The Electric Power System

- Great Britain-
Basic facts

- Area: 229,500km$^2$
- Population: 64.6 Million (source: Office for National Statistics)
- Number of electricity consumers: 26 Million
- Number of TSOs: 3 onshore, 7 offshore
- Number of DNOs: 9
- Peak load: 56 GW
- Transmission reliability 99.9999%
Global map of the grid and of its interconnections

- Interconnectors with:
  - Northern Ireland
  - Ireland
  - France
  - Netherlands

GB Power System
Grid facts and characteristics

- The electricity grid in Great Britain is split with:
  - 3 onshore transmission owners;
  - 7 offshore transmission owners;
  - 1 system operator;
  - 1 regulator;
  - 9 distribution network operators;
  - 218 generator companies with transmission agreements
Structure of the GB electrical power system

TO (England and Wales)

400 kV

275 kV

132 kV

33/11 kV

415 V

Non-Embedded Customers

Households

Industry

Distributed Generation

TO (Scotland)

Offshore Transmission
Map of the high voltage grid

Legend

- 400kV Circuit
- 275kV Circuit
- 132kV Circuit
- 400kV Substation
- 275kV Substation
- 132kV Substation

Note: Not all radial 132kV circuits are indicated on this diagram
## Information on TSO(s)

<table>
<thead>
<tr>
<th></th>
<th>SHE Transmission</th>
<th>SP Transmission</th>
<th>National Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network length [km] (400 kV)</td>
<td>49</td>
<td>942</td>
<td>11,131</td>
</tr>
<tr>
<td>Network length [km] (275 kV)</td>
<td>1,804</td>
<td>1,269</td>
<td>3,269</td>
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<tr>
<td>Network length [km] (132 kV)</td>
<td>3,009</td>
<td>1,729</td>
<td>0</td>
</tr>
<tr>
<td>Served area [km²]</td>
<td>78,400</td>
<td></td>
<td>151,100</td>
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<tr>
<td>Annual transmission [TWh]</td>
<td></td>
<td>339</td>
<td></td>
</tr>
<tr>
<td>Share load [%]</td>
<td>2.3</td>
<td>6.5</td>
<td>91.2</td>
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</tbody>
</table>

Co-operation of TSO and DNOs

Distribution Network Operators (DNOs) own and operate the distribution network of towers and cables that bring electricity from our national transmission network to homes and businesses. They don’t sell electricity to consumers. This is done by the electricity suppliers.
Responsibilities of TSO & DSOs

- **System Operator**
  - Transmission security
  - Frequency control
  - Transmission network access planning

- **Transmission Owners**
  - Transmission network access facilitation
  - Transmission voltage control
  - Transmission maintenance and construction activities

- **Distribution Network Operators**
  - Distribution security and voltage control
Power structure of the country
Installed capacity with reference to primary resources

- 2011
- 2012
- 2013
- 2014

Installed Capacity (MW):

- Other Fuels
- Renewables
- Nuclear
- Gas
- Coal

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Energy production with reference to primary resources

![Energy Production Chart]

- **Other Fuels**
- **Renewables**
- **Nuclear**
- **Gas**
- **Coal**
Development of generation capacity since 2011
Consumption per customer group

- Domestic
- Industry
- Energy industry use
- Commercial
- Public administration
- Agriculture
- Transport
- Losses
Development of wind power

![Graph showing annual build rate and total installed capacity from 2010 to 2014.]
Development of photovoltaic power

Annual Build Rate (MW)

Total Installed Capacity (MW)

2010 2011 2012 2013 2014

0 500 1000 1500 2000 2500 3000

0 500 1000 1500 2000 2500 3000 3500 4000 4500 5000 5500 6000

Annual Build Rate (MW)  Total Installed Capacity (MW)

GB Power System
RES installed capacity since 2010
RES production since 2010
Price development for industry consumers

Price of Electricity purchased by non domestic consumers in the UK (incl. Climate Change Levy) - P/kWh

Price development for households

Domestic Standard Electricity Unit Price
Assuming yearly consumption of 3800kWh/yr
Assuming 0.7 Euros per GBP
Electricity market organisation: Participants

Generation & Supply:
- e.on
- EDF
- Scottish and Southern Energy
- British Gas
- npower
- SCOTTISHPOWER

Transmission & Distribution:
- Independent distribution network operators
- Scottish and Southern Energy
- SP Energy Networks
- NORTHERN POWERGRID
- WESTERN POWER DISTRIBUTION
- nationalgrid

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Electricity market organisation: Market Structure

- **Generation**
  - Through forward markets generators contract with suppliers to produce the right amount of energy.
  - On the day generators decide which of their generating units run to meet their contractual obligations.

- **Markets**
  - Forwards and Futures Markets (>24h ahead)
  - Power exchanges (<24h) fine tune positions.
  - All contracts are ‘pay as bid’ and are firm.

- **Suppliers**
  - Supply companies forecast their electricity requirements per half hour.
  - Arrange contracts with generators per half-hour.
Electricity market organisation: Parallel Streams

System Operation

Generation on to Grid

Sells Energy

Market

Demand from the Grid

Buys Energy

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## Power balance since 2010

<table>
<thead>
<tr>
<th></th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
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<tr>
<td>Generation</td>
<td>381.8</td>
<td>367.4</td>
<td>363.6</td>
<td>359.2</td>
<td>338.9</td>
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<tr>
<td>Total demand</td>
<td>384.9</td>
<td>374.3</td>
<td>376.0</td>
<td>374.6</td>
<td>360.0</td>
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<tr>
<td>Imports</td>
<td>7.1</td>
<td>8.7</td>
<td>13.7</td>
<td>17.5</td>
<td>23.2</td>
</tr>
<tr>
<td>Exports</td>
<td>-4.5</td>
<td>-2.5</td>
<td>-1.9</td>
<td>-3.1</td>
<td>-2.7</td>
</tr>
<tr>
<td>Losses</td>
<td>27.0</td>
<td>28.1</td>
<td>28.9</td>
<td>27.7</td>
<td>28.6</td>
</tr>
</tbody>
</table>
Electricity Market: Timescales

Suppliers contract directly with generators to source the electricity they need ~ 90+%

£30bn

Power Exchanges

Rolling half hour trades (fine tuning) ~ 5%

T - 24 hrs

Forward Markets

Generation & demand balanced by National Grid as SO ~ 3%

£1bn

Balancing Mechanism

Reserve

T – 1hr

Imbalance Settlement

Post event settlement (Elexon)

T + 14 months

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The Balancing Mechanism

Bilateral trading activities

- FPNs
- Op Data
- Bids/Offers

BM data

~1,500,000 items/day

Balancing mechanism

Bid / offer acceptances

1 hour

Gate closure

Real time

Settlement

- BM actions
- ~600 Balancing actions/day

FPNs

~600

Op Data

Bids/Offers

BM actions

GB Power System
Specific aspects of the electricity market

Price Coupling of Regions (PCR) in Europe

**WHAT is PCR?**
Price Coupling of Regions (PCR) is the initiative of seven European Power Exchanges to harmonise the European electricity markets

**HOW is this done?**
By developing a single price coupling algorithm to be used to calculate electricity prices across Europe