is an aggregate measure of gross value added for all resident institutional units. It can be measured in three conceptually equivalent ways:

(a) *Income measure of GDP*. The income measure of GDP is derived as compensation of employees plus gross operating surplus plus gross mixed incomes plus taxes less subsidies on both production and imports;

(b) *Expenditure measure of GDP*. The expenditure measure of GDP is derived as the sum of expenditure on final consumption plus gross capital formation plus exports less imports;

(c) *Production measure of GDP*. The production measure of GDP is derived as the value of output less intermediate consumption plus any taxes less subsidies on products not already included in the value of output. (SEEA Central Framework, 2.62, 6.30)

Gross capital formation shows the acquisition less disposal of produced assets for purposes of fixed capital formation, inventories or valuables. (SEEA Central Framework, 2.35)

Gross energy input reflects the total energy captured from the environment, energy products that are imported and energy from residuals within the economy. (7.11, SEEA Central Framework, 3.181)

Gross fixed capital formation is measured by the total value of a producer's acquisitions, less disposals, of fixed assets during the accounting period plus certain specified expenditure on services that adds to the value of non-produced assets. (6.61, SEEA Central Framework, 2.35)

Gross operating surplus is the surplus or deficit accruing from production before taking account of any interest, rent or similar flows payable or receivable and efore the deduction of consumption of fixed capital. (6.28, SEEA Central Framework, 2.65, table 5.5, 6.31)

Gross value added is the value of output less the value of intermediate consumption. (SEEA Central Framework, 2.36)

H

Household is a group of persons who share the same living accommodation, who pool some, or all, of their income and wealth and who consume certain types of goods and services collectively, mainly housing and food. (SEEA Central Framework, 2.111)

Household consumption of energy entails 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, for example, energy produced from fuelwood or animal waste gathered by households and electricity generated by windmills for own use by households. (3.141)

I

Industry consists of a group of establishments engaged in the same, or similar, kinds of activity. (SEEA Central Framework, 2.116)

Input-output identity requires that the total flows into the economy (for example, in the form of natural gas extracted from natural deposits) over an accounting period be used in production processes, consumed by final users, accumulated in the economy or returned to the environment. (2.39)

Inputs of energy from renewable sources are the non-fuel sources of energy provided by the environment. (3.39, SEEA Central Framework, 3.59)

Institutional sector is a grouping of similar institutional units. An institutional unit can be allocated to only one type of institutional sector. (SEEA Central Framework, 2.110)

Institutional unit 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. (2.8)

Intermediate consumption consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. (6.30, SEEA Central Framework, 2.32)

Inventories of energy products in SEEA-Energy encompass primary energy products that are being accumulated after extraction and before processing (e.g., coal, crude oil and natural gas) and secondary energy products, which are derived from further processing. (e.g., town gas, fuel oil, gasoline and diesel). (5.36)

K

Known deposits consist of commercially recoverable resources, potentially recoverable resources and non-commercial and other known deposits. (5.5)

L

Losses of energy during distribution or transmission are losses that occur between a point of abstraction, extraction or supply and a point of use. (3.114, SEEA Central Framework, 3.101)

Losses of energy 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 resource. (3.112; SEEA Central Framework, 3.101)

Losses of energy during storage are losses of energy products held in inventories, which may be caused by evaporation, leakages, wastage or accidental damage. (3.117; SEEA Central Framework, 3.101)

Losses of energy during transformation or conversion refer to the energy lost, for example, in the form of heat, during the transformation or conversion of one energy product into another energy product. (3.117; SEEA Central Framework, 3.101)

M

Main activity producers are enterprises that produce electricity or heat as their principal activity. (2.119)

Market prices are defined as amounts of money that willing buyers pay to acquire something from willing sellers. (4.6, SEEA Central Framework, 2.144)

Mineral and energy resources comprise known deposits of oil resources, natural gas resources, coal and peat resources, non-metallic minerals and metallic minerals. (2.46, SEEA Central Framework, 5.173)

N

Natural gas is a mixture of gaseous hydrocarbons (primarily methane but, generally, also ethane, propane and higher hydrocarbons in much smaller amounts) and some non-combustible gases such as nitrogen and carbon dioxide. (3.50)

Natural inputs are all physical inputs that are moved from their location in the environment as a part of economic production processes or are directly used in production. (SEEA Central Framework, 2.89, 3.45)

National resident unit is an institutional unit that is resident because it has a center of economic interest in the economic territory of a country (or a grouping like the European Union (EU) or the euro area) (3.21)

Natural resource inputs comprise physical inputs to the economy from natural resources. (SEEA Central Framework, 3.47)

Natural resource residuals are natural resource inputs that do not subsequently become incorporated into production processes and, instead, immediately return to the environment. (SEEA Central Framework, 3.98)

Natural resources include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources. (SEEA Central Framework, 2.101, 5.18)

Net domestic energy use is the end use of energy products less exports of energy products plus all losses of energy. (7.11, SEEA Central Framework, 3.182)

Net present value is the value of an asset determined by estimating the stream of income expected to be earned in the future and then discounting the future income back to the present accounting period. (1.41, SEEA Central Framework, 5.110)

Net worth is defined as the value of all the assets owned by an institutional unit or sector less the value of all its outstanding liabilities. (SEEA Central Framework, 2.69)

Non-commercial and other known deposits consist of resources for which the level of uncertainty regarding future extraction is even higher than that for potentially commercially recoverable resources. (6.10)

Non-financial corporations are corporations whose principal activity is the production of market goods or non-financial services. (SEEA Central Framework,2.111)

Non-market output consists of goods and individual or collective services produced by non-profit institutions serving households (NPISHs) or government that are supplied free, or at prices that are not economically significant, to other institutional units or the community as a whole. (SEEA Central Framework, 2.146)

Nuclear fuels include uranium, plutonium and derived products that can be used in nuclear reactors as a source of electricity and/or heat. (3.56)

O

Oil is made up of liquid hydrocarbons of fossil fuel origin comprising (a) crude oil, (b) liquids extracted from natural gas, (c) fully or partly processed products derived from the refining of crude oil, and (d) hydrocarbons and organic chemicals of vegetal or animal origin that are functionally similar to liquid hydrocarbons of fossil fuel origin. (3.51)

Oil shale/oil sands constitutes a sedimentary rock that contains organic matter in the form of kerogen. Kerogen is a waxy, hydrocarbon-rich material that is regarded as a precursor of petroleum. (3.49)

Other changes in the volume of assets are those changes in assets, liabilities and net worth during an accounting period that are due neither to transactions nor to holding gains and losses. (SEEA Central Framework, 5.65)

Output is defined as the goods and services produced by an establishment, excluding the value of any goods and services used in an activity for which the establishment does not assume the risk of using the products in production, and excluding the value of goods and services consumed by the same establishment except for goods and services used for capital formation (fixed capital or changes in inventories) or own final consumption. (6.29, SEEA Central Framework, 2.31)

Own-account activity consists of the production and use of goods and services within an establishment or household. (2.64, SEEA Central Framework, 2.117)

P

Peat and peat products are composed of a solid formed through 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)

Physical flows are reflected in the movement and use of materials, water and energy. (SEEA Central Framework, 2.88)

Potential commercially recoverable resources, which includes resources that may be extracted in the future. However, since the feasibility of extraction is subject to further evaluation, and extraction and sale have not yet been confirmed to be economic, there is a significantly high level of uncertainty regarding whether future extraction will occur. (6.10)

Primary energy products are obtained through the removal or capture of energy from natural inputs from the environment. Primary energy products include heat and electricity that are produced by harnessing energy from renewable sources within the environment (e.g.,, solar or hydropower). (2.17)

Principal activity of the producer unit is the activity whose value added exceeds that of any other activity carried out within the same unit. (2.75, SEEA Central Framework, 2.114)

Produced assets are assets that have come into existence as outputs of production processes that fall within the production boundary of the SNA. (SEEA Central Framework, 5.34)

Producers price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any VAT, or similar deductible tax, invoiced to the purchaser. It excludes any transport charges invoiced separately by the producer. (4.9, SEEA Central Framework, 2.153)

Products are goods and services (including knowledge-capturing products) that result from a process of production. (SEEA Central Framework, 2.9, 2.91, 3.64)

Production is an activity, carried out under the responsibility, control and management of an institutional unit, that uses inputs of labor, capital, and goods and services to produce outputs of goods and services. (SEEA Central Framework, 2.9)

Production boundary of the SNA includes the following activities: (a) the production of all goods or services that are supplied to units other than their producers, or intended to be so supplied, including the production of goods or services used up in the process of producing such goods or services; (b) the own-account production of all goods that are retained by their producers for their own final consumption or gross capital formation; (c) the own-account production of knowledge capturing products that are retained by their producers for their own final consumption or gross capital formation but excluding (by convention) such products produced by households for their own use; (d) the own-account production of housing services by owner occupiers; and (e) the production of domestic and personal services by employing paid domestic staff. (2.11, SEEA Central Framework, 2.9)

Purchasers' price is the amount paid by the purchaser, excluding any VAT or similar tax deductible by the purchaser, in order to take delivery of a unit of a good or service at the time and place required by the purchaser. The purchaser's price of a good includes any transport charges paid separately by the purchaser to take delivery at the required time and place. (4.9, SEEA Central Framework, 2.154)

R

Reappraisals reflect changes in the measured stock of assets due to the use of updated information that permits a reassessment of the size of the stock. Reappraisals only apply to known deposits. (5.28, SEEA Central Framework, 5.48, 5.49)

Reclassifications are changes in assets that result from situations in which an asset is used for a different purpose. A reclassification of an asset in one category should be offset by an equivalent reclassification in another category. (5,28, SEEA Central Framework, 5.48, 5.49)

Residence of an institutional unit is the economic territory with which it has the strongest connection, in other words, its center of predominant economic interest. (SEEA Central Framework, 2.122)

Residence principle assigns flows of energy to the country of residence of the producing or consuming unit. (3.11)

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. (SEEA Central Framework, 2.92, 3.73) (See also Energy residuals)

Resource management activities are those activities whose primary purpose is preserving and maintaining the stock of natural resources and hence safeguarding against depletion. (SEEA Central Framework, 4.13)

Resource rent is that part of an extractor's operating surplus that represents a return on a mineral and energy resource. In practice, the resource rent is calculated by subtracting all extraction costs from the total output of products, that is, 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. (6.37)

Rest of the world consists of all non-resident institutional units that enter into transactions with resident units, or have other economic links with resident units. (SEEA Central Framework, 2.121)

Return on environmental assets consist of the income attributable to the use of environmental assets in a production process after deducting all costs of extraction including any costs of depletion of natural resources. (SEEA Central Framework, 5.116, 5.117)

Return to produced assets: the income attributable to the use of produced assets in a production process after deducting any associated consumption of fixed capital. (SEEA Central Framework, 5.116, 5.141)

Revaluations relate to changes in the value of assets due to price changes and reflect nominal holding gains and losses on environmental assets. The nominal holding gain for environmental assets is calculated in the same way as for non-financial assets, as the increase in value accruing to the owner of the asset as a result of a change in its price over a period of time. (6.41, SEEA Central Framework, 5.60)

S

Secondary energy products are derived 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 oil and charcoal produced from fuelwood. (2.18)

Statistical difference is an item in energy balances, which, as calculated in the balances, can be positive or negative depending on whether the calculated supply is higher or lower, respectively, than the calculated use. (3.182)

Subsidies are current unrequited payments that government units, including non-resident government units, make to enterprises on the basis of the levels of their production activities or the quantities or values of the goods or services that they produce, sell or import. (4.13, SEEA Central Framework, 4.138)

T

Taxes are compulsory, unrequited payments, in cash or in kind, made by institutional units to government units. (4.12, SEEA Central Framework, 4.149)

Taxes on energy products is one of the four broad categories of environmental taxes and include taxes on energy products used for stationary processes (including fuel oils, natural gas, coal and electricity or transport). (4.68) (See also Environmental taxes, and Taxes)

Terminal costs are costs that can and should be anticipated during the production periods prior to closure of an operating asset. (SEEA Central Framework, 4.194)

Territory principle assigns flows of energy to the country in which the producing or consuming unit is located at the time of the flow. (2.9)

Timber resources are defined, within the relevant areas, by the volume of trees, living or dead, and include all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground that can still be used for timber or fuel. (SEEA Central Framework, 5.350)

Transaction: an economic flow that is an interaction between institutional units by mutual agreement or an action within an institutional unit that it is analytically useful to treat like a transaction, often because the unit is operating in two different capacities. (SEEA Central Framework, 2.96)

Transfer is a transaction in which one institutional unit provides a good, service or asset to another unit without receiving from the latter any good, service or asset in return as a direct counterpart. (SEEA Central Framework, 4.136)

Transformation of energy also termed as energy conversion, is the process of changing energy from one of its forms into another. (3.131)

U

Unit resource rent is the resource rent per unit of resource extracted. (6.40, SEEA Central Framework, 5.157)

User cost of produced assets is the sum of the consumption of fixed capital and the return to produced assets. (6.35, SEEA Central Framework, 5.141)

V

Value added (gross) is the value of output less the value of intermediate consumption. Net value added is gross value added less consumption of fixed capital. (SEEA Central Framework, 2.36)

W

Waste is made up of materials voluntarily discarded by their owner. In cases where the owner of the waste receives payment for passing on the waste to another party, the waste is considered a product. In cases where no payment is received by the discarding unit, the waste is considered a residual. (3.53)

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