Energy Balances for the estimation of GHG emissions

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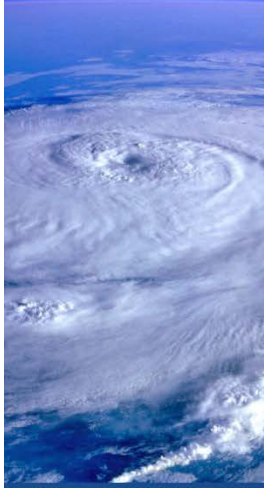
“ECRAN Modeling Workshop“

Outline

- The concept of energy balance
- Energy flows
- The principles of energy balance
- The estimation of GHG emissions based on energy balances
- Sources of information
  - International Recommendations for Energy Statistics by United Nations Statistics Division
  - Statistical Manual of the International Energy Agency
  - Energy Statistics Methodology by Eurostat

Concept of energy balance



Energy balance

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An energy balance is an accounting framework for compilation and reconciliation of data on all energy products entering, exiting and used within the national territory of a given country during a reference period.

The basis for an energy balance is energy commodity balances - balances compiled for individual energy commodities

The energy balance is based on the 1st law of thermodynamics

- "The amount of energy within any closed system is fixed"

United Nations Statistics Division. 2011. International Recommendations for Energy Statistics (IRES)

National vs international energy balances

- IPCC recommends using national energy balances for the estimation of GHG emissions

- When national sources are not available, IPCC suggests using data from international organizations

- National and international energy balances rely on different methodologies and the balance presentation

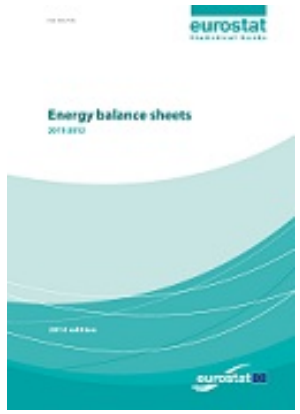
Energy balances

- The main sources of international energy statistics

- Prepared by United Nations Statistical Division – until 2011
  - Albania, Montenegro – available, Kosovo – not available
  - URL: http://unstats.un.org/unsd/energy/balance/default.htm

- Prepared by International Energy Agency – until 2012
  - All countries
  - URL: http://www.iea.org/statistics/statisticssearch/

- Prepared by EUROSTAT – until 2013
  - Albania, Montenegro – available, Kosovo – not available
  - URL: http://ec.europa.eu/eurostat/web/energy/data/energy-balances



- All sources collect data from the national administrations of the member countries through questionnaires

The scope of an energy balance

- The scope of an energy balance is determined by:

The scope of an energy balance

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The scope of an energy balance is determined by:

- Territory boundary

Albania: Balances for 2012

in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis

2012 | Indicators | Balances | Coal | Electricity and Heat | Natural Gas | Oil | Renewables and Waste

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	1	1031	0	13	0	406	12	206	0	0	1670
Imports	161	0	984	0	0	0	0	0	218	0	1364
Exports	0	-957	-18	0	0	0	0	0	0	0	-975
International marine bunkers***	0	0	0	0	0	0	0	0	0	0	0
International aviation bunkers***	0	0	-21	0	0	0	0	0	0	0	-21
Stock changes	0	37	0	0	0	0	0	0	0	0	37

The scope of an energy balance

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The scope of an energy balance is determined by:

- Territory boundary
- Time boundary

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- Time boundary
- Product boundary

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Stock changes	0	37	0	0	0	0	0	0	0	0	37

The scope of an energy balance

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The scope of an energy balance is determined by:

- Territory boundary
- Time boundary
- Product boundary
- Flow boundary

Albania: Balances for 2012

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International marine bunkers***	0	0	0	0	0	0	0	0	0	0	0
International aviation bunkers***	0	0	-21	0	0	0	0	0	0	0	-21
Stock changes	0	37	0	0	0	0	0	0	0	0	37

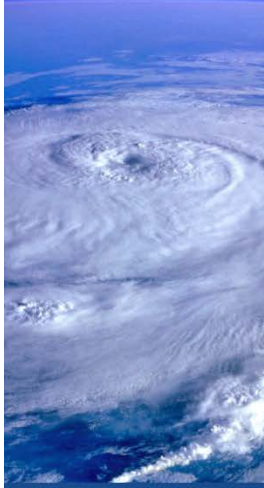
The scope of an energy balance

Usually, energy balances do not include:

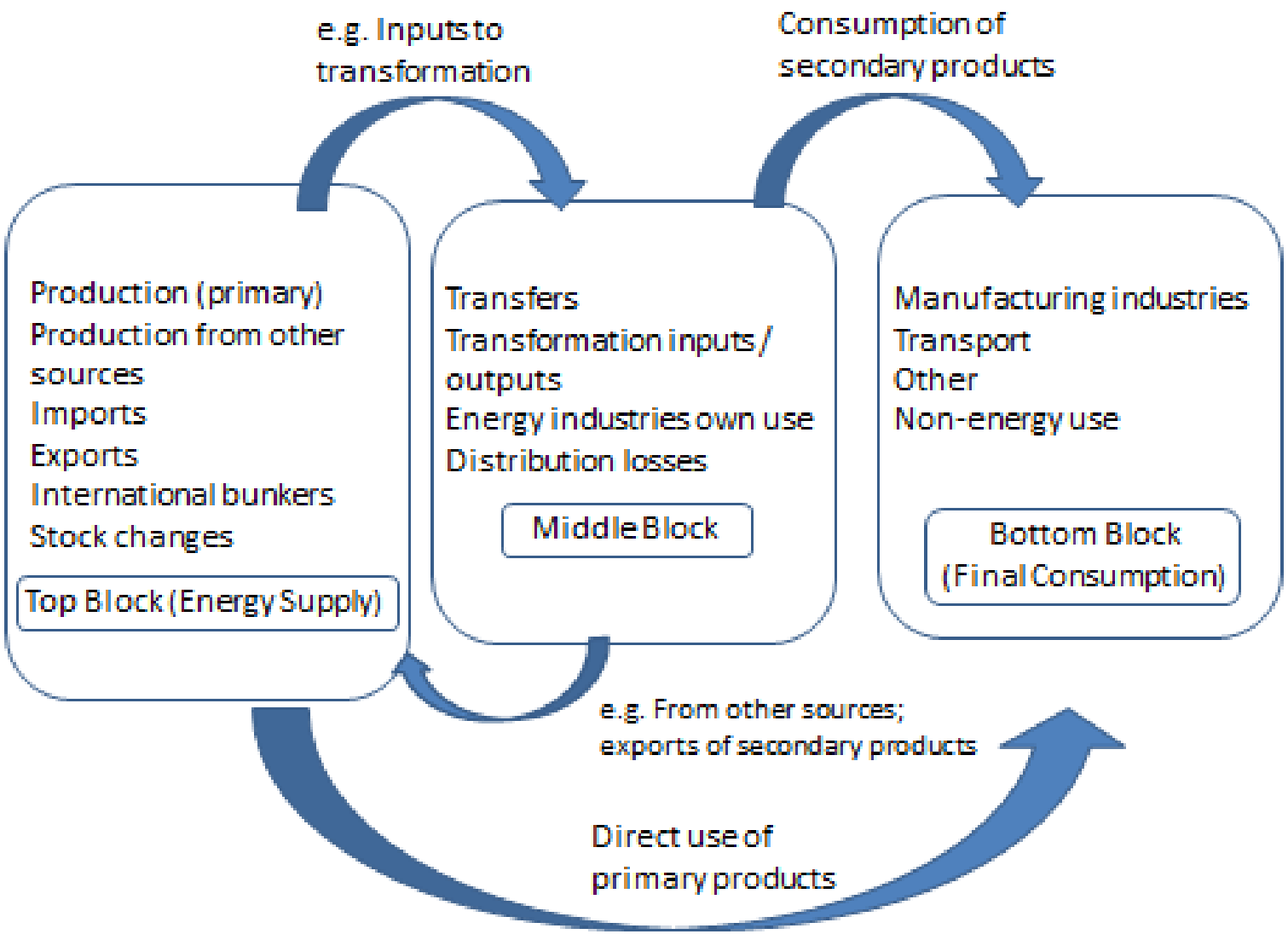
- Passive energy such as the heat gain of buildings and solar energy falling on the land to grow crops, etc.
- Deposits of energy resources and reserves
- Extraction of any materials not covered in primary energy production
- Waste and biomass used for non-energy purposes

United Nations Statistics Division. 2011. International Recommendations for Energy Statistics (IRES)

Energy flows



Flows in the energy balances



Oslo Group on Energy Statistics. UN Manuals on Energy Accounts and Balances. Chapter 5.

Top block: Energy supply

Total primary energy supply	
+	*Primary production*
+	*Imports*
-	*Exports*
+/-	*Stock changes*
-	*International marine bunkers*
-	*International aviation bunkers*

The middle block: Transformation

Net energy supply available for final consumption		
-/+	***Transfers***	
-/+	***Transformation input/output***	
	+/-	Electricity plans
	+/-	CHP Plants
	+/-	Heat plants
	+/-	Gas works
	+/-	Oil refineries
	+/-	Coal transformation
	+/-	Liquefication plants
		Other transformation
-	***Energy sector own use***	
-	***Transmission and distribution losses***	

Bottom block: Final energy consumption

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Final energy use

- + ***Final energy consumption***
  - + Industry
    - + Iron & steel industry
    - + Chemical and Petrochemical industry
    - + Non-ferrous metal industry
    - + Non-metallic Minerals (Glass, pottery & building mat. Industry)
    - + Transport Equipment
    - + Machinery
    - + Mining and Quarrying
    - + Food and Tabasco
    - + Paper, Pulp and Print
    - + Wood and Wood Products
    - + Construction
    - + Textile and Leather
    - + Non-specified (Industry)
  - + Transport
    - + Rail
    - + Road
    - + International aviation
    - + Domestic aviation
    - + Domestic Navigation
    - + Pipeline transport
    - + Non-specified (Transport)
  - + Other Sectors
    - + Services
    - + Residential
    - + Agriculture / Forestry
    - + Fishing
    - + Non-specified (Other)
- + ***Non-energy use consumption***
  - + Non-Energy Use in Transformation sector
  - + Non-Energy Use in Energy sector
  - + Non-Energy Use in Industry sector
  - + Non-Energy Use in Transport sector
  - + Non-Energy Use in Other sectors
  - + Non-Energy Use in Industry, Transformation and Energy Sectors

Statistical difference

Albania: Balances for 2012

in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis

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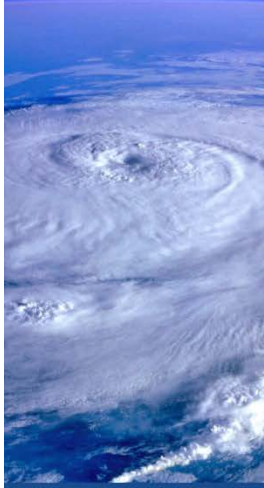
	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	1	1031	0	13	0	406	12	206	0	0	1670
Imports	161	0	984	0	0	0	0	0	218	0	1364
Exports	0	-957	-18	0	0	0	0	0	0	0	-975
International marine bunkers***	0	0	0	0	0	0	0	0	0	0	0
International aviation bunkers***	0	0	-21	0	0	0	0	0	0	0	-21
Stock changes	0	37	0	0	0	0	0	0	0	0	37
TPES	**162**	**111**	**945**	**13**	**0**	**406**	**12**	**206**	**218**	**0**	**2075**
Transfers	0	0	0	0	0	0	0	0	0	0	0
Statistical differences	0	0	-1	0	0	0	0	0	24	0	23
Electricity plants	0	0	0	0	0	-406	0	0	406	0	0

Principles of energy balances



Energy unit

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All entries into the energy balance are expressed in one energy unit

Examples

- USA uses Mbtu
- IEA uses Mtoe
- UNSD uses terajoules
- EUROSTAT uses ktoe
- Russia and China use Mtce
- Albania uses ktoe
- Kosovo uses ktoe
- Montenegro uses terajoule

Commercial units of the same fuel (e.g. tons of coal) could be converted into energy units using different conversion factors because caloric values of fuels may vary from country to country and sometimes by flow

- -> This could be a reason in difference in the same flow of the same country reported by different sources.

Net calorific values (NCVs) or gross caloric values (GCVs)

- Countries use either net calorific values (NCVs) or gross caloric values (GCVs) for measuring the energy content of energy products.

- The difference between NCV and GCV is the latent heat of vaporisation of the water produced during combustion

- Using different basis to calculate caloric values of fuels could be another reason for differences in energy balances reported for the same countries by different sources

- The corresponding conversion factors should be usually reported and countries should clearly identify which method is used for calculating its energy balance

Calculation of primary energy equivalent for electricity

Partial substitution method

- Represents the amount of energy necessary in conventional thermal plants
- Difficult to choose efficiency
- Not relevant for countries with a high share of hydro

Physical energy content method

- Most commonly used
- Uses physical energy content of the primary energy source

Karen Tréanton (IEA). From Basic Energy Statistics to Energy Balances. Presentation in 2012

Physical energy content vs. partial substitution

Energy Balance of Russia : 2009

Using physical energy content method

Renewables = 3.4%

Thousand tonnes of oil equivalent

SUPPLY AND CONSUMPTION	Coal & peat	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geotherm. solar etc.	Biofuels & waste	Electricity	Heat	Total
Production	153640	493641	-	469561	42959	14980		6410	-	-	181589
Imports	14530	1793	808	6675	-	-		-	264	-	24071
Exports	-68671	-250141	-101195	-131210	-	-		-	-1541	-	-552699
Intl. marine bunkers	-	-	-	-	-	-		-	-	-	-
Intl. aviation bunkers	-	-	-5858	-	-	-		-	-	-	-5858
Stock changes	-4228	-1635	451	5268	-	-		-43	-	-	-187
TPES	95271	243658	-106734	350295	42959	14980	399	0.34	-1278	-	648915
Electricity and Heat Output											
Elec. generated - GWh	184112	17	18004	489034	183584	174183	488	2643	-	-	990046
Heat generated - TJ	1088585	27298	302519	3806801	13730	-	298725	118008	-	-	5663844

Nuclear Hydro Geo-thermal Solar

Using partial substitution method

Renewables = 6.8%

Thousand tonnes of oil equivalent

SUPPLY AND CONSUMPTION	Coal & peat	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geotherm. solar etc.	Biofuels & waste	Electricity	Heat	Total
Production	153640	493641	-	469561	36869	38908	105	6410	-	-	199134
Imports	14530	1793	808	6675	-	-	-	-	264	-	24071
Exports	-68671	-250141	-101195	-131210	-	-	-	-	-1541	-	-552699
Intl. marine bunkers	-	-	-	-	-	-	-	-	-	-	-
Intl. aviation bunkers	-	-	-5858	-	-	-	-	-	-	-	-5858
Stock changes	-4228	-1635	451	5268	-	-	-	-43	-	-	-187
TPES	95271	243658	-106734	350295	36869	38908	104	6367	-1278	-	664461
Electricity and Heat Output											
Elec. generated - GWh	184112	17	18004	489034					-	-	990046
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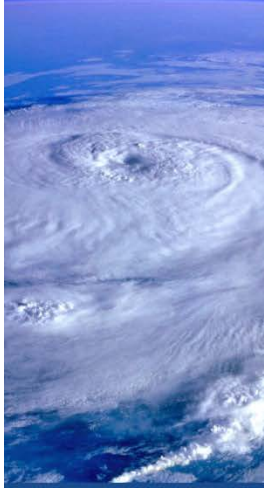
Nuclear Hydro Geo-thermal Solar

TPER 36869 38908 104 0.89

Karen Tréanton (IEA). From Basic Energy Statistics to Energy Balances. Presentation in 2012

Estimating GHG emissions using energy balances



Methodology for the estimation of GHG emissions

The methodological guidance on the estimation of national GHG emissions as a part of the preparation of national inventories is provided by the Intergovernmental Panel on Climate Change (IPCC)

The current basis for official national reporting of GHG inventories under the UNFCCC and the Kyoto Protocol includes

- Revised 1996 IPCC Guidelines for National GHG Inventories + Good Practice Guidance
- Uncertainty Management National GHG Inventories (2000)
- Good Practice Guidance for Land Use, Land- Use Change and Forestry (2003)

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories were prepared and their adoption for reporting under UNFCCC is currently under discussion

Estimation of GHGs emissions, IPCC sectoral approaches

Tier-1 methods

- Quantities of fuel combusted X emission factors
- Fuel combusted is usually taken from national energy statistics
- Emission factors are default

Tier-2 methods

- Quantities of fuel combusted X emission factors
- Fuel combusted is usually taken from national energy statistics (more detailed)
- Emission factors are country-specific
- More details than Tier -1

Tier-3

- Detailed country-specific emission models and inventory data are used
- Tier-3 is more detailed than Tier-2

Example: Sectoral approach

Stock changes	-15	0	0	0	0	0	0	0	0	0	-15
TPES	**1533**	**0**	**567**	**0**	**0**	**8**	**1**	**247**	**13**	**0**	**2369**
Transfers	0	0	0	0	0	0	0	0	0	0	0
Statistical differences	0	0	0	0	0	0	0	0	0	0	0
Electricity plants	-1462	0	-4	0	0	-8	0	0	511	0	-963
CHP plants	0	0	0	0	0	0	0	0	0	0	0
Heat plants	0	0	-6	0	0	0	0	0	0	5	-1
Gas works	0	0	0	0	0	0	0	0	0	0	0
Oil refineries	0	0	0	0	0	0	0	0	0	0	0
Coal transformation	0	0	0	0	0	0	0	0	0	0	0
Liquefication plants	0	0	0	0	0	0	0	0	0	0	0
Other transformation	0	0	0	0	0	0	0	0	0	0	0
Energy industry own use	0	0	-5	0	0	0	0	0	-60	0	-65
Losses	0	0	0	0	0	0	0	0	-80	-1	-81
Total final consumption	**70**	**0**	**552**	**0**	**0**	**0**	**1**	**247**	**385**	**3**	**1258**
Industry	**51**	**0**	**105**	**0**	**0**	**0**	**0**	**11**	**108**	**0**	**275**
Transport	**0**	**0**	**331**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**331**
Other	**19**	**0**	**77**	**0**	**0**	**0**	**1**	**236**	**277**	**3**	**612**
Residential	16	0	18	0	0	0	0	227	210	2	474
Commercial and public services	3	0	47	0	0	0	0	7	60	1	118
Agriculture / forestry	0	0	11	0	0	0	0	2	7	0	20
Fishing	0	0	0	0	0	0	0	0	0	0	0
Non-specified	0	0	0	0	0	0	0	0	0	0	0
Non-energy use	**0**	**0**	**40**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**41**
-of which chemical/petrochemical	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*

Estimation of emissions, IPCC reference (top-down) approach

The Reference approach requires statistics on the production of fuels, on their external trade, as well as on changes in their stocks. It also requires some data on the consumption of fuels used for non-energy purposes.

Example: Reference approach

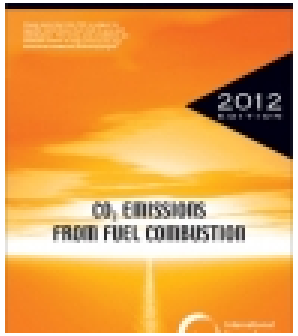
Kosovo: Balances for 2012

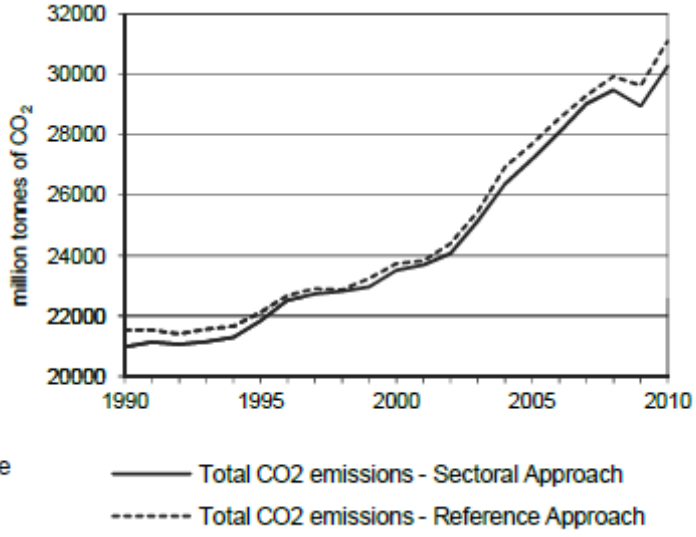
in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis

2012 | Indicators | Balances | Coal | Electricity and Heat | Natural Gas | Oil | Renewables and Waste

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	1496	0	0	0	0	8	1	244	0	0	1749
Imports	51	0	582	0	0	0	0	4	238	0	875
Exports	0	0	-1	0	0	0	0	-1	-225	0	-227
International marine bunkers***	0	0	0	0	0	0	0	0	0	0	0
International aviation bunkers***	0	0	-14	0	0	0	0	0	0	0	-14
Stock changes	-15	0	0	0	0	0	0	0	0	0	-15

Reference vs sectoral: the world, 2010





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2010 CO_2 emissions by sec

million tonnes of CO_2	Coal/peat	Oil	Natural gas	Other *	Total	% change 90-10
Sectoral Approach **	**13 065.9**	**10 890.5**	**6 179.1**	**140.6**	**30 276.1**	**44.4%**
Main activity producer elec. and heat	8 449.2	702.2	2 169.2	40.9	11 361.4	71.5%
Unallocated autoproducers			1.3	61.5	1 119.1	26.3%
Other energy industry own use			8.2	0.9	1 570.8	55.4%
Manufacturing industries and construction			0.0	32.5	6 186.4	36.6%
Transport **			2.1	-	6 755.8	47.0%
of which: road			*0.6*	-	*4 972.1*	51.1%
Other			8.3	4.9	3 282.6	-1.3%
of which: residential	*301.0*	*595.3*	*984.1*	*0.0*	*1 880.4*	3.2%
Reference Approach **	**13 700.9**	**11 007.0**	**6 253.8**	**140.6**	**31 102.3**	**44.4%**
Diff. due to losses and/or transformation	308.2	99.0	81.3	0.0	488.6	
Statistical differences	326.8	17.4	- 6.6	- 0.0	337.6	
Memo: international marine bunkers	-	*643.7*	-	-	*643.7*	*77.6%*
Memo: international aviation bunkers	-	*455.3*	-	-	*455.3*	*78.3%*

Residential only includes emissions from fuels actually combusted in households (hence its relatively small share), not electricity or heat consumption

* Other includes industrial waste and non-renewable municipal waste.
** World includes international marine bunkers and international aviation bunkers.

IPCC methodology: sectoral approaches

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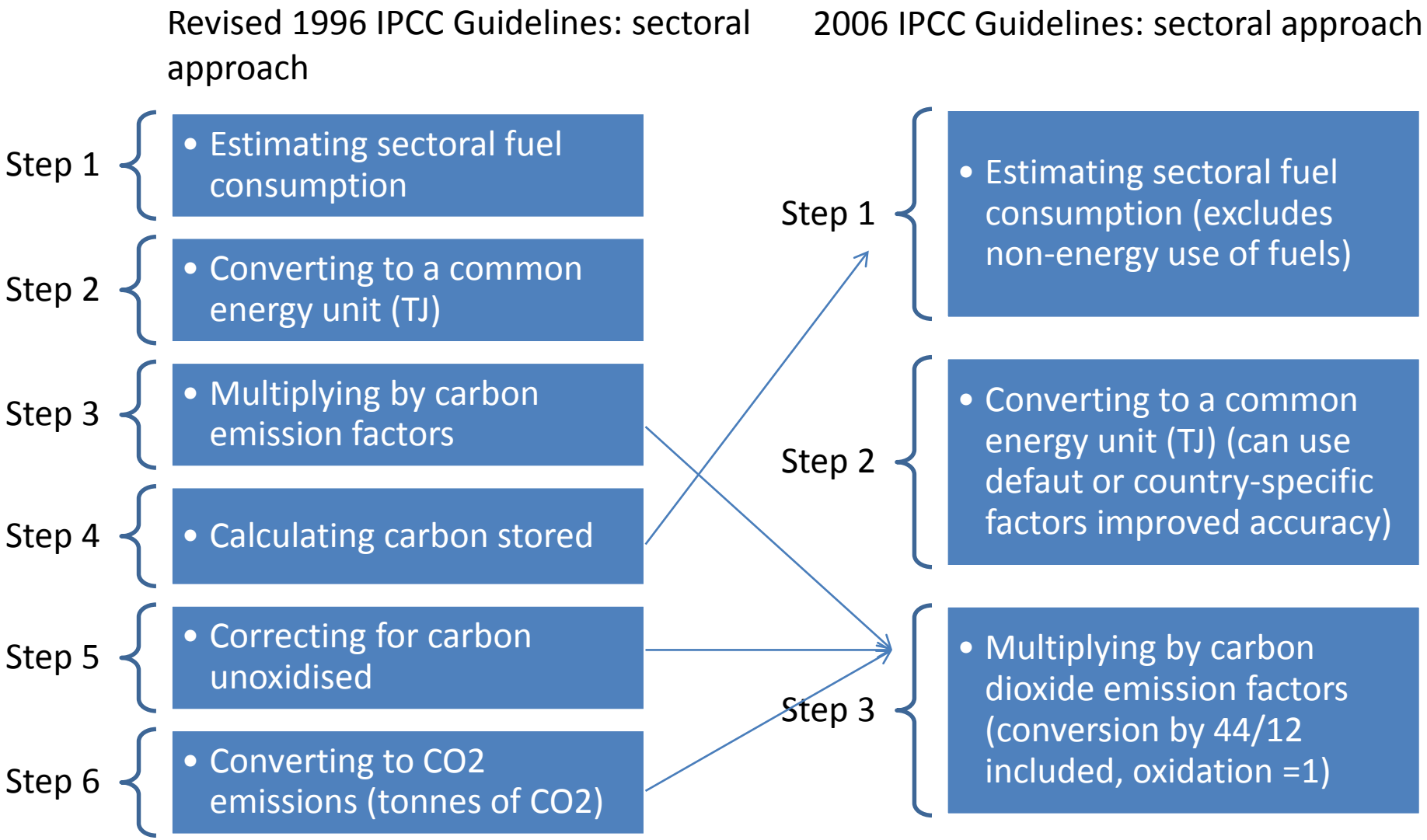
Revised 1996 IPCC Guidelines: sectoral approach

Step 1	• Estimating sectoral fuel consumption	Country-specific NCVs for natural gas and coal are given explicitly in the Revised 1996 IPCC Guidelines
Step 2	• Converting to a common energy unit (TJ)	Emission factors are provided in the Revised 1996 IPCC Guidelines
Step 3	• Multiplying by carbon emission factors	Default factors are provided in the IPCC Guidelines
Step 4	• Calculating carbon stored	Default values: fraction of carbon oxidised
Step 5	• Correcting for carbon unoxidised	Multiply by 44/12 (the molecular weight ratio of CO2 to C)
Step 6	• Converting to CO2 emissions (tonnes of CO2)	

Karen Tréanton (IEA). The Use of Energy Statistics to Estimate CO2 emissions. Presentation in 2012

IPCC methodology: sectoral approaches



Karen Tréanton (IEA). The Use of Energy Statistics to Estimate CO2 emissions. Presentation in 2012

Differences in the presentation of IEA and EUROSTAT balances

Transformation Sector

- Eurostat balances show the transformation input separately from the transformation output. IEA balances show the inputs as negative numbers and the outputs as positive numbers on the same line.

Transfers of nuclear, hydro and wind to the electricity column

- Eurostat balances transfer the nuclear in the transformation input and transformation output sectors. For hydro and wind, the “interproduct transfers” row is used. The IEA balances treat nuclear, hydro and wind in the same way as other transformation processes, i.e. the inputs as negative numbers and the outputs as positive numbers.

Definition of Supply

- Eurostat balances subtract international marine bunkers out of supply, but international aviation bunkers are included with domestic air transport in final consumption. The IEA balances have just been changed as a result of the work done by InterEnerStat so that both the international marine and the international aviation bunkers are treated in the same way and both are now subtracted out of supply.

Karen Treanton (IEA). Energy balances and uniform IEA/EUROSTAT/UNECE methodology. Basis, interpretation, use

Differences in the IEA and UNFCCC GHG emission data

There can be many reasons for differences between the two datasets, including:

- The IEA uses a Tier 1 Method
- The IEA still uses the 1996 Guidelines
- Underlying energy data can be different (multiple official sources)
- The IEA uses average NCVs
- The IEA uses average CEFs
- The IEA has no detailed information on carbon stored
- Autoproducers are unallocated in the IEA data
- Military emissions can be treated differently
- IEA data include emissions from coke inputs to blast furnaces
- Units can be different

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