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**

\[
\text{Power} = \frac{\text{Energy}}{\text{Time}}
\]

\[
1 \text{ Watt} = 1 \text{ Joule} / \text{second}
\]

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.

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Thermal</td>
<td>Combustible Fuels</td>
</tr>
<tr>
<td>Geothermal</td>
<td>Electric Boilers</td>
</tr>
<tr>
<td>Nuclear</td>
<td>Heat Pumps</td>
</tr>
</tbody>
</table>

Duncan Millard, 2019
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

<table>
<thead>
<tr>
<th>Main Activity</th>
<th>Producer Autoproducer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Only</td>
<td>Report all production</td>
</tr>
<tr>
<td>Heat Only</td>
<td>Report all production</td>
</tr>
<tr>
<td>CHP</td>
<td>Report all production</td>
</tr>
</tbody>
</table>

*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

<table>
<thead>
<tr>
<th>Main Activity</th>
<th>Autoproducer</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Electricity Only</strong></td>
<td>Gross – Own Use = Net</td>
</tr>
<tr>
<td><strong>Heat Only</strong></td>
<td>Gross – Own Use = Net</td>
</tr>
<tr>
<td><strong>CHP</strong></td>
<td>Gross – Own Use = Net</td>
</tr>
</tbody>
</table>
Supply & Demand

Fuel Inputs

Gross Production

Own use

Net Production

Used for:

- Pumped Storage Hydro
- Electric Boilers*
- Heat Pumps*

* For heat sold only

Trade

Losses

Final Consumption

Losses

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

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

Example:

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 Units</td>
<td>40 Units</td>
</tr>
</tbody>
</table>

Heat Lost

40 Units

Energy

20 Units

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%

Average efficiencies % for electricity plants

<table>
<thead>
<tr>
<th>FUEL</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>fuel oil</td>
<td>17% - 33%</td>
</tr>
<tr>
<td>gas/diesel</td>
<td>35% - 41%</td>
</tr>
<tr>
<td>anthracite</td>
<td>30% - 40%</td>
</tr>
<tr>
<td>natural gas</td>
<td>30% - 50%</td>
</tr>
<tr>
<td>CHP plants</td>
<td>50% – 70%</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Source</th>
<th>Capacity Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>74.3</td>
</tr>
<tr>
<td>Hydro</td>
<td>34.5</td>
</tr>
<tr>
<td>Geothermal</td>
<td>80.6</td>
</tr>
<tr>
<td>Solar</td>
<td>13.3</td>
</tr>
<tr>
<td>Wind</td>
<td>26.2</td>
</tr>
<tr>
<td>Fossil</td>
<td>44.9</td>
</tr>
</tbody>
</table>
Calculating Capacity factors

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?

Should never exceed 100%. If it does it means...

Capacity is too low or electricity production is too high.

This happens sometimes with co-firing, as the capacity data available is usually related to only one fuel.

Another suggestion for using utilisation rates is to check the time series.

Any big drop or increase is usually the cause of capacity fluctuations – check the data if there were no changes.
Example Capacity (load) factors: Wind

Capacity Utilisation Rate - Wind

- Denmark
- Germany
- UK
- USA
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.
  

- 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

1 & 2 Gross & net generation
3 & 4 Supply & consumption
5 Electrical capacities
6 Combustible fuel breakdown
7 Autoproducers
8 Imports & Exports
Tables/Questionnaire relations in Electricity and Heat Questionnaire

- **Table 1**: Gross Production
- **Table 2**: Net Production
- **Table 3**: Ele and Heat Supply & Consumption
- **Table 4**: Consumption in Industry & Energy Sectors
- **Table 5**: Net production by Autoproducers
- **Table 6**: Gross production from combustible fuels
- **Table 7a**: Net maximum electrical capacity and peak load
- **Table 7b**: Net maximum electricity capacity of combustible fuels
- **Table 8**: Imports/Exports

Additional notes:
- Total imports
- Total exports
- Total Energy sector
- Total Industry sector
- Total Net Prod:
- Total Gross Prod.
- Utilisation rate
- Total Autoproducer
- Input to gross production
- Combustible fuels from other annual questionnaires
- Total combustible fuel
- Net production by Autoproducers
- Gross production from combustible fuels
## Net electricity and heat production

<table>
<thead>
<tr>
<th>Type of Plant</th>
<th>Type of Producer</th>
<th>Details on the type of combustible fuel are also collected.</th>
<th>Sources of electricity and heat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity</td>
<td>MAIN ACTIVITY PRODUCER PLANTS</td>
<td>AUTOPRODUCER PLANTS</td>
<td>TOTAL</td>
</tr>
<tr>
<td>ELECTRICITY &amp; HEAT</td>
<td>ELECTRICITY ONLY</td>
<td>CHP</td>
<td>HEAT ONLY</td>
</tr>
<tr>
<td>Electricity</td>
<td>A</td>
<td>B</td>
<td>C</td>
</tr>
<tr>
<td>Nuclear</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hydro</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Solar</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wave and Ocean</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Wind</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Combustible Fuels</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Heat from Chemical Sources</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Other Sources</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
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>
<thead>
<tr>
<th>ELECTRICITY UNIT: GWh (10^6 kWh)</th>
<th>MAIN ACTIVITY PRODUCER PLANTS</th>
<th>AUTOPRODUCER PLANTS</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ELECTRICITY (ONLY)</td>
<td>CHP</td>
<td>HEAT (ONLY)</td>
</tr>
<tr>
<td>Electricity</td>
<td>a  5 020</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Nuclear</td>
<td>b</td>
<td></td>
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<tr>
<td>Hydro</td>
<td>c  20</td>
<td></td>
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</tr>
<tr>
<td>Geothermal</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Solar</td>
<td>f</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tide, Wave and Ocean</td>
<td>g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind</td>
<td>h</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combustible Fuels</td>
<td>i  5 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat from Chemical Sources</td>
<td>j</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Sources</td>
<td>m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Gross electricity and heat production from combustible fuels 1/2

#### 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

**Input:**
Anthracite
100 kt, 22 TJ/kt

**Output:**
Gross Electricity
124 GWh

Efficiency = \( \frac{124 \text{ GWh} \times 3.6 \text{ (TJ/GWh)}}{100 \text{ kt} \times 22 \text{ (TJ/kt)}} \) = 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


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).

Click to download it free of charge!
Thank you for listening
– Any Questions

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ANNUAL ELECTRICITY DATA COLLECTION IN THE UK

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