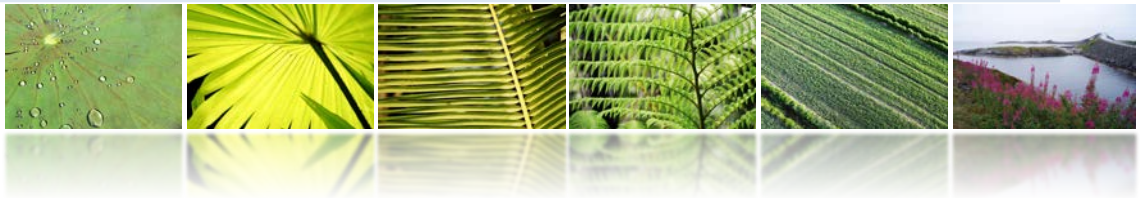
United Nations
Statistics Division

Energy balances 2

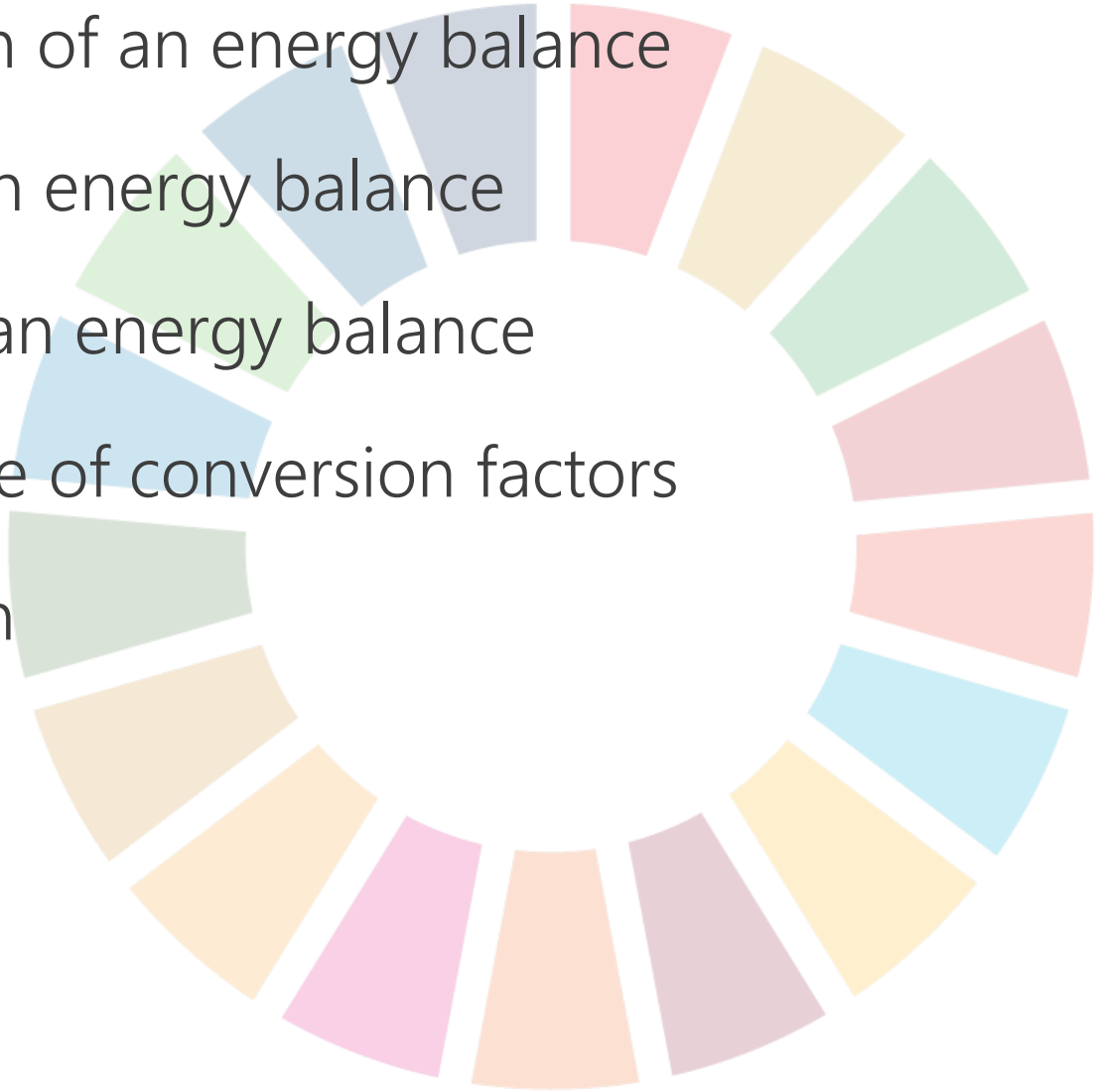


Agnieszka KOSCIELNIAK
Statistician, Energy Statistics Section

Cape Town, South Africa, 1 May 2019
JODI Energy Data Transparency Workshop

Overview

- Calculation of an energy balance
- Reading an energy balance
- Checking an energy balance
- Importance of conversion factors
- Conclusion



Framework

An Energy Balance is an accounting framework that presents :

- country's energy supply and demand;
- all energy products entering, exiting and used within a national territory;
- energy transformation processes (inputs and outputs)

  in one energy unit

  using net calorific values to measure the energy content of energy products.

Structure and principles

Matrix structure

An energy balance is a matrix consisting of rows and columns:

- Rows represent energy flows (i.e. sources and uses);
- Columns represent energy products (or commodities).

Country Z - 2015 - TJ						
	Coal	Oil	Primary biofuels /Waste	Char coal	Electri city	Total energy
Primary production	477	..	416701	..	12611	429789
Imports	22860	49677	..	..	6329	78866
Exports	..	..	..	..	-11	-11
International bunkers	..	-4101	..	..	..	-4101
Stock changes	..	..	..	..	..	..
Total energy supply	**23337**	**45576**	**416701**	**..**	**18929**	**504543**
Statistical Difference	0	0	0	0	29	29
Transfers	..	..	..	..	..	..
Transformation	..	..	-937	325	..	-613
Charcoal plants	..	..	-937	325	..	-613
Energy ind. own use	..	..	..	..	-140	-140
Losses	..	..	..	..	-4734	-4734
Final consumption	**23337**	**45576**	***415764**	**325**	**14026**	***499027**
Final energy cons.	23337	45174	*415764	325	14026	*498625
Manufacturing, const.	23237	431	*20166	89	4356	48278
Transport	..	29240	..	..	22	29262
Agriculture, forestry, fishing	..	4902	..	..	364	5266
Commerce, services	..	4534	2235	236	1822	8826
Households	100	6067	*393363	..	7081	*406611
Other consumers	..	..	..	..	382	382
Non-energy use	..	402	..	..	..	402

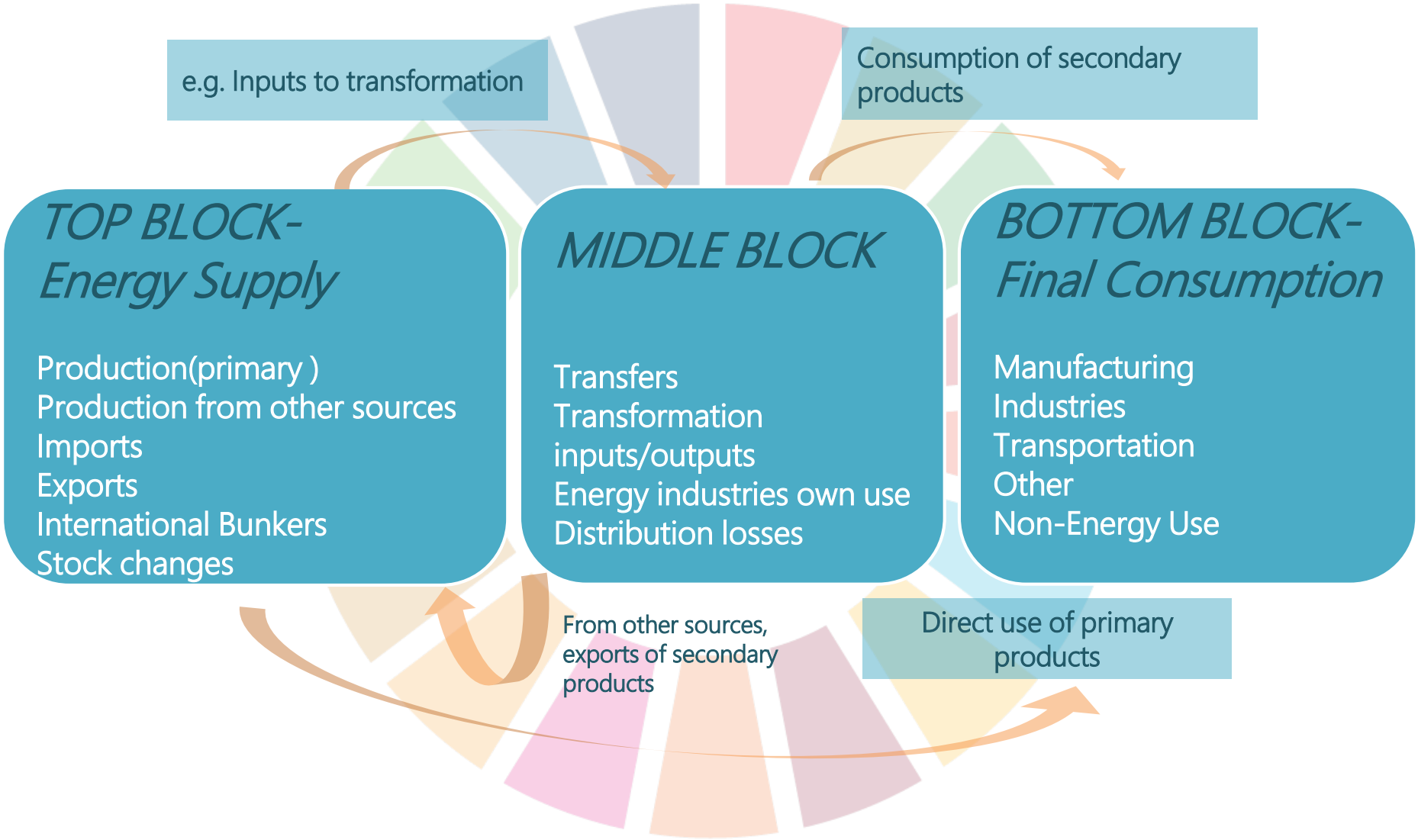
Energy balance format

Africa, 2016, TJ	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
Primary production	6,313.20	-	15,631.30	-	7,357.40	14,629.60	162.3	467.6	182.9	44,744.20	*15,273.30*
Imports	330.3	10.7	1,619.80	5,118.00	641.1	4.5	-	151.7	-	7,876.10	*4.5*
Exports	-1,879.20	-7.4	-12,134.60	-1,728.30	-3,342.20	-14.4	-	-134.8	-	-19,241.00	*-14.4*
International bunkers	-	-	-	-546.5	-	-	-	-	-	-546.5	-
Stock changes	94.4	-2.2	-108.4	-16.2	18	-	-	-	-	-14.3	-
Total energy supply	**4,858.60**	**1.1**	**5,008.10**	**2,827.00**	**4,674.20**	**14,619.80**	**162.3**	**484.5**	**182.9**	**32,818.50**	***15,263.40***
Statistical difference	*-44.1*	*0+*	*-5.3*	*62*	*-195.8*	*-2.7*	-	*67.2*	*0-*	*-118.7*	*485.2*
Transfers	-	-	-194.7	237	-	-	-	-	-	42.3	-
Transformation	**-3,777.90**	**121.4**	**-4,750.60**	**4,075.00**	**-2,638.20**	**-2,569.70**	**-162.3**	**2,450.40**	**-163.3**	**-7,415.10**	***-2,721.40***
Electricity plants	-3,230.80	-	-67.1	-829.3	-2,481.80	-41.9	-162.3	2,446.80	-174.9	-4,541.20	*-193.6*
CHP and heat plants	-1.1	-	-	-	-1.5	-21.5	-	3.6	11.6	-9	*-21.5*
Coke ovens	-98.6	91	-	-	-	-	-	-	-	-7.6	-
Oil refineries	-	-	-4,382.30	4,340.60	-	-	-	-	-	-41.8	-
Other transformation	-447.3	30.4	-301.2	563.7	-154.9	-2,506.30	-	-	-	-2,815.50	*-2,506.20*
Energy industries own use	-501.1	-0.7	-33.9	-124.6	-575.3	-0.01	-	-197.5	0+	-1,433.20	*-0.01*
Losses	-	-	-34.3	-7.5	-21.1	-1.3	-	-371.4	-	-435.6	*-1.3*
Final consumption	623.7	121.8	-	6,944.90	1,635.40	12,051.40	-	2,298.80	19.6	23,695.70	*12,055.50*
Final energy consumption	567.6	121.8	-	6,550.10	1,280.40	12,051.40	-	2,298.80	19.6	22,889.80	*12,055.50*
Industry	375.1	120.2	-	765.8	815.4	874.6	-	916.4	11.5	3,879.10	*871.5*
Transport	0.1	-	-	4,776.70	50.2	1.4	-	20	-	4,848.40	*1.4*
Households	118	0.1	-	610.7	366.2	10,299.00	-	800	3	12,196.90	*10,301.00*
Commerce, public services	58.5	1.4	-	77.1	6.5	369.8	-	389.7	0.1	903.1	*369.9*
Other energy use	15.9	0.1	-	319.8	42.1	506.6	-	172.7	5.1	1,062.30	*511.7*
Non-energy use	56.1	-	-	394.8	355	-	-	-	-	805.9	-

Energy balance format

Africa, 2016, TJ	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
Primary production Imports Exports International bunkers Stock changes **Total energy supply**					Energy Supply						
Statistical difference Transfers **Transformation** Electricity plants CHP and heat plants Coke ovens Oil refineries Other transformation **Energy industries own use** **Losses**					Transformation + Transfers + Energy industry own use +Losses					Total	Renewables
Final consumption Final energy consumption Industry Transport Households Commerce, public services Other energy use Non-energy use					Final consumption						

Main blocks



Source: Energy Statistics Compilers Manual, Figure 6.2

Formats

- An energy balance can be highly detailed or presented in a more aggregated format.
- IRES recommends that countries collect and compile energy balances at a relatively high level of detail.

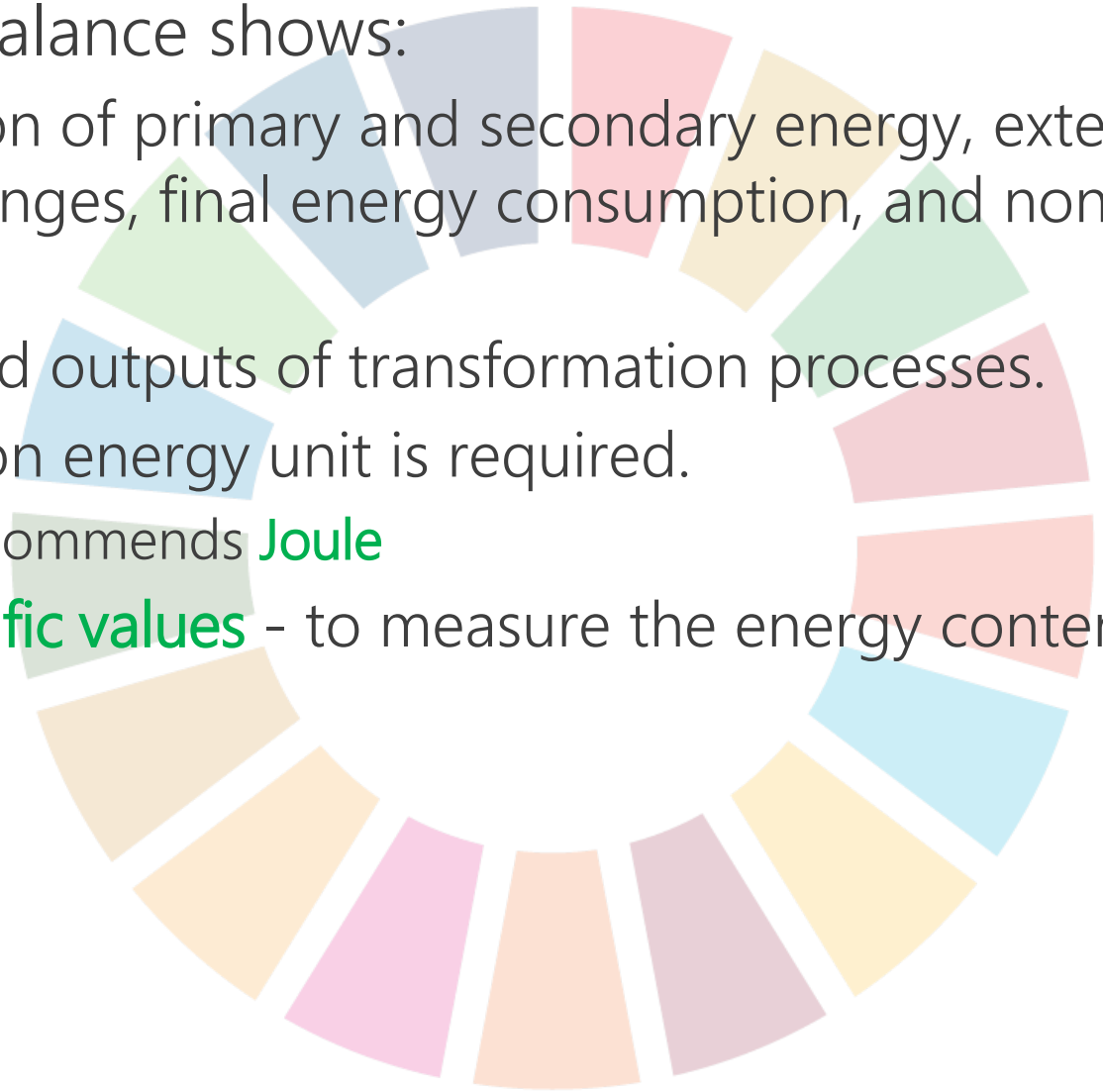
Table 8.2
Template of an aggregated energy balance

Item code	Flows	Energy products					
		E1	E2	E3	...	Total	of which: Renewables
1.1	Primary production						
1.2	Imports						
1.3	Exports						
1.4	International bunkers						
1.5	Stock change (closing-opening)						
1	Total energy supply						
2	Statistical difference						
3	Transfers						
4	Transformation processes						
5	Energy industries own use						
6	Losses						
7	Final consumption						
7.1	Final energy consumption						
7.1.1	Manufacturing, const. and non-fuel mining industries, total						
7.1.1.1	Iron and steel						
7.1.1.2	Chemical and petrochemical						
7.1.1.X	Other industries						
7.1.2	Transport, total						
7.1.2.1	Road						
7.1.2.2	Rail						
7.1.2.3	Domestic aviation						
7.1.2.4	Domestic navigation						
7.1.2.X	Other Transport						
7.1.3	Other, total						
7.1.3.1	*of which*: Agriculture, forestry and fishing						
7.1.3.2	*of which*: Households						
7.2	Non-energy use						

Principles

An energy balance shows:

- Production of primary and secondary energy, external trade, stock changes, final energy consumption, and non-energy use.
- Inputs and outputs of transformation processes.
- A common energy unit is required.
  - IRES recommends Joule
- Net calorific values - to measure the energy content of energy products.



Calculation of an energy balance

Commodity balances

Commodity balances - basic energy statistics

- combinations of products and flows
- flows grouped under the commodity header

Limitations of commodity balances

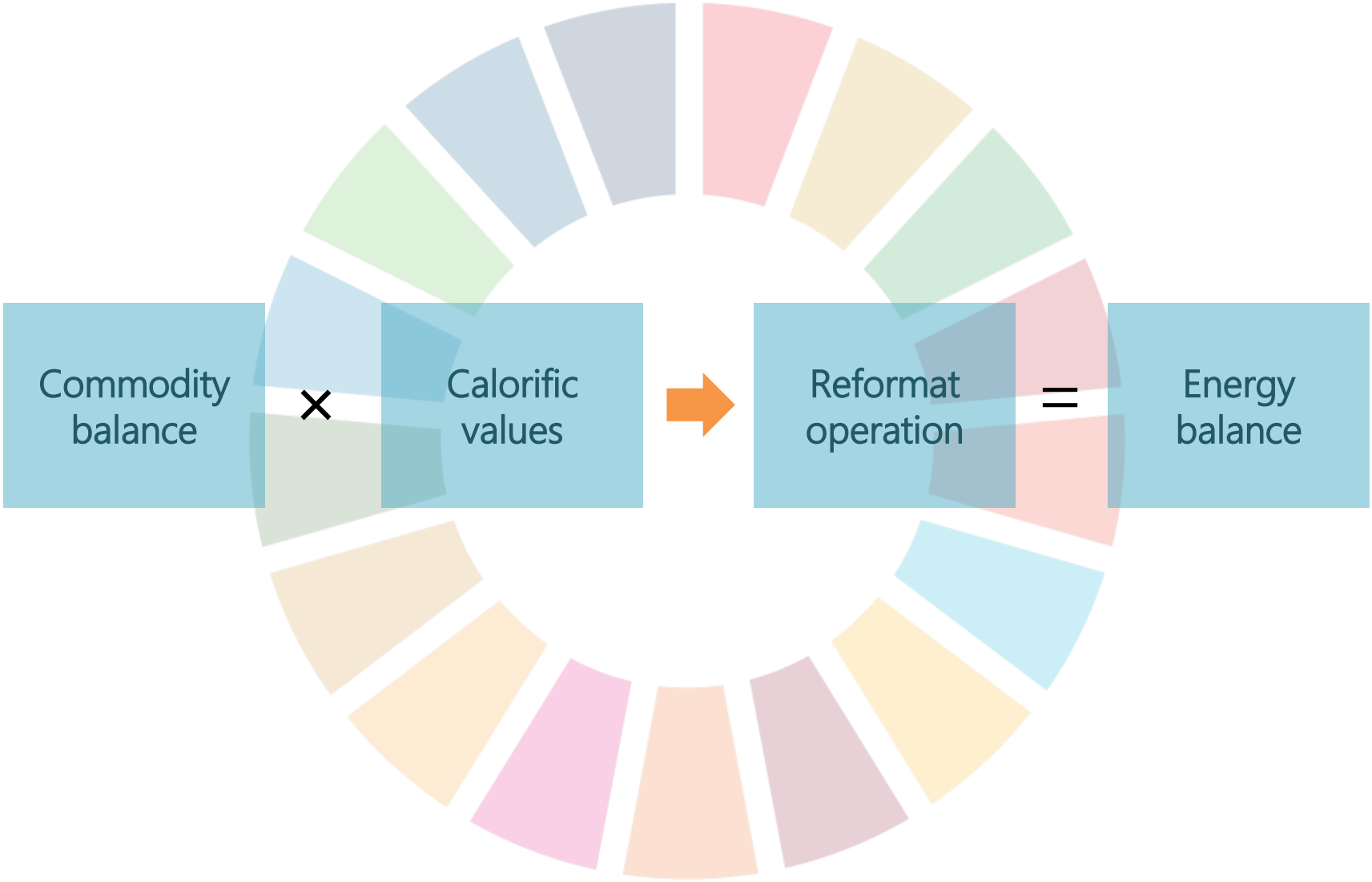
- different units/calorific values - commodities incomparable
- production double counted

Motor Gasoline; Metric tons, thousand	2014	2015
Production	3627	3939
Receipts from other sources	206	238
Imports	371	363
Exports	672	762
Stock changes	-56	-22
Total energy supply	3588	3800
Final consumption	3577	3800
Final energy consumption	3577	3800
Transport	3572	3796
Road	3572	3796

Natural Gas ; Terajoules	2014	2015
Production	173349	171329
Imports	451673	464842
Exports	2880	2112
Total energy supply	623574	640849
Transformation	83409	96802
Energy industries own use	53212	55607
Losses	1259	1237
Final consumption	484232	493534
Non-energy uses	95888	98600
Final energy consumption	388344	394934

Fuelwood ; Cubic metres, thousand	2014	2015
Production	22044	22388
Total energy supply	22044	22388
Transformation	4657.8	4776.5
Transformation in electricity and heat	4657.8	4776.5
Final consumption	17386	17611
Non-energy uses		
Final energy consumption	17386	17611
Households	11544	11544

Calculation of an energy balance



Source: International Energy Agency, *Energy Statistics Manual*, Figure 7.1

Commodity and energy balance

Commodity balance

Energy Supply

Production (primary +second.)
Production from other sources
Imports/Exports
International Bunkers
Stock changes

MIDDLE BLOCK

Transfers
Transformation inputs
Energy industries own use
Distribution losses

Final Consumption

Manufacturing Industries
Transportation
Other
Non-Energy Use

Energy balance

Energy Supply

Production (primary)
Production from other sources
Imports/Exports
International Bunkers
Stock changes

MIDDLE BLOCK

Transfers
Transformation inputs/outputs
Energy industries own use
Distribution losses

Final Consumption

Manufacturing Industries
Transportation
Other
Non-Energy Use

Reading an energy balance

Energy supply

Africa	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
					2016 (TJ)						
Primary production	6,313.20	-	15,631.30	-	7,357.40	14,629.60	162.3	467.6	182.9	44,744.20	*15,273.30*
Imports	330.3	10.7	1,619.80	5,118.00	641.1	4.5	-	151.7	-	7,876.10	*4.5*
Exports	-1,879.20	-7.4	-12,134.60	-1,728.30	-3,342.20	-14.4	-	-13	-	-19,241.00	*-14.4*
International bunkers	-	-	-	-546.5	-	-	-	-	-	-546.5	-
Stock changes	94.4	-2.2	-108.4	-16.2	18	-		-	-	-14.3	-
Total energy supply	**4,858.60**	**1.1**	**5,008.10**	**2,827.00**	**4,674.20**	**14,619.80**	**1**	**484.5**	**182.9**	**32,818.50**	***15,263.40***

Total primary production of Africa

Total energy supply in Africa

Energy supply

Africa	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
					2016 (TJ)						
Primary production	6,313.20	-	15,631.30	-	7,357.40	14,629.60	162.3	467.6	182.9	44,744.20	*15,273.30*
Imports	330.3	10.7	1,619.80	5,118.00	641.1	4.5	-	151.7	-	7,876.10	*4.5*
Exports	-1,879.20	-7.4	-12,134.6	-28.30	-3,342.20	-14.4	-	-134.8	-	-19,241.00	*-14.4*
International bunkers	-	-		-546.5	-	-	-	-	-	-546.5	-
Stock changes	94.4	-2.2	.4	-16.2	18	-	-	-	-	-14.3	-
Total energy supply	**4,858.60**	**1.1**	**8.10**	**2,827.00**	**4,674.20**	**14,619.80**	**162.3**	**484.5**	**182.9**	**32,818.50**	***15,263.40***

Refined products are secondary energy products, so oil products primary production is always 0

Energy supply

Africa	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
					2016 (TJ)						
Primary production	6,313.20	-	15,631.30	-	7,357.40	14,629.60	162.3	467.6	182.9	44,744.20	*15,273.30*
Imports	330.3	10.7	1,619.80	5,118.00	641.1	4.5	-	151.7	-	7,876.10	*4.5*
Exports	-1,879.20	-7.4	-12,134.60	-1,728.30	-3,342.20	-14	-	-134.8	-	-19,241.00	*-14.4*
International bunkers	-	-	-	-546.5	-	-	-	-	-	-546.5	-
Stock changes	94.4	-2.2	-108.4	-16.2	18	-	-	-		-14.3	-
Total energy supply	**4,858.60**	**1.1**	**5,008.10**	**2,827.00**	**4,674.20**	**19.80**	**162.3**	**484.5**	**182.9**	**32,818.50**	***15,263.40***

Heat output as well as the primary heat equivalent of electricity production from nuclear sources.

Electricity for hydro, wind, tide, wave and other marine, and solar photovoltaic.

Middle block

Africa	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
					2016 (TJ)						
Transfers	-	-	-194.7	237	-	-	-	-	-	42.3	-
Transformation	**-3,777.90**	**121.4**	**-4,750.60**	**4,075.00**	**-2,638.20**	**-2,569.70**	**-162.3**	**2,450.40**	**-163.3**	**-7,415.10**	***-2,721.40***
Electricity plants	-3,230.80	-	-67.1	-829.3	-2,481.80	-41.9	-162.3	2,446.80	-174.9	-4,541.20	*-193.6*
CHP and heat plants	-1.1	-	-	-	-1.5	-21.5	-	3.6	11.6	-9	*-21.5*
Coke ovens	-98.6	91	-	-	-	-	-	-	-	-7.6	-
Oil refineries	-	-	-4,382.30	4,340.60	-	-	-	-	-	-41.8	-
Other transformation	-447.3	30.4	-301.2	563.7	-154.9	-2,506.30	-	-	-	-2,815.50	*-2,506.20*
Energy industries own use	-501.1	-0.7	-33.9	-124.6	-575.3	-0.01	-	-197.5	0+	-1,433.20	*-0.01*
Losses	-	-	-34.3	-7.5	-21.1	-1.3	-	-371.4	-	-435.6	*-1.3*

- **Transfers** – comprise products transferred and interproduct transfers, present changes in use or identity of a product.
- **Transformation** – processes that convert an energy product into another energy product which, in general, is more suitable for specific uses
- **Energy industries own use** – consumption of fuels and energy for the direct support of the production, and preparation for use of fuels and energy
- **Losses** – losses during the transmission, distribution and transport of fuels, heat and electricity

Transformation – refinery

Africa	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
					2016 (TJ)						
Transfers	-	-	-194.7	237	-	-	-	-	-	42.3	-
Transformation	**-3,777.90**	**121.4**	**-4,750.60**	**4,075.00**	**-2,638.20**	**-2,569.70**	**-162.3**	**2,450.40**	**-163.3**	**-7,415.10**	***-2,721.40***
Electricity plants	-3,230.80	-	-67.1	-829.3	-2,481.80	-41.9	-162.3	2,446.80	-174.9	-4,541.20	*-193.6*
CHP and heat plants	-1.1	-	-	-	-1.5	-21.5	-	3.6	11.6	-9	*-21.5*
Coke ovens	-98.6	91	-	-	-	-	-	-	-	-7.6	-
Oil refineries	-	-	-4,382.30	4,340.60	-	-	-	-	-	-41.8	-
Other transformation	-447.3	30.4	-301.2	563.7	-154.9	-2,506.30	-	-	-	-2,815.50	*-2,506.20*
Energy industries own use	-501.1	-6.	-33.9	.6	-575.3	-0.01	-	-197.5	0+	-.3.20	*-0.01*
Losses	-		-34.3	.5	-21.1	-1.3	-	-371.4	-	435.6	*-1.3*

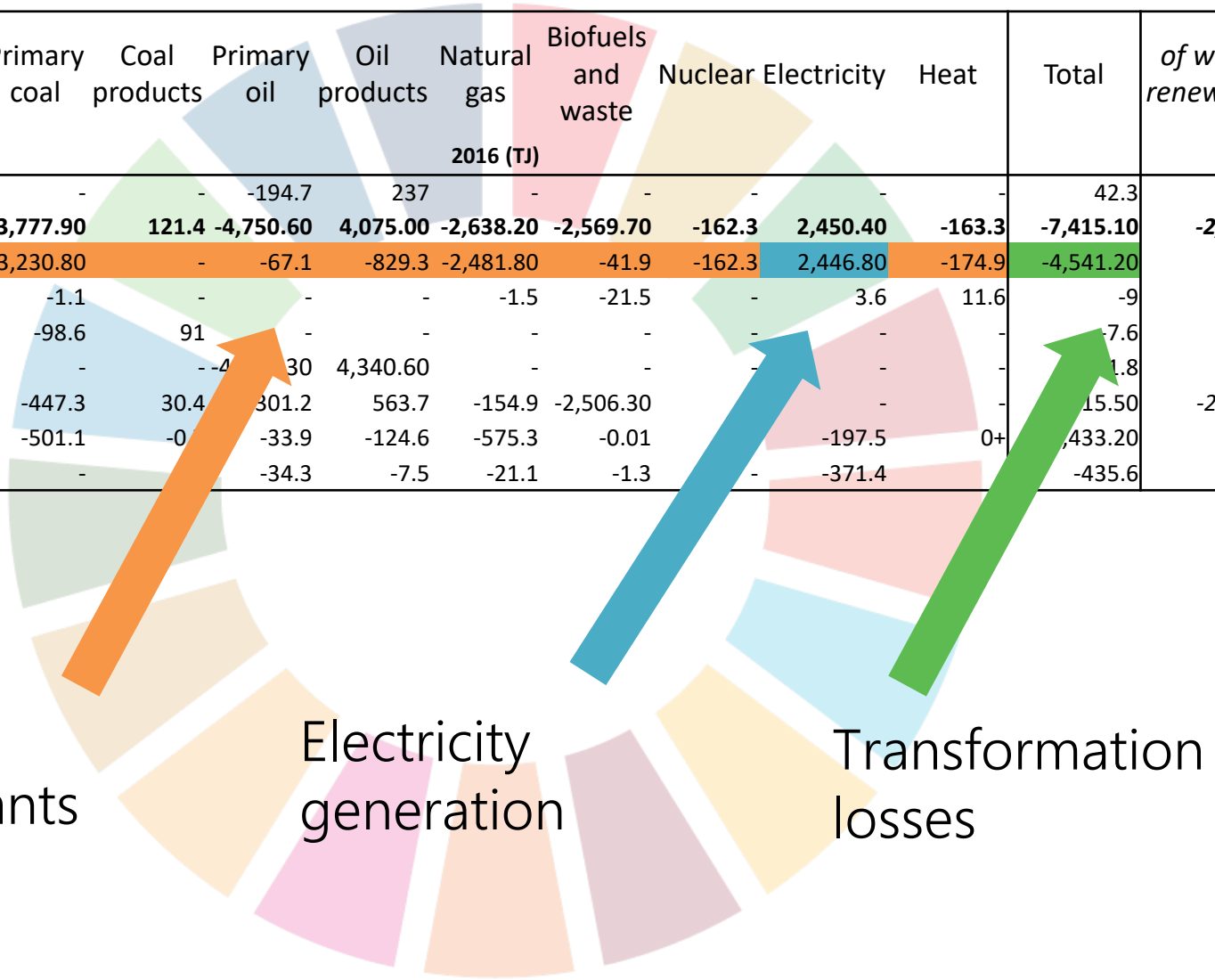
Refinery intake (negative sign)

Refinery output (positive sign)

Refinery losses

Transformation – electricity plants

Africa	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
					2016 (TJ)						
Transfers	-	-	-194.7	237	-	-	-	-	-	42.3	-
Transformation	**-3,777.90**	**121.4**	**-4,750.60**	**4,075.00**	**-2,638.20**	**-2,569.70**	**-162.3**	**2,450.40**	**-163.3**	**-7,415.10**	***-2,721.40***
Electricity plants	-3,230.80	-	-67.1	-829.3	-2,481.80	-41.9	-162.3	2,446.80	-174.9	-4,541.20	*-193.6*
CHP and heat plants	-1.1	-	-	-	-1.5	-21.5	-	3.6	11.6	-9	*-21.5*
Coke ovens	-98.6	91	-	-	-	-	-	-	-	-7.6	-
Oil refineries	-	-	-4	30	4,340.60	-	-	-	-	1.8	-
Other transformation	-447.3	30.4	301.2	563.7	-154.9	-2,506.30		-	-	15.50	*-2,506.20*
Energy industries own use	-501.1	-0	-33.9	-124.6	-575.3	-0.01		-197.5	0+	433.20	*-0.01*
Losses	-		-34.3	-7.5	-21.1	-1.3	-	-371.4		-435.6	*-1.3*



Input to electricity plants

Electricity generation

Transformation losses

Consumption

Africa	Primary coal	Coal products	Primary oil	Oil products	Natural gas	Biofuels and waste	Nuclear	Electricity	Heat	Total	*of which: renewables*
					2016 (TJ)						
Final consumption	623,7	121,8	-	6 944,90	1 635,40	12 051,40	-	2 298,80	19,6	23 695,70	*12 055,50*
Final energy consumption	567,6	121,8	-	6 550,10	1 280,40	12 051,40	-	2 298,80	19,6	22 889,80	*12 055,50*
Industry	375,1	120,2	-	765,8	815,4	874,6	-	916,4	11,5	3 879,10	*871,5*
Transport	0,1	-	-	4 776,70	50,2	1,4	-	20	-	4 848,40	*1,4*
Households	118	0,1	-	610,7	366,2	10 299,00	-	800	3	12 196,90	*10 301,00*
Commerce, public services	58,5	1,4	-	77,1	6,5	369,8	-	389,7	0,1	903,1	*369,9*
Other energy use	15,9	0,1	-	319,8	42,1	506,6	-	172,7	5,1	1 062,30	*511,7*
Non-energy use	56,1	-	-	394,8	355	-	-	-	-	805,9	-

Checking an energy balance

Checking an energy balances

- Transformation losses:
  - may highlight problems in either the basic energy data in commodity balances or in the conversion equivalents
- Statistical differences:
  - if much higher than in the commodity balance, could indicate problems with calorific values
  - Example: domestically produced lignite has a different calorific value from imported lignite.
- Generation efficiencies can be used to reconcile inputs and outputs from each transformation activity.

Relevance of an energy balance

- In an ideal world “Supply” = “Demand”.
- An energy balance is an accounting framework that seeks to reconcile supply with demand. When aggregate supply is different from aggregate demand, the difference is shown as statistical difference.
- Energy balances are a powerful tool for validation and reconciliation.

Importance of conversion factors

Conversion to energy units

Physical units are:

- converted to energy units using Net Calorific Values (NCV),
- NCV ideally are measured frequently for different processes and sources and then averaged for the country/flow.

Ideally:

- Specific NCV for different flows, when available (most importantly, Production and Imports)
- Weighted-average NCV for all other flows (if only NCVs for Production and Imports are available).
- Default NCV if no information available (undesirable case)

If commodities are reported in energy units, the appropriate conversion to a common unit must be made.

Importance of specific NCVs – emissions

	Coal (kt)	Default NCV	Coal (TJ) default NCV	Default emission factor for coal (t CO2/TJ)	CO2 (tons) default NCV
2016					
Primary production	**131.8**	**25.8**	3400		
Imports	**29.0**	**25.8**	748		
Exports	**-12.4**	**25.8**	-319		
Stock changes	**-0.5**	**25.8**	-14		
Total energy supply	**147.9**		**3,815**	94.6	**360,899**

Importance of specific NCVs – emissions

	Coal (kt)	Specific NCVs	Coal (TJ) specific NCV	CO2 (tons) specific NCV
	2016			
Primary production	**131.8**	**20.10**	2649	
Imports	**29.0**	**23.20**	673	
Exports	**-12.4**	**28.20**	-349	
Stock changes	**-0.5**	**20.10**	-11	
Total energy supply	**147.9**		**2,962**	**280,193**

29% higher CO_2 emission estimates by using default NCVs!

Conclusion

Conclusion

While the structure of an energy balance depends on a country's energy production and consumption patterns and the level of detail that the country requires, it is recommended that common approaches be followed to ensure international comparability and consistency.

Conclusion

To verify if your energy balance follows international recommendations please refer to IRES "recommendations and encouragements".

Table 1.1 Summary of the main recommendations and encouragements contained in IRES

Chapter VIII. Energy balances	
8.1	The energy balance **should be** as complete as possible so that all energy flows are, in principle, accounted for. It **should be** based firmly on the first law of thermodynamics, which states that the amount of energy within any closed system is fixed and can neither be increased nor diminished unless energy is brought into or sent out from that system.
8.5	It is **recommended** that countries collect data at a level of detail that allows for the compilation of a detailed energy balance, as presented in table 8.1. When such a level of detail is not available or practical, it is recommended that countries, at a minimum, follow the template of the aggregated energy balance presented in table 8.2.
8.9 (*a*)	The energy balance is compiled with respect to a clearly defined reference period. In this respect, it is **recommended** that countries, as a minimum, compile and disseminate an energy balance on an annual basis.
8.9(*h*)	All entries in the energy balance **should be** expressed in one energy unit (it is **recommended** that Joule is used for this purpose, although countries could use other energy units, such as toe, tce, etc.). The conversion between energy units should be through the application of appropriate conversion factors (see chapter IV) and the applied factors should be reported with the energy balance to make any conversion from physical units to Joules or other units transparent and comparable.
8.9(*j*)	In the case of electricity generation from primary heat (nuclear, geothermal and concentrating solar), it is **recommended** that an estimate of the heat input be used based on an efficiency of 33 per cent for nuclear and concentrating solar, and 10 per cent for geothermal as a default, unless country- or case-specific information is available.
8.10	While the structuring of an energy balance depends on a country's energy production and consumption patterns and the level of detail that the country requires, it is **recommended** that common approaches be followed to ensure international comparability and consistency (see section 8.C).
8.12	While different columns (except "total") represent various energy products, they might be grouped and sequenced in a way that adds to the analytical value of the balance. In this connection, it is **recommended** that: (*a*) Groups of energy products be mutually exclusive and based on SIEC; (*b*) The column "total" follow the columns for individual energy products (or groups of products); (*c*) The column "total" be followed by supplementary columns containing additional subtotals such as "renewables". The definition of such subtotals and any additional clarification on the column's coverage should be provided in appropriate explanatory notes.
8.14	It is **recommended** that an energy balance contain three main blocks of rows as follows: (*a*) Top block—flows representing energy entering and leaving the national territory, as well as stock changes to provide information on the supply of energy on the national territory during the reference period; (*b*) Middle block—flows showing how energy is transformed, transferred, used by energy industries for own use and lost in distribution and transmission; (*c*) Bottom block—flows reflecting final energy consumption and non-energy use of energy products.

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