International Energy Agency

# Using energy statistics: the basics of energy balances

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# Energy Balances

- **A. Introductory elements**
  - Importance of energy balances
  - Energy balance table
  - Benefits of energy balances

- **B. Technical details**
  - How energy balances are calculated
  - Methodology options
  - IEA energy balance layout

# The importance of energy balances: bringing all information together


"…An accounting **framework** for compilation of data on **all energy products entering, exiting, and used** within the national territory of a given **country** during a reference period."

*Source: International Recommendations on Energy Statistics (IRES), UNSD, 2011*

# Why do we develop energy balances?

- **To understand overall energy use in country, i.e.**
  - compute the total energy supply and use
  - assess  relative contribution of different sources in energy mix and/or different sectors in energy demand
  - compute efficiencies of various transformation processes (e.g. electricity generation)

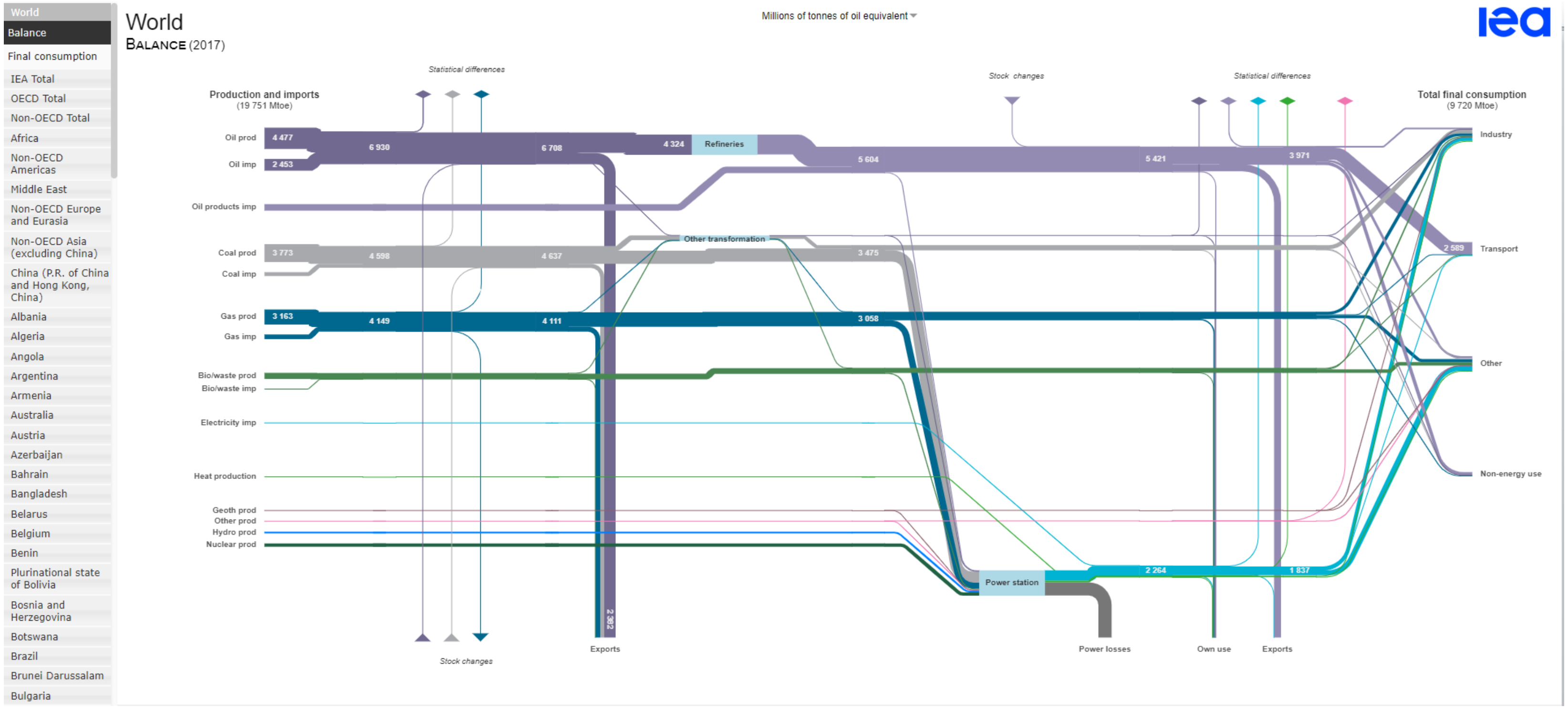
- **To estimate high-level indicators** (i.e. self-sufficiency, energy intensity) **and $CO_2$ emissions from fuel combustion**

- **To assess data completeness and check quality of the various energy commodity balances**

# Energy balance table

How does it look like?

# Energy balance can be depicted as a Sankey chart




https://www.iea.org/sankey/

# The energy balance matrix

| | Coal and peat | Crude oil | Oil products | Natural gas | Nuclear | Hydro | Geothermal, solar, etc. | Biofuels and waste | Electricity | Heat | Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Production | 255731 | 44494 | 0 | 67266 | 0 | 1101 | 16192 | 55467 | 0 | 0 | 440251 |
| Imports | 53 | 19767 | 32674 | 0 | 0 | 0 | 0 | 0 | 257 | 0 | 52751 |
| Exports | -225992 | -15223 | -4121 | -32291 | 0 | 0 | 0 | -1354 | 0 | 0 | -278981 |
| International marine bunkers*** | 0 | 0 | -201 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -201 |
| International aviation bunkers*** | 0 | 0 | -769 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -769 |
| Stock changes | 0 | 600 | -41 | 0 | 0 | 0 | 0 | -24 | 0 | 0 | 536 |
| **TPES** | **29792** | **49638** | **27543** | **34975** | **0** | **1101** | **16192** | **54089** | **257** | **0** | **213587** |
| Transfers | 0 | -1870 | 2069 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 198 |
| Statistical differences | 1778 | 4192 | 998 | 650 | 0 | 0 | 0 | 0 | 123 | 0 | 7742 |
| Electricity plants | -26885 | 0 | -9187 | -10308 | 0 | -1101 | -16192 | -84 | 16847 | 0 | -46910 |
| CHP plants | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Heat plants | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Gas works | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oil refineries | 0 | -48299 | 46449 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1850 |
| Coal transformation | -2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2 |
| Liquefication plants | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Other transformation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -745 | 0 | 0 | -745 |
| Energy industry own use | 0 | 0 | -2219 | -7764 | 0 | 0 | 0 | 0 | -614 | 0 | -10596 |
| Losses | 0 | 0 | 0 | -225 | 0 | 0 | 0 | 0 | -1535 | 0 | -1759 |

- Columns present the "commodity balances" for all products
- Rows present the "flows of energy" across products
- Total energy can be defined

All data are comparable thanks to a common energy unit - IEA methodology uses **ktoe**

# Give your opinion

➢ To convert mass to energy units, we need…

- **Specific gravity**

- **Calorific value**

Typically in units of energy per mass or per volume

- **Emission factor**

# Understanding the flows of energy

201· ▼ | Indicators | Balances | Coal and Peat | Electricity and Heat | Natural Gas | Oil | Renewables and Waste

| | Coal and peat | Crude oil | Oil products | Natural gas | Nuclear | Hydro | Geothermal, solar, etc. | Biofuels and waste | Electricity | Heat | Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Production | 33658 | 173317 | 0 | 132349 | 24390 | 32309 | 901 | 12106 | 0 | 0 | 409029 |
| Imports | 5954 | 34510 | 12790 | 25960 | 0 | 0 | 0 | 759 | 1287 | 0 | 81260 |
| Exports | -20076 | -118761 | -19053 | -76831 | 0 | 0 | 0 | -570 | -4430 | 0 | -239722 |
| International marine bunkers** | 0 | 0 | -524 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -524 |
| International aviation bunkers** | 0 | 0 | -1214 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1214 |
| Stock changes | 66 | 1064 | -206 | 2092 | 0 | 0 | 0 | 0 | 0 | 0 | 3016 |
| TPES | 19603 | 90130 | -8207 | 83569 | 24390 | 32309 | 901 | 12295 | -3144 | 0 | 251845 |
| Transfers | | | | | | | | | | | |
| Statistical differences | | | | | | | | | | | |
| Electricity plants | | | | | | | | | | | |
| CHP plants | | | | | | | | | | | |
| Heat plants | | | | | | | | | | | |
| Gas works | | | | | | | | | | | |
| Oil refineries | 0 | -91737 | 95461 | -849 | 0 | 0 | 0 | 0 | 0 | 0 | 2875 |
| Coal transformation | -1182 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1182 |
| Liquefication plants | 0 | 802 | 0 | -1940 | 0 | 0 | 0 | 0 | 0 | 0 | -1138 |
| Other transformation | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Energy industry own use | -4 | 0 | -7956 | -13986 | 0 | 0 | 0 | -1 | -4019 | 0 | -25966 |
| Losses | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -2984 | 0 | -2984 |
| Total final consumption | 3117 | 0 | 90009 | 55912 | 0 | 0 | 0 | 9766 | 44625 | 546 | 203975 |
| Industry | | | | | | | | | | | |
| Transport | | | | | | | | | | | |
| Other | | | | | | | | | | | |
| Residential | | | | | | | | | | | |
| Commercial and public services | 0 | 0 | 3008 | 10823 | 0 | 0 | 0 | 10 | 12623 | 0 | 26464 |
| Agriculture / forestry | 0 | 0 | 3280 | 724 | 0 | 0 | 0 | 0 | 812 | 0 | 4816 |
| 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 | 634 | 0 | 20603 | 3392 | 0 | 0 | 0 | 0 | 0 | 0 | 24629 |
| *-of which petrochemical feedstocks* | *0* | *0* | *12022* | *3392* | *0* | *0* | *0* | *0* | *0* | *0* | *15415* |

Supply

Transformation

Final consumption

Rows present energy flows across the various products

Three main “blocks” of flows

# 1: Energy supply

| | Coal and peat | Crude oil | Oil products | Natural gas | Nuclear | Hydro | Geothermal, solar, etc. | Biofuels and waste | Electricity | Heat | Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Production | 33658 | 173317 | 0 | 132349 | 24390 | 32309 | 901 | 12106 | 0 | 0 | 409029 |
| Imports | 5954 | 34510 | 12790 | 25960 | 0 | 0 | 0 | 759 | 1287 | 0 | 81260 |
| Exports | -20076 | -118761 | -19053 | -76831 | 0 | 0 | 0 | -570 | -4430 | 0 | -239722 |
| International marine | | | | | | | | | | 0 | -524 |
| International aviatio | | | | | | | | | | 0 | -1214 |
| Stock changes | | | | 209 | | | | | | 0 | [illegible] |
| **TPES** | | | | **8356** | | | | | | [illegible] | **251845** |

| Producers | Mt | % of world total |
|---|---|---|
| United States | 666 | 14.9 |
| Saudi Arabia | 575 | 12.8 |
| Russian Federation | 554 | 12.4 |
| Canada | 259 | 5.8 |
| Iraq | 231 | 5.2 |
| Islamic Rep. of Iran | 221 | 4.9 |
| People's Rep. of China | 188 | 4.2 |
| United Arab Emirates | 179 | 4.0 |
| Kuwait | 148 | 3.3 |
| Brazil | 135 | 3.0 |
| Rest of the world | 1 326 | 29.5 |
| **World** | **4 482** | **100.0** |

*2018 provisional data*

| Net exporters | Mt |
|---|---|
| Saudi Arabia | 348 |
| Russian Federation | 252 |
| Iraq | 187 |
| Islam Rep. of Iran | 132 |
| Canada | 131 |
| United Arab Emirates | 118 |
| Kuwait | 103 |
| Nigeria | 89 |
| Venezuela | 82 |
| Angola | 75 |
| Others | 563 |
| **Total** | **2 080** |

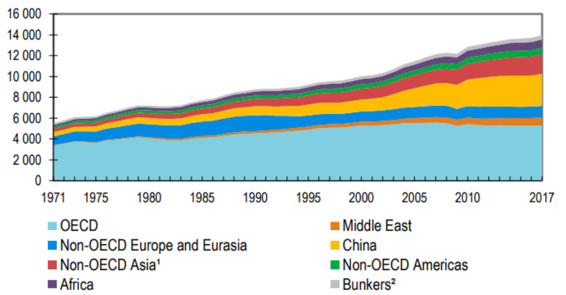
*2017 data*

| Net importers | Mt |
|---|---|
| People's Rep. of China | 415 |
| United States | 349 |
| India | 220 |
| Japan | 158 |
| Korea | 151 |
| Germany | 91 |
| Italy | 69 |
| Spain | 65 |
| Netherlands | 59 |
| France | 58 |
| Others | 527 |
| **Total** | **2 162** |

*2017 data*

## World total primary energy supply by region

World TPES from 1971 to 2017 by region (Mtoe)




"High-level" information: **Total primary energy supply, production, trade, totals, etc…**

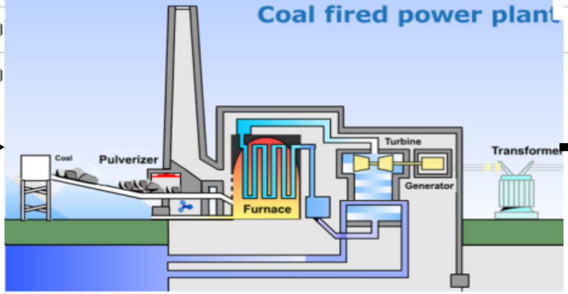
*Source: IEA, Key World Energy Statistics, 2019*

# 2: Transformation and energy sectors

| | Coal and peat | Crude oil | Oil products | Natural gas | Nuclear | Hydro | Geothermal, solar, etc. | Biofuels and waste | Electricity | Heat | Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Electricity plants | -17629 | 0 | -1820 | -10824 | -24390 | -32309 | -901 | -2426 | 53814 | 0 | -36484 |
| CHP plants | 0 | 0 | -41 | -2468 | 0 | 0 | 0 | -39 | 958 | 544 | -1047 |
| Heat plants | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | -62 | 0 | 34 | -28 |
| Gas works | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0 | 0 | 0 | 0 |
| Oil refineries | 0 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 0 | 0 | 0 | 2875 |
| Coal transformation | -1182 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | -1182 |
| Liquefication plants | 0 | 802 | 0 | -1940 | 0 | 0 | 0 | 0 | 0 | 0 | -1138 |
| Other transformation | 0 | 0 | [illegible] | [illegible] | [illegible] | [illegible] | 0 | 0 | 0 | 0 | 0 |
| Energy industry | [illegible] | 0 | [illegible] | [illegible] | [illegible] | [illegible] | 0 | [illegible] | [illegible] | [illegible] | -25966 |

**Transforming energy sources**

**Input (coal)**



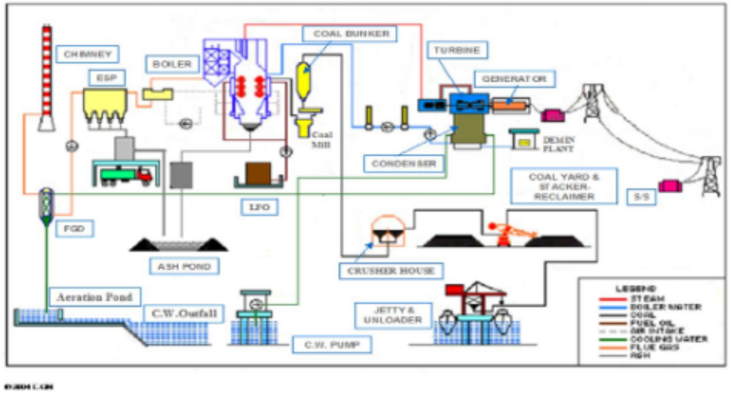

**Output (electricity)**

**The concept of transformation efficiency = output / input**

# Give your opinion

➢ <u>What is the average efficiency for a **coal electricity-only** power plant?</u>

- **37%**
- **52%**
- **65%**




*Source: IEA, World Energy Balances, 2017*

# 3: Final consumption

| | Coal and peat | Crude oil | Oil products | Natural gas | Nuclear | Hydro | Geothermal, solar, etc. | Biofuels and waste | Electricity | Heat | Total* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total final consumption** | **3117** | **0** | **90009** | **55912** | **0** | **0** | **0** | **9766** | **44625** | **546** | **203975** |
| **Industry** | **2450** | **0** | **6067** | **23876** | **0** | **0** | **0** | **5840** | **17698** | **545** | **56476** |
| **Transport** | **0** | **0** | **54404** | **2436** | **0** | **0** | **0** | **1637** | **331** | **0** | **58808** |
| **Other** | **33** | **0** | **8935** | **26208** | **0** | **0** | **0** | **2289** | **26596** | **0** | **64062** |
| Residential | 33 | 0 | 2647 | 14661 | 0 | 0 | 0 | 2279 | 13161 | 0 | 32782 |
| Commercial and public services | 0 | 0 | 3008 | 10823 | 0 | 0 | 0 | 10 | 12623 | 0 | 26464 |
| Agriculture / forestry | 0 | 0 | 3280 | 724 | 0 | 0 | 0 | 0 | 812 | 0 | 4816 |
| 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** | **634** | **0** | **20603** | **3392** | **0** | **0** | **0** | **0** | **0** | **0** | **24629** |

**Deliveries of energy products to all final consumers**

# And finally…

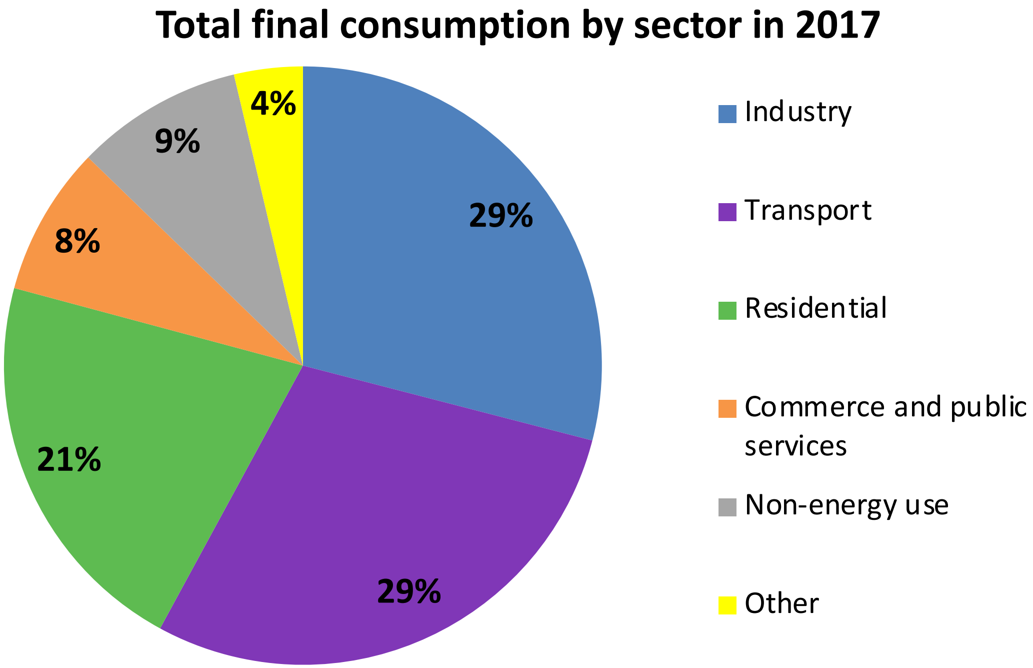
➢ What is the largest energy-consuming sector in the world?

- **Residential**
- **Transport**
- **Industry**

# Answer

➢ What is the largest energy-consuming sector in the world?

- Residential
- Transport
- Industry




*Source: IEA, World Energy Balances, 2019*

# Benefits of energy balances

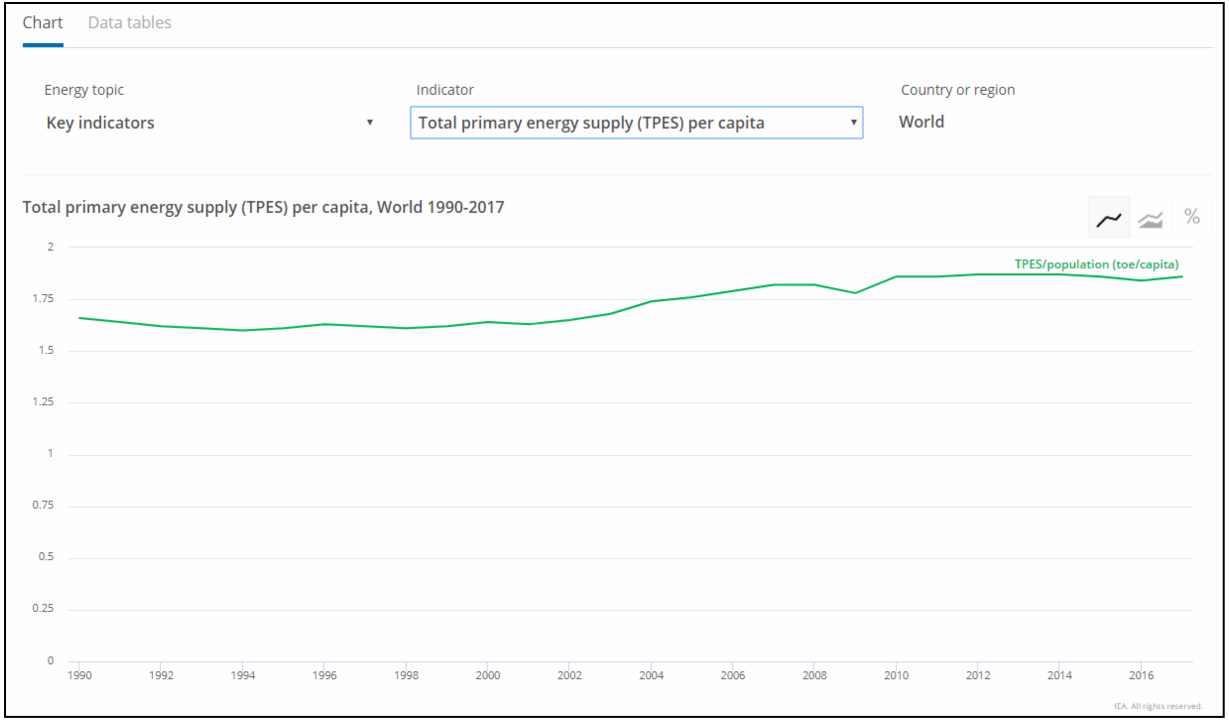
Some examples

# Using the energy balance with economic indicators

- 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

# Developing high-level indicators




- TPES per capita
- TPES per GDP
- TPES per GDP (PPP)
- Net energy imports
- Total $CO_2$ emissions
- $CO_2$ emissions per capita
- $CO_2$ emissions per GDP
- $CO_2$ emissions per GDP (PPP)
- $CO_2$ intensity (TPES/ $CO_2$)
- Electricity final consumption

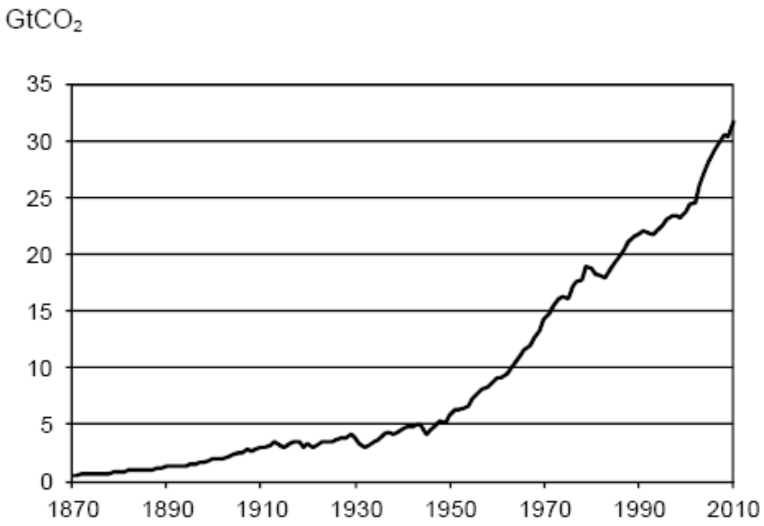
www.iea.org/areas-of-work/data-and-statistics

Coupling **energy balances data** with various **macro-economic variables**

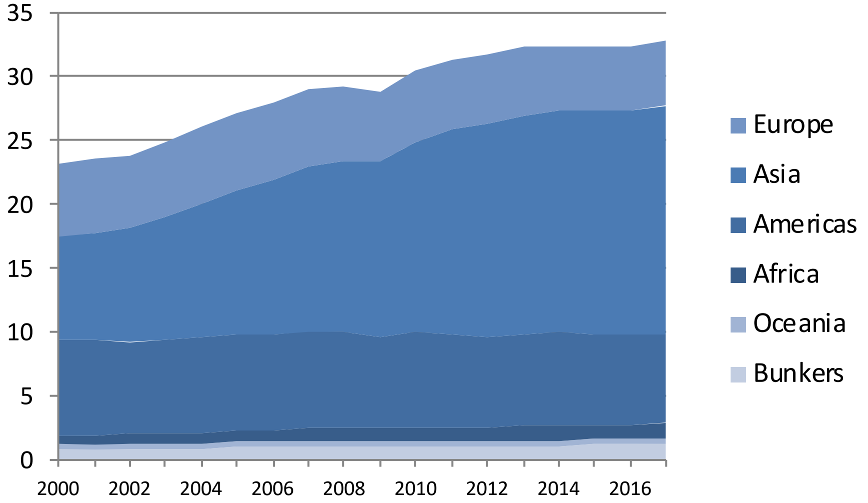
**Source:**
IEA, World Energy Balances, 2019

# Estimating $CO_2$ emissions from fuel combustion

Figure 3. Trend in $CO_2$ emissions from fossil fuel combustion




Source: Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, US Department of Energy, Oak Ridge, Tenn., United States.



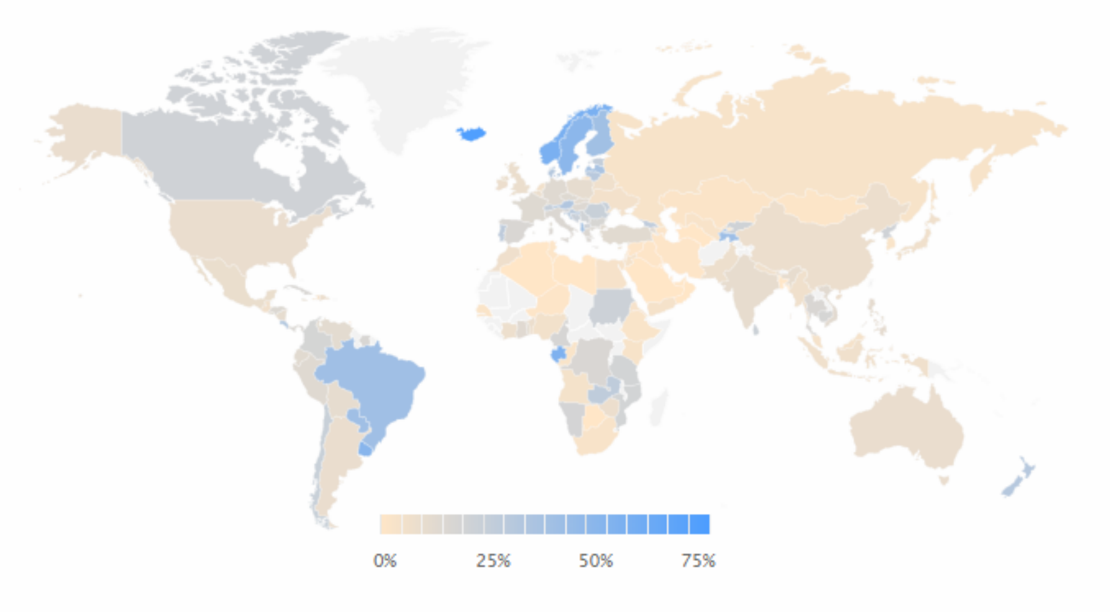

Based on **energy balances** and **IPCC methodologies**

**Source:** IEA, World $CO_2$ Emissions from Fuel Combustion, 2019

# Tracking official SDG targets

SUSTAINABLE DEVELOPMENT GOALS

**World map: Modern renewable share in TFC, 2016**




**Derived from IEA's Energy Balances:**

- **SDG 7.2** on renewable energy
- **SDG 7.3** on energy efficiency
- **SDG 9.4** on emissions per value added

**Further targets monitored by IEA:**

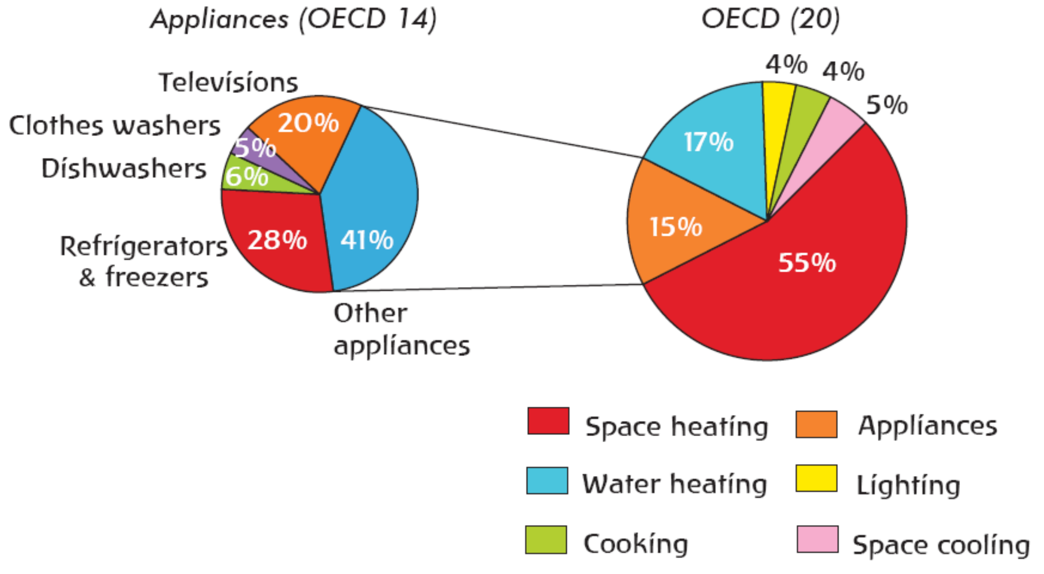
- **SDG 7.1** on access to electricity
- **SDG 7.1** on access to clean cooking
- **SDG 12.c** on rationalising fossil-fuel subsidies

**Source:**
IEA, World Energy Balances, 2018

www.iea.org/sdg/

# Beyond energy balances: monitoring energy efficiency

**Figure 4.4** • *Breakdown of residential consumption by end use in 2010 for 20 selected OECD countries*




Note: The breakdown into individual appliances is available only for 14 countries.

**Starting from energy balances and getting more insights in energy efficiency**

*Source: IEA, Energy Efficiency Indicators: Fundamentals on Statistics, 2016*

# Exercises

Part 1

# Technical details

Process, structure, methodological choices

# How energy balances are calculated

# Flow of data processing at the IEA

**Annual Questionnaires**

OR

**National publications, websites**

Coal

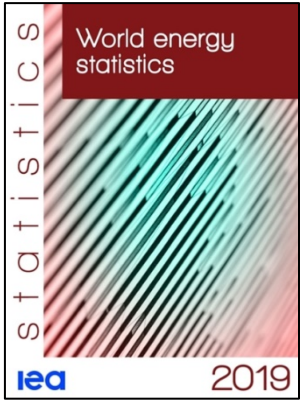
Oil

Natural gas

Renewables

Electricity & Heat

**Commodity Statistics**




**Energy balances**

# From energy statistics to energy balance – How?

Statistics by product —**x**→ Calorific values ——→ Format change **=** Energy balance

## <u>A calorific value</u>

- is the amount of heat obtained from one unit (mass or volume) of the fuel and is the only way to convert a fuel quantity from **physical units** (mass or volume) into **energy units** (e.g. ktoe).

# Calorific values – Key to data quality

| Commodity balances | Bituminous coal kt | Product 2 m3 | … |
|---|---|---|---|
| Production | 100 | | |
| Import | 20 | | |
| Export | 40 | | |
| **Supply** | **80** | | |
| *Statistical differences* | *0* | | |
| Input to Electricity | 50 | | |
| … | | | |
| Final consumption | 30 | | |

| Net Calorific Values | Bituminous coal TJ/kt | Product 2 TJ/m | … |
|---|---|---|---|
| Production | 23 | | |
| Import | 25 | | |
| Export | 22.5 | | |
| | | | |
| | | | |
| Input to Electricity | 22 | | |
| … | | | |
| Final consumption | 20 | | |

| Energy balance (excerpt) | Bituminous coal TJ | Product 2 TJ | … |
|---|---|---|---|
| Production | 2300 | | |
| Import | 500 | | |
| Export | 900 | | |
| **Supply** | **1900** | | |
| *Statistical differences* | *200* | | |
| Input to Electricity | 1100 | | |
| … | | | |
| Final consumption | 600 | | |
| …. | | | |

Need to collect good data for
**physical quantities** AND **calorific values**

# Methodology options

# Energy balance methodological choices:

1. Common unit of account
2. Net vs. Gross calorific value approach
3. Calorific values by product
4. Primary energy form for energy transformations that do not involve combustion
5. Physical energy content vs. Partial substitution method

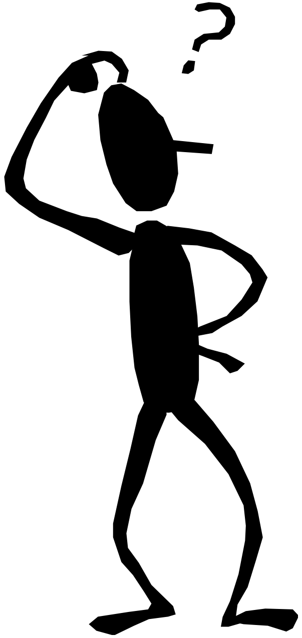
# 1. Which energy unit?

Btu

toe

Joules

Watt-hours



The IEA opted for:

**toe**

WORLD ENERGY BALANCES (2019 edition) - **II.5**

**World**

**2017**

Million tonnes of oil equivalent

| SUPPLY AND CONSUMPTION | Coal[1] | Crude oil[2] | Oil products | Natural gas | Nuclear | Hydro | Geotherm./ Solar/ etc. | Biofuels/ Waste | Electricity | Heat | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Production | 3773.42 | 4477.21 | - | 3162.89 | 687.48 | 351.03 | 256.83 | 1324.11 | - | 1.92 | 14034.90 |
| Imports | 825.07 | 2453.09 | 1364.75 | 986.14 | - | - | - | 26.28 | 62.42 | 0.01 | 5717.75 |
| Exports | -851.61 | -2381.80 | -1477.49 | -1029.84 | - | - | - | -21.11 | -62.73 | -0.00 | -5824.59 |
| Stock changes | 43.06 | 11.76 | 1.98 | -12.39 | - | - | - | -0.22 | - | - | 44.19 |
| **TPES** | **3789.93** | **4560.25** | **-110.76** | **3106.80** | **687.48** | **351.03** | **256.83** | **1329.06** | **-0.31** | **1.92** | **13972.24** |
| Transfers | -1.23 | -241.79 | 271.62 | - | - | - | - | - | - | - | 28.60 |
| Statistical differences | -2.80 | 10.79 | 0.40 | -8.85 | - | - | 0.01 | 0.32 | -3.26 | 4.06 | 0.66 |
| Electricity plants | -1708.53 | -40.14 | -158.92 | -878.85 | -681.92 | -351.03 | -207.40 | -124.10 | 1857.76 | -0.80 | -2293.92 |
| CHP plants | -643.30 | -0.05 | -16.67 | -320.77 | -5.57 | - | -2.67 | -63.62 | 343.97 | 240.12 | -468.55 |
| Heat plants | -22.07 | -0.49 | -9.11 | -64.05 | - | - | -1.47 | -12.71 | -0.80 | 101.13 | -9.57 |
| Blast furnaces | -191.72 | - | -0.03 | -0.03 | - | - | - | -0.05 | - | - | -191.82 |
| Gas works | -12.93 | - | -2.73 | 5.59 | - | - | - | -0.51 | - | - | -10.58 |
| Coke/pat.fuel/BKB/PB plants | -90.48 | - | -2.43 | -0.01 | - | - | - | -0.11 | - | - | -93.03 |
| Oil refineries | - | -4323.70 | 4239.17 | - | - | - | - | - | - | - | -84.53 |
| Petrochemical plants | - | 38.62 | -37.75 | - | - | - | - | - | - | - | 0.87 |
| Liquefaction plants | -14.47 | 15.46 | - | -14.65 | - | - | - | - | - | - | -13.66 |
| Other transformation | -0.26 | 12.20 | -0.55 | -14.47 | - | - | - | -77.26 | - | -0.70 | -81.04 |
| Energy industry own use | -79.87 | -8.86 | -201.60 | -290.77 | - | - | -0.00 | -13.09 | -185.90 | -36.73 | -816.82 |
| Losses | -2.25 | -7.74 | -0.45 | -17.60 | - | - | -0.01 | -0.17 | -173.82 | -19.52 | -221.56 |
| **TFC** | **1020.04** | **14.56** | **3970.18** | **1502.34** | - | - | **45.28** | **1037.76** | **1837.64** | **289.49** | **9717.29** |
| **INDUSTRY** | **817.63** | **5.85** | **314.98** | **567.60** | - | - | **0.96** | **207.10** | **769.11** | **137.66** | **2820.89** |
| Iron and steel | 313.42 | 0.00 | 6.98 | 55.41 | - | - | 0.00 | 3.64 | 97.74 | 13.82 | 491.01 |
| Chemical and petrochemical | 108.46 | 0.04 | 62.67 | 136.65 | - | - | 0.00 | 2.14 | 109.84 | 58.21 | 478.01 |
| Non-ferrous metals | 25.42 | - | 4.56 | 16.59 | - | - | 0.00 | 0.06 | 92.30 | 4.90 | 143.83 |
| Non-metallic minerals | 217.33 | 0.00 | 39.66 | 52.59 | - | - | 0.00 | 9.17 | 50.40 | 2.99 | 372.14 |
| Transport equipment | 2.31 | - | 2.11 | 12.48 | - | - | 0.00 | 0.02 | 25.52 | 3.88 | 46.32 |
| Machinery | 7.88 | 0.00 | 5.50 | 25.82 | - | - | 0.00 | 0.15 | 82.68 | 8.76 | 130.79 |
| Mining and quarrying | 6.09 | - | 23.66 | 8.07 | - | - | 0.00 | 0.22 | 31.46 | 2.10 | 71.60 |
| Food and tobacco | 27.80 | 0.01 | 9.47 | 47.53 | - | - | 0.00 | 36.79 | 44.00 | 11.67 | 177.27 |
| Paper pulp and printing | 16.25 | 0.01 | 3.72 | 24.59 | - | - | 0.00 | 65.55 | 39.68 | 12.25 | 162.05 |
| Wood and wood products | 1.28 | - | 2.19 | 2.96 | - | - | 0.00 | 7.72 | 9.90 | 2.37 | 26.41 |
| Construction | 4.06 | - | 31.40 | 8.69 | - | - | 0.00 | 0.53 | 16.22 | 0.99 | 61.89 |
| Textile and leather | 10.10 | 0.01 | 3.41 | 8.54 | - | - | 0.00 | 3.14 | 27.36 | 9.64 | 62.20 |
| Non-specified | 77.25 | 5.78 | 119.65 | 167.67 | - | - | 0.95 | 77.98 | 142.00 | 6.09 | 597.36 |
| **TRANSPORT** | **0.06** | **0.00** | **2588.51** | **104.71** | - | - | - | **83.59** | **31.27** | - | **2808.15** |
| World aviation bunkers | - | - | 195.37 | - | - | - | - | - | - | - | 195.37 |
| Domestic aviation | - | - | 128.04 | - | - | - | - | - | - | - | 128.04 |
| Road | - | - | 1960.37 | 43.81 | - | - | - | 82.73 | 4.55 | - | 2091.45 |
| Rail | 0.05 | - | 28.84 | - | - | - | - | 0.50 | 22.12 | - | 51.52 |
| Pipeline transport | - | - | 0.25 | 60.62 | - | - | - | - | 2.89 | - | 63.75 |
| World marine bunkers | - | - | 216.87 | 0.06 | - | - | - | 0.22 | - | - | 217.15 |
| Domestic navigation | 0.00 | - | 54.48 | 0.07 | - | - | - | 0.14 | - | - | 54.69 |
| Non-specified | 0.01 | 0.00 | 4.29 | 0.15 | - | - | - | 0.00 | 1.71 | - | 6.17 |
| **OTHER** | **151.72** | **0.01** | **433.19** | **644.07** | - | - | **44.33** | **747.07** | **1037.27** | **151.82** | **3209.47** |
| Residential | 75.55 | - | 214.76 | 440.58 | - | - | 32.73 | 702.72 | 496.58 | 101.36 | 2064.27 |
| Comm. and public services | 33.30 | - | 84.66 | 190.31 | - | - | 8.14 | 30.42 | 398.73 | 39.01 | 784.56 |
| Agriculture/forestry | 16.42 | 0.01 | 107.02 | 9.89 | - | - | 2.18 | 10.75 | 55.18 | 3.47 | 204.93 |
| Fishing | 0.00 | - | 6.13 | 0.04 | - | - | 0.06 | 0.01 | 0.65 | 0.06 | 6.96 |
| Non-specified | 26.44 | 0.00 | 20.62 | 3.24 | - | - | 1.22 | 3.17 | 86.12 | 7.93 | 148.74 |
| **NON-ENERGY USE** | **50.62** | **8.70** | **633.51** | **185.96** | - | - | - | - | - | - | **878.79** |
| In industry/transf./energy | 50.33 | 8.70 | 588.30 | 185.96 | - | - | - | - | - | - | 833.29 |
| *of which: chem./petrochem.* | *2.96* | *8.62* | *443.96* | *184.97* | - | - | - | - | - | - | *640.60* |
| In transport | - | - | 11.02 | - | - | - | - | - | - | - | 11.02 |
| In other | 0.30 | - | 34.19 | - | - | - | - | - | - | - | 34.48 |
| **Electricity and Heat Output** | | | | | | | | | | | |
| **Electr. Generated - TWh** | **9863.34** | **127.37** | **714.51** | **5882.82** | **2636.03** | **4082.47** | **1700.27** | **595.57** | - | **3.86** | **25606.25** |
| *Electricity plants* | *7482.21* | *127.33* | *657.19* | *4583.03* | *2617.12* | *4082.47* | *1690.43* | *362.17* | - | *3.00* | *21604.96* |
| *CHP plants* | *2381.13* | *0.03* | *57.32* | *1299.80* | *18.91* | - | *9.84* | *233.40* | - | *0.86* | *4001.29* |
| **Heat Generated - PJ** | **5978.06** | **17.68** | **508.55** | **6175.34** | **26.77** | - | **461.89** | **1081.99** | **24.57** | **92.75** | **14367.60** |
| *CHP plants* | *5183.96* | *0.06* | *209.20* | *3953.16* | *26.77* | - | *19.54* | *660.52* | *0.55* | *44.52* | *10098.27* |
| *Heat plants* | *794.10* | *17.63* | *299.35* | *2222.18* | - | - | *442.35* | *421.48* | *24.02* | *48.23* | *4269.33* |

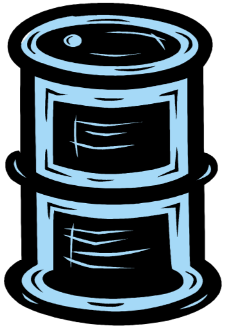
1. Includes peat and oil shale.
2. Includes crude oil, NGL, refinery feedstocks, additives and other hydrocarbons.

INTERNATIONAL ENERGY AGENCY

# 2. Net vs. Gross calorific values?

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

5%



5%

10%

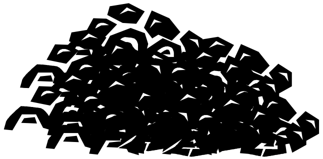
**IEA uses Net Calorific Values (NCVs)**

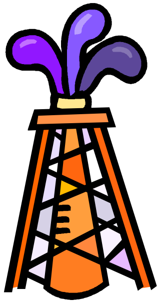
# 3. Choice of calorific values by product

## For Coal, Natural Gas, Crude Oil and Oil products

Calorific values vary:

- over **time** (i.e. vary from year to year)
- between **commodities** (i.e. coal ≠ oil products)
- from **country** to country
- from **flow** to flow (in some cases, i.e. trade ≠ consumption)





# 4a. How to determine primary equivalents for non-combustible sources?

- **Combustible sources** have measurable inputs in the context of a transformation (i.e. natural gas input for gas-fired generation)

- But how about non-combustible sources like **nuclear, geothermal, solar, wind, wave**?

  The output is clear (electricity, heat), but how much is the input?

| | Coal* | Crude oil* | Oil products | Natural gas | Nuclear | Hydro | Geothermal, solar, etc. | Biofuels and waste | Electricity | Heat | Total** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Electricity plants | -371875 | 0 | -5332 | -183947 | ? | ? | ? | -14180 | 339376 | 0 | -490319 |

# 4b. What is the primary energy form for non-combustible sources?

- We need to define the form of primary energy to be considered in the supply part for the following sources:

## Heat for:

- nuclear electricity
- geothermal (heat and electricity)
- solar thermal heat

## Electricity for:

- hydro
- wind
- wave/ocean
- solar photovoltaics

→ **First energy form downstream** for which **multiple energy uses** are practical

## 5a. Method for calculating the primary energy equivalent (non-combustible sources)

IEA opted for:

**Physical energy content method**

- **Primary energy equivalent** refers to the physical energy content of the primary energy source chosen in the previous step.
- **Implied efficiencies are:**

*Heat as primary energy form*

- 33% nuclear for electricity generation
- 10% geothermal for electricity generation
- 50% geothermal for heat generation

*Electricity as primary energy form*

- 100% hydro
- 100% wind
- 100% solar-PV

# 5b. Examples: primary energy equivalent calculation

| Primary energy equivalent | Implied Efficiencies | | Energy Outputs |
|---|---|---|---|
| 1 000 toe Wind | 100% | Wind | 1 000 toe electricity |
| 3 000 toe Nuclear | 33% | Nuclear | 1 000 toe electricity |
| 10 000 toe Geothermal | 10% | Geothermal | 1 000 toe electricity |
| 2 000 toe Geothermal | 50% | Geothermal | 1 000 toe heat |

**Primary energy equivalent = Energy outputs ÷ Implied efficiencies**

# IEA energy balance layout

# Key structural features of the IEA energy balance

| SUPPLY AND CONSUMPTION [unit] | Coal | Crude oil | Oil products | Natural Gas | Nuclear | Hydro | Geotherm. solar etc. | Biofuels & Waste | Electricity | Heat | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Production | 39725 | 3597 | - | 65 | | | | 254 | - | | |
| Imports | 39665 | 92632 | 39411 | 816 | | | | 389 | 2437 | | |
| Exports | -1401 | -103 | -22700 | -193 | | | | 455 | -6781 | | |
| Intl. marine bunkers | - | - | -2790 | | | | | - | - | | |
| Intl. aviation bunkers | - | - | -8657 | | | | | - | - | | |
| Stock changes | -756 | 773 | -737 | 14 | | | | - | - | - | 775 |
| **TPES** | **77233** | **96899** | **4527** | **703** | | | | **688** | **-4344** | **-3** | **310123** |
| Transfers | - | 1405 | -660 | - | - | - | - | - | - | - | 745 |
| Statistical differences | -1404 | 11 | -858 | 3373 | - | - | - | 1 | - | - | 1123 |
| Electricity plants | -54256 | - | -783 | -3111 | -22052 | -1767 | -10184 | -5699 | 44631 | - | -53220 |
| CHP plants | -6495 | - | -436 | -12100 | - | - | - | -8434 | 10702 | 8127 | -8635 |
| Heat plants | -332 | - | -137 | [illegible] | | | [illegible] | -1347 | - | 3081 | -970 |
| Blast furnaces | -5531 | - | -32 | | | | | - | - | - | -5564 |
| Gas works | - | | - | | | | | - | - | - | - |
| Coke/pat.fuel/BKB/PBplants | -581 | - | -355 | | | | | - | - | - | -936 |
| Oil refineries | - | -104174 | 102579 | | | | | - | - | - | -1595 |
| Petrochemical plants | - | 5859 | -6006 | | | | | - | - | - | -148 |
| Liquefaction plants | - | - | - | | | | | - | - | - | - |
| Other transformation | - | - | - | | | | | - | - | - | - |
| Energy industry own use | -821 | - | -5624 | [illegible] | | | | -535 | -4288 | -299 | -12824 |
| Losses | -544 | - | - | | | | | -23 | -2215 | -1125 | -3906 |
| **TFC** | **7268** | **-** | **92214** | **55** | | | | **4651** | **44486** | **9782** | **224191** |
| **INDUSTRY** | **6318** | **-** | **2352** | **19** | | | | **3907** | **19484** | **4273** | **55823** |
| **TRANSPORT** | **-** | **-** | **52820** | **446** | **-** | **-** | **-** | **2572** | **1009** | **-** | **56846** |
| **RESIDENTIAL** | **520** | **-** | **11447** | **22092** | **-** | **-** | **663** | **5846** | **11023** | **4420** | **56010** |
| **COMMERCIAL AND PUBLIC SERVICES** | **27** | **-** | **7009** | **10388** | **-** | **-** | **89** | **2327** | **12970** | **1089** | **33899** |

**Supply**
- Refined products and electricity are secondary energy
- Production equals to zero to avoid double counting

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

**TPES**
Total Primary Energy Supply

# Conclusion: Good Energy Balances…

- … require good quality statistics (physical data & calorific values)
- … are a compact source of energy information (convenient!)
- … enable accurate checks of energy statistics (i.e. efficiencies)
- … constitute the foundation for basic energy indicators, energy accounts and for $CO_2$ emissions estimates

BALANCES@iea.org

# Exercises

Part 2

www.iea.org/areas-of-work/data-and-statistics

IEA