



Understanding energy balances

Roberta Quadrelli Head – Energy Balances, Emissions, Prices, Efficiency - IEA Energy Data Centre
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The importance of energy balances: bringing all information together

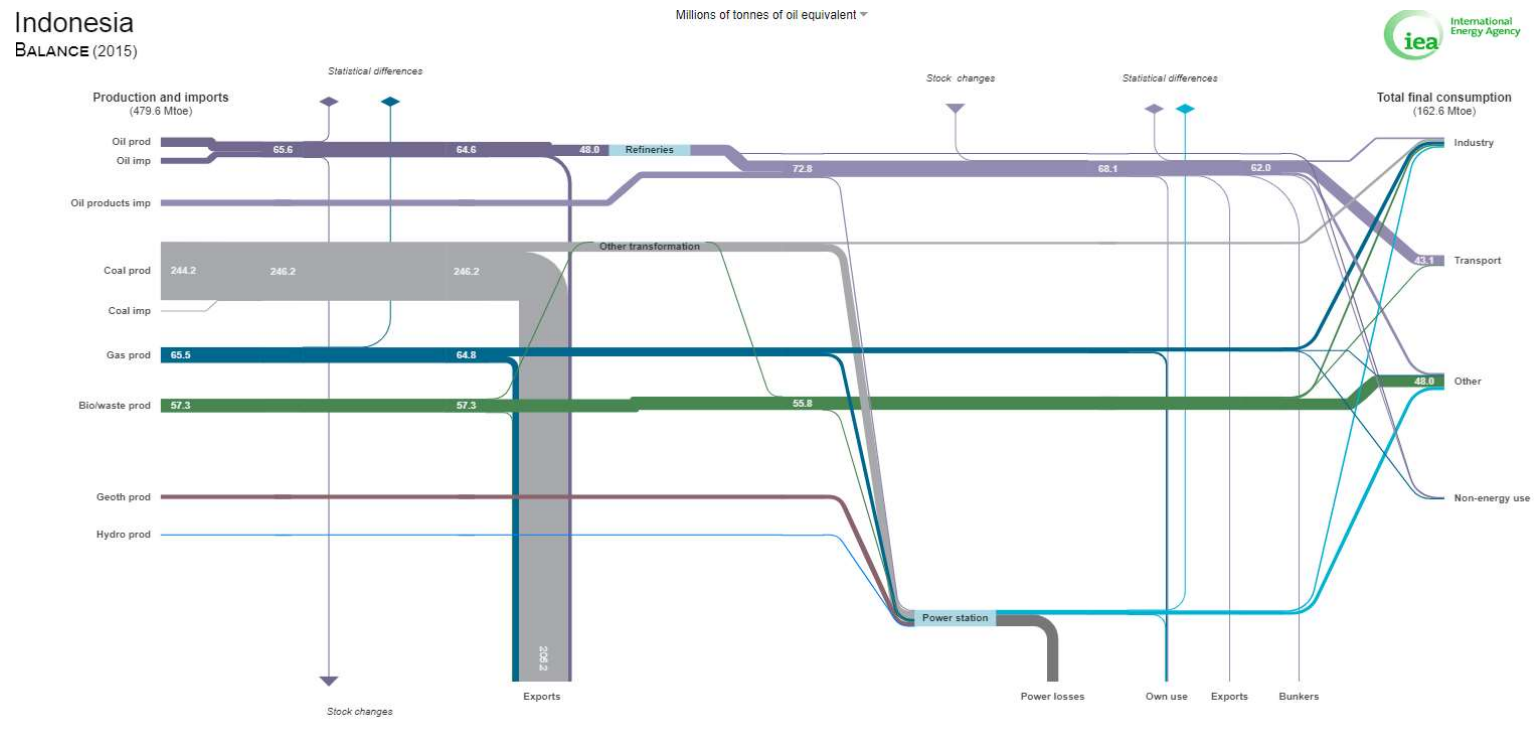


"...An accounting **framework** for compilation of data on **all energy products entering, exiting, and used** within the national territory of a given **country** during a reference period."

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

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The complete picture – Sankey diagram example of energy balance



“Energy balances” are the starting point to develop energy indicators

Why do we develop energy balances?



- **To understand overall energy use in country, e.g.**
- **To estimate high-level indicators and CO₂ emissions** from fuel combustion
- **To assess data completeness and check quality** of the various energy commodity balances

Reading an energy balance

The energy balance table



	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	574102	172933	0	267262	20839	27438	32414	384131	0	0	1479119
Imports	215884	394274	270806	61503	0	0	0	460	3116	0	946043
Exports	-231319	-53719	-205851	-81954	0	0	0	-776	-1171	0	-574790
International marine bunkers***	0	0	-48701	0	0	0	0	0	0	0	-48701
International aviation bunkers***	0	0	-26553	0	0	0	0	0	0	0	-26553
Stock changes	-6734	3830	-2092	-867	0	0	0	-106	0	0	-5968
TPES	551933	517319	-12391	245944	20839	27438	32414	383711	1945	0	1769151
Transfers	0	-1536	2375	0	0	0	0	0	0	0	839
Statistical differences	-2205	-5161	-3641	272	0	0	0	-3	604	0	-10134
Electricity plants	-355445	0	-31163	-119138	-20839	-27438	-31647	-21908	231911	0	-375667
CHP plants	-9940	0	-360	-178	0	0	0	0	3536	1068	-5875
Heat plants	0	0	0	0	0	0	0	0	0	0	0
Gas works	-30	0	0	0	0	0	0	0	0	0	-30
Oil refineries	0	-508585	501625	0	0	0	0	0	0	0	-6960
Coal transformation	-18358	0	0	0	0	0	0	0	0	0	-18358
Liquefaction plants	0	465	0	-862	0	0	0	0	0	0	-397
Other transformation	0	0	0	-49	0	0	0	-16141	0	0	-16190
Energy industry own use	-2575	-628	-20444	-25030	0	0	0	-4	-13904	-65	-62651
Losses	-243	-200	0	-4945	0	0	0	0	-31469	-33	-36890
Total final consumption	163136	1674	436001	96013	0	0	767	345654	192623	971	1236838
Industry	145924	0	53750	39845	0	0	40	57411	84544	236	381748
Transport	17	0	228485	7755	0	0	0	3697	1820	0	241774
Other	16999	0	70468	13385	0	0	727	284546	106260	735	493119
Residential	4588	0	40544	10416	0	0	631	276141	52296	404	385020
Commercial and public services	5583	0	7637	2628	0	0	63	7610	29916	294	53731

Asia excluding China: Balances for 2015
in thousand tonnes of oil equivalent (ktoe) on a net calorific value basis

- Columns present the "commodity balances" for all products
- All data are comparable thanks to a common energy unit
- Total energy can be defined

For discussion



➤ To convert mass (*energy commodities*) to energy units (*energy balances*), what additional data do we need?

A. Density



B. Calorific value



C. Carbon content



For discussion



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Typically in units
of energy per
mass (**kJ/kg**)

Understanding energy flows



Supply

Transformation

Final consumption

	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	574102	172933	0	267262	20839	27438	32414	384131	0	0	1479119
Imports	215884	394274	270806	61503	0	0	0	460	3116	0	946043
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Transfers										0	839
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Electricity plants										0	-375667
CHP plants										0	-5875
Heat plants	0	0	0	0	0	0	0	0	0	0	0
Gas works	-30	0	0	0	0	0	0	0	0	0	-30
Oil refineries	0	-508585	501625	0	0	0	0	0	0	0	-6960
Coal transformation	-18358	0	0	0	0	0	0	0	0	0	-18358
Liquefaction plants	0	465	0	-862	0	0	0	0	0	0	-397
Other transformation										0	-16190
Energy industry own use										-65	-62651
Losses										-33	-36890
Total final consumption	163136	1674	436001	96013	0	0	767	345654	192623	971	1236838
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Other	16999	0	70468	13385	0	0	727	284546	106260	735	493119
Residential	4588	0	40544	10416	0	0	631	276141	52296	404	385020
Commercial and public services	5583	0	7637	2628	0	0	63	7610	29916	294	53731

Rows present energy flows across energy products

Three main "blocks" of flows

2018

1: Energy supply



	Coal*	Crude oil*	Oil products	Natural gas	Nuclear	Hydro	Geothermal, solar, etc.	Biofuels and waste	Electricity	Heat	Total**
Production	574102	172933	0	267262	20839	27438	32414	384131	0	0	1479119
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Producers	Mt	% of world total
Saudi Arabia	583	13.5
Russian Federation	546	12.6
United States	537	12.4
Canada	220	5.1
Islamic Rep. of Iran	200	4.6
People's Rep. of China	200	4.6
Iraq	191	4.4
United Arab Emirates	182	4.2
Kuwait	159	3.7
Brazil	135	3.1
Rest of the world	1 368	31.8
World	4 321	100.0

2016 provisional data

Net exporters	Mt
Saudi Arabia	369
Russian Federation	243
Iraq	148
United Arab Emirates	125
Canada	116
Nigeria	104
Kuwait	100
Venezuela	98
Angola	86
Islamic Rep. of Iran	64
Others	539
Total	1 992

2015 data

Net importers	Mt
United States	348
People's Rep. of China	333
India	203
Japan	165
Korea	139
Germany	91
Italy	67
Spain	65
Netherlands	59
France	57
Others	514
Total	2 941

2015 data

Source: IEA, Key World Energy Statistics, 2017

“High-level” information: **TPES, Totals, etc...**

1: Energy supply



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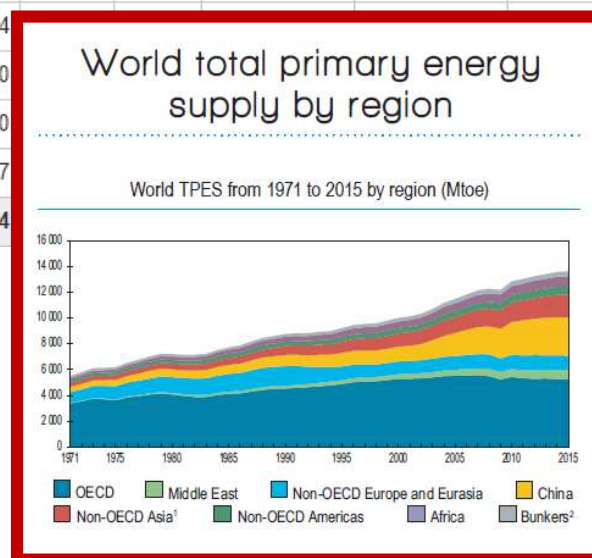
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2015 data



Source: IEA, Key World Energy Statistics, 2017

“High-level” information: **Total primary energy supply, production, trade, etc...**

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	-355445	0	-31163	-119138	-20839	-27438	-31647	-21908	231911	0	-375667
CHP plants	-9940	0	-360	-178	0	0	0	0	3536	1068	-5875
Heat plants	0							0	0	0	0
Gas works	-30							0	0	0	-30
Oil refineries	0	-508585	501625	0	0	0	0	0	0	0	-6960
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Other transformation	0	0					0	-16141	0	0	-16190
Energy industry		-628								-65	-62651
Losses		-200								-33	-36890

Transforming energy sources

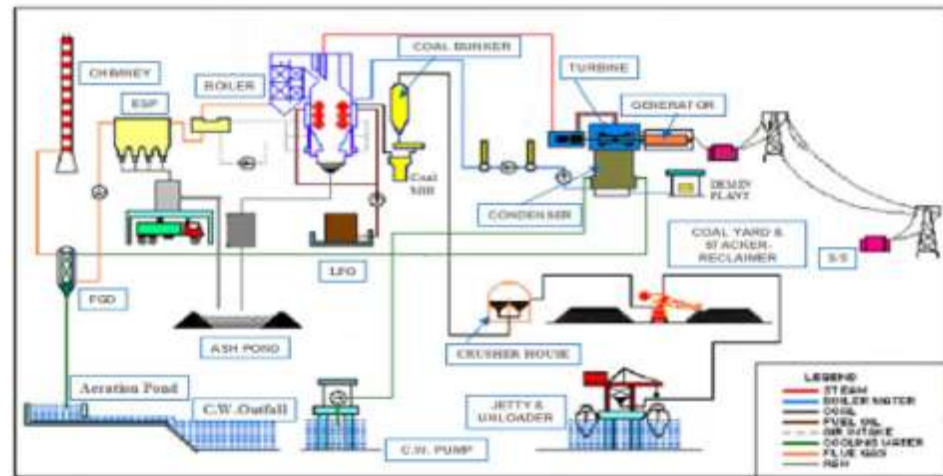


The concept of transformation efficiency = output / input



➤ What is the average efficiency for a **coal electricity-only** power plant?

- A. 37%**
- B. 52%**
- C. 65%**



Source: IEA, World Energy Balances, 2017

Answer

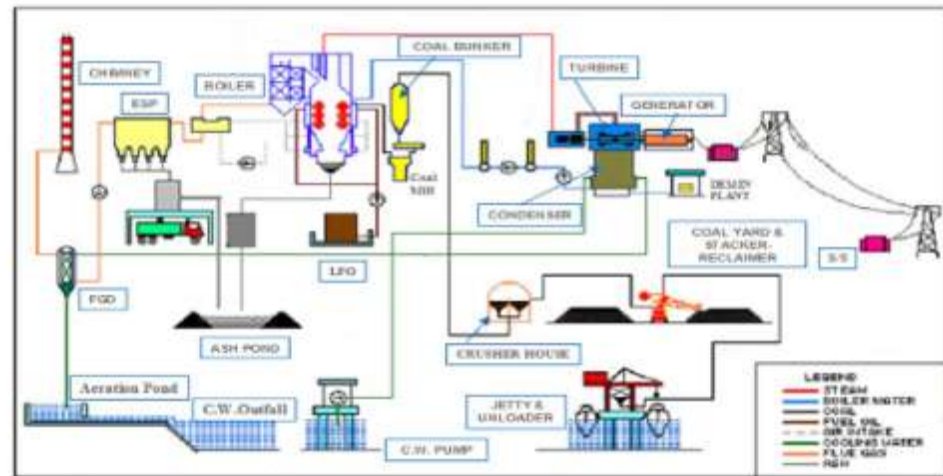


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Commercial and public services	5583	0	7637	2628	0	0	63	7610	29916	294	53731
Agriculture / forestry	22	0	17281	180	0	0	0	8	17852	5	35348
Fishing	0	0	1309	0	0	0	0	3	108	0	1419
Non-specified	6806	0	3698	160	0	0	33	784	6089	32	17602
Non-energy use	196	1674	83297	35028	0	0	0	0	0	0	120196

Delivery of energy products to all final consumers (sectors)

Quiz



➤ What is the largest energy-consuming sector globally?

- **Residential**



- **Transport**



- **Industry**



Answer



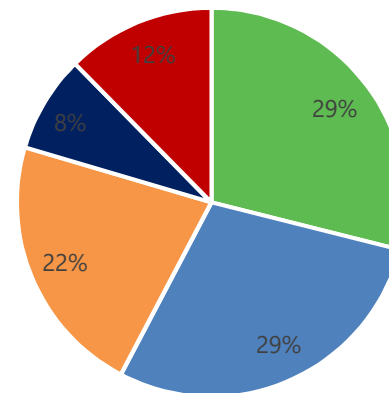
➤ What is the largest energy-consuming sector globally?

World total final consumption, 2015

■ **Residential**

■ **Transport**

■ **Industry**



■ Industry ■ Transport ■ Residential ■ Services ■ Other

Source: IEA, World Energy Balances, 2017

Developing indicators from energy balances

From energy balances we derive high-level information



Supply

Transformation

Final consumption

SUPPLY AND CONSUMPTION	Energy sources or equivalents										Total
	Coal ¹	Crude oil ²	Oil products	Natural gas	Nuclear	Hydro	Geotherm/ Solar/ etc.	Biofuels/ Waste	Electricity	Heat	
Production	3976.14	4308.45	-	2928.32	661.35	334.94	181.07	1413.06	-	2.10	13805.44
Imports	842.15	2213.37	1193.32	844.32	-	-	-	20.22	61.73	0.01	5175.12
Exports	-663.14	-2159.50	-1242.64	-863.25	-	-	-	-18.97	-59.35	-0.01	-5206.85
Stock changes	-36.66	-12.46	-15.23	-8.81	-	-	-	-1.41	-	-	-74.56
TYPES	3918.49	4349.86	-44.56	2960.58	661.35	334.94	181.07	1412.91	2.38	2.10	13699.13
Transfers	-0.47	-204.85	231.24	-	-	-	-	-	-	-	25.92
Statistical differences	-21.01	0.12	4.51	14.68	-	-	-0.06	0.16	-0.43	-0.45	-3.38
Electricity plants	-2112.98	-40.82	-201.89	-771.07	-653.73	-334.94	-140.89	-95.03	1868.42	-0.72	-2483.47
CHP plants	-164.61	-0.01	-17.07	-307.53	-7.62	-	-2.58	-57.43	179.71	148.31	-228.81
Heat plants	-130.32	-0.68	-13.19	-78.82	-	-	-1.00	-11.45	-0.38	179.67	-56.17
Blast furnaces	-206.84	-	-0.38	-0.16	-	-	-	-0.05	-	-	-210.43
Gas works	-10.92	-	-2.73	5.08	-	-	-	-0.06	-	-	-8.67
Coke/peat/fuel/BK/PS plants	-76.25	-	-2.80	-0.01	-	-	-	-0.12	-	-	-79.19
Oil refineries	-	-4123.03	4049.60	-	-	-	-	-	-	-	-73.43
Petrochemical plants	-	33.00	-32.62	-	-	-	-	-	-	-	0.38
Liquefaction plants	-9.67	14.03	-	-17.42	-	-	-	-	-	-	-13.07
Other transformation	-0.43	10.07	-0.52	-11.88	-	-	-	-82.90	-	-0.73	-86.40
Energy industry own use	-101.76	-11.42	-205.29	-291.69	-	-	-0.00	-13.94	-174.52	-34.81	-833.44
Losses	-3.89	-8.90	-0.65	-21.77	-	-	-0.01	-0.19	-169.29	-19.58	-224.20
TFC	1075.42	17.57	3743.64	1419.98	-	36.54	1151.86	1765.90	273.77	-	8424.68
INDUSTRY	858.49	6.80	294.67	548.54	-	0.78	193.52	725.37	123.00	-	2751.17
Iron and steel	329.62	-	7.71	55.34	-	-	3.50	101.39	15.47	-	513.02
Chemical and petrochemical	99.40	0.06	55.00	121.06	-	-	0.00	1.63	100.81	50.24	428.20
Non-ferrous metals	24.28	-	4.97	16.80	-	-	0.00	0.06	79.63	3.35	129.09
Non-metallic minerals	242.62	0.01	41.50	54.75	-	-	0.00	9.07	51.78	3.12	402.84
Transport equipment	3.63	-	2.06	11.93	-	-	0.00	0.05	23.59	4.04	45.31
Machinery	14.39	-	7.21	25.71	-	-	0.00	0.16	78.57	5.35	131.40
Mining and quarrying	10.28	-	23.01	7.20	-	-	0.00	0.17	29.52	2.31	72.48
Food and tobacco	32.20	0.01	10.92	45.22	-	-	0.00	30.82	40.51	11.01	170.69
Paper pulp and printing	19.03	-	4.47	23.25	-	-	0.20	61.18	33.92	11.90	153.95
Wood and wood products	3.63	-	2.07	2.90	-	-	0.00	7.59	10.20	2.02	28.41
Construction	4.86	-	28.81	6.79	-	-	0.00	0.33	15.02	1.34	57.16
Textile and leather	13.95	0.01	4.02	6.24	-	-	0.00	0.27	28.71	6.96	60.16
Non-specified	60.60	6.71	102.91	171.33	-	-	0.57	78.69	131.73	5.91	558.45
TRANSPORT	2.86	-	2426.33	97.90	-	0.00	73.89	26.04	-	-	2627.02
World aviation bunkers	-	-	168.48	-	-	-	-	-	-	-	168.48
Domestic aviation	-	-	107.52	-	-	-	-	-	-	-	107.52
Road	-	-	1864.65	38.10	-	-	-	73.12	0.27	-	1978.14
Rail	2.81	-	29.66	-	-	-	-	0.25	19.95	-	52.68
Pipeline transport	-	-	0.35	59.00	-	-	-	-	2.72	-	62.06
World marine bunkers	-	-	194.64	-	-	-	-	0.08	-	-	194.72
Domestic navigation	-	-	53.35	0.11	-	-	-	0.43	-	-	53.88
Non-specified	0.05	-	7.69	0.70	-	-	0.00	0.01	3.09	-	11.54
OTHER	155.39	0.18	424.53	613.41	-	35.76	884.45	954.49	150.78	-	3218.98
Residential	75.05	-	207.08	419.66	-	-	27.09	847.51	400.41	105.31	2142.13
Comm. and public services	34.97	-	85.50	181.72	-	-	6.48	24.49	378.24	35.25	744.04
Agriculture/forestry	15.13	0.01	106.89	8.68	-	-	1.25	9.83	47.92	3.15	192.87
Fishing	0.00	-	5.84	0.06	-	-	0.07	0.01	0.50	0.02	6.50
Non-specified	30.23	0.16	19.22	3.29	-	-	0.87	2.60	69.42	7.05	132.85
NON-ENERGY USE	58.68	10.60	588.11	160.13	-	-	-	-	-	-	827.52
in industry/transf./energy	58.12	10.60	596.46	160.13	-	-	-	-	-	-	795.31
of which: chem./petrochem.	3.17	10.54	414.10	158.57	-	-	-	-	-	-	585.38
in transport	-	-	5.38	-	-	-	-	-	-	-	5.38
in other	0.56	-	26.27	-	-	-	-	-	-	-	26.83
Electricity and Heat Output											
Electricity Generated - TWh	9707.49	1.63	879.30	5154.83	2535.33	3894.74	1005.96	492.85	-	7.34	25815.80

Energy intensity,
Self-sufficiency ...

Efficiencies of
transformation sector

Shares of energy
consumption by sector

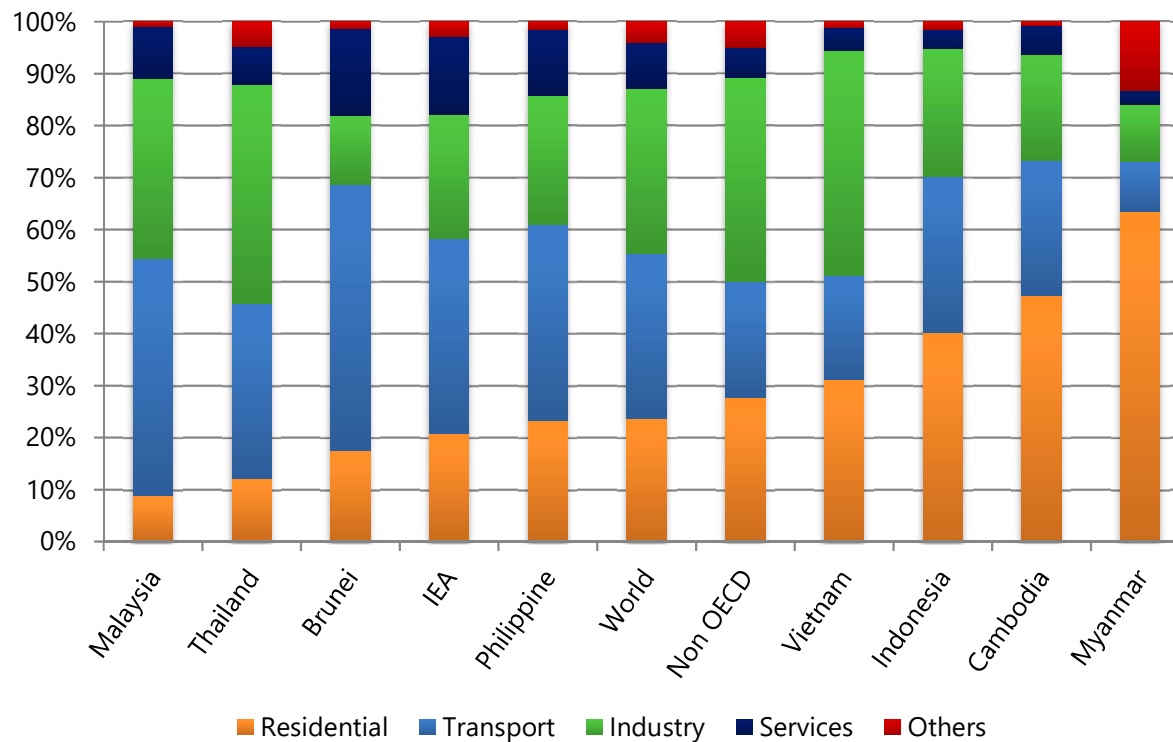
...develop energy intensities and other indicators



Source: IEA, World Energy Balances, 2017

Coupling energy balances data with various macro-economic variables

...understand the shares of sectors in total final consumption



* Total Final Consumption
excluding Non-energy uses

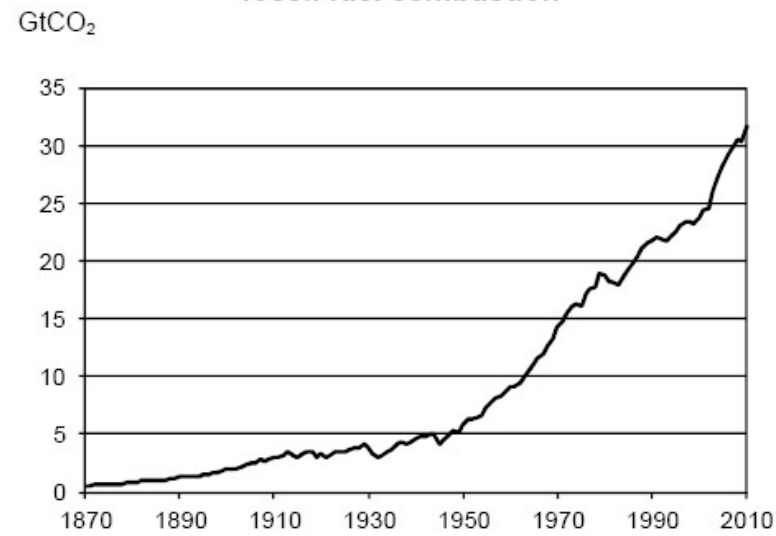
Source, IEA World Energy Balances, 2018

Key to understand where energy is used and to define policy priorities

... estimate CO₂ emissions from fuel combustion



Figure 3. Trend in CO₂ emissions from fossil fuel combustion



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

Source: IEA, World CO₂ Emissions from Fuel Combustion, 2016

Based on energy balances and IPCC methodologies

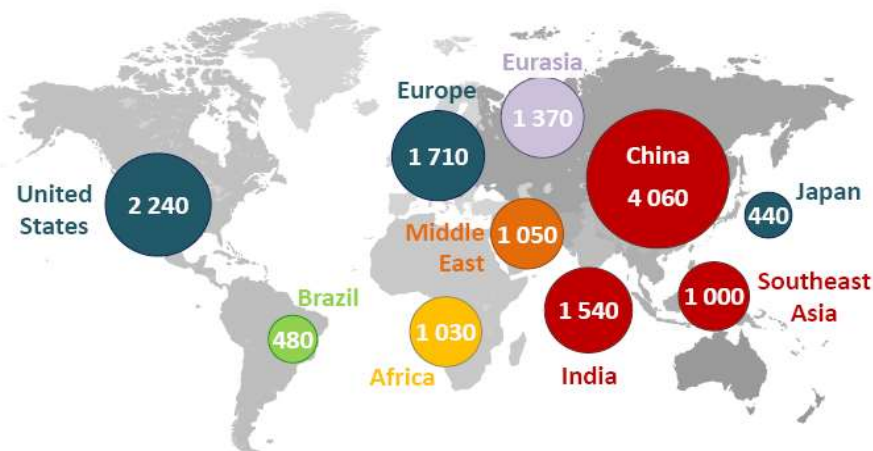
And project energy demand across countries



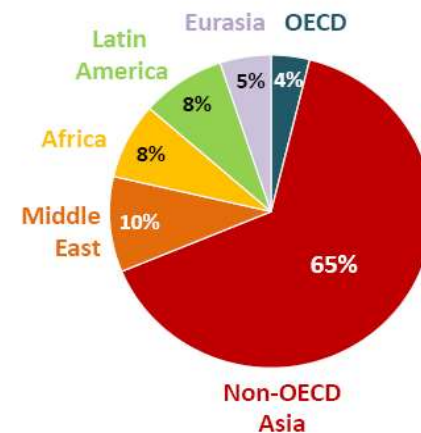
The engine of energy demand growth moves to South Asia

WORLD
ENERGY
OUTLOOK
2013

Primary energy demand, 2035 (Mtoe)



Share of global growth
2012-2035



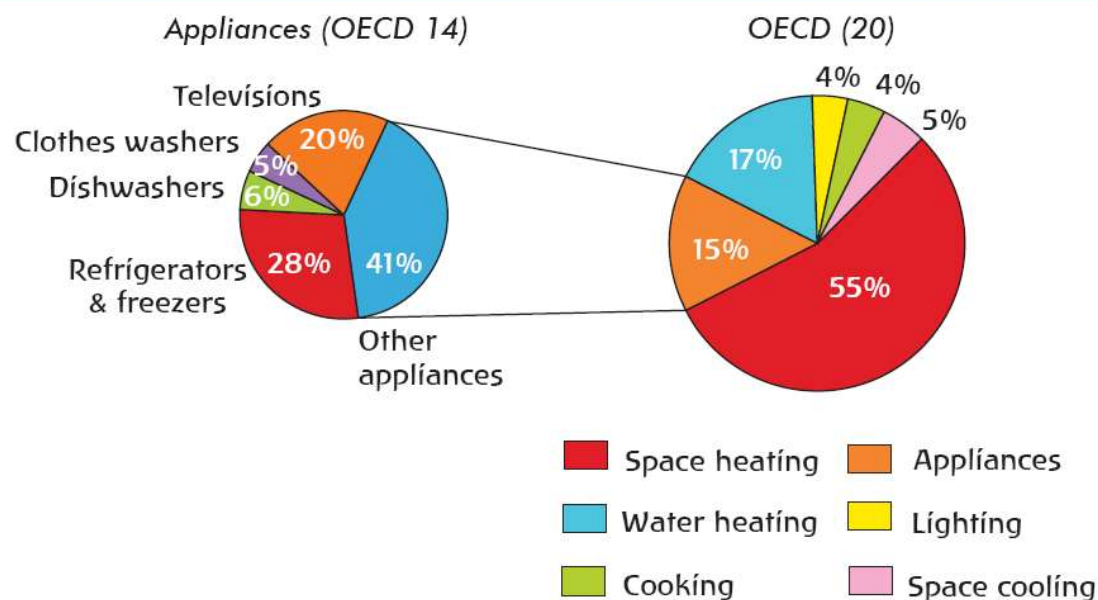
Source: IEA, World Energy Outlook, 2013

Comparability of energy statistics across countries is key

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.

Source: IEA, Energy Efficiency Indicators: Fundamentals on Statistics, 2014

Starting from energy balances and getting more insights in energy efficiency

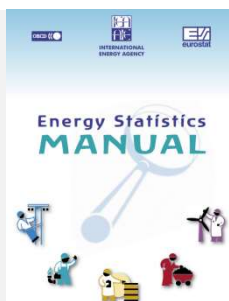
Learn more about Energy Statistics



The IEA produced a comprehensive Energy Statistics Manual covering most of our data collection methodologies, consistently with the IRES framework.

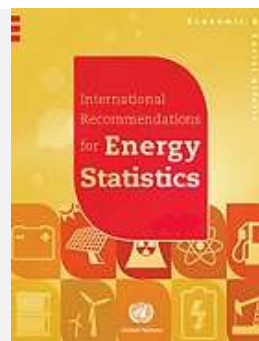
A comprehensive Energy Statistics Manual available in 10 languages.

Click on the manual to download it free of charge!



Visit the **IEA's Statistics website** to access additional resources, including our questionnaires, glossary and documentation related to our data collection methodologies.

To learn more about the international framework for energy statistics, please refer to the United Nations' International Recommendations for Energy Statistics (IRES).





www.iea.org/statistics

