From Statistics to Energy Balances

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SESRIC Webinar Series on statistical experience sharing energy statistics for the SDG7 Indicators

9 November, 2021

International Energy Agency

Energy Balances

World

2019 - unit PJ	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geotherm., solar, wind, etc.	Biofuels and waste	Electricity	Heat	Total
Production	167549	190442	-	143639	30461	15195	13513	56539	-	95	617338
Imports	35644	102662	56858	42995	-	-	2589	1341	2589	0	242089
Exports	-37098	-102077	-60177	-44313	-	-	-2606	-1076	-2606	0	-247347
International marine bunkers	-	-	-	-	-	-	-	-	-	-	-
International aviation bunkers	-	-	-	-	-	-	-	-	-	-	-
Stock changes	-3720	-177	-167	-1537	-	-	-	9	-	-	-5591
TES	**162376**	**190851**	**-3486**	**140784**	**30461**	**15195**	**13436**	**56813**	**-17**	**96**	**606430**
Transfers	-104	-9823	11218	-	-	-	-	-	-	-	1291
Statistical differences	-1850	839	-107	-881	-	-	998	33	963	36	-968
Electricity plants	-72727	-1417	-5727	-38996	-30315	-15195	71105	-5156	81984	-	-98427
CHP plants	-29624	0	-575	-13993	-146	-	26012	-3364	14371	11182	-21690
Heat plants	-1042	-22	-359	-2552	-	-	4078	-540	-	4155	-437
Blast furnaces	-7902	-	-6	-1	-	-	-	-2	-	-	-7912
Gas works	-706	-	-120	254	-	-	-	-40	-	-	-612
Coke/pat. Fuel/BKB plants	-4138	-	-86	-1	-	-	-	-5	-	-	-4230
Oil refineries	-	-182111	178099	-	-	-	-	-	-	-	-4012
Petrochemical plants	-20	-	-	-	-	-	-	0	-	-	-20
Liquefaction plants	-953	892	-	-730	-	-	-	-	-	-	-791
Other transformation	-12	562	-25	-939	-	-	-33	-3637	-14	-19	-4144
Energy industry own use	-3433	-357	-8949	-13438	-	-	-10182	-680	-8392	-1790	-37039
Losses	-99	-317	-8	-1041	-	-	-8082	-8	-7244	-837	-9554
TFC	**39786**	**599**	**168375**	**68405**	**-**	**-**	**97392**	**43415**	**82252**	**12823**	**417973**
INDUSTRY	**32571**	**65**	**12208**	**25700**	**-**	**-**	**40540**	**9895**	**34439**	**6066**	**120979**
Iron and steel	13566	1	246	2607	-	-	5300	198	4734	566	21919
Chemical and petrochemical	2975	1	2462	6383	-	-	7578	103	4637	2881	19503
Non-ferrous metals	1171	0	152	720	-	-	4365	5	4123	242	6412
Non-metallic minerals	8616	0	1616	2674	-	-	2414	490	2261	133	15810
Transport equipment	33	-	82	565	-	-	1274	1	1121	153	1955
Machinery	289	-	191	1357	-	-	4035	6	3877	158	5884
Mining and quarrying	285	-	1005	501	-	-	1571	9	1478	93	3371
Food and tobacco	885	0	340	2062	-	-	2714	1752	2182	532	7753
Paper, pulp and print	483	0	142	980	-	-	2202	2648	1664	539	6457
Wood and wood products	15	-	80	129	-	-	535	451	431	104	1210
Construction	152	0	1530	327	-	-	803	289	750	52	3100
Textile and leather	237	0	86	478	-	-	1617	79	1209	408	2498
Not-specified	3862	62	4270	6917	-	-	6132	3864	5893	203	25106
TRANSPORT	**40**	**0**	**110471**	**4963**	**0**	**0**	**1510**	**3987**	**1510**	**0**	**120972**
Domestic aviation	-	-	5817	-	-	-	-	-	-	-	5817
Road	-	-	83071	2231	-	-	292	3948	292	-	88541
Rail	2	-	1377	-	-	-	1027	23	1027	-	2430
Pipeline transport	-	0	13	2694	-	-	123	-	123	-	2830
Domestic navigation	-	-	2414	3	-	-	-	6	-	-	2423
Non-specified	38	0	210	27	-	-	68	0	68	-	344
OTHER	**5101**	**1**	**17752**	**29531**	**-**	**-**	**55342**	**29533**	**46302**	**6757**	**137319**
Residential	2530	-	8933	20286	-	-	28236	21734	21859	4613	87180
Commercial and public servic	1115	-	3155	8123	-	-	13551	1109	11458	1722	33659
Agriculture/forestry	558	0	4488	438	-	-	2907	536	2681	141	8928
Fishing	0	-	263	2	-	-	33	1	28	2	299
Non-specified	897	0	912	142	-	-	4603	33	4276	278	6653
NON-ENERGY USE	**2074**	**533**	**27945**	**8152**	**-**	**-**	**-**	**-**	**-**	**-**	**38703**
in industry/transformat/energ	2065	533	25914	8152	-	-	-	-	-	-	36664
of which: feedstocks	*142*	*530*	*19086*	*8121*	-	-	-	-	-	-	*27881*
in transport	-	-	467	-	-	-	-	-	-	-	467
in other	9	0	1563	-	-	-	-	-	-	-	1572
Electricity and Heat Output											
Electr. generated - GWh	**3914448**	**113259**	**633912**	**6346003**	**2789634**	**4220733**	**2262594**	**655310**	**-**	**3916**	**26935358**
Electricity plants	*7440453*	*113259*	*583822*	*5003164*	*2778655*	*4220733*	*3251919*	*384265*	-	*3061*	*23776370*
CHP plants	*2473995*	-	*50090*	*1342839*	*11039*	-	*10615*	*271025*	-	*854*	*4159588*
Heat generated - TJ	**6853127**	**17900**	**480296**	**6284406**	**25647**	-	**635391**	**1172748**	**27835**	**104608**	**15601957**
CHP plants	*6001382*	*35*	*179890*	*4204503*	*25647*	-	*83489*	*732896*	*369*	*45312*	*11045573*
Heat plants	*851746*	*17865*	*300406*	*2079902*	-	-	*551902*	*439851*	*27466*	*59296*	*4556384*

- I. What is an energy balance
- II. Why we create energy balances
- III. How energy balances are calculated
- IV. Uses of energy balances

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I. What is an Energy Balance?

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Energy balances are a compact source of information

SUPPLY AND CONSUMPTION 2019 [PJ]	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geotherm., solar, wind, etc.	Biofuels and waste	Electricity	Heat	Total
Production	167549	190442	-	143639	30461	15195	13513	56539	-	95	617338
Imports	35644	102662	56858	42995	-	-	2589	1341	2589	0	242089
Exports	-37098	-102077	-60177	-44313	-	-	-2606	-1076	-2606	0	-247347
International marine bunkers	-	-	-	-	-	-	-	-	-	-	-
International aviation bunkers	-	-	-	-	-	-	-	-	-	-	-
Stock changes	-3720	-177	-167	-1537	-	-	-	9	-	-	-5591
TES	**162376**	**190851**	**-3486**	**140784**	**30461**	**15195**	**13496**	**56813**	**-17**	**96**	**606490**
Transfers	-104	-9823	11218	-	-	-	-	-	-	-	1291
Statistical differences	-1850	839	-107	-881	-	-	998	33	963	36	-968
Electricity plants	-72727	-1417	-5727	-38996	-30315	-15195	71105	-5156	81984	-	-98427
CHP plants	-29624	0	-575	-13993	-146	-	26012	-3364	14971	11182	-21690
Heat plants	-1042	-22	-359	-2552	-	-	4078	-540	-	4155	-437
Blast furnaces	-7902	-	-6	-1	-	-	-	-2	-	-	-7912
Gas works	-706	-	-120	254	-	-	-	-40	-	-	-612
Coke/pat. Fuel/BKB plants	-4138	-	-86	-1	-	-	-	-5	-	-	-4230
Oil refineries	-	-182111	178099	-	-	-	-	-	-	-	-4012
Petrochemical plants	-20	-	-	-	-	-	-	0	-	-	-20
Liquefaction plants	-953	892	-	-730	-	-	-	-	-	-	-791
Other transformation	-12	562	-25	-999	-	-	-33	-3637	-14	-19	-4144
Energy industry own use	-3433	-357	-8949	-13438	-	-	-10182	-680	-8392	-1790	-37039
Losses	-99	-317	-8	-1041	-	-	-8082	-8	-7244	-837	-9554
TFC	**39786**	**599**	**168375**	**68405**	**-**	**-**	**97392**	**43415**	**82252**	**12823**	**417973**
INDUSTRY	32571	65	12208	25700	-	-	40540	9895	34439	6066	120979
TRANSPORT	13566	1	246	2607	-	-	5300	198	4734	566	21919
OTHER	2975	1	2462	6383	-	-	7578	103	4697	2881	19503
NON-ENERGY USE	1171	0	152	720	-	-	4365	5	4123	242	6412

International Recommendations on Energy Statistics: "…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."

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Energy balances are a compact source of information

	SUPPLY AND CONSUMPTION 2019 [PJ]	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geotherm., solar, wind, etc.	Biofuels and waste	Electricity	Heat	Total
Supply	Production	167549	190442	-	143639	30461	15195	13513	56539	-	95	617338
	Imports	35644	102662	56858	42995	-	-	2589	1341	2589	0	242089
	Exports	-37098	-102077	60177	14332	-	-	1896	1176	1506	0	-247347
	International marine bunkers	-	-	-	-	-	-	-	-	-	-	-
	International aviation bunkers	-	-	-	-	-	-	-	-	-	-	-
	Stock changes	-3720	-177	-167	-1537	-	-	-	9	-	-	-5591
	TES	**162376**	**190851**	**-3486**	**140784**	**30461**	**15195**	**13496**	**56813**	**-17**	**96**	**606490**
Transformation and energy industries own use	Transfers	-104	-9823	11218	-	-	-	-	-	-	-	1291
	Statistical differences	-1850	839	-107	-881	-	-	998	33	963	36	-968
	Electricity plants	-72727	-1417	-5727	-38996	-30315	-15195	71105	-5156	81984	-	-98427
	CHP plants	-29624	0	-575	-13993	-146	-	26012	-3364	14971	11182	-21690
	Heat plants	-1042	-22	-359	-2552	-	-	4078	-540	-	4155	-437
	Blast furnaces	-7902	-	-6	-1	-	-	-	-2	-	-	-7912
	Gas works	-706	-	-120	254	-	-	-	-40	-	-	-612
	Coke/pat. Fuel/BKB plants	-4138	-	-86	-	-	-	-	-5	-	-	-4230
	Oil refineries	-	-182111	178099	-	-	-	-	-	-	-	-4012
	Petrochemical plants	-20	-	-	-	-	-	-	0	-	-	-20
	Liquefaction plants	-953	892	-	730	-	-	-	-	-	-	-791
	Other transformation	-12	562	-25	-999	-	-	-33	-3637	-14	-19	-4144
	Energy industry own use	-3433	-357	-8949	-13438	-	-	-10182	-680	-8392	-1790	-37039
	Losses	-99	-317	-8	-1041	-	-	-8082	-8	-7244	-837	-9554
	TFC	**39786**	**599**	**168375**	**68405**	**-**	**-**	**97392**	**43415**	**82252**	**12823**	**417973**
Final consumption	**INDUSTRY**	32571	65	12208	25700	-	-	40540	9895	34439	6066	120979
	TRANSPORT	13566	1	246	2607	-	-	5300	198	4734	566	21919
	OTHER	2975	1	2462	6383	-	-	7578	103	4697	2881	19503
	NON-ENERGY USE	1171	0	152	720	-	-	4365	5	4123	242	6412

Comparable information for all products

Comparable energy units (TJ)

Global picture of energy situation in a country

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II. Why do we create energy balances?

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So we can compute and monitor:

- Total energy supply and consumption as well as patterns for the whole energy market
- Relative weight of different energy sources in the total mix
- Consumption shares across sectors of economic activity
- Energy intensity, dependence on energy imports and other socio-economic indicators
- Similarities or differences with other countries' energy systems

- Data quality (e.g. high statistical difference, efficiency in transformation sector as a quality indicator)

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III. How energy balances are calculated

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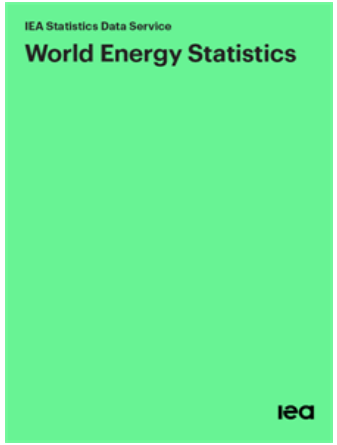
Flow of data processing at the IEA

Annual Questionnaires
OR
National publications, websites

- Coal
- Oil
- Natural gas
- Renewables
- Electricity & Heat

Commodity statistics



Energy balances

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From energy statistics to energy balance – How?

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

A calorific value

- 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. kJ).

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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 and primary energy equivalent for energy transformations that do not involve combustion

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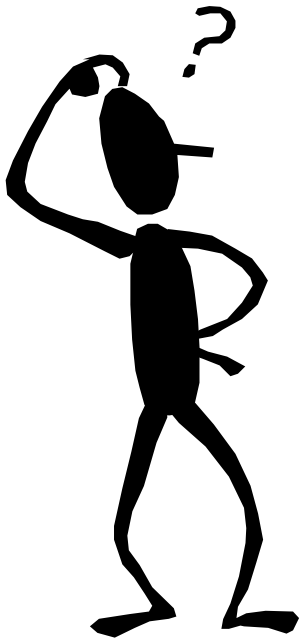
1. Which energy unit?

Btu

toe

Joules

Watt-hours



The IEA opted for:

Joules

World

2019 - unit PJ	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geotherm., solar, wind, etc.	Biofuels and waste	Electricity	Heat	Total
Production	167543	130442	-	142533	30461	15195	13513	56533	-	95	617338
Imports	35644	102662	56658	42395	-	-	2589	1341	2589	0	242089
Exports	-37098	-102077	-60177	-44313	-	-	-2606	-1076	-2606	0	-247347
International marine bunkers	-	-	-	-	-	-	-	-	-	-	-
International aviation bunkers	-	-	-	-	-	-	-	-	-	-	-
Stock changes	-3120	-117	-167	-1537	-	-	-	9	-	-	-5331
TES	**162376**	**130851**	**-3486**	**140784**	**30461**	**15195**	**13436**	**56813**	**-17**	**96**	**606430**
Transfers	-104	-9823	11218	-	-	-	-	-	-	-	1291
Statistical differences	-1650	839	-101	881	-	-	998	33	963	36	-958
Electricity plants	-12727	-1411	-5727	-38996	-30315	-15195	11105	-556	81994	-	-58427
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Petrochemical plants	-20	-	-	-	-	-	-	0	-	-	-20
Liquefaction plants	-553	892	-	-700	-	-	-	-	-	-	-361
Other transformation	-12	562	-25	-989	-	-	-33	-3637	-14	-19	-4144
Energy industry own use	-3433	-351	-8349	-13438	-	-	-10182	-660	-8392	-1790	-37033
Losses	-59	-311	-8	-1041	-	-	-8082	-8	-7244	-837	-9554
TFC	**39786**	**539**	**168375**	**68405**	**-**	**-**	**97392**	**43415**	**82252**	**12823**	**417973**
INDUSTRY	**32571**	**65**	**12208**	**25100**	**-**	**-**	**40540**	**3635**	**34439**	**6066**	**120373**
Iron and steel	15966	1	246	2607	-	-	5300	198	4734	566	29819
Chemical and petrochemical	2375	1	2462	6383	-	-	7578	103	4637	2881	13503
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Not-specified	3862	62	4270	6917	-	-	6132	3864	5835	203	25106
TRANSPORT	**40**	**0**	**110471**	**4363**	**0**	**0**	**1510**	**3387**	**1510**	**0**	**120312**
Domestic aviation	-	-	5917	-	-	-	-	-	-	-	5917
Road	-	-	83071	2231	-	-	232	3348	232	-	89541
Rail	2	-	1377	-	-	-	1027	23	1027	-	2430
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OTHER	**5101**	**1**	**17752**	**29531**	**-**	**-**	**55342**	**29533**	**46302**	**6757**	**137319**
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Fishing	0	-	260	2	-	-	33	1	28	2	293
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in industry/transformation/energy	2065	533	25394	8152	-	-	-	-	-	-	36664
of which: feedstocks	*142*	*539*	*19088*	*8021*	-	-	-	-	-	-	*27789*
in transport	-	-	467	-	-	-	-	-	-	-	467
in other	9	0	1563	-	-	-	-	-	-	-	1572
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Electr. generated - GWh	**3914448**	**113253**	**633312**	**6346009**	**2783634**	**4220733**	**2262534**	**655310**	**-**	**3916**	**26935358**
Electricity plants	*3440452*	*113253*	*593832*	*3980984*	*2770653*	*4220733*	*2225979*	*594285*	-	*3861*	*22778030*
CHP plants	*473995*	-	*39480*	*2365024*	*12981*	-	*36555*	*61025*	-	*55*	*4155568*
Heat generated - TJ	**6853127**	**17300**	**480236**	**6284406**	**25647**	**-**	**635391**	**1172748**	**27835**	**104608**	**15601357**
CHP plants	*6001582*	*35*	*179690*	*4204502*	*25647*	-	*83469*	*733896*	*969*	*45312*	*11243703*
Heat plants	*851546*	*17265*	*300406*	*2079902*	-	-	*551922*	*438851*	*27466*	*59296*	*4357654*

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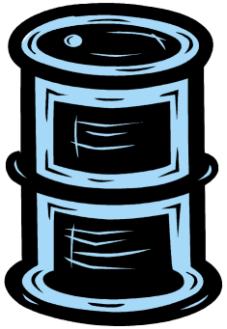
2. Net vs. Gross calorific values?

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)

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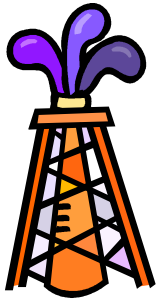
3. Choice of calorific values by product

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)



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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 related amount of primary energy?

	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geotherm., solar, wind, etc.	Biofuels and waste	Electricity	Heat	Total
Electricity plants	-72727	-1417	-5727	-38996	?	?	?	-5156	81984	-	-98427

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4b. Primary energy form and primary energy equivalent

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

Heat:

- nuclear electricity
- geothermal
- solar thermal

Electricity:

- hydro
- wind
- wave/ocean
- solar photovoltaics

IEA opted for: **Physical energy content method**

Implied efficiencies are:

Heat as primary energy form

- **33%** nuclear for electricity generation
- Geothermal { **10%** for electricity generation; **50%** for heat generation
- Solar thermal { **33%** for electricity generation; **100%** for heat generation

Electricity as primary energy form

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

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IV. Uses of energy balances

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Using the energy balance with economic indicators

- **Population**
- **GDP**

Examples:

- Energy Production/TES
- TES/Population
- Oil Supply/GDP
- **SDG 7 indicators**
- Electricity Consumption/Population
- Industry/GDP
- CO_2 emissions per capita

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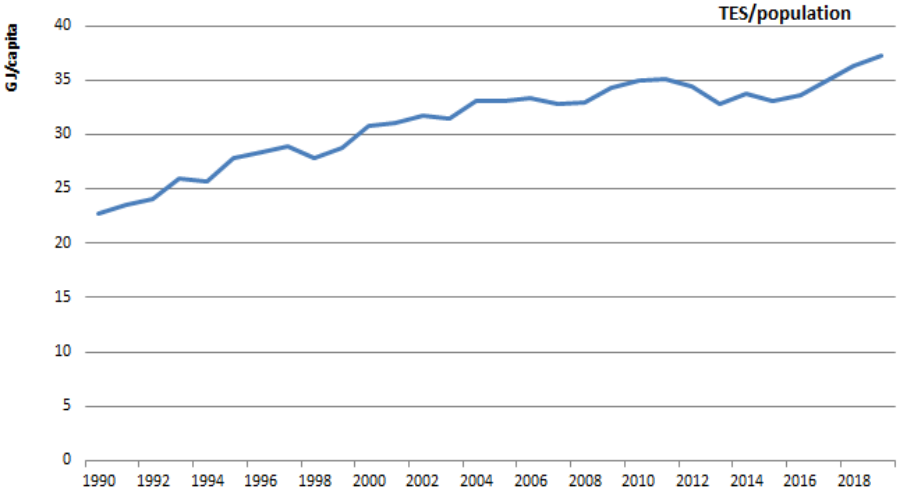
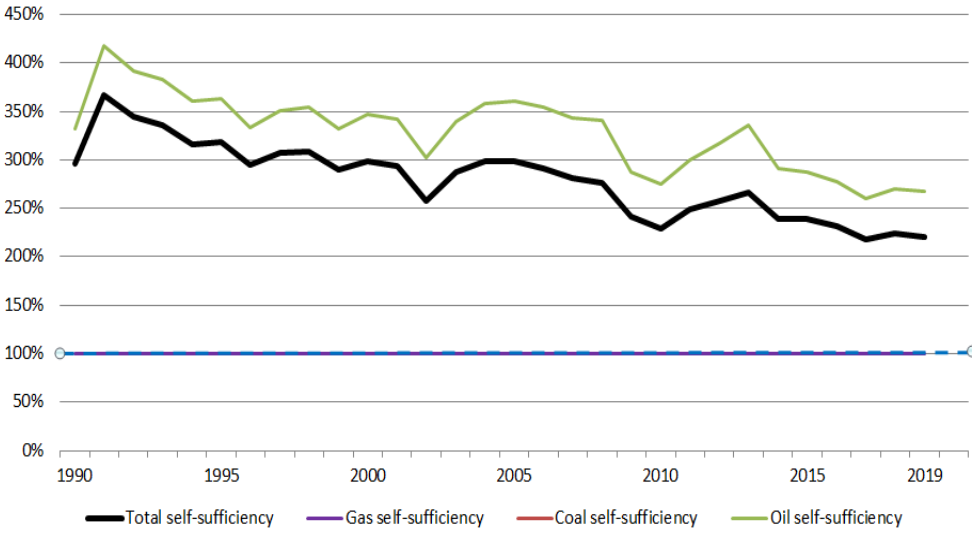
Developing high-level indicators

Indonesia total energy supply (TES) per capita



Saudi Arabia self-sufficiency:



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

www.iea.org/statistics/

Source:
IEA, World Energy Balances, 2021

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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 energy indicators (**among which the SDG 7 ones**), energy accounts and for CO_2 emissions estimates

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Thank you!

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V. Examples and more information

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4c. Examples: primary energy equivalent calculation

Primary energy equivalent	Implied Efficiencies	Energy Outputs
1 000 TJ Wind	100% Wind	1 000 TJ electricity
3 030 TJ Nuclear	33% Nuclear	1 000 TJ electricity
10 000 TJ Geothermal	10% Geothermal	1 000 TJ electricity
2 000 TJ Geothermal	50% Geothermal	1 000 TJ heat

Primary energy equivalent = Energy outputs ÷ Implied efficiencies

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Key structural features of the IEA energy balance

SUPPLY AND CONSUMPTION 2019 [PJ]	Coal	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Geotherm., solar, wind, etc.	Biofuels and waste	Electricity	Heat	Total
Production	167549	190442	-	14				56539	-		
Imports	35644	102662	56858	4				1341	2589		
Exports	-37098	-102077	-60177	-4				-1076	-2606		
International marine bunkers	-	-	-					-	-		
International aviation bunkers	-	-	-					-	-		
Stock changes	-3720	-177	-167	-				9	-	-	-5591
TES	**162376**	**190851**	**-3486**	**140**				**5813**	**-17**	**96**	**606490**
Transfers	-104	-9823	11218	-	-	-	-	-	-	-	1291
Statistical differences	-1850	839	-107	-881	-	-	998	33	963	36	-968
Electricity plants	-72727	-1417	-5727	-38996	-30315	-15195	71105	-5156	81984	-	-98427
CHP plants	-29624	0	-575	-13993	-146	-	26012	-3364	14971	11182	-21690
Heat plants	-1042	-22	-359					-540	-	4155	-437
Blast furnaces	-7902	-	-6					-2	-	-	-7912
Gas works	-706	-	-120					-40	-	-	-612
Coke/pat. Fuel/BKB plants	-4138	-	-86					-5	-	-	-4230
Oil refineries	-	-182111	178099					-	-	-	-4012
Petrochemical plants	-20	-	-					0	-	-	-20
Liquefaction plants	-953	892	-					-	-	-	-791
Other transformation	-12	562	-25					-3637	-14	-19	-4144
Energy industry own use	-3433	-357	-8949					-680	-8392	-1790	-37039
Losses	-99	-317	-8					-8	-7244	-837	-9554
TFC	**39786**	**599**	**168375**	**6**				**3415**	**82252**	**12823**	**417973**
INDUSTRY	32571	65	12208	25700	-	-	40540	9895	34439	6066	120979
TRANSPORT	13566	1	246	2607	-	-	5300	198	4734	566	21919
OTHER	2975	1	2462	6383	-	-	7578	103	4697	2881	19503
NON-ENERGY USE	1171	0	152	720	-	-	4365	5	4123	242	6412

Supply

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

TES
Total Energy Supply

Transformation

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

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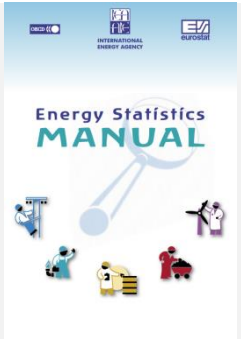
Learn more about Energy Statistics

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.

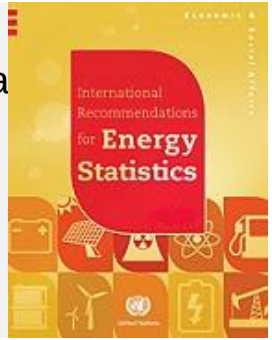
Click on the manual to download it free of charge!



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

STATISTICS

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



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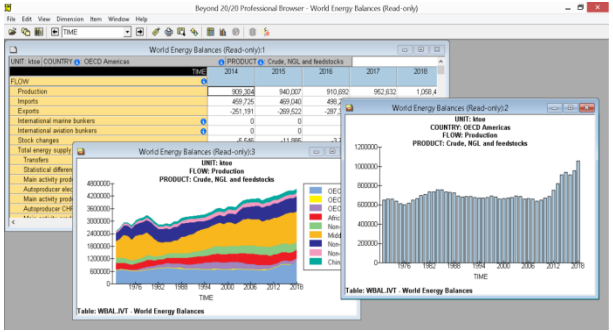
Beyond data collection

Data services for purchase



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[World Energy Balances & Statistics](#)
[Monthly Oil Data Service](#)
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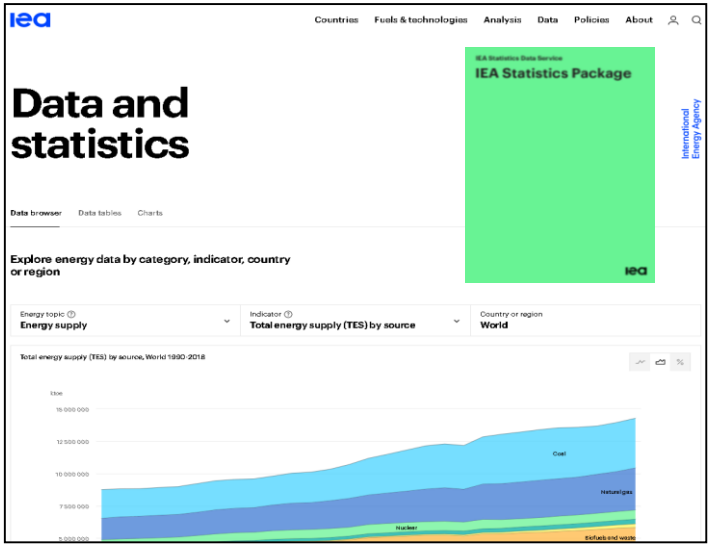
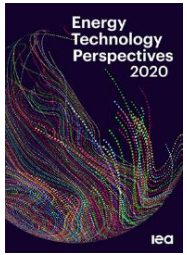
Free products

[Key World Energy Statistics](#)
[Data and Statistics data browser](#)
[Energy Balance Flows (Sankey diagrams)](#)
[Energy Atlas](#)
[Weather for Energy Tracker](#)
[Monthly OECD oil](#), [gas](#) and [electricity statistics](#)
Annual highlights:
[Energy balance](#), [CO_2 emissions](#), [Energy Technology RD&D](#), [Efficiency indicators](#), [Gas Trade Flows](#)



Data support for the Agency

[COVID-19 impact on electricity](#)



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