

# Energy Balances Overview

Joint IEA, ESCWA and RCREEE National Workshop  
on Energy Statistics

Cairo, Egypt

27 April – 01 May 2014



# Energy balances

ENERGY BALANCES OF OECD COUNTRIES (2002=100) - 2008

OECD Total : 2008

Source/Use	Total	Coal	Oil	Gas	Nuclear	Hydro	Geothermal	Wind	Solar	Other	Total
	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000	1000000
Production	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Imports	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Exports	-100.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-100.00
Net change in stocks	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Losses	-100.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-100.00
Final energy	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
Electricity	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
Heat	90.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	90.00
Transport	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
Industry	40.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.00
Buildings	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00
Transport	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00
Other	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.00

INTERNATIONAL ENERGY AGENCY

- What is an energy balance?
- Why calculate an energy balance?
- How to compute energy balances
- IEA energy balance layout
- Use of energy balances



# IEA energy balance layout: compact source of information

Statisland

Million 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	
<b>Supply</b>	Production	0.21	-	-	1.0	3.60	5.66	0.22	10.38	-	0.27	30.35
	Imports	154	19.59	7.37	-	-	-	-	1.18	-	-	30.79
	Exports	-0.19	-0.38	-1.68	-	-	-	-	-0.78	-	-	-13.03
	Intl. marine bunkers	-	-	-2.09	-	-	-	-	-	-	-	-2.09
	Intl. aviation bunkers	-	-	-0.71	-	-	-	-	-	-	-	-0.71
	Stock changes	0.36	0.32	-0.58	-	-	-	-	-	-	-	0.11
	<b>TYPES</b>								4.40	0.27		<b>45.41</b>
	Transfers	-	-	-	-	-	-	-	-	-	-	0.09
	Statistical differences	0.06	0.27	-0.02	0.02	-	-	-	-	-	-	0.33
	Electricity plants	-	-	-0.03	-	3.60	-5.66	-0.21	10.38	-	-	-9.13
	CHP plants	-0.66	-	-0.03	-	-	-	-3.76	137	2.81	-	-0.97
	Heat plants	-0.05	-	-0.03	-	-	-	-1.16	-0.14	139	-	-0.07
	Blast furnaces	0.11	-	-	-	-	-	-	-	-	-	-0.41
	Gas works	0.02	-	-0.01	-0.00	-	-	-	-	-	-	0.00
	Coke/pat. fuel/BKB plants	-0.29	-	-0.01	-	-	-	-	-	-	-	-0.29
	Oil refineries	-	-20.85	20.46	-	-	-	-	-	-	-	-0.39
	Petrochemical plants	-	-	-	-	-	-	-	-	-	-	-
	Liquefaction plants	-	-	-	-	-	-	-	-	-	-	-
	Other transformation	-	-	-	-	-	-	-	-	-	-	-
	Energy industry own use	-0.03	-	-	-	-	-	-	-0.55	-	-	-1.48
	Losses	-0.04	-	-	-	-	-	-	-0.85	-0.21	-	-1.10
	<b>TFC</b>	0.47	-	-	0.57	-	-	0.01	5.45	10.61	4.26	<b>31.98</b>
	<b>INDUSTRY</b>	0.44	-	-	0.41	-	-	4.03	4.42	0.38	-	<b>10.74</b>
	Iron and steel	0.17	-	0.21	0.03	-	-	-	0.31	-	-	0.73
	Chemical and petrochem.	0.01	-	0.06	0.18	-	-	0.01	0.38	-	-	0.64
	Non-ferrous metals	0.04	-	0.03	0.01	-	-	-	0.20	-	-	0.27
	Non-metallic minerals	0.15	-	0.11	0.04	-	-	-	0.08	-	-	0.38
	Transport equipment	0.01	-	0.02	0.01	-	-	-	0.15	-	-	0.19
	Machinery	-	-	0.05	0.01	-	-	-	0.18	-	-	0.24
	Mining and quarrying	0.06	-	0.06	-	-	-	-	0.21	-	-	0.33
	Food and tobacco	-	-	-	-	-	-	-	-	-	-	0.41
	Paper, pulp and printing	0.04	-	0.04	0.01	-	-	3.64	1.92	-	-	5.92
	Wood and wood products	0.01	-	0.02	-	-	-	-	0.18	-	-	0.54
	Construction	-	-	-	-	-	-	-	0.02	-	-	0.09
	Textile and leather	-	-	0.01	0.00	-	-	-	0.01	-	-	0.03
	Non-specified	0.00	-	0.01	0.01	-	-	-	0.50	-	-	0.98
	<b>TRANSPORT</b>	-	-	-	-	-	-	3.34	0.21	-	-	<b>7.67</b>
	Domestic aviation	-	-	-	-	-	-	-	-	-	-	0.14
	Road	-	-	-	-	-	-	-	-	-	-	7.19
	Rail	-	-	0.00	-	-	-	-	0.21	-	-	0.21
	Pipeline transport	-	-	-	-	-	-	-	-	-	-	-
	Domestic navigation	-	-	0.13	-	-	-	-	-	-	-	0.13
	Non-specified	-	-	-	-	-	-	-	-	-	-	-
	<b>OTHER</b>	0.01	-	0.84	0.14	-	-	0.01	1.05	5.98	3.88	<b>11.91</b>
	Residential	0.01	-	0.08	0.07	-	-	0.01	0.68	3.52	2.58	6.95
	Comm. and public service	0.01	-	0.55	0.05	-	-	-	0.05	2.30	1.29	4.23
	Agriculture/forestry	-	-	0.18	0.02	-	-	-	0.32	0.16	0.01	0.68
	Fishing	-	-	0.03	-	-	-	-	-	-	-	0.03
	Non-specified	-	-	0.01	-	-	-	-	-	-	-	0.01
	<b>NON-ENERGY USE</b>	0.01	-	1.64	-	-	-	-	-	-	-	<b>1.65</b>
	in industry/transport/energy	0.01	-	1.59	-	-	-	-	-	-	-	1.60
	of which: feedstocks	-	-	1.08	-	-	-	-	-	-	-	1.08
	in transport	-	-	0.06	-	-	-	-	-	-	-	0.06
	in other	-	-	-	-	-	-	-	-	-	-	-
	<b>Electricity and Heat Output</b>											
	<b>Elec. generated - TW</b>	1.60	-	0.73	1.55	52.17	65.85	2.49	12.20	-	-	<b>136.59</b>
	Electricity plants	-	-	0.16	-	52.17	65.85	2.49	-	-	-	120.68
	CHP plants	1.60	-	0.57	1.55	-	-	-	12.20	-	-	15.91
	<b>Heat generated - PJ</b>	17.90	-	6.12	16.38	-	-	-	##	0.63	19.52	<b>187.15</b>
	CHP plants	16.17	-	2.55	15.94	-	-	-	83.05	0.29	5.44	123.44
	Heat plants	1.73	-	3.57	0.44	-	-	-	43.55	0.34	4.09	63.71

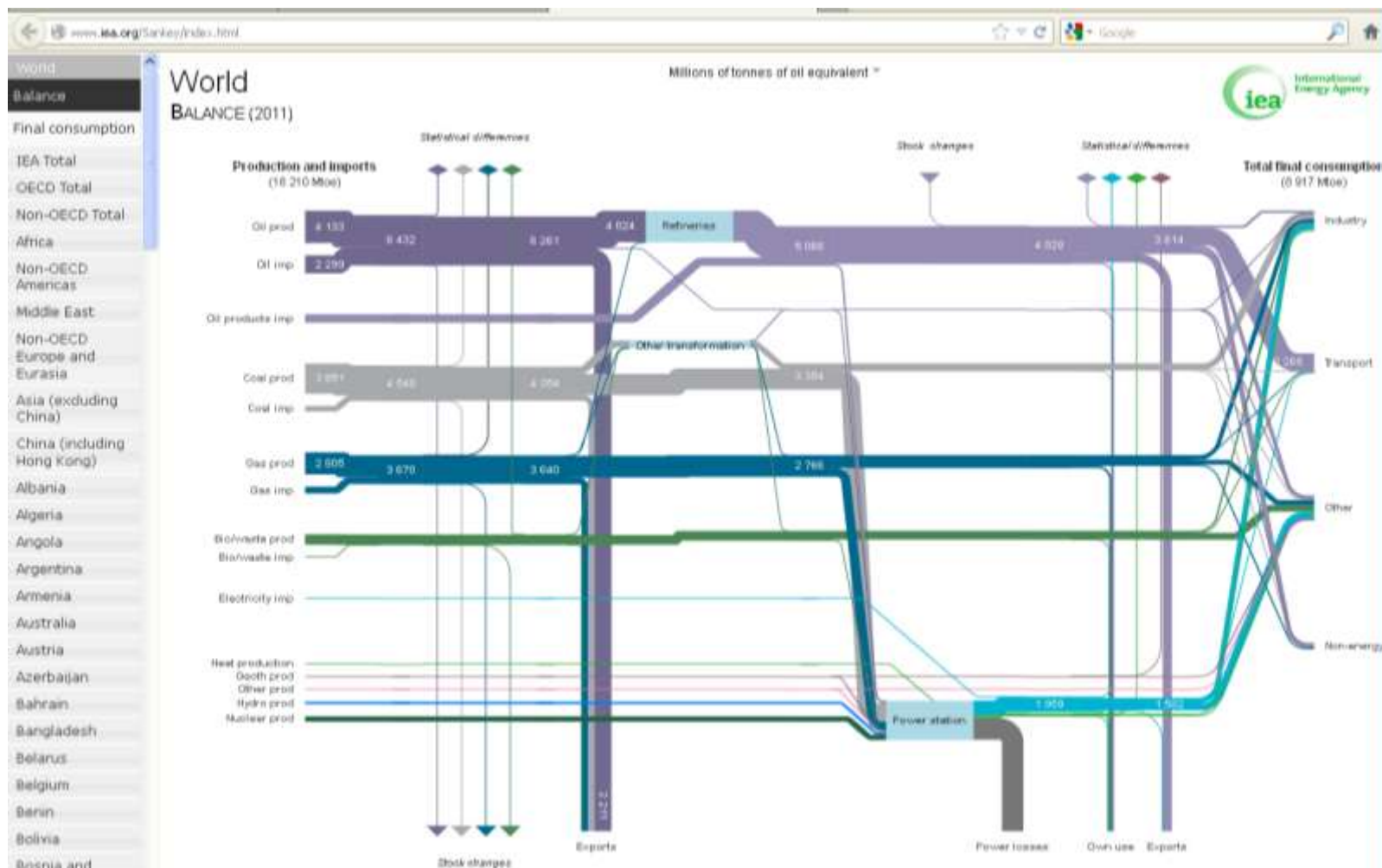
**Totals**

Comparable information for all products

Comparable energy units (Mtoe)

Global picture of energy situation in a country

# Energy balance as a Sankey chart



<http://www.iea.org/Sankey/index.html>

# Why calculate an energy balance?

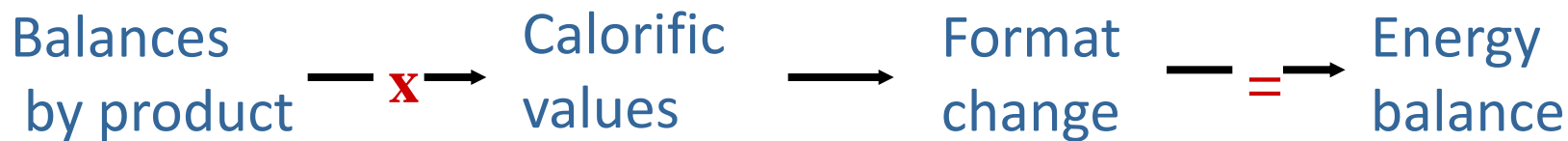
## To compare

- Energy sources in the energy supply of a country
- Sectors of economic activity
- Countries

## To analyse and monitor

- Energy patterns for whole energy market
- Energy intensity, dependence on energy imports (self sufficiency) and other socio-economic indicators
- Data quality (efficiency in transformation sector as a quality indicator)

# From energy statistics to energy balance: How?



with some detailed methodological choices

# Flow of data processing in IEA

5 IEA/Eurostat/UNECE  
Annual Questionnaires

OR

National publications, websites



Coal



Oil



Gas



Renewables  
+ Waste



Electricity  
+ Heat

Original  
Units



Mtoe



Mt of CO<sub>2</sub>



# Energy balance methodological choices

- choice of unit
- net vs. gross calorific values
- choice of calorific values
- choice of primary energy form for energy that is not combusted
- physical energy content vs. substitution method



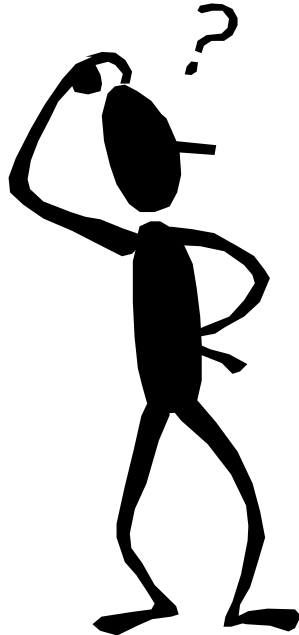
# Which energy units?

Btu

Watt-hours

toe

Joules



ENERGY BALANCE OF OECD COUNTRIES (2010 Edition) - # 11

OECD Total 2008

SECTOR	Total	Losses	Net	Change	Total	Losses	Net	Change
	1000 toe	1000 toe	1000 toe	1000 toe	1000 toe	1000 toe	1000 toe	1000 toe
<b>INDUSTRY</b>	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Manufacturing	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>RESIDENTIAL</b>	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Manufacturing	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>TRANSPORT</b>	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Manufacturing	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Buildings</b>	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Manufacturing	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Electricity and heat</b>	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Manufacturing	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
<b>Other</b>	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Manufacturing	102.58	102.58	0.00	102.58	102.58	102.58	0.00	102.58
Construction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Buildings	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electricity and heat	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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IEA opted for toe

# 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: calorific values

## Coal, natural gas, crude oil and oil products

Natural units are converted to energy units using Net Calorific Values (NCV)

Either default values or as reported in the questionnaires

Varies over time, from commodity to commodity, from country to country and from flow to flow in some cases

Same unit enables cross product analysis



# How to determine Total Primary Energy Supply (TPES)?

- Combustible sources are fired into a power plant
  - There is a transformation loss, typical efficiency of 30-40%
  - E.g. 100 units of coal will give 30-40 units of electricity
- But how about nuclear, geothermal, solar, wind, wave?
  - The output is clear (electricity)
  - But what is the primary energy equivalent?
  - Upstream, did the electricity ever have another form of energy for which multiple energy uses are practical?

# Choice of primary energy form for non-combustible sources

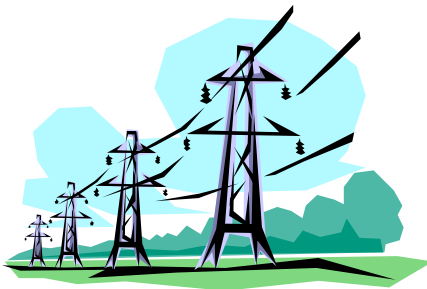
First energy form downstream for which multiple energy uses are practical

## Heat for:



- ◆ nuclear electricity
- ◆ geothermal electricity
- ◆ solar heat

## Electricity for:



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

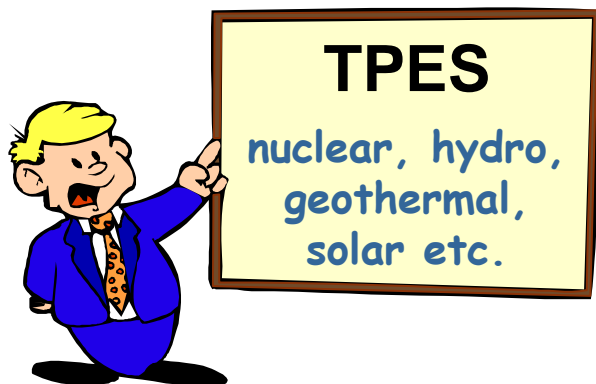
# Choice of method for calculating primary energy equivalent (non-combustible sources)

IEA opted for

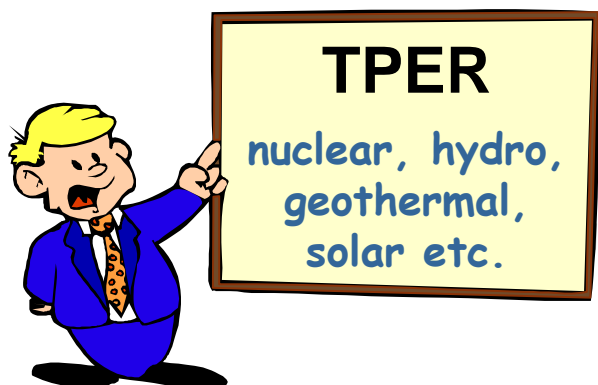


## Physical energy content method

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



# Alternative method for calculating primary energy equivalent (non-combustible sources)

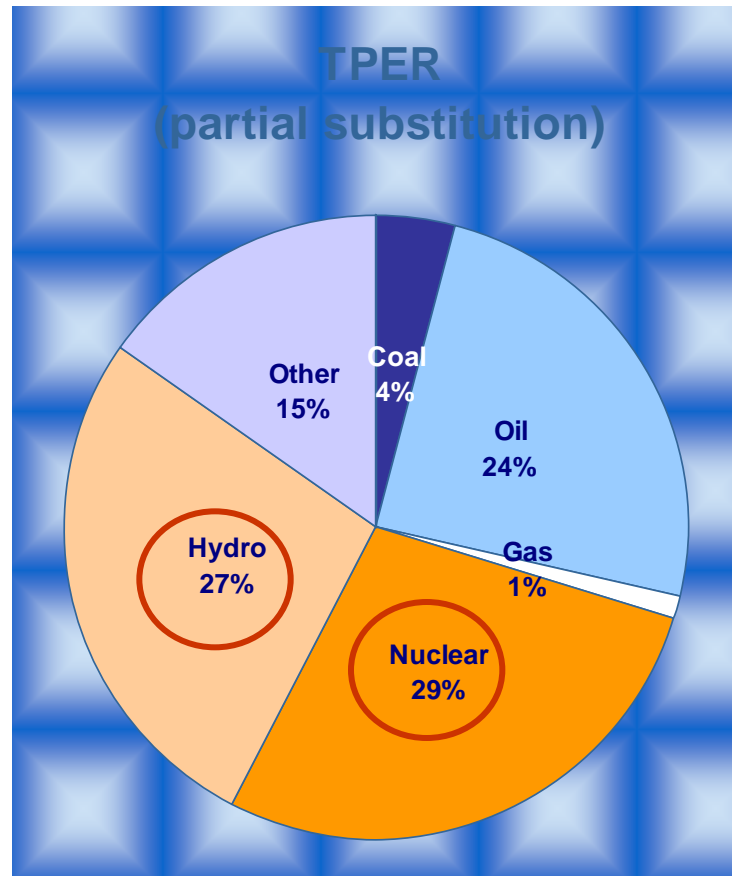
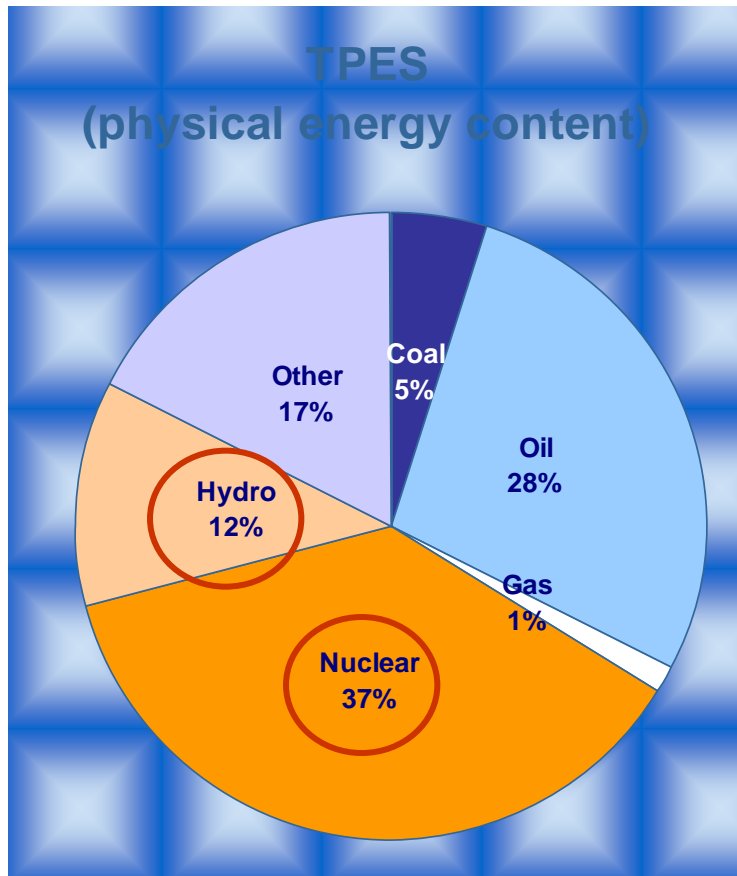


## Partial substitution method

- ◆ 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 vs. Partial Substitution

Example: Sweden, 1999



**Nuclear and hydro: very different shares!**



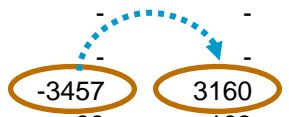
# Key structural features of the IEA energy balance

SUPPLY AND CONSUMPTION	Coal & peat	Crude oil	Oil products	Gas	Nuclear	Hydro	Geotherm. solar etc.	Combust. renew. & waste	Electricity	Heat	Total
Production	7371	660	-	21				806	-		9922
Imports	945	2660	1285	178				1	763		7440
Exports	-57	-1	-237					-4	-757		-1056
Intl. marine bunkers	-	-	-					-	-		-
Intl. aviation bunkers	-	-	-48					-	-		-48
Stock changes	-136	-71	-21					1	-		-227
<b>TPES</b>	<b>8122</b>	<b>3248</b>	<b>979</b>	<b>200</b>				<b>804</b>	<b>6</b>		<b>16032</b>
Transfers	-	51	-47					-	-		4
Statistical differences	303	59	-48					-	5	10	329
Electricity plants	-6785	-	-17	-17		-823		-	3127		-4515
CHP plants	-	-	-33	-99		-		-	36	39	-58
Heat plants	-104	-	-349	-389		-		-1			
Blast furnaces	-247	-	-	-		-		-			
Gas works	-	-	-	-		-		-			
Coke/pat.fuel/BKB plants	-99	-	-	-		-		-			
Oil refineries	-	-3457	3160	-		-		-			
Petrochemical plants	-	99	-103	-		-		-			
Liquefaction plants	-	-	-	-		-		-			
Other transformation	-	-	-	-		-		-			
Energy industry own use	-	-	-	-45		-		-	-322	-20	-387
Losses	-76	-	-	-31		-		-	-508	-81	-696
<b>TFC</b>	<b>1115</b>	<b>-</b>	<b>3541</b>	<b>1420</b>				<b>804</b>	<b>2344</b>	<b>727</b>	<b>9956</b>
<b>INDUSTRY</b>	<b>582</b>	<b>-</b>	<b>498</b>	<b>1002</b>				<b>22</b>	<b>608</b>	<b>296</b>	<b>3007</b>
TRANSPORT	1	-	2178	4					23		2206
OTHER	511	-	176	281			6	781	1714	431	3901
NON-ENERGY USE	21	-	689	132							842

**Supply**  
 Refined products and electricity are secondary energy: production = 0 to avoid double counting

**Transformation**  
 - Negative value represents an input, positive value represents an output  
 - Transformation losses appear in the Total column as negative figures

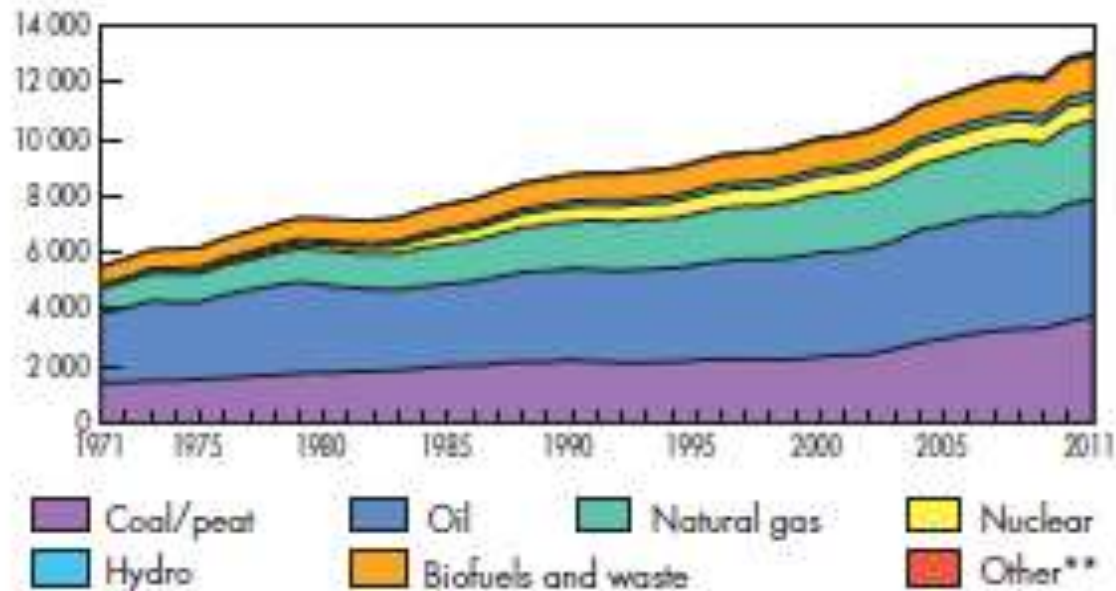
**TPES**  
 Total primary energy supply



# TOTAL PRIMARY ENERGY SUPPLY

## World

World\* total primary energy supply from 1971 to 2011 by fuel (Mtoe)



# Using the energy balance with economic indicators

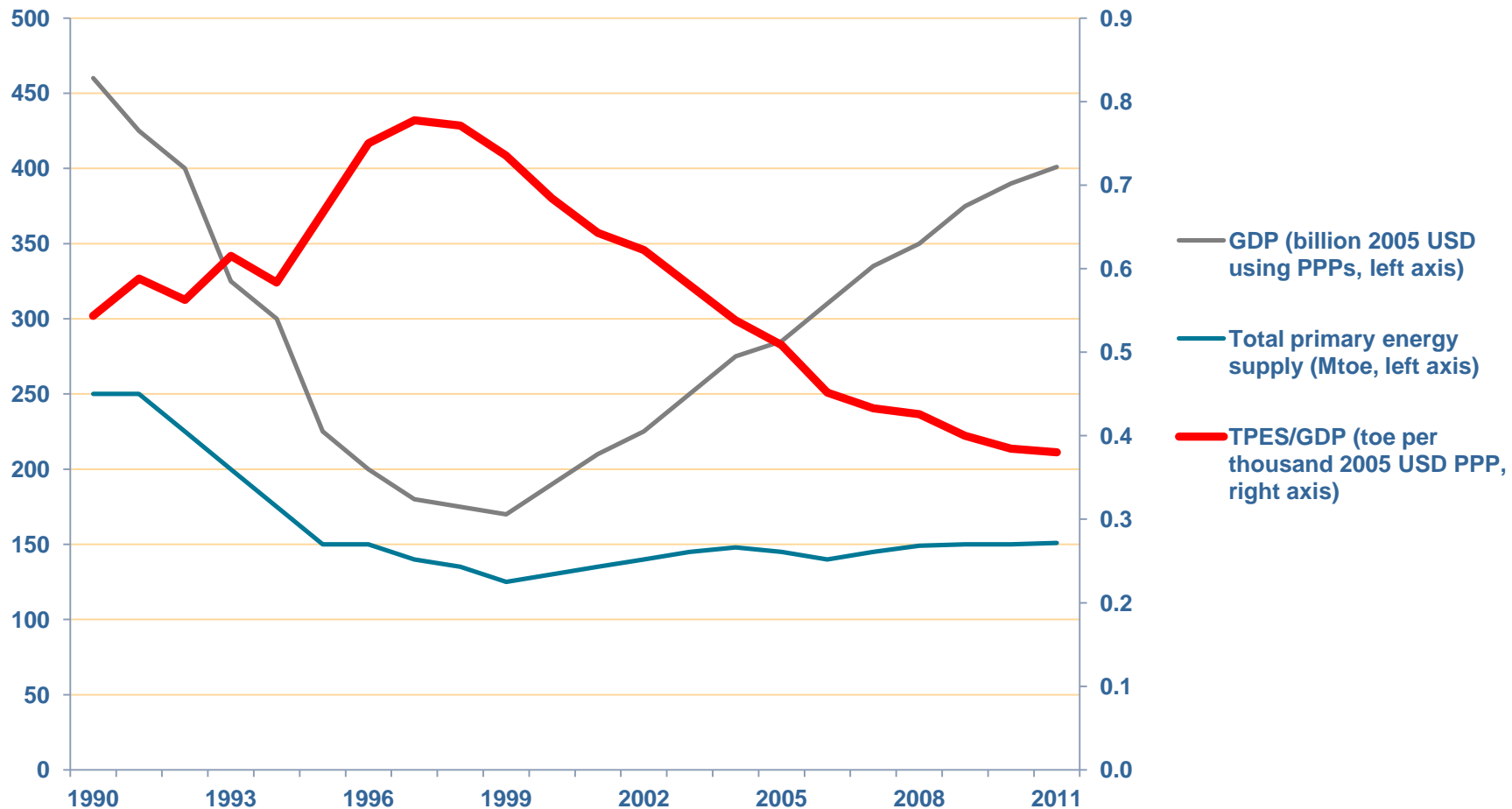
Using:

- Population
- GDP



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

# TPES & GDP

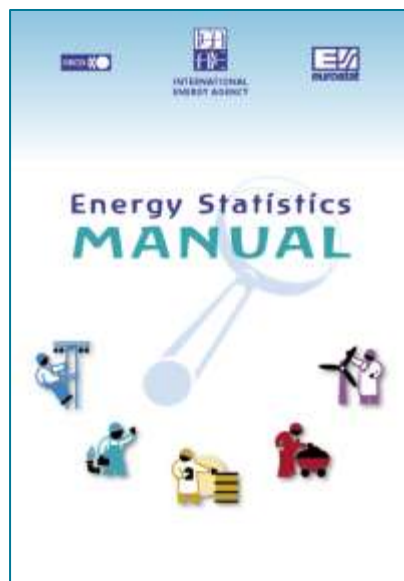


# Users of harmonised energy balances

- National administrations
- Data users
- Policy makers
- General public
- International organisations

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

# Joint manuals help the process



- In 2004/2005 the IEA and Eurostat prepared a joint manual to help countries collect and submit energy data
- The UN has just completed International Recommendations on Energy Statistics (IRES)

## In conclusion, good energy balances:

- Are a compact source of energy information (convenient!)
- Require good quality statistics (data, calorific values)
- Enable accurate checks of energy statistics (efficiencies...)
- Are the foundation for basic energy indicators, energy accounts and for CO<sub>2</sub> emissions estimates

BALANCES@iea.org

Thank you