ELECTRICITY AND HEAT

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Outline

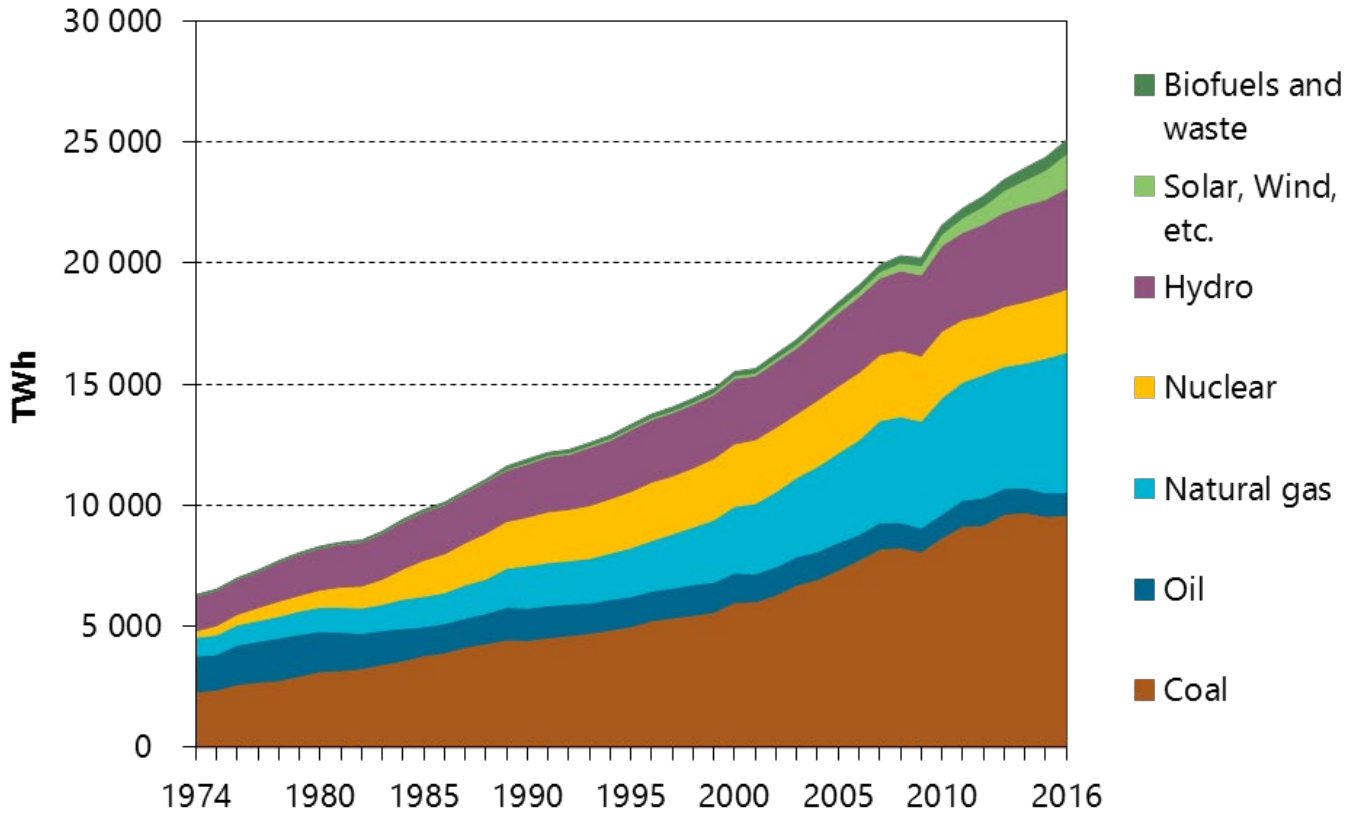
Key Electricity trends

Key concepts

Key points for reporting

Key Electricity trends

World Electricity Production by Source



Change since 1974:

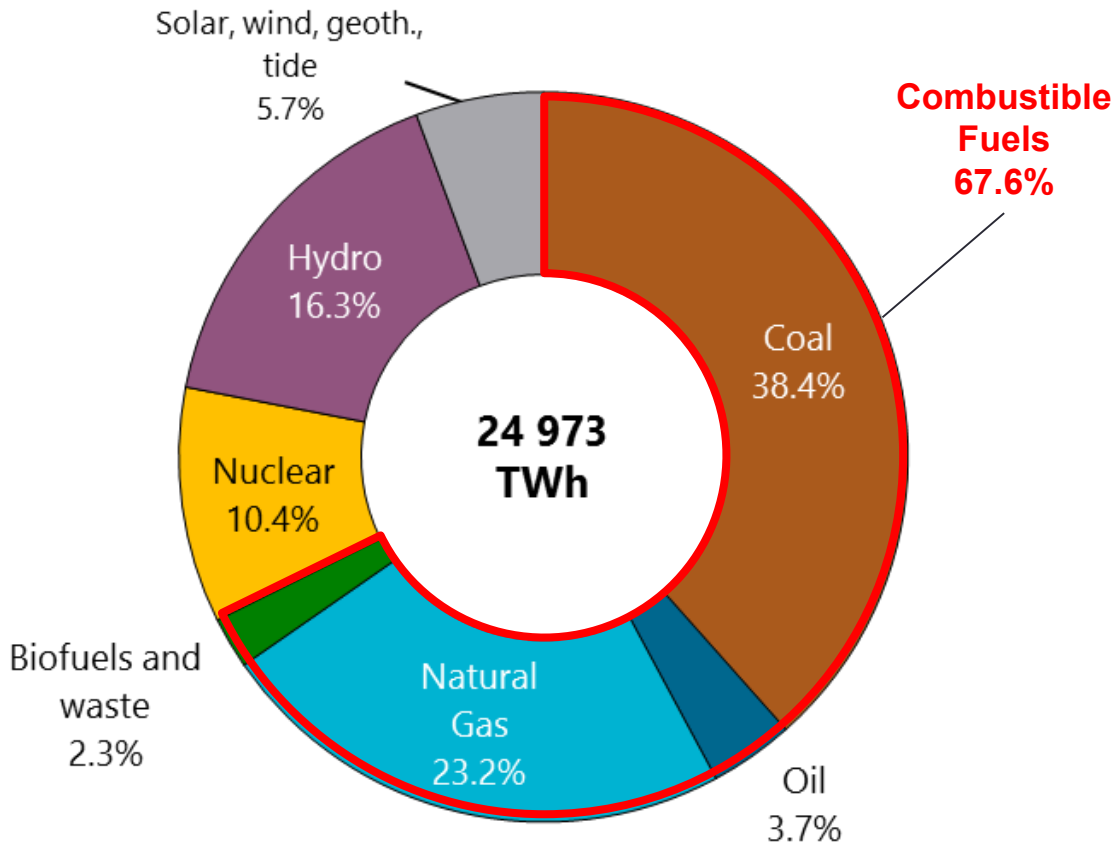
Total: **1974:** 6 298 TWh
2016: 25 082 TWh

4X increase in global electricity production

- Lower share of Oil
- Lower share of Hydro
- Higher share of Natural Gas
- Higher share of Nuclear
- Higher share of Solar & Wind

Source: *Electricity Information*, OECD/IEA, 2018

World Electricity Production by Source (2016)

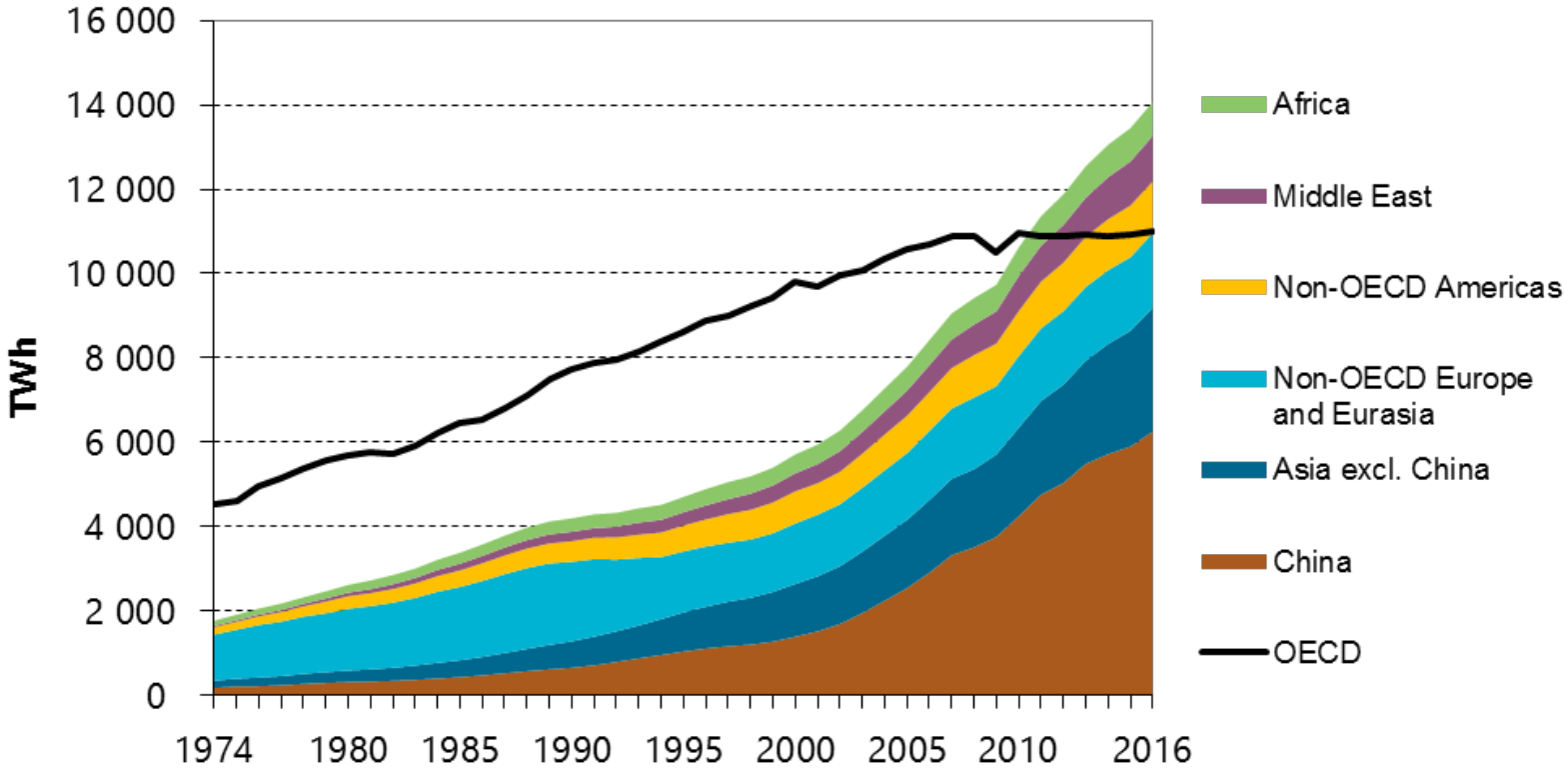


As of 2016:

- Coal is the dominant fuel
- 68% of electricity output is from combustible fuels
- Solar and wind output is small, but growing

Source: World Energy Balances OECD/IEA, 2018

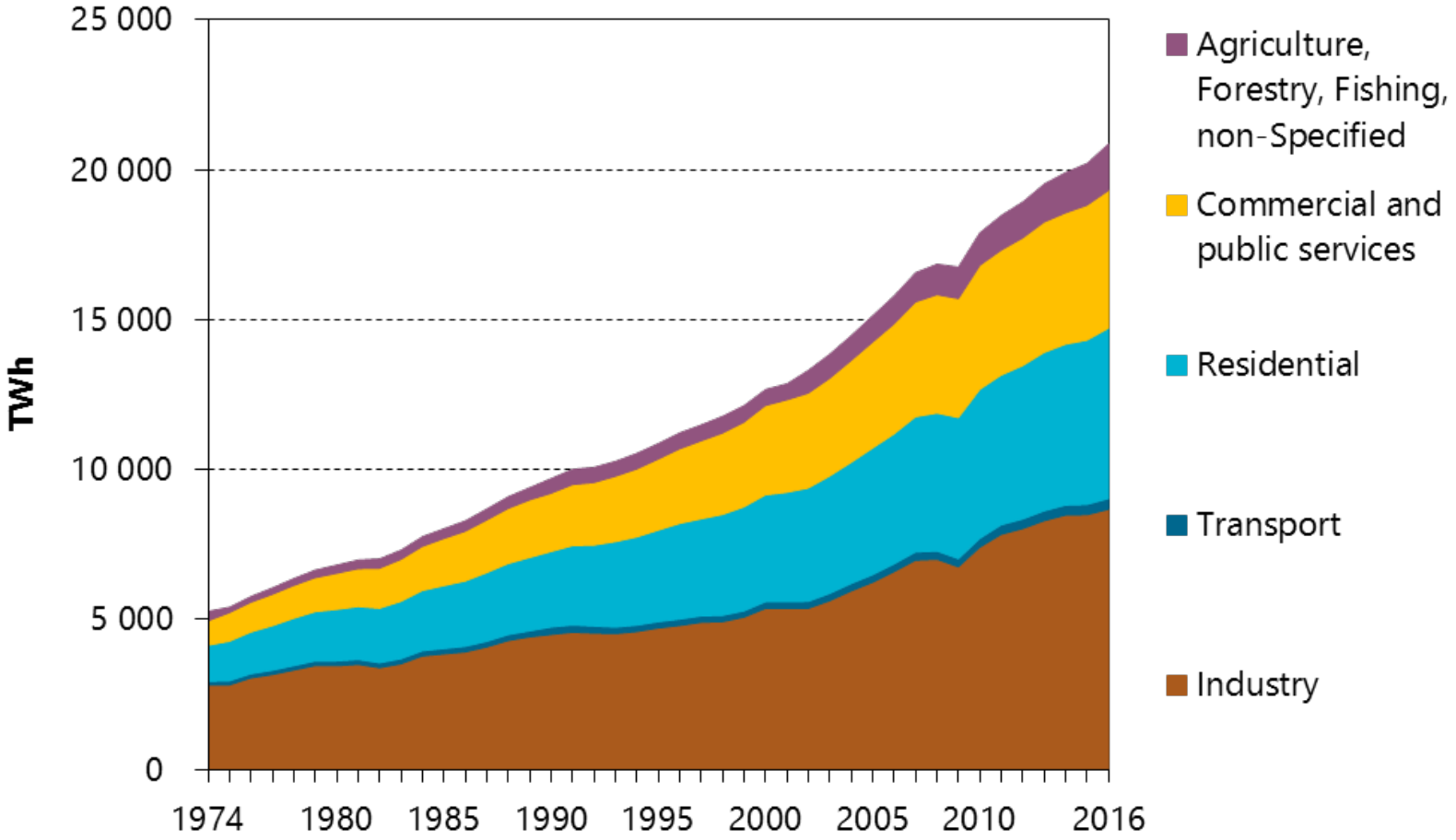
World Electricity Production by Region



- Trends in production growth differ by region
- As of 2011, non-OECD countries produce the majority of global electricity (2016: 56%)
- Strong growth in Asia in recent years

Source: *Electricity Information*, OECD/IEA, 2018

World Electricity Consumption by Sector (2016)



- Electricity consumption has increased 4x since 1974
- Industry remains the largest consuming sector
- However, the Residential and Commercial sectors are increasing their share of consumption

Source: *Electricity Information*, OECD/IEA, 2018

Key concepts

Energy vs. Power

Power	**=**	**Energy / Time**
1 Watt	=	1 Joule / second

In 1 hour: 1 Watt of Power consumes 3 600 Joules of energy
For convenience, this amount is known as a watt hour (Wh)

i.e. 1 Watt hour = 3600 Joules

Key point: Watts are units of power

Watt hours are units of energy

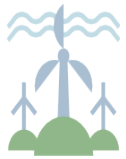
Electricity: Primary vs. Secondary

Electricity is produced as both primary and secondary energy

Primary

Hydro

Solar PV



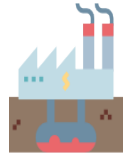
Wind

Tide/Wave

Secondary

Combustible Fuels

Nuclear



Geothermal

Solar Thermal
(Concentrated solar power)

Heat: Primary vs. Secondary

Heat is also produced as both primary and secondary energy

Primary

Solar Thermal

Geothermal

Nuclear

Secondary

Combustible Fuels

Electric Boilers

Heat Pumps

Production: Two Producer Types

Main Activity Producer

Generate electricity / heat for third parties as a primary activity.

Autoproducer

Generate electricity / heat wholly or partly for their own use as an activity which supports their primary activity.

Note: classifications in the energy balance are not dependent on ownership (public or private) or on size of generation plant

Production: Three Plant Types

Electricity Only

Generate electricity only

Heat Only

Generate heat only

Combined Heat and Power (CHP)

Generate both electricity and heat simultaneously

Reporting Conventions: Electricity & Heat

Main Activity Producer

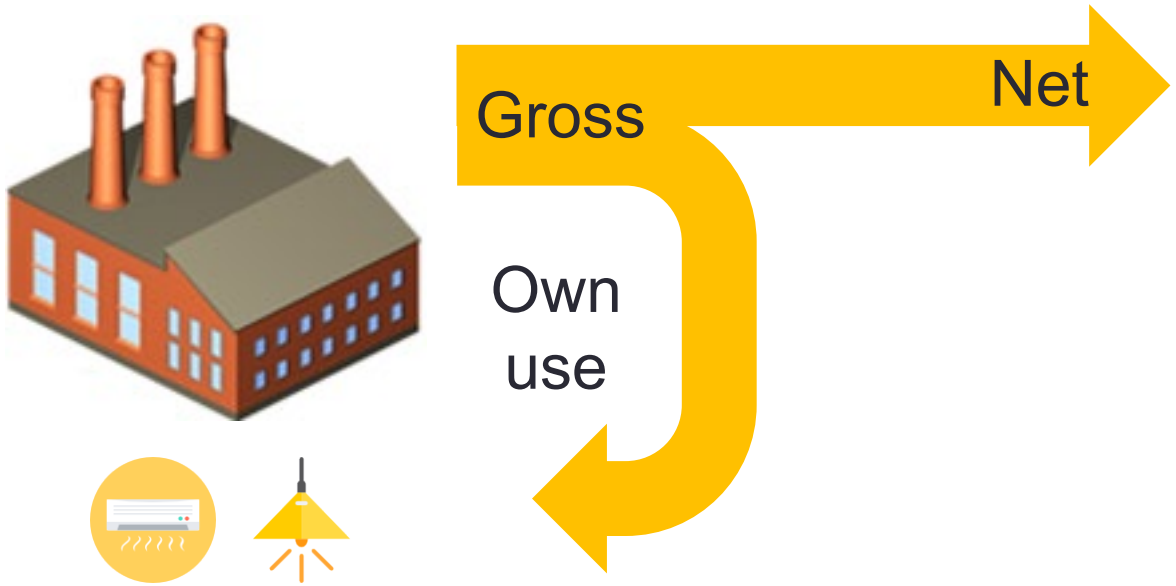
Autoproducer

	Main Activity Producer	Autoproducer
Electricity Only	Report all production	Report all production
Heat Only	Report all production	Report heat SOLD only*
CHP	Report all production	Report all electricity production Report heat SOLD only*

*Only report fuel inputs related to heat sold

Production: Gross vs. Net

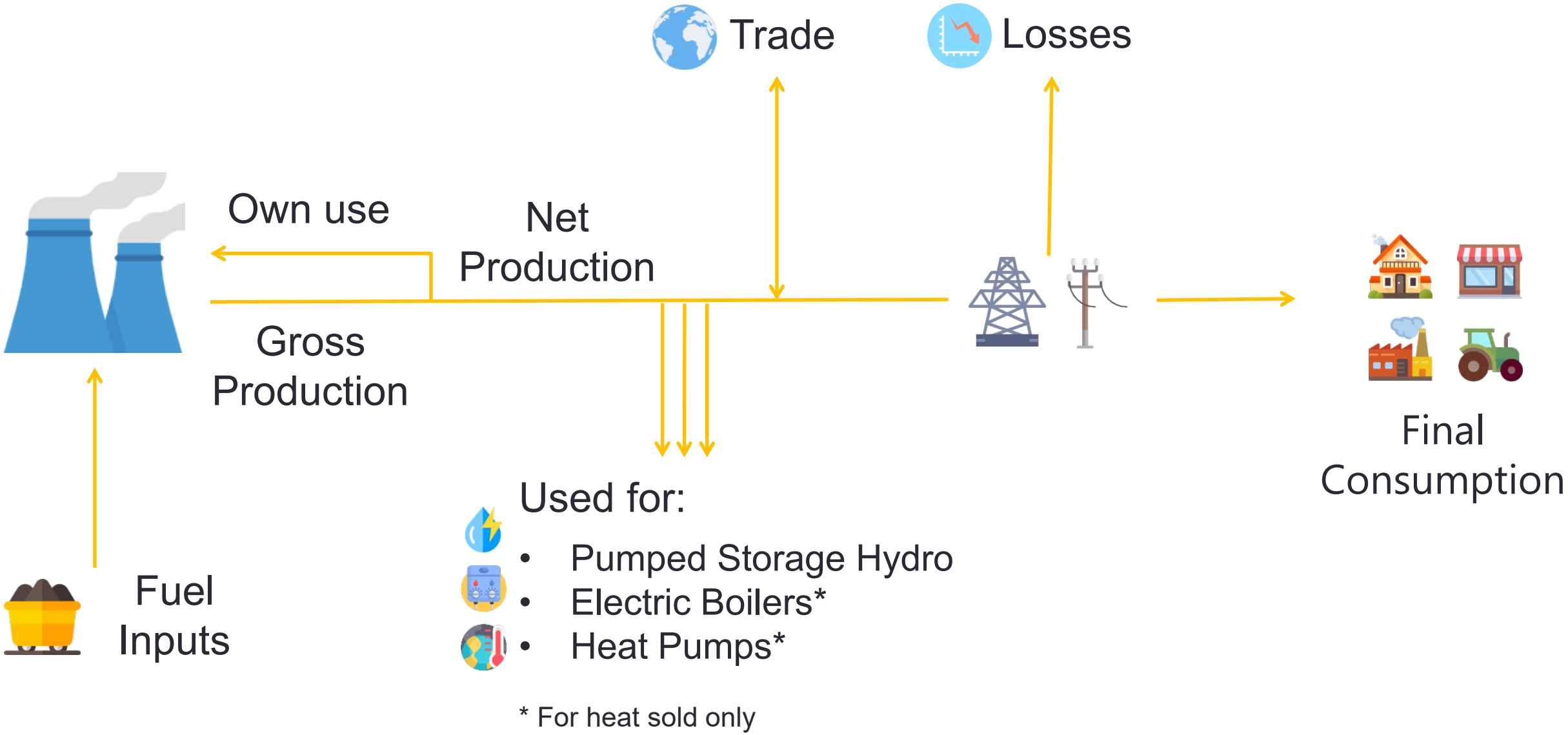
- **Gross Production:** All electricity / heat produced
- **Own Use:** Amount consumed to support plant operation
- **Net Production:** Electricity / heat distributed



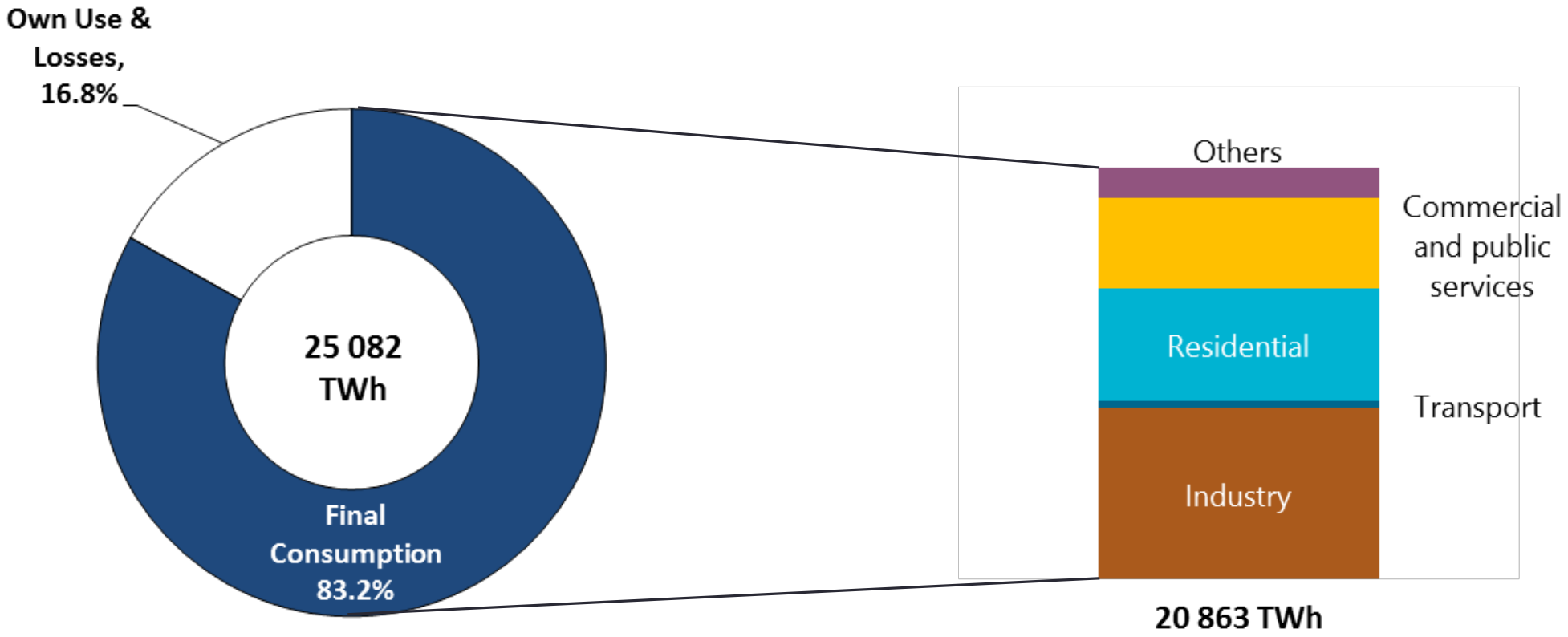
Reporting Conventions: Own Use

	 Main Activity Producer	 Autoproducer
 Electricity Only	Gross – Own Use = Net	Gross – Own Use = Net
 Heat Only	Gross – Own Use = Net	Assume Gross = Net (of heat sold)
 CHP	Gross – Own Use = Net	Electricity: Gross – Own Use = Net Heat: Assume Gross = Net (of heat sold)

Supply & Demand



Gross production vs Final consumption (2016)



The difference between Gross production and final consumption is due to **Own Use** and **Transmission and Distribution losses**

Source: IEA/OECD *Electricity Information*, 2018

Transmission and Distribution Losses

- Energy is lost as electricity travels through cables and transformers
- In general, losses would be expected to be in the range of about 5 -15%
- However, higher losses can occur especially in distribution (unauthorised use)

Losses:	~1-2%	~ 2-4%	~ 1-2%	~ 4-6%

Source: IEA ETSAP - Technology Brief E12, 2012; IEC, Geneva, 2007

Trade

Unlike other fuels, trade of electricity and heat:

- Is reported on the basis of borders crossed, NOT origin and destination or ownership of plant.
- Includes all trade, including transit.

Example:
Exports of electricity from Portugal to France transiting through Spain, would be reported as:

- Portugal: Exports to Spain
- Spain: Imports from Portugal and
  Exports to France
- France: Imports from Spain
- This is true even if the plant was German owned.

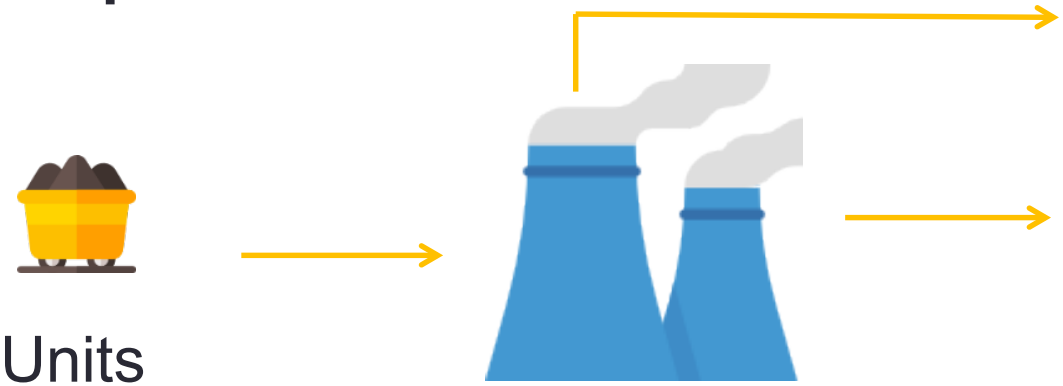
Generation efficiency

Efficiency = Output / Input (NCV)

- It is always < 100 %
- It differs by fuel / technology
- It must be calculated in energy units

Average efficiencies % for electricity plants	
FUEL	**Efficiency**
fuel oil	17% - 33%
gas/diesel	35% - 41%
anthracite	30% - 40%
natural gas	30% - 50%
CHP plants	50% – 70%

Example:



60 Units

Inputs

Heat Lost

40 Units

Energy

20 Units

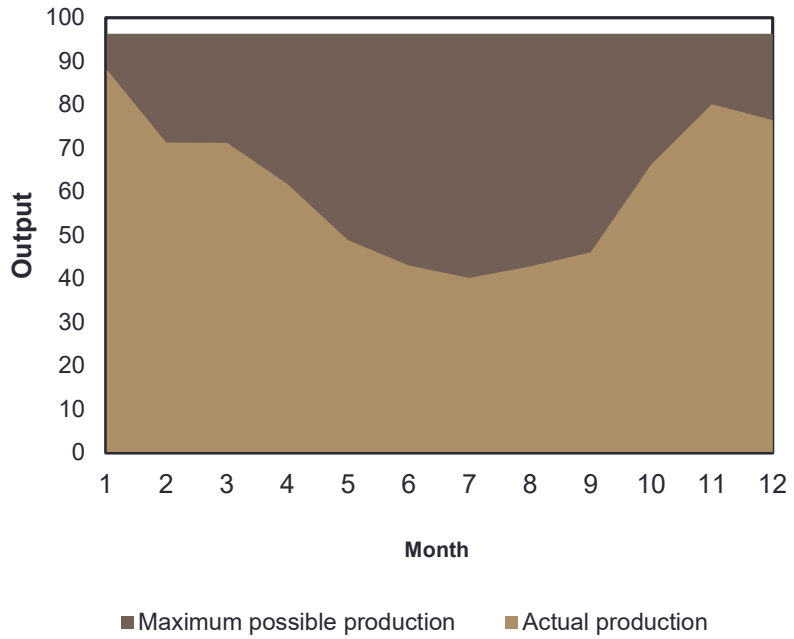
Outputs

Efficiency = (20)/60
= 33%

If plant was a CHP, producing 20 unit of heat (so heat loss reduced to 20) Efficiency = (20+20)/60 = 66%

Capacity Factors (Load Factors, Utilisation rates)

An indicator of use of the power station over the year



Calculation

$$\text{Capacity factor} = \frac{\text{Actual production}}{\text{Maximum possible production}}$$

Must always be between 0-100%!

Maximum possible production: Assumes its continuous operation at full nameplate capacity over the relevant period of time (capacity x hours in the year)

Actual production: The actual energy output over the same period of time.
Varies due to design, technical and operational reasons

Net maximum capacity is the maximum potential power that can be supplied with at the point of outlet, with all plant running, on 31 December.

OECD recent average capacity factors

- Nuclear **74.3**
- Hydro **34.5**
- Geothermal **80.6**
- Solar **13.3**
- Wind **26.2**
- Fossil **44.9**

Calculating Capacity factors

$$\text{Capacity factor} = \frac{Net\ electricity\ production}{Capacity\ \times\ Time}$$

Example

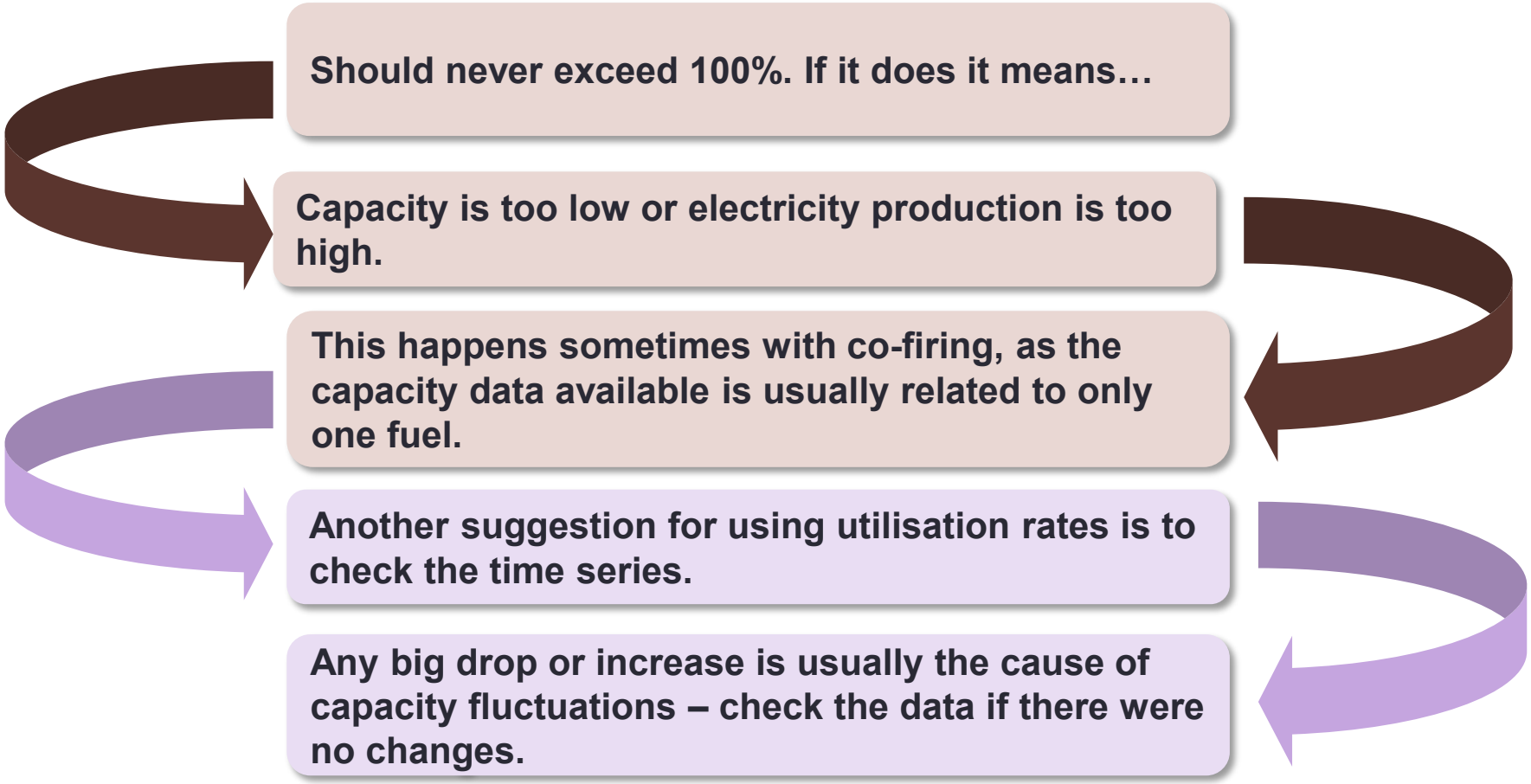
- **Reported capacity for wind is 28,700 MW**
- **Net annual electricity production of wind is 45 TWh**

How to calculate rate for the year?

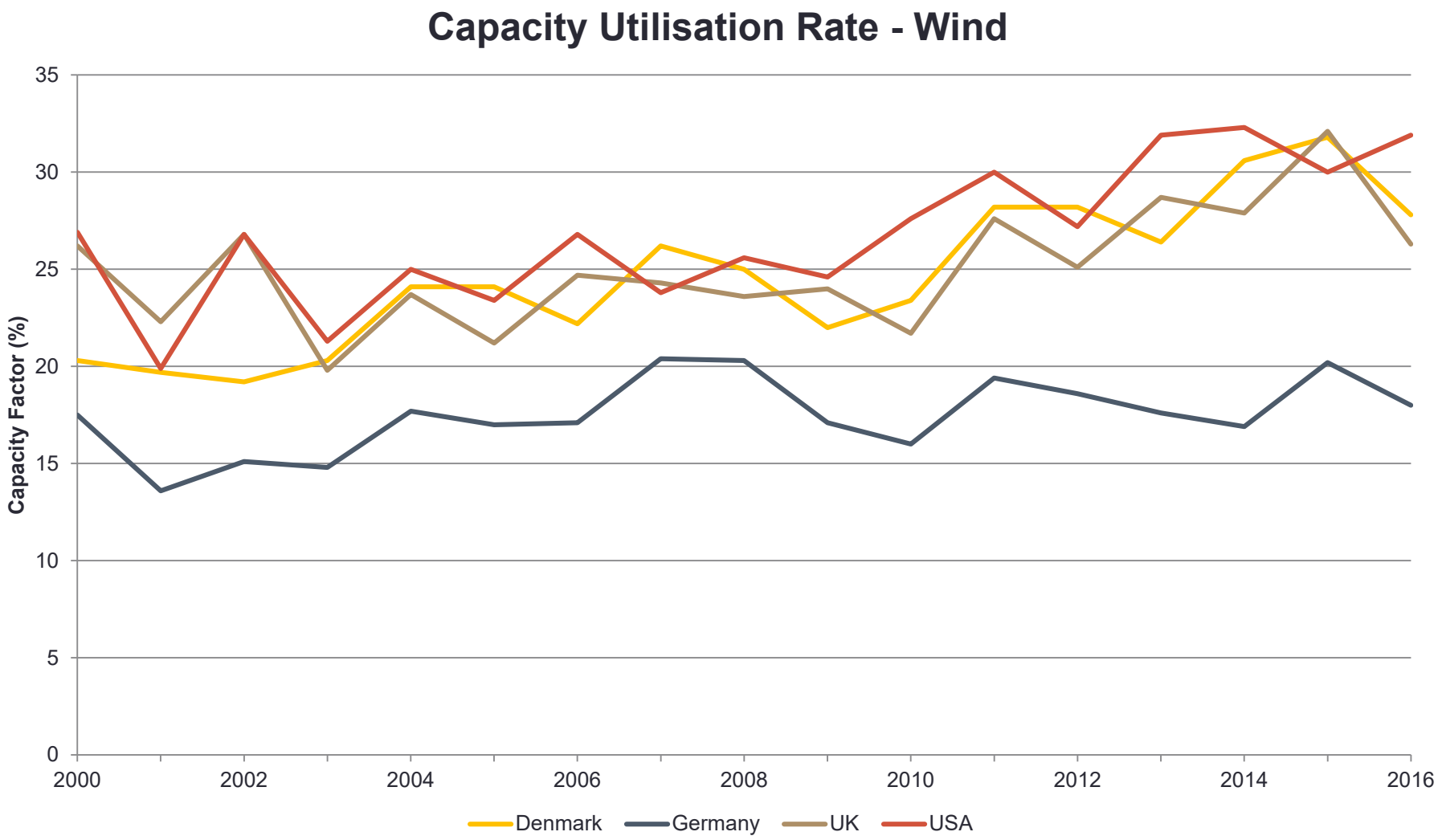
1. **45 TWh = 45,000,000 MWh**
2. **Capacity factor** $= \frac{45{,}000{,}000\ MWh}{28{,}700\ MW \times 24\ h/d \times 365 d/y}$ **= 17,9 %**

Can you think of how the capacity factor can be used to check data?

Capacity factors – how are they used to check data?



Example Capacity (load) factors: Wind



Impacts of changing capacity and weather

- Within renewables, use (and thus) utilisation factors can be heavily influenced by:
  - weather conditions;
  - wind speeds affect for onshore and offshore wind,
  - rainfall for hydro
  - hours of sunshine for solar PV.

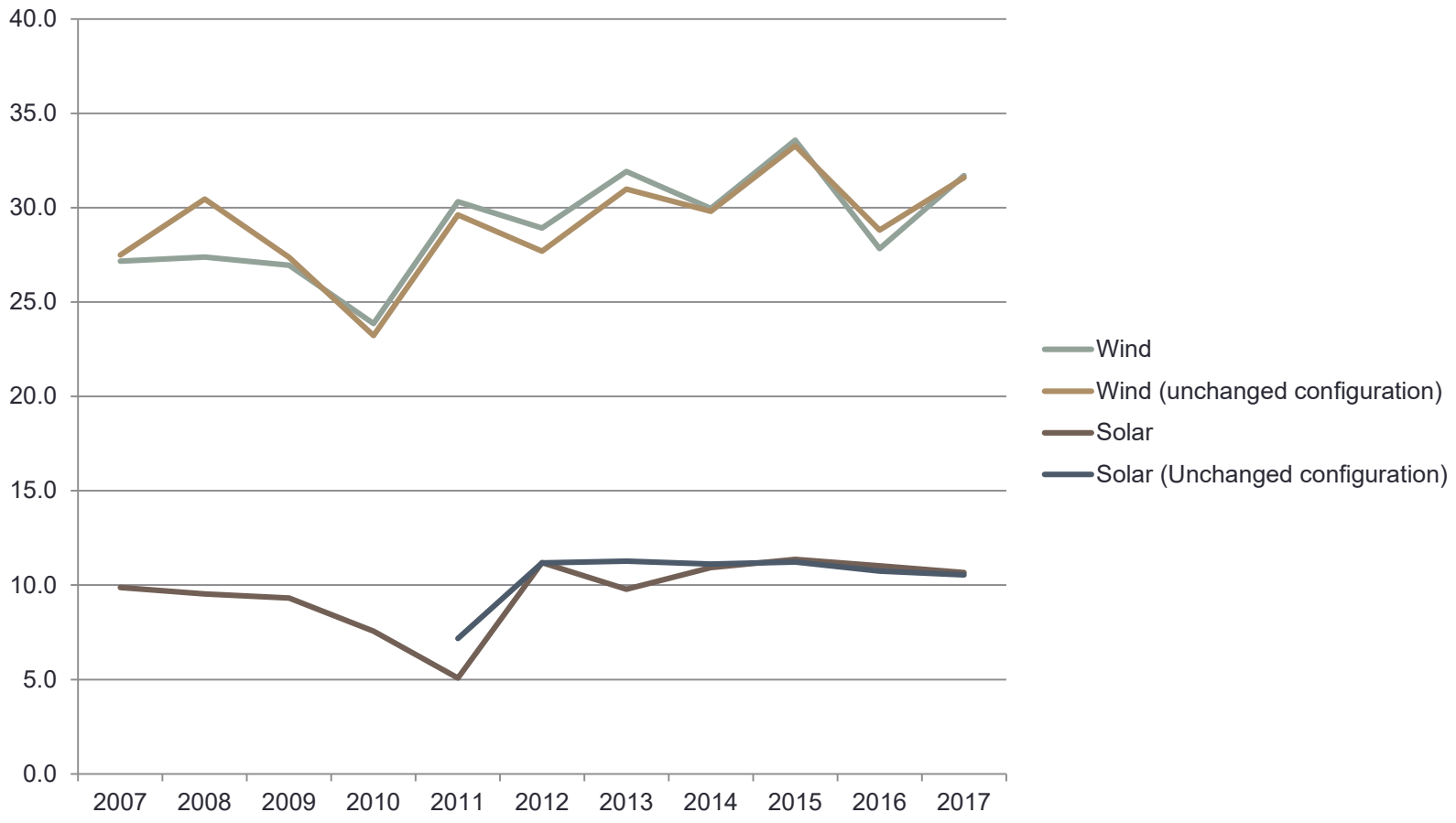
  - The non-uniform addition of capacity for example, a large generator could add a high capacity installation towards the end of the year and only generate for a very short period.

- To remove the first effect, the EU uses long-term (5, wind and 15, Hydro years) average load factors in its calculation of renewables for its Renewable target.

- For the second an approach is the “unchanged configuration basis”

  - i.e. only include plants who are producing at the start and end of the year providing a more reflective picture of the underlying trend.

UK load factors all and unchanged configuration



Electricity data sources – types of data collection

Surveys

Power producers, transmission and distribution system operators, market operators /electricity exchanges
Enterprises
Households

Administrative data

Energy regulators
Customs offices
Data collected from programme/policy implementation

Direct measurements

Conventional and smart meters

Estimation/modelling

e.g. Plant capacity information – e.g. Solar PV capacity -> Solar PV electricity generation behind the meter

Generation estimation techniques

- Best approach is direct measurement – generation by operator is known

- Apply average load factors to know capacity
- “Borrow” know load factors from neighboring or similar climatic country
- Gross up using small scale pilot studies

- Data matching studies for residential PV

Capacity estimation

- Using trade data to estimate amount of PV being installed
  - Solar panels account for almost all trade under HS Code 854140, import statistics for this product group are a good indicator of the amount of solar panels imported into a country.
  - For further info see https://www.irena.org/publications/2018/Dec/Measurement-and-estimation-of-off-grid-solar-hydro-and-biogas-energy
- Satellite images
- Press/media reporting?

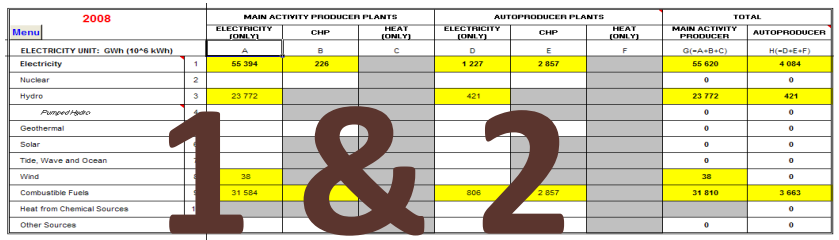
Key points for reporting electricity & heat data

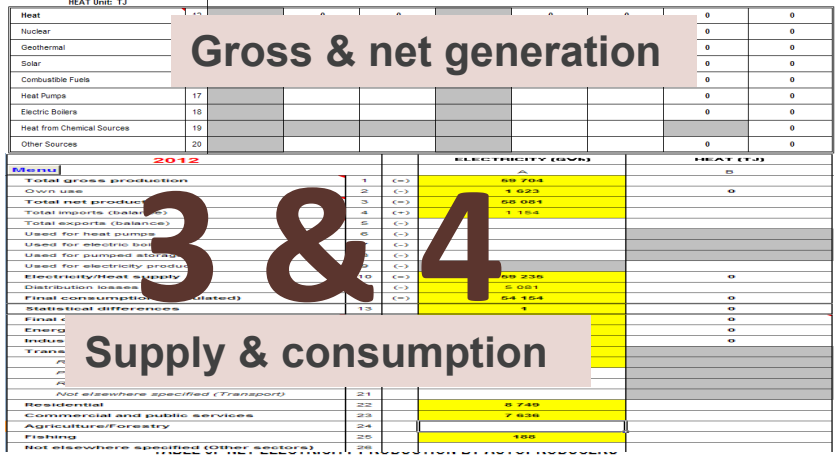
Tables and products

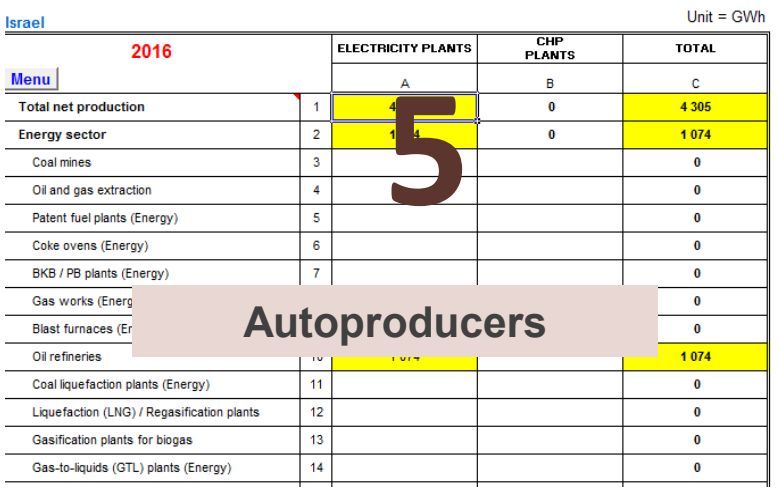
IEA has 8 Tables covering

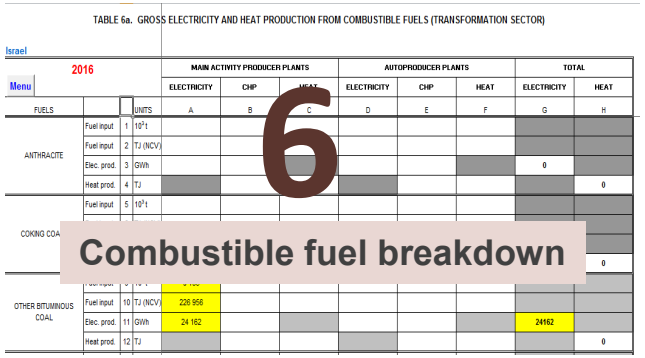
- **Electricity and heat data** generation by:
  - **47** individual fuels
  - type of producer
  - type of plant/unit
- **Consumption data** by sector
- **Technical information** on electrical systems

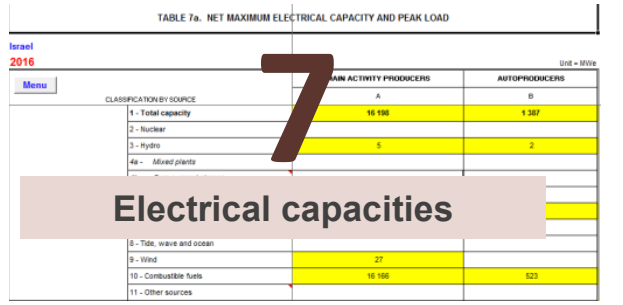
https://www.iea.org/media/statistics/questionnaires/EleQues.xlsm

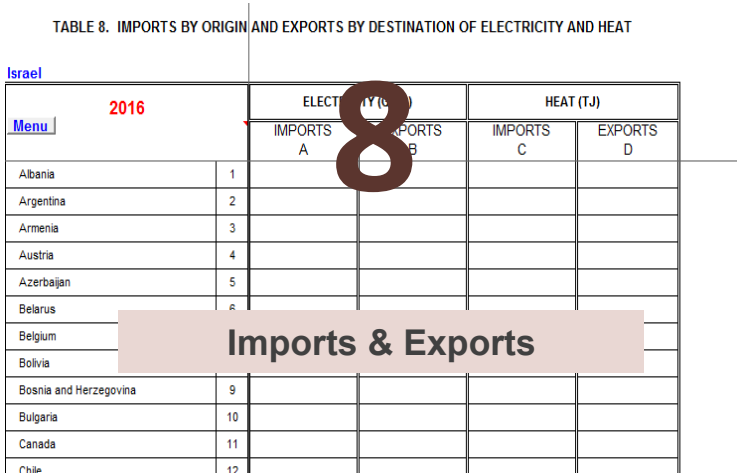




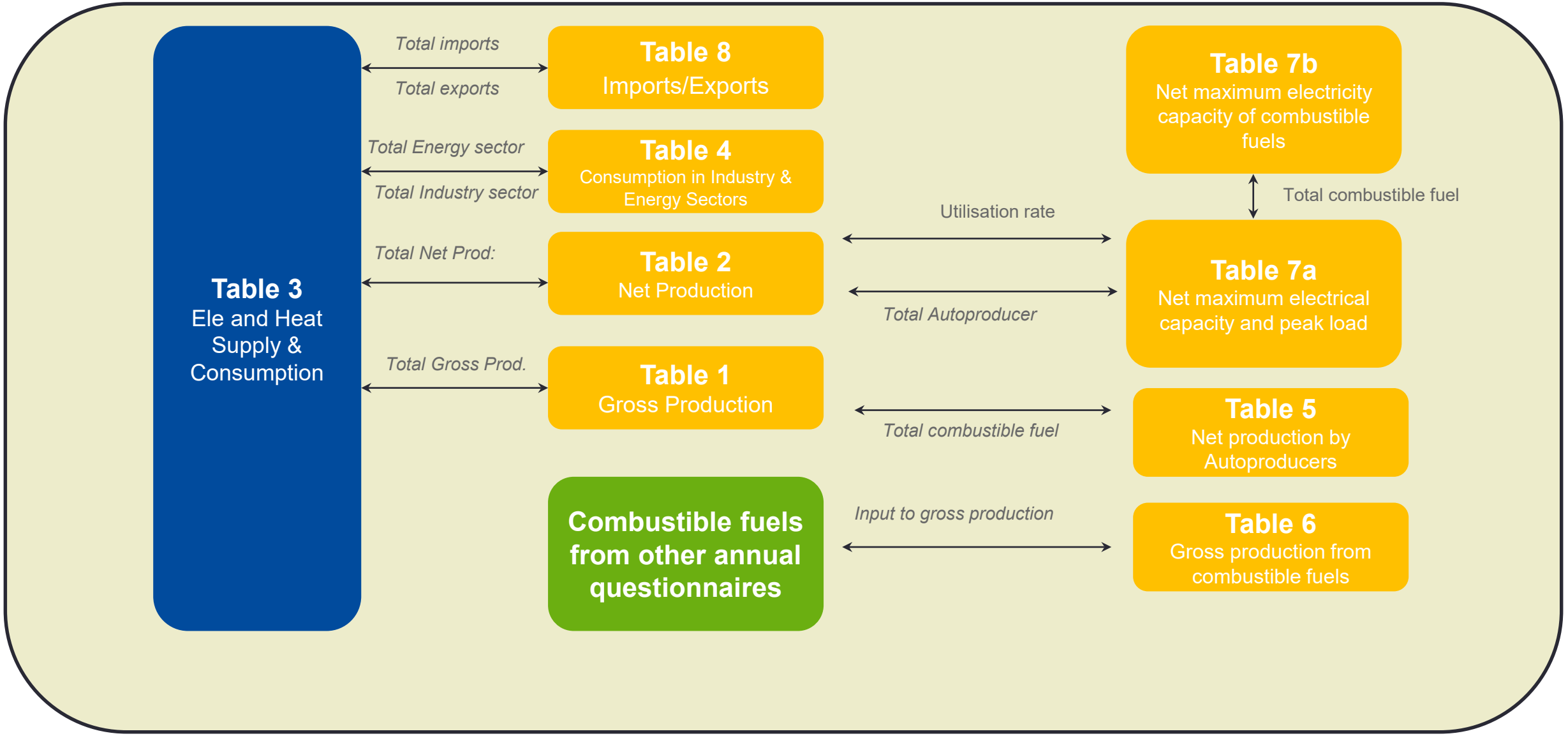








Tables/Questionnaire relations in Electricity and Heat Questionnaire



Duncan Millard, 2019

Net electricity and heat production

Menu		MAIN ACTIVITY PRODUCER PLANTS			AUTOPRODUCER PLANTS			TOTAL	
		ELECTRICITY (ONLY)	CHP	HEAT (ONLY)	ELECTRICITY (ONLY)	CHP	HEAT (ONLY)	MAIN ACTIVITY PRODUCER	AUTOPRODUCER
ELECTRICITY UNIT: GWh (10^6 kWh)		A	B	C	D	E	F	G(=A+B+C)	H(=D+E+F)
Electricity	1	55 394	226		1 227	2 857		55 620	4 084
Nuclear	2							0	0
Hydro	3	23 772			421			23 772	421
Pumped Hydro	4							0	0
Geothermal	5							0	0
Solar	6								0
Tide, Wave and Ocean	7								0
Wind	8	38						38	0
Combustible Fuels	9	31 584	226		806	2 857		31 810	3 663
Heat from Chemical Sources	10								0
Other Sources	11								0
HEAT Unit: TJ									
Heat	12		0	0					0
Nuclear	13							0	0
Geothermal	14							0	0
Solar	15							0	0
Combustible Fuels	16							0	0
Heat Pumps	17							0	0
Electric Boilers	18							0	0
Heat from Chemical Sources	19								0
Other Sources	20							0	0

Type of Plant

Type of Producer

Details on the type of combustible fuel are also collected.

Sources of electricity and heat

Net electricity and heat production

Example:

- A power plant is using natural gas and is producing 5000 GWh of electricity
- A hydro power plant is producing 20 GWh of electricity
- A waste recycling facility uses waste to produce 45 GWh of electricity

TABLE 2. NET ELECTRICITY AND HEAT PRODUCTION : (TRANSFORMATION SECTOR)

2015		MAIN ACTIVITY PRODUCER PLANTS			AUTOPRODUCER PLANTS			TOTAL	
		ELECTRICITY (ONLY)	CHP	HEAT (ONLY)	ELECTRICITY (ONLY)	CHP	HEAT (ONLY)	MAIN ACTIVITY PRODUCER	AUTOPRODUCER
ELECTRICITY UNIT: GWh (10^6 kWh)		A	B	C	D	E	F	G(=A+B+C)	H(=D+E+F)
Electricity	a	**5 020**	**0**		**45**	**0**		**5 020**	**45**
Nuclear	b							**0**	**0**
Hydro	c	20						**20**	**0**
Pumped Hydro	d							**0**	**0**
Geothermal	e							**0**	**0**
Solar	f							**0**	**0**
Tide, Wave and Ocean	g							**0**	**0**
Wind	h							**0**	**0**
Combustible Fuels	i	5 000			45			**5 000**	**45**
Heat from Chemical Sources	l								**0**
Other Sources	m							**0**	**0**

Gross electricity and heat production from combustible fuels 1/2

2008 Menu				MAIN ACTIVITY PRODUCER PLANTS		
				ELECTRICITY (ONLY)	CHP	HEA (ONI
FUELS			UNITS	A	B	C
ANTHRACITE	Fuel input	1	10^3 t			
	Fuel input	2	TJ (NCV)			
	Elec. prod.	3	GWh			
	Heat prod.	4	TJ			

For each combustible fuel:

INPUT shall:

- be reported both in natural (e.g. ktons) and energy units (e.g. TJ)
- match INPUT given in the other questionnaires.

INPUT (TJ) = INPUT (ktons) x NCV (TJ/ktons)

NCV shall:

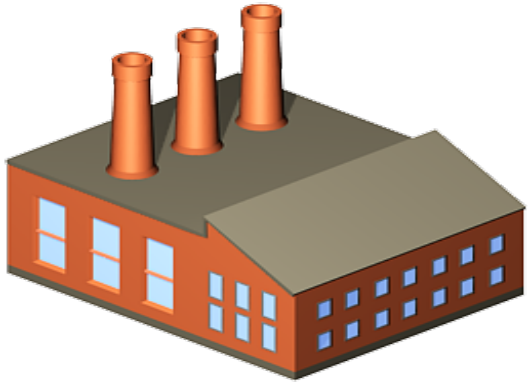
- be in reference ranges for a given fuel (reliability)
- match NCVs given in the other questionnaires.

Gross electricity and heat production from combustible fuels 2/2

2008 Menu				MAIN ACTIVITY PRODUCER PLANTS		
				ELECTRICITY (ONLY)	CHP	HE (ON
FUELS			UNITS	A	B	C
ANTHRACITE	Fuel input	1	10^3 t			
	Fuel input	2	TJ (NCV)			
	Elec. prod.	3	GWh			
	Heat prod.	4	TJ			

Input:
Anthracite

100 kt, 22 TJ/kt



Output:
Gross Electricity

124 GWh

$$Efficiency = \frac{\text{124 GWh *3.6 (TJ/GWh)}}{\text{100kt *22(TJ/kt)}} = \text{20.3\%}$$

Final Check list

- **Main activity producers** generate electricity/heat as **primary activity** **vs** **Autoproducers** generate electricity/heat as an **additional activity** (partly or wholly for their own use.

- For electricity: **Net production = Gross production - Own use**

- For Heat:
  - Main activity: **Net production = Gross production - Own use**
  - Autoproducers: **Net production = Gross production**

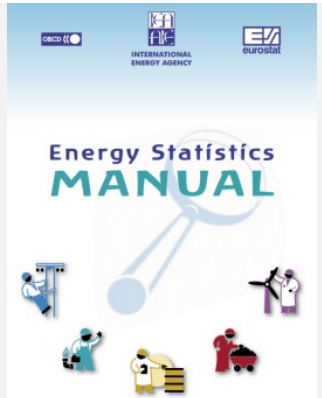
- **Generation efficiency = Output / Input (NCV)** and should always be **<100**

- **Capacity factor = Actual production / Maximum potential production**
  - **Maximum potential production = Capacity * 24 (hours) * 365 (days)**

Learn more about Energy Statistics

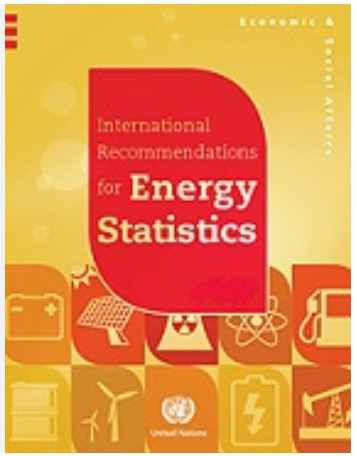
A comprehensive Energy Statistics Manual available in 10 languages.

Click to download it free of charge!



*Visit the **IEA's Statistics website** to access additional resources, including our **webinars**, 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).



Thank you for listening – Any Questions

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ANNUAL ELECTRICITY DATA COLLECTION IN THE UK

https://www.gov.uk/government/organisations/department-for-business-energy-and-industrial-strategy/about/statistics

For reference

This is personal reflection on the data collection of electricity data in the UK presented by the former Chief Energy and Climate Change statistician in the UK for the period 2008 to 2015.

DECC's activities were integrated within the department for Business, Energy and Industrial Strategy (BEIS) in 2016.

Annual electricity data collection

- Each year, three main electricity surveys are carried out
  - one detailed survey of the major power producers (MPPs),
  - one survey of the major suppliers, and
  - one less detailed survey of electricity distributors.

- These are supplemented with additional data from the electricity
  - autogenerators survey,
  - the National Grid,
  - Iron and Steel Statistics Bureau,
  - Small scale renewables (contracted out), as well as internal analysis.
- The annual statistics are published one year in arrears (t-1), but revisions are typically carried out to the previous two years, t-2 and t-3, where revised data has been received.

Surveys (1)

- Major Power Producers (MPPs) survey (annual): census of approximately 35 MPPs surveyed electronically –
  - Collects for fuel used, CVs, electricity generated, net electricity supplied to the grid, own use of electricity, sales, and capacity, broken down by generation type/fuel. For pumped storage plants, any electricity consumed in pumping is also reported.
  - Coverage: all MPPs, representing approximately 90% of electricity generation
  - Response rate: approximately 100%
  - Some MPPs' power stations will report individually
- Electricity Suppliers survey (annual): approximately 30 main suppliers surveyed electronically – sales data split by SIC code. This also includes information on the value of sales, used in the calculation of energy prices.
  - Covering approx. 95% of electricity sales, Response rate: ~ 100%
- Electricity Distributors survey (annual): 13 Distribution Network Operators (DNOs) – all except the two Scottish DNOs, surveyed for quantity of electricity distributed and losses.

Other data collection – Autogenerators/CHP

- 50 per cent of production from ‘other generators’ comes from good quality combined heat and power (CHP). Good quality CHP data are collected annually via the administrative data of the CHPQA scheme The CHPQA data collection system covers all plants which are certified as having Good Quality CHP.
- A further 15 per cent of electricity produced by ‘other generators’ is produced by the ‘power only’ part of the CHP plants, which consists of the electrical capacity in CHP plants which do not qualify as Good Quality and is derived from the data collected through the CHPQA process.
- EGI quarterly survey: A further 15 per cent of electricity generation came from ‘power only’ plants. Data for these plants are collected quarterly via a survey run by the Office of National Statistics (ONS) on behalf of DECC.

Additional data sources

- Iron and Steel Statistics Bureau (ISSB) (annual): electricity generated, consumed and lost by the iron and steel industry, blast furnaces and coke ovens.
- Renewables database (annual): renewables (including co-firing) generation (for non-MPP).
- DECC (annual internal analysis): Calorific Values and Conversion factors, used to convert fuel masses to energy units.
- British Energy (annual): Average thermal efficiencies for Nuclear electricity.
- National Grid: electricity exports/imports to/from France and the Netherlands, half-hourly,
- Single Electricity Market Operator: electricity exports/imports to/from the Republic of Ireland, half-hourly,
- Elexon (monthly): transmission losses and generation data for the GB National Grid.
- Ofgem: distribution units and loss percentages summary

Electricity supplied by fuel type, 1990 to 2017