



System of
Environmental
Economic
Accounting

Introduction to Physical Energy Flow Accounts

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United Nations

Contents

- Introduction
- Physical energy flow accounts (PEFA)
- Indicators/applications for climate change



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Introduction



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What are physical supply and use tables for energy?

- Compilation of all energy flows that enter, are used within and leave a country's economy
- Illustrates relationship between inputs to and outputs from energy transformation process
 - > Assess how an economy supplies and uses energy products
 - > Changes in production and consumption patterns over time

Physical energy flow accounts



- Global Assessment 2022: 59 countries compile PEFA, including 11 in Asia

Central Asia	1
Eastern Asia	2
South-eastern Asia	3
Southern Asia	2
Western Asia	3

Physical energy flow accounts in context

- Energy statistics and balances provide a wealth of information
- Some similarities between energy balances and accounts
- But accounts provide value added
 - > Coherence with SNA allows for economic analysis and expanded policy applications
 - > Can help improve data sources/quality
 - > Comprehensive (cover the entire economy)



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Physical energy flow accounts



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Scope of the economy in SEEA-Energy and PEFA

- In accordance with the System of National Accounts and SEEA-CF, the scope of SEEA-Energy covers the economic activity of resident units
- Resident of a country = institutional unit with centre of economic interest in the economic territory of a country
- Resident units can operate inside or outside of the national territory
- Use of residence principle is in contrast to energy statistics and balances

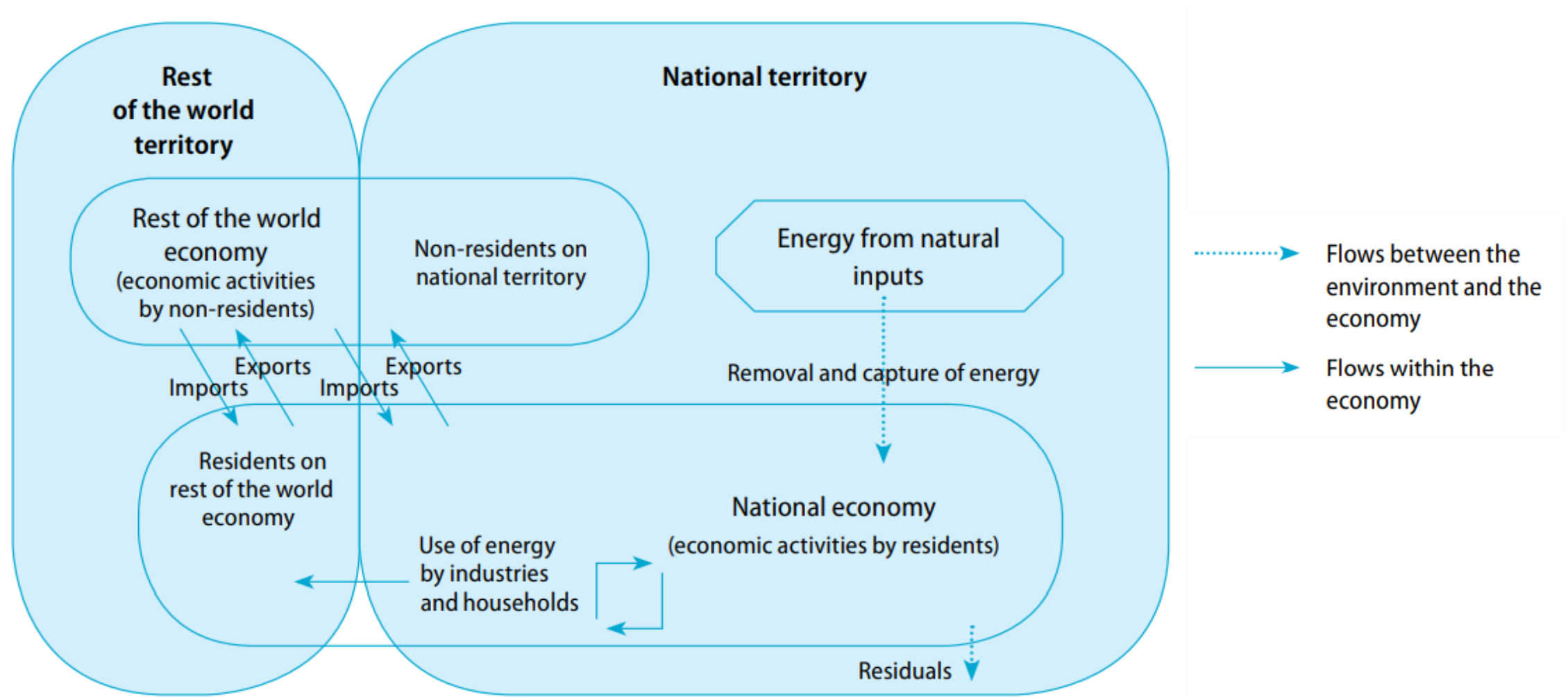
	Residents	Non-residents	
National territory	Sold on territory to resident units	Sold on territory to non-residents (foreign tourists, transport companies, embassies)	Energy statistics and balances
Rest of the world	Sold to residents operating abroad (tourists, transport companies, etc.)		
	SEEA-Energy		

Physical flows of energy

- In accordance with the SEEA-CF, energy presents itself in three different ways in SEEA-Energy
 - > Energy resources in the environment which can be extracted/captured
- Natural inputs
 - > Energy resources in the environment which can be extracted/captured
- Energy products
 - > Products exclusively or mainly used as a source of energy
 - > Include fuels produced/generated, electricity and heat
- Energy residuals
 - > Flows of energy that are discarded, discharged or emitted by establishments and households
- Energy flows completely outside of the economy are not in scope



Physical flows of energy



Energy as natural inputs

- Classification of energy from natural inputs provides classification by type of resource and is based on the purpose of 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

Energy as products

- Energy statistics usually classify products according to the Standard International Energy Product (SIEC) classification—can also be used for the SEEA
- But in national accounts, energy products are classified according to Central Product Classification (CPC)
- May need to utilize a cross-walk, though it should be noted that there is not always a 1:1 relationship between CPC and 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

Energy as residuals

- Energy losses as well as other energy residuals
- Energy residuals are grouped into five groups:
 - > Losses during extraction, e.g. flaring of natural gas during extraction
 - > Losses during distribution, e.g. oil tanker spill
 - > Losses during storage, e.g. petrol leaks from a tank
 - > Losses during transformation, e.g. heat losses when coal is used for production of electricity
 - > Other energy residuals, primarily dissipative heat generated through the end use of energy products, e.g. fuel combustion for vehicles or electricity for heating
- Other residual flows
 - > Residuals from end use for non-energy purposes, e.g. naptha for plastics

Physical supply and use tables

SUPPLY TABLE						
	Industries	Households	Accumulation	Rest of the World	Environment	Totals
Energy from natural inputs					Energy inputs from the environment	Total supply of energy from natural inputs
Energy products	Output			Imports		Total supply of energy products
Energy Residuals	Energy residuals generated by industry	Energy residuals generated by household consumption	Energy residuals from accumulation	Energy residuals received from the rest of the world	Energy residuals recovered from the environment	Total supply of energy residuals
USE TABLE						
	Industries	Households	Accumulation	Rest of the World	Environment	Totals
Energy from natural inputs	Extraction of energy from natural inputs					Total use of energy from natural inputs
Energy products	Intermediate consumption	Household consumption	Changes in inventories	Exports		Total use of energy products
Energy residuals	Collection & treatment of energy residuals		Accumulation of energy residuals	Energy residuals sent to the rest of the world	Energy residual flows direct to environment	Total use of energy residuals

Supply

PHYSICAL SUPPLY TABLE (unit:PJ)	Production (incl. household own account) & generation of residuals							Accumulation	Flows from the rest of the World (Imports)	Flows from the environment	TOTAL	
	Industries (by ISIC)						Households					
	Agriculture Forestry & Fishery	Mining & Quarrying	Manufacturing	Electricity, gas, steam & air conditioning supply	Transportation & Storage	Other Industries						Total Industry
	(ISIC A)	(ISIC B)	(ISIC C)	(ISIC D)	(ISIC H)							
1. Energy from natural inputs:												
Natural resource inputs										1166	1166	
Inputs of energy from renewable sources										124	124	
Other natural inputs										2	2	
2. Energy Products:												
<i>Production of energy products by SIEC class:</i>												
Coal										225	225	
Peat and peat products												
Oil shale / oil sands												
Natural gas		395		369			764				764	
Oil		721	347				1068		930		1998	
Biofuels	5			2			7				7	
Waste	39		55				94		17		111	
Electricity				212			212		22		234	
Heat				79			79				79	
Nuclear fuels and other fuels												
3. Energy Residuals:												
Total energy residuals	50	48	432	307	632	96	1565	240			1805	
4. Other Residual Flows:												
Residuals from end-use for non-energy purposes			51								51	
Energy from solid waste								94			94	
5. TOTAL SUPPLY												
	94	1164	885	969	632	96	3840	240	94	1194	1292	6660



Use

PHYSICAL USE TABLE (unit: PJ)	Intermediate consumption, use of energy resources, receipt of energy losses						Final Consumption Households	Accumulation	Flows to the rest of the World (Exports)	Flows to the environment	TOTAL
	Industries (by ISIC)										
	Agriculture Forestry & Fishery	Mining & Quarrying	Manufacturing	Electricity, gas, steam & air conditioning supply	Transportation & Storage	Other Industries					
(ISIC A)	(ISIC B)	(ISIC C)	(ISIC D)	(ISIC E)	(ISIC F)	(ISIC G)					
1. Energy from natural inputs:											
Natural resource inputs	5	1161									1166
Inputs of energy from renewable sources				124							124
Other natural inputs				2							2
2. Energy Products:											
<i>Transformation of energy products by SIEC class:</i>											
Coal				223			223				223
Peat and peat products											
Oil shale / oil sands											
Natural gas				482			482				482
Oil			360	16			376				376
Biofuels											
Waste				31			31				31
Electricity											
Heat											
Nuclear fuels and other fuels											
<i>End-use of energy products by SIEC class:</i>											
Coal	2		17				19	1	-21	2	1
Peat and peat products											
Oil shale / oil sands											
Natural gas	2		39			12	53	26	2	201	282
Oil	34	2	326			621	1032	102	-3	441	1572
Biofuels				2			2	5			7
Waste	3		4	37		1	45	33		1	79
Electricity	7	1	22	50	10	15	105	29		100	234
Heat	2		11	2	1	19	35	44			79
Nuclear fuels and other fuels											
End-use of energy products for non-energy purposes			51				51				51
3. Energy Residuals:											
Total energy residuals											1805
4. Other residual flows:											
Residuals from end-use or non-energy purposes								51			51
Energy from solid waste	39		55								94
5. TOTAL USE	94	1164	885	969	632	96	3840	240	29	745	1805

Accounting rules and principles

- Supply and use identity
 - > Total supply of each product = output + imports
is equal to
Total use of each product = Intermediate consumption + final consumption
+ changes in inventories + exports
- Input-output identity
 - > Identity regarding flows between environment and economy
 - > Total inputs into the economy: product inputs + resource inputs + imports
is equal to
Total outputs from the economy = production outputs + residuals + net additions to stock
+ exports

Compilation of supply and use tables

- Identify source data, usually from various places (basic energy statistics, energy balances, national accounts data, traffic and transport data, etc)
- Put the data into the accounting format
- Allocate supply and use to ISIC
- Make corrections for residence principle
- Ensure accounting identities are met
- Quality assurance

Compilation of supply and use tables - demo

- Extraction of crude oil by mining industry (1500 PJ) // Loss of 100 PJ during extraction
- Supply of crude oil to refinery (1400 PJ)
- Refining of crude oil to diesel (1200 PJ, 200 lost during transformation)
- Use of diesel by transport industry (600 PJ) and households (600 PJ)
- Based on Statistics Netherlands example

Extraction of oil resources

- Extraction of crude oil by mining industry (1500 PJ)
- Environment supplies crude; crude is used/extracted by ISIC B

Supply		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources							1500	1500
Energy products	Crude								
	Petrol								
Residuals	Losses during extraction								
	Losses during transformation								
	Other energy residuals								
Total								1500	1500

Use		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources	1500							1500
Energy products	Crude								
	Petrol								
Residuals	Losses during extraction								
	Losses during transformation								
	Other energy residuals								
Total		1500							1500

From natural input to product

- 100 PJ of crude is lost during extraction, and only 1400 PJ of crude is supplied to the refinery

Supply		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources							1500	1500
Energy products	Crude	1400							1400
	Petrol								
Residuals	Losses during extraction	100							100
	Losses during transformation								
	Other energy residuals								
Total		1500						1500	3000

Use		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources	1500							1500
Energy products	Crude		1400						1400
	Petrol								
Residuals	Losses during extraction							100	100
	Losses during transformation								
	Other energy residuals								
Total		1500	1400					100	3000

Supply and use of energy products

- Refinery refines all crude (1400PJ) into diesel, but 200 is lost during transformation
- Use of diesel by transport industry (600 PJ) and households (600 PJ)

Supply		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources							1500	1500
Energy products	Crude	1400							1400
	Petrol		1200						1200
Residuals	Losses during extraction	100							100
	Losses during transformation		200						200
	Other energy residuals								
Total		1500	1400					1500	4400

Use		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources	1500							1500
Energy products	Crude		1400						1400
	Petrol			600	600				
Residuals	Losses during extraction							100	100
	Losses during transformation							200	200
	Other energy residuals								
Total		1500	1400	600	600			300	3200

Balancing

- Dissipative heat following combustion of petrol by ISIC H and Households is recorded as “other energy residuals”

Supply		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources							1500	1500
Energy products	Crude	1400							1400
	Petrol		1200						1200
Residuals	Losses during extraction	100							100
	Losses during transformation		200						200
	Other energy residuals			600	600				
Total		1500	1400	600	600			1500	4400

Use		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources	1500							1500
Energy products	Crude		1400						1400
	Petrol			600	600				
Residuals	Losses during extraction							100	100
	Losses during transformation							200	200
	Other energy residuals							1200	1200
Total		1500	1400	600	600			1500	4400

Supply = use

- Supply now equals use for final total and row/column totals
- Note that we double record the energy content

Supply		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources							1500	1500
Energy products	Crude	1400							1400
	Petrol		1200						1200
Residuals	Losses during extraction	100							100
	Losses during transformation		200						200
	Other energy residuals			600	600				
Total		1500	1400	600	600			1500	4400

Use		ISIC B Mining	ISIC C Manufacturing	ISIC H Transportation	Households	Accumulation	Imports	Flows from Environment	Total
Natural inputs	Oil resources	1500							1500
Energy products	Crude		1400						1400
	Petrol			600	600				
Residuals	Losses during extraction							100	100
	Losses during transformation							200	200
	Other energy residuals							1200	1200
Total		1500	1400	600	600			1500	4400

Indicators and applications



7 AFFORDABLE AND CLEAN ENERGY
ENSURE ACCESS TO AFFORDABLE, RELIABLE, SUSTAINABLE AND MODERN ENERGY FOR ALL

- Indicators
 - > SDG target 7.3: By 2030, double the global rate of improvement in energy efficiency
 - Indicator 7.3.1: Energy intensity → energy use / value added
 - > Net domestic energy use: End use of energy products (including changes in inventories) less exports of energy products plus all losses of energy
 - > Gross energy input: Energy from natural inputs plus imports of energy products plus energy from waste
- Decoupling GDP from energy use
 - > Growth rate of an environmental pressure is less than that of its economic driving force
 - > i.e. growth in energy use is less than that of GDP
- Input-Output modelling
- Calculation of air emission accounts

Climate change related indicators

- Total energy use by the national economy
- Share of fossil fuels in total energy use by the national economy
- Total energy intensity of production activities by the national economy
- Energy use by resident households per capita
- Renewable energy share in total energy use by the national economy

Questions?