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Energy Balance Statistics
Energy Statistics Division

From Basic Energy Statistics to Energy Balances

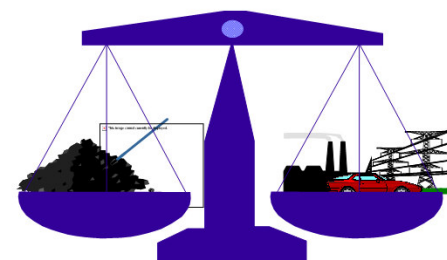
**IEA Data TRAINING WORKSHOP in South Africa
Pretoria, South Africa, 11-13 October, 2010**



Energy balances

[illegible]

- **Why calculate an energy balance?**
- **Energy balance principles**
- **IEA energy balance layout**
- **Using the energy balance with economic indicators**
- **Harmonisation**



Why calculate an energy balance?

The energy balance is a way of reporting energy data in a common unit and with products aggregated by category: coal, oil, petroleum products, gas, biomass, etc.

Advantages:

- ◆ **It allows comparison of the shares of each source in the energy supply of a country and in each sector of economic activity**
- ◆ **With an energy balance it is possible to analyse energy efficiency**
- ◆ **A country can determine its dependence on energy imports or exports**
- ◆ **Different countries can be compared when they are calculated with the same methodology**
- ◆ **Good for quality control: can check inputs/outputs in the transformation sector**

Message can differ

Which data to use/trust when assessing
legally binding commitments?

- **What is the importance of renewables in the energy mix?**
- **What is happening with CO₂ emissions (Kyoto targets)?**
- **General confusion by users**
 - **this could pave the way to speculation**

What is the importance of renewables in the energy mix?

Answer will depend on:

- Principles:
calculation of the **primary energy equivalent** of electricity from non-combustion processes (physical energy content vs. substitution)
- Classification / definitions:
what is renewable? peat is sometimes included with fossil and sometimes with renewables
- Presentation:
how is **supply** calculated? (e.g. bunkers in or out, statistical difference above or below)

What is happening with CO₂ emissions (Kyoto targets)?

- Answer will depend on:
- Principles:
temperature adjustments
- Methods:
treatment of non-energy use;
blast furnace accounting
- Conversion factors:
level of detail of calorific values

Denmark:

1990 unusually warm (about 24%)

CO₂ estimates will be affected

IEA energy balance system

5 IEA/Eurostat/UNECE Annual Questionnaires



Coal



Oil



Gas



Renewables
+ Waste



Electricity
+ Heat



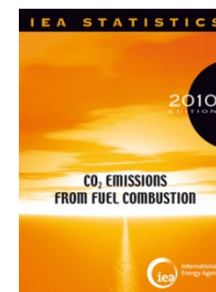
Original
Units



Mtoe



Mt of CO₂



Energy balance principles

- **choice of unit**
- **net vs. gross calorific values**
- **choice of conversion factors**
- **choice of primary energy form for energy that is not combusted**
- **physical energy content vs. substitution method**
- **temperature adjustments**
- **fiscal year vs. calendar year**

What units?

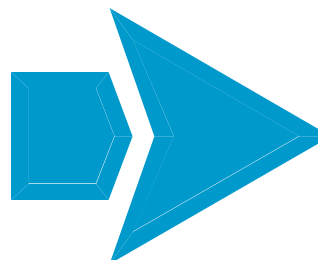
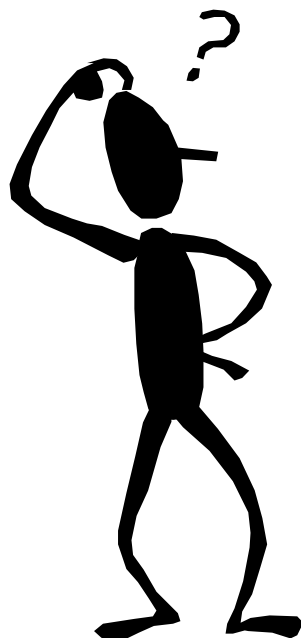
MBtu

kilowatt-hours

Mtoe

Mtce

terajoules



ENERGY BALANCES OF OECD COUNTRIES, 1987-1988 - R.1Y

OECD Total / OCDE Total : 1988												
Units: 1000 toe / 1000 tonnes												
	Total	Crude Petroleum	Gas	Nuclear	Hydro	Geothermal	Solar	Electricity	Losses	Total		
	Crude Oil	Products	Gas	Nuclear	Hydro	Geothermal	Solar	Electricity	Losses	Total		
SUPPLY AND CONSUMPTION												
APPROPRIATION												
AT DEMAND												
Indigenous Production	100.00	100.00	-	-	-	-	-	-	-	100.00		
Imports	400.00	400.00	-	-	-	-	-	-	-	400.00		
Exports	-200.00	-200.00	-	-	-	-	-	-	-	-200.00		
Net Balance	200.00	200.00	-	-	-	-	-	-	-	200.00		
LOSSES												
Transformation	-50.00	-50.00	-	-	-	-	-	-	-	-50.00		
Transmission	-10.00	-10.00	-	-	-	-	-	-	-	-10.00		
Other	-10.00	-10.00	-	-	-	-	-	-	-	-10.00		
INDUSTRY SECTOR												
Iron and Steel	10.00	10.00	-	-	-	-	-	-	-	10.00		
Non-Ferrous Metals	5.00	5.00	-	-	-	-	-	-	-	5.00		
Chemical and Petrochemical	15.00	15.00	-	-	-	-	-	-	-	15.00		
Other	10.00	10.00	-	-	-	-	-	-	-	10.00		
TRANSPORT SECTOR												
Domestic Air Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
Domestic Road Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
Domestic Water Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
Domestic Rail Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
Domestic Other	1.00	1.00	-	-	-	-	-	-	-	1.00		
International Air Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
International Road Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
International Water Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
International Rail Transport	1.00	1.00	-	-	-	-	-	-	-	1.00		
International Other	1.00	1.00	-	-	-	-	-	-	-	1.00		
OTHER SECTORS												
Electricity	1.00	1.00	-	-	-	-	-	-	-	1.00		
Heat	1.00	1.00	-	-	-	-	-	-	-	1.00		
Other	1.00	1.00	-	-	-	-	-	-	-	1.00		
NON-ENERGY USE												
Domestic	1.00	1.00	-	-	-	-	-	-	-	1.00		
International	1.00	1.00	-	-	-	-	-	-	-	1.00		
Other	1.00	1.00	-	-	-	-	-	-	-	1.00		

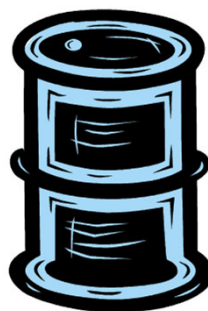
IEA opted for Mtoe

Net vs. Gross Calorific Values?

Difference between NCV and GCV is the latent heat of vaporisation of the water produced during combustion



5%



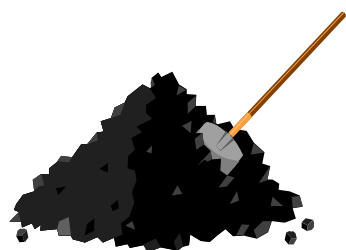
5%



10%

IEA uses Net Calorific Values

Conversion to energy units (1)



COAL

Physical units (tonnes) are converted to energy units using NCV [kJ/kg], reported in the questionnaires (varies over time)

Specific NCV for Production, Imports, Exports, Inputs to Public Power Plants, Coal used in Coke Ovens, Blast Furnaces and Industry

Average NCV for all other flows

CRUDE OIL AND OIL PRODUCTS

Using NCV [kJ/kg]

Primary oil - Specific NCV for Production, Imports and Exports, reported in the questionnaires (varies over time)

Oil products - region specific default values



Conversion to energy units (2)



NATURAL GAS

Figures collected in Mm^3 and gross TJ (energy unit). They are converted to net TJ ($0.9 \cdot \text{gross TJ}$) and then to Mtoe ($1 \text{ PJ} = 0.02388 \text{ Mtoe}$)

OTHER GASES

Data collected in gross TJ, then converted to net TJ ($0.9 \cdot \text{gross TJ}$) and then to Mtoe ($1 \text{ PJ} = 0.02388 \text{ Mtoe}$)

ELECTRICITY

Figures collected in TWh, then electricity production is converted to Mtoe ($1 \text{ TWh} = 0.086 \text{ Mtoe}$)

Gross electricity production is shown and the own use and losses are shown separately



Latest developments concerning NCVs

- **The IPCC analysed country submissions to the UNFCCC and suggested new default NCVs for the 2006 IPCC Guidelines.**
- **The IEA decided to remove double rounding errors by keeping NCVs in kJ/kg instead of toe/tonne (affects all the fuels).**
- **The IEA and Eurostat were using different NCVs for oil products – we have agreed to use the same values for Europe**
- **For the last 3 years, the IEA has used region-specific values for the oil products in OECD countries (also revised NCVs for some non-OECD countries)**

Solid fuel equivalents (kJ/kg)

	IEA defaults			
	Europe	N. Amer.	Pacific	Non- OECD
Hard Coal	country-specific			
Lignite	country-specific			
Peat	country-specific			
Coal briquettes	country-specific			
Lignite briq.				
Peat briq.				
Gas coke	country-specific			
Oven coke	country-specific			
Brown coal coke	country-specific			
Pet. coke	32 000	32 000	33 800	32 000
Charcoal	country-specific			
Fuelwood	not applicable			

Liquid fuel equivalents (kJ/kg)

	IEA defaults			
	Europe	N. Amer.	Pacific	Non-OECD
LPG	46 000	47 300	47 700	47 300
Gasoline	44 000	44 800	44 600	44 800
Jet fuel - gas	43 000	44 800	44 600	44 800
Jet fuel – kero	43 000	44 600	44 500	44 600
Kerosene	43 000	43 800	42 900	43 800
Gas-diesel oil	42 600			43 800
Resid. fuel oil	40 000	40 200	42 600	40 200
Lubricants	42 000	42 000	42 900	42 000
Bitumen	39 000	40 000	38 800	39 000
Pet. coke	32 000	32 000	33 800	32 000
Petroleum wax	40 000			
White spirit	43 600	43 000	43 000	43 000
Naphtha	44 000	45 000	43 200	45 000

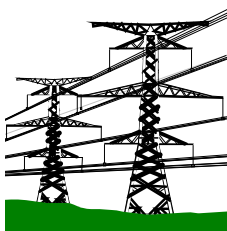
Choice of primary energy form

First energy form downstream for which multiple energy uses are practical



Heat

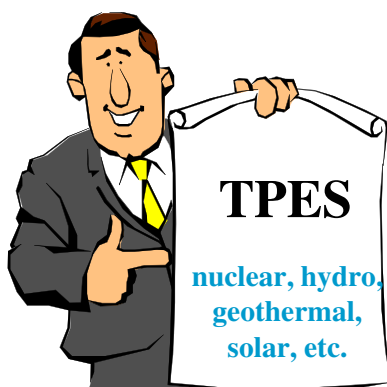
- ◆ nuclear heat and electricity production
- ◆ geothermal heat and electricity production
- ◆ solar heat production



Electricity

- ◆ hydro
- ◆ wind
- ◆ wave/ocean
- ◆ photovoltaic solar electricity production

Choice of method for calculating primary energy equivalent



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

IEA opted for



Physical energy content method

- ◆ uses physical energy content of the primary energy source
- ◆ nuclear 33%
- ◆ geothermal 10%
- ◆ solar, wind, etc. 100%

Physical energy content vs. partial substitution

2008 Energy Balance of Sweden

Using physical energy
content method

Million tonnes of oil equivalent / Million de tonnes d'équivalent pétrole											
SUPPLY	Coal & peat	Crude oil	Petroleum products	Gas	Nuclear	Hydro	Geotherm. solar etc.	Combust. renew. & waste	Electricity	Heat	Total
Production	0.21	-	-	-	16.63	5.92	0.18	10.12	-	0.27	33.33
Imports	2.32	21.73	7.42	0.83	-	-	-	-	1.10	-	33.39
Exports	-0.03	-0.47	-12.07	-	-	-	-	-	-1.27	-	-13.84
Intl. marine bunkers	-	-	-2.01	-	-	-	-	-	-	-	-2.01
Intl. aviation bunkers	-	-	-0.68	-	-	-	-	-	-	-	-0.68
Stock changes	0.04	-0.44	-0.07	-	-	-	-	-	-	-	-0.47
TPES	2.54	20.82	-7.41	0.83	16.63	5.92	0.18	10.12	-0.17	0.27	49.73
Electricity and Heat Output											
Elec. generated - TWh	3.01	-	1.07	0.78	63.82	68.80	1.97	10.03	-	-	149.49
Heat generated - PJ	16.09	-	4.77	6.00	-	-	-	140.36	0.76	19.98	187.95

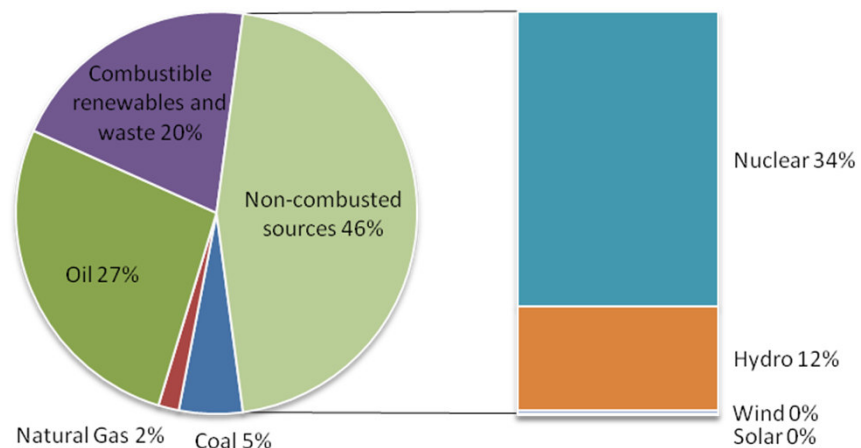
Using partial
substitution method

Million tonnes of oil equivalent / Million de tonnes d'équivalent pétrole											
SUPPLY	Coal & peat	Crude oil	Petroleum products	Gas	Nuclear	Hydro	Geotherm. solar etc.	Combust. renew. & waste	Electricity	Heat	Total
Production	0.21	-	-	-	14.26	15.37	0.44	10.12	-	0.27	40.67
Imports	2.32	21.73	7.42	0.83	-	-	-	-	1.10	-	33.39
Exports	-0.03	-0.47	-12.07	-	-	-	-	-	-1.27	-	-13.84
Intl. marine bunkers	-	-	-2.01	-	-	-	-	-	-	-	-2.01
Intl. aviation bunkers	-	-	-0.68	-	-	-	-	-	-	-	-0.68
Stock changes	0.04	-0.44	-0.07	-	-	-	-	-	-	-	-0.47
TPER	2.54	20.82	-7.41	0.83	14.26	15.37	0.44	10.12	-0.17	0.27	57.07
Electricity and Heat Output											
Elec. generated - TWh	3.01	-	1.07	0.78	63.82	68.80	1.97	10.03	-	-	149.49
Heat generated - PJ	16.09	-	4.77	6.00	-	-	-	140.36	0.76	19.98	187.95

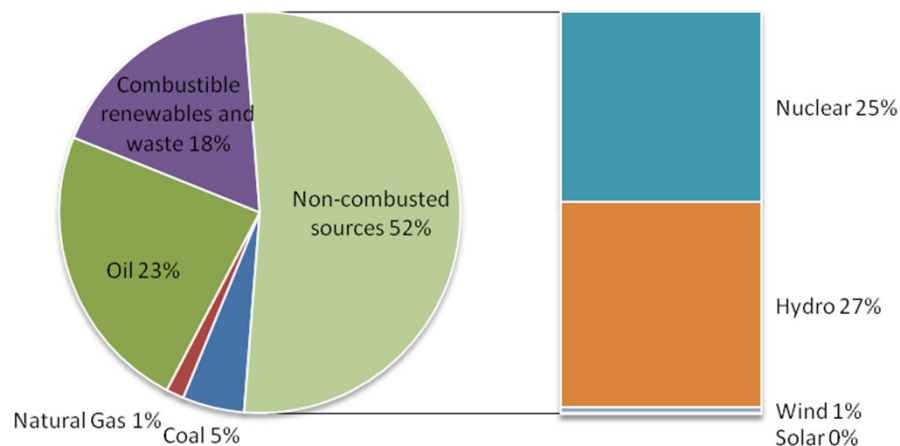
Physical energy content vs. partial substitution

2008 Supply of Sweden

Using physical energy
content method



Using partial substitution
method



Non-combusted sources can have very different shares!

Physical energy content vs. partial substitution

2008 Energy Balance of South Africa

Using physical energy
content method

Renewables = 10.5%

Thousand tonnes of oil equivalent													
SUPPLY AND CONSUMPTION	Coal & peat	Crude oil	Oil products	Gas	Nuclear	Hydro	Solar PV	Solar thermal	Wind	Combust. renew. & waste	Electricity	Heat	Total
Production	142459	954	-	1742	3389	108	2	50	3	14244	-	-	162951
Imports	942	20090	2925	2421	-	-	-	-	-	-	909	-	27287
Exports	-40154	-556	-2531	-	-	-	-	-	-	263	-1218	-	-44722
Intl. marine bunkers	-	-	-2735	-	-	-	-	-	-	-	-	-	-2735
Intl. aviation bunkers	-	-	-876	-	-	-	-	-	-	-	-	-	-876
TPES	95832	20487	-3218	4163	3389	108	2	50	3	13981	-309	-	134489
Electricity and Heat Output													
Electr. generated - GWh	240799	-	143	-	13004	1260	22	-	54	259	-	-	255519
Heat generated - TJ	-	-	-	-	-	-	-	-	-	-	-	-	-
Thousand tonnes of oil equivalent													
SUPPLY AND CONSUMPTION	Coal & peat	Crude oil	Oil products	Gas	Nuclear	Hydro	Solar PV	Solar thermal	Wind	Combust. renew. & waste	Electricity	Heat	Total
Production	142459	954	-	1742	2904	281	5	50	12	14244	-	-	162652
Imports	942	20090	2925	2421	-	-	-	-	-	-	909	-	27287
Exports	-40154	-556	-2531	-	-	-	-	-	-	263	-1218	-	-44722
Intl. marine bunkers	-	-	-2735	-	-	-	-	-	-	-	-	-	-2735
Intl. aviation bunkers	-	-	-876	-	-	-	-	-	-	-	-	-	-876
TPER	95832	20487	-3218	4163	2904	281	5	50	12	13981	-309	-	134189
Electricity and Heat Output													
Electr. generated - GWh	240799	-	143	-	13004	1260	22	-	54	259	-	-	255519
Heat generated - TJ	-	-	-	-	-	-	-	-	-	-	-	-	-

Using partial
substitution method

Renewables = 10.7%

IEA energy balance layout: compact source of information

Sweden : 2007

Flows

Supply

Transformation and energy industries own use

Final consumption

Industry

Transport

Other final consumption

Non-energy use

Electricity and heat output

Million tonnes of oil equivalent									
SUPPLY AND CONSUMPTION	Coal & peat	Crude oil	Petroleum products	Gas	Nuclear	Hydro	Geotherm.	Combust. solar etc.	Electricity
Production	0.16	-	7.52	0.91	17.45	5.69	0.13	9.87	0.28
Imports	2.50	18.57	-	-	-	-	-	-	138
Exports	-0.02	-0.66	-9.92	-	-	-	-	-	-127
Intl. marine bunkers	-	-	-2.05	-	-	-	-	-	-
Intl. aviation bunkers	-	-	-0.65	-	-	-	-	-	-
Stock changes	0.01	0.01	0.52	-	-	-	-	-	-
TPES	2.64	1.93	1.92	0.93	17.45	5.69	0.13	9.87	0.28
Transfers	-	-	-	-	-	-	-	-	-
Statistical differences	0.15	-0.11	-0.03	-0.08	-	-	-	-	-
Electricity plants	-	-	-	-	-	-	-	11.58	-
CHP plants	-0.64	-	-	-	-	-	-	1.22	2.52
Heat plants	-0.12	-	-0.10	-0.01	-	-	-	-120	1.44
Gas works	-	-	-0.02	0.02	-	-	-	-	-
Petroleum refineries	-	-18.94	18.02	-	-	-	-	-	-
Coal transformation	-100 e	-	-0.04	-	-	-	-	-	-
Liquefaction plants	-	-	-	-	-	-	-	-	-
Other transformation	-	-	-	-	-	-	-	-	-
Own use	-0.10	-	-	-	-	-	-	-0.55	-
Distribution losses	-0.05	-	-	-	-	-	-	-0.93	-0.15
TFC	0.50	12.19	0.56	0.85	17.45	5.32	0.13	11.27	4.09
INDUSTRY SECTOR	0.88	1.52	0.03	0.03	0.01	0.01	0.01	4.89	0.38
Iron and steel	0.52 e	0.34	0.03	-	-	-	-	0.45	-
Chemical and petrochem	0.01	0.12	0.15	-	-	-	-	0.01	0.53
Non-ferrous metals	0.03	0.02	0.01	-	-	-	-	0.28	-
Non-metallic minerals	0.18	0.15	0.03	-	-	-	-	0.00	0.10
Transport equipment	0.01	0.05	0.01	-	-	-	-	0.22	-
Machinery	-	0.11	0.01	-	-	-	-	0.15	-
Mining and quarrying	0.09	0.07	-	-	-	-	-	0.22	-
Food and tobacco	0.01	0.01	-	-	-	-	-	0.01	-
Paper, pulp and printing	0.02	0.40	0.02	-	-	-	-	0.61	2.13
Wood and wood products	0.00	0.03	0.01	-	-	-	-	0.42	0.19
Construction	-	0.01	0.01	-	-	-	-	0.03	0.42
Textile and leather	-	0.01	0.01	-	-	-	-	0.03	0.42
Non-specified	0.01	0.12	0.02	-	-	-	-	0.03	0.42
TRANSPORT SECTOR	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Domestic aviation	-	-	-	-	-	-	-	-	-
Road	-	-	-	-	-	-	-	-	-
Rail	-	0.00	-	-	-	-	-	0.25	-
Pipeline transport	-	-	-	-	-	-	-	-	-
Domestic navigation	-	0.11	-	-	-	-	-	-	-
Non-specified	-	-	-	-	-	-	-	-	-
OTHER SECTORS	-	0.79	0.18	-	-	0.01	0.96	6.03	3.71
Residential	-	0.15	0.05	-	-	-	0.01	0.60	3.41
Comm. and public service	-	0.39	0.10	-	-	-	-	0.04	2.45
Agriculture/forestry	-	0.20	0.02	-	-	-	-	0.31	0.18
Fishing	-	0.04	-	-	-	-	-	-	-
Non-specified	-	0.02	-	-	-	-	-	-	-
NON-ENERGY USE	0.02	2.40	-	-	-	-	-	-	-
in industry/transf./energy	0.02	2.20	-	-	-	-	-	-	-
of which: feedstocks	-	1.49	-	-	-	-	-	-	-
in transport	-	0.21	-	-	-	-	-	-	-
in other sectors	-	-	-	-	-	-	-	-	-
Electricity and Heat Output									
Elec. generated - TW	1.71	-	1.08	0.82	66.97	66.16	1.43	10.66	-
Electricity plants	-	0.10	-	-	66.97	66.16	1.43	-	-
CHP plants	1.71	-	0.97	0.82	-	-	-	10.66	-
Heat generated - PJ	19.37	-	7.14	8.29	-	-	-	0.88	0.88
CHP plants	15.25	-	3.46	7.93	-	-	-	78.82	0.39
Heat plants	4.12	-	3.68	0.36	-	-	-	42.00	0.50

Totals

Comparable information
for all products

Comparable energy
units (Mtoe)

Global picture of energy
situation in a country

Energy balance: oil and oil products

South Africa		2008	
		Unit: ktoe	
	Crude oil	LPG	Gas/diesel oil
Production	805	0	0
Net imports	19534	0	1400
International marine bunkers	0	0	-242
International aviation bunkers	0	0	0
Stock changes	-22	0	0
Total primary energy supply	20338	0	1158
Transfers	0	0	0
Statistical differences	-1516	-2	0
Transformation	-18823	316	6898
Electricity/heat plants	0	0	-35
Oil refineries	-18823	316	6933
Gas works	0	0	0
Energy industry own use	0	0	0
Losses	0	0	0
Total final consumption	0	314	8057
Industry	0	9	906
Transport	0	0	6189
Residential	0	305	0
Commercial and public services	0	0	0
Agriculture/forestry	0	0	961
Non-energy use	0	0	0

Supply

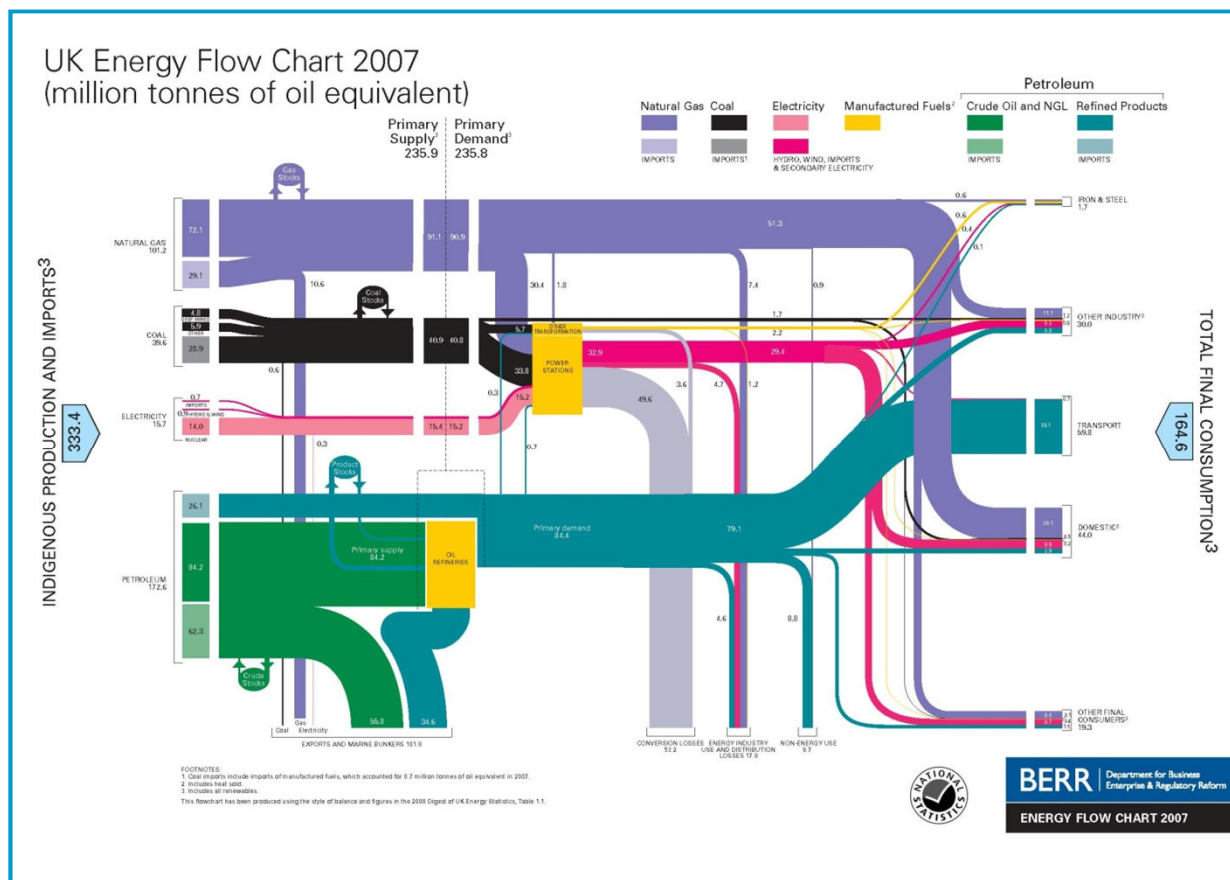
Refined products are secondary energy: production = 0

Transformation

- Negative value represents an input, positive value represents an output

- Transformation **losses** appear in the **Total** column as negative figures

Alternative presentations



Some countries use “flow” charts to visualise their energy balances - no confusion as long as similar principles have been used

Using the energy balance with economic indicators

Using:

- **Population**
- **GDP (using 2000 exchange rates to US dollars)**
- **GDP-PPP (using 2000 PPPs to US dollars)**

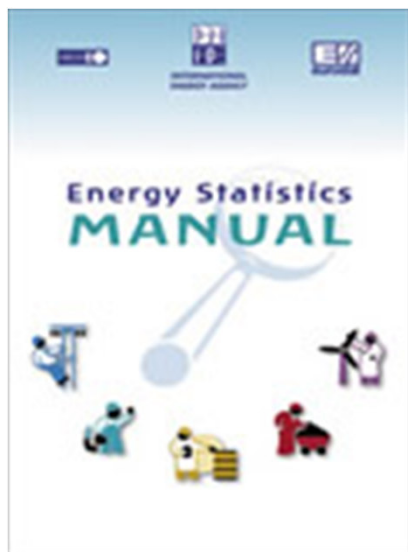


- | | |
|---------------------------------|---|
| • Energy Production/TPES | • Oil Supply/GDP |
| • Net Oil Imports/GDP | • Oil Supply/Population |
| • TPES/GDP | • Electricity Consumption/GDP |
| • TPES/Population | • Electricity Consumption/Population |

Need for additional harmonisation

- There are at least 3 levels for harmonisation:
- **country - organisation**
- **organisation – organisation** (InterEnerStat)
- **energy – economic – environmental** (Oslo City Group, London City Group)

Joint manuals allow countries to see what international organisations are doing



- ◆ In 2004/2005 the IEA and Eurostat have prepared a joint manual to help countries collect and submit energy data
- ◆ The UN is currently working on International Recommendations on Energy Statistics (IRES) to update the previous UN manuals from the 1980s/1990s

InterEnerStat is trying to harmonise definitions across organisations

- **APEC and Eurostat/IEA:** Crude oil is a mineral oil of natural origin comprising a mixture of hydrocarbons and associated impurities, such as sulphur. It exists in the liquid phase under normal surface temperature and pressure and its physical characteristics (density, viscosity, etc.) are highly variable. This category includes field or lease condensate recovered from associated and non-associated gas where it is commingled with the commercial crude oil stream.
- **OLADE:** This is a complex mixture of hydrocarbons of different molecular weights, with a fraction (generally small) of compounds containing sulphur and nitrogen. The composition of petroleum is variable and may be divided into three classes according to the residues that are formed during distillation: paraffins, asphalts or a mixture of the two. Crude oil is used as a raw material for refineries where it is processed to obtain products.
- **OPEC:** Crude oil is technically defined as a mixture of hydrocarbons that exists in the liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities. Production volumes reported as crude oil include:
 - 1. Liquids technically defined as crude oil
 - 2. Small amounts of hydrocarbons that exist in the gaseous phase in natural underground reservoirs but are liquid at atmospheric pressure after being recovered from oil well (casing head) gas in lease separators.
 - 3. Small amounts of non-hydrocarbons produced and remaining with oil.
- **UNSD:** Crude Oil/Petroleum: A mixture of pentanes and heavy hydrocarbons that may be contaminated with sulphur compounds which is recovered at a well from an underground reservoir and is liquid when its volume is measured. Excludes raw gas and condensate.

Benefits of harmonisation would be felt at all levels

In general, harmonisation would:

- **help policy makers take informed decisions**
- **reduce the workload on administrations collecting and supplying data**
- **reduce the need for organisations to explain differences between different data sets to inexperienced users**
- **help the general public understand the energy situation of their own country as well as other countries**
- **Statistics of South Africa are published by several organisations (UNSD, IEA, etc.) Harmonisation in the definitions will certainly help comparability**

Although harmonisation is the way to go, we all know that it is a lengthy process.

In conclusion, good (hopefully harmonised) energy balances:

- **Require good quality statistics (data, calorific values)**
- **Are a compact source of energy information (convenient!)**
- **Enable accurate checks of energy statistics (efficiencies...)**
- **Are the foundation for basic energy indicators, energy accounts and for CO₂ emissions estimates**
- **...Are not necessary, but highly recommended!**

Thank you