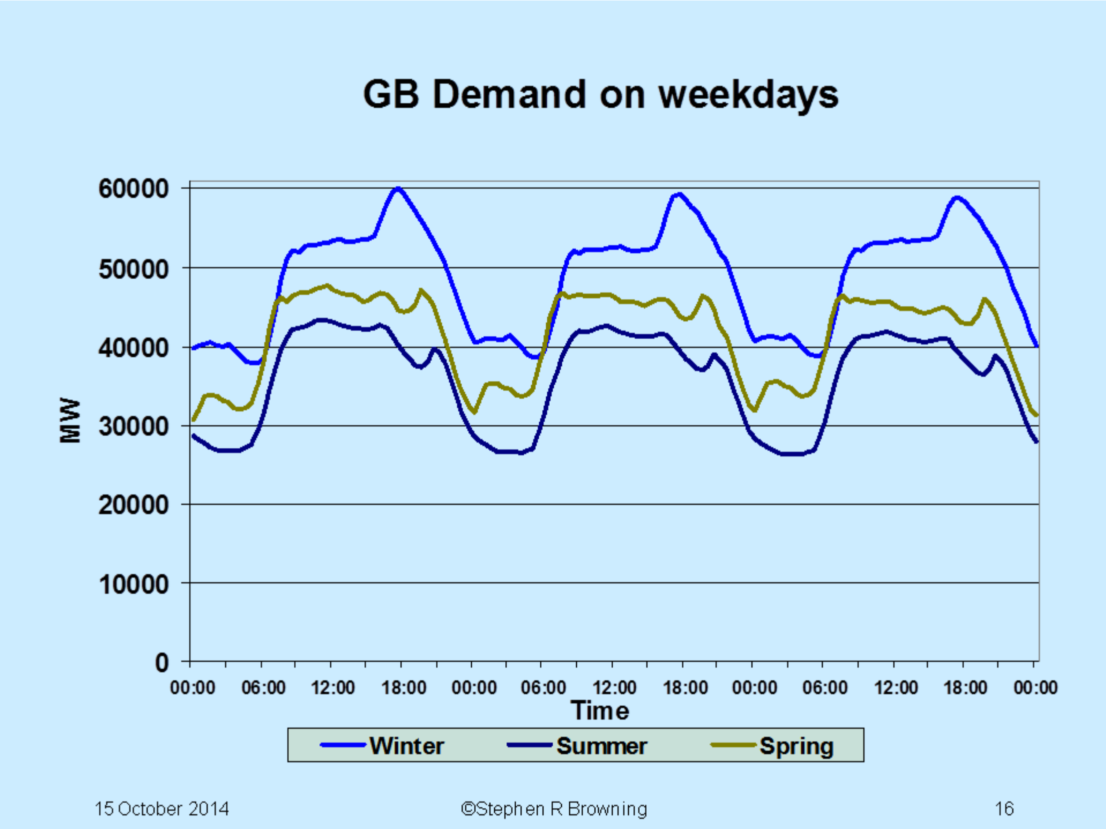
Future Power Systems 2 - Matching Monitoring and Predicting Generation and Demand

Demand Profile

The demand is continually changing, thus generation has to be scheduled and dispatched to track it, plus provide adequate response and spare, which can react in the appropriate timescales to cater for inaccuracies in demand prediction or unexpected generation output. Here are some examples of different weekday demand patterns in Great Britain (GB).

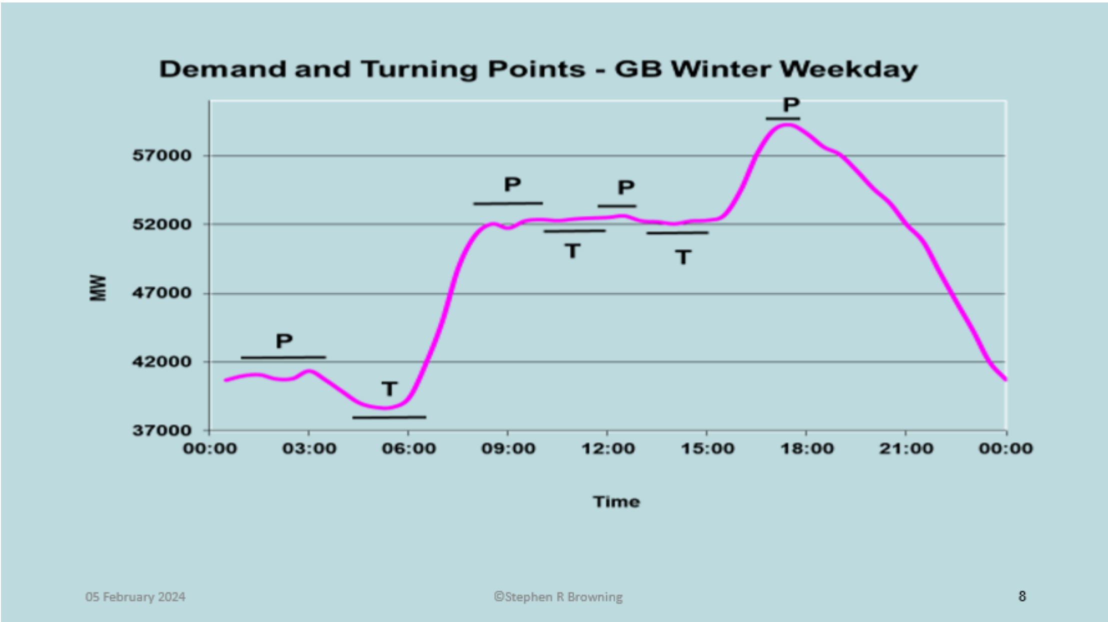


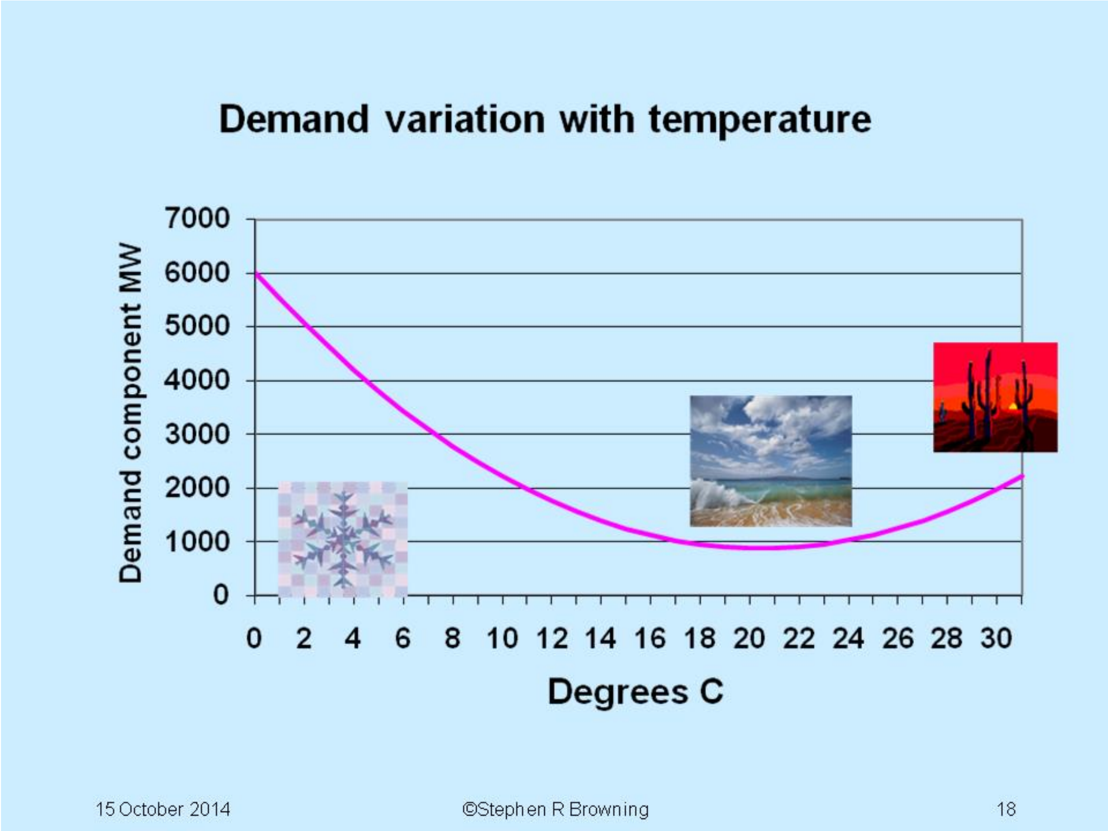
The metering from all generation sources +/- interconnector flows will of course summate to the demand as the system is always in balance. The system operator will maintain continuous and integrated metering for the main plant, transmission system and interconnection flows. Total and nodal demand histories are derived from this and stored.

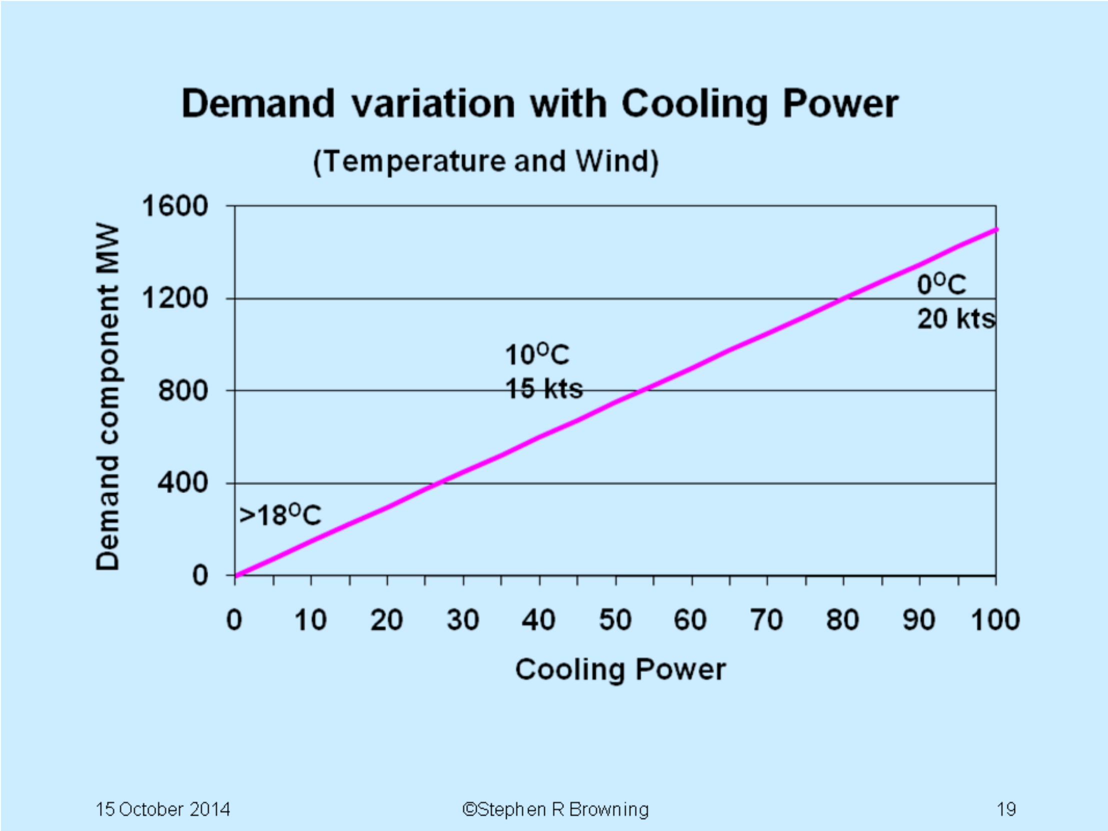
Future Power Systems 2 - Matching Monitoring and Predicting Generation and Demand

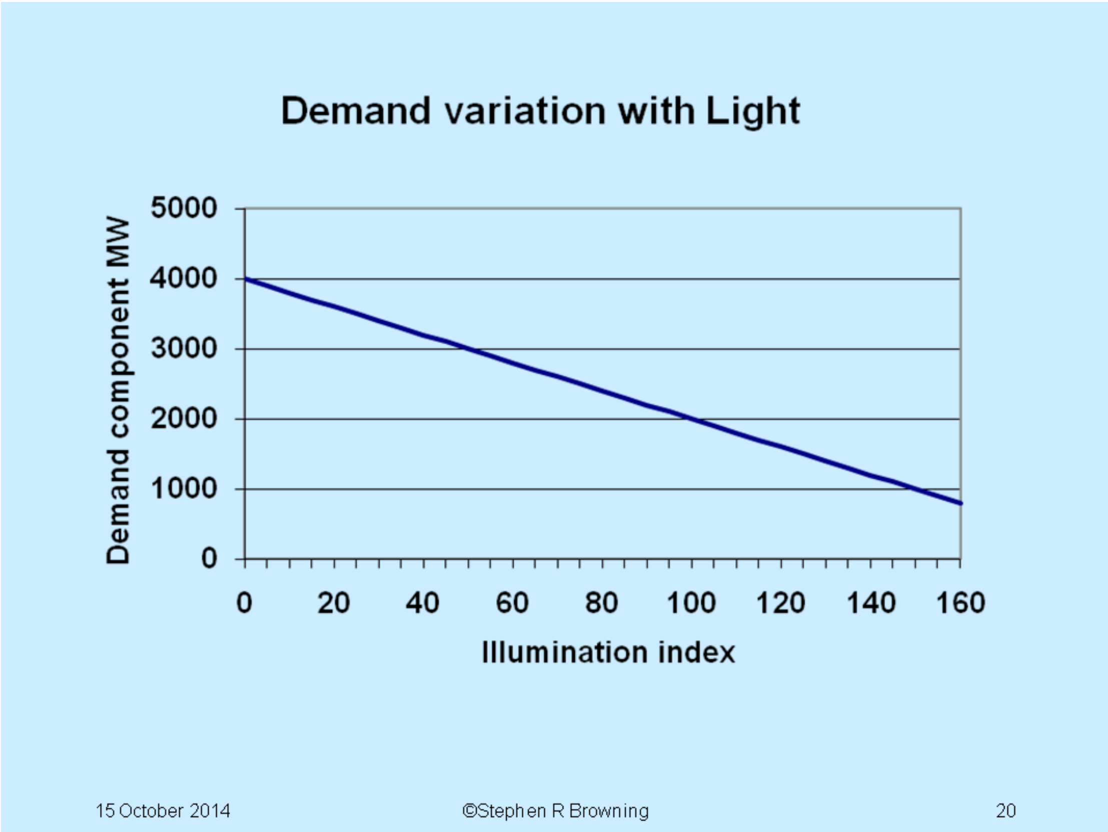
Demand Prediction

Demand prediction is normally carried out from analysis of total historical demand data against weather for each cardinal point periods (time of day) in the relevant groups (day of the week, season of the year). This gives a set of weather coefficients and a base profile across each season for each Cardinal point. Using the base patterns levels and forecast weather, future demands for each Cardinal point can be derived.




Demand variation with temperature
Demand component MW
7000
6000
5000
4000
3000
2000
1000
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30
Degrees C
15 October 2014
©Stephen R Browning
18

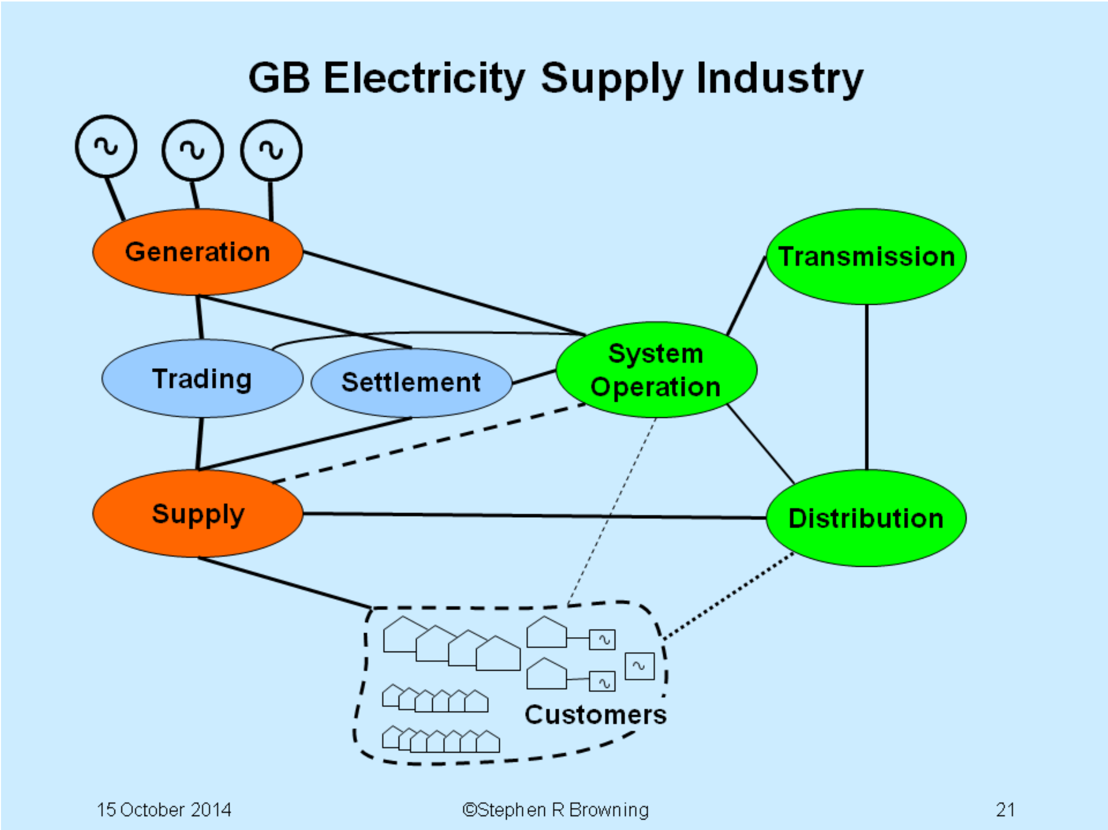

Demand variation with Cooling Power
(Temperature and Wind)
Demand component MW
1600
1200
800
400
0
0
10
20
30
40
50
60
70
80
90
100
Cooling Power
>18°C
10°C
15 kts
0°C
20 kts
15 October 2014
©Stephen R Browning
19


Demand variation with Light
Demand component MW
5000
4000
3000
2000
1000
0
0
20
40
60
80
100
120
140
160
Illumination index
15 October 2014
©Stephen R Browning
20

Future Power Systems 2 - Matching Monitoring and Predicting Generation and Demand

Industry Structure

Operation of conventional main generation is of course under the plant operator's control, with output committed and dispatched through market and system operation mechanisms. The instructed profile is compared with the demand prediction and plant ordering and dispatch adjusted to match across all lead timescales. This diagram shows the business elements of the 'unbundled' industry in Great Britain.

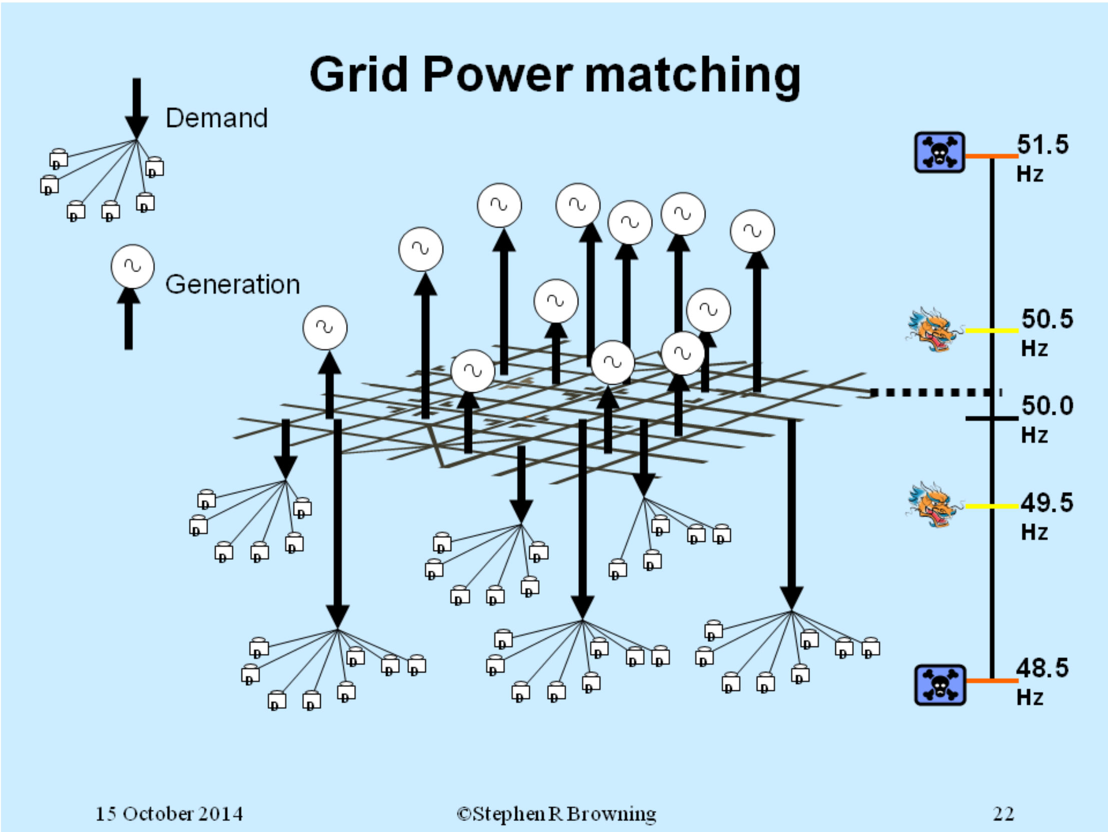


Future Power Systems 2 - Matching Monitoring and Predicting Generation and Demand

Transmission design/modelling and Distribution design

The Transmission System is 'Active', with Power flows changing in magnitude and direction with as demand and generation output changes. Thus detailed fast metering of Power flow, voltage and other data is required. Predictive modelling of flows, voltage and stability are needed to ensure stable and secure operation.

To do this we need the predicted loading profile on the wires. This is derived by application of nodal (substation) demand data derived from nodal demand history and ratioed to match forecast total demand. Instructed generation output is applied at each connection node and the resulting nodal profile is applied to the grid technical data to calculate load flows. The system is then analysed to ensure it will be secure - loading, voltage and stability in the steady state and after fault.



To this data we need to add the Interconnector Imports and Exports at their points of connection.

Passive distribution systems are designed and customer connections analysed to ensure the system will be secure at the peak and trough conditions in each year. Thus the passive system is always sized to meet the maximum demand on it.

Future Power Systems 2 - Matching Monitoring and Predicting Generation and Demand

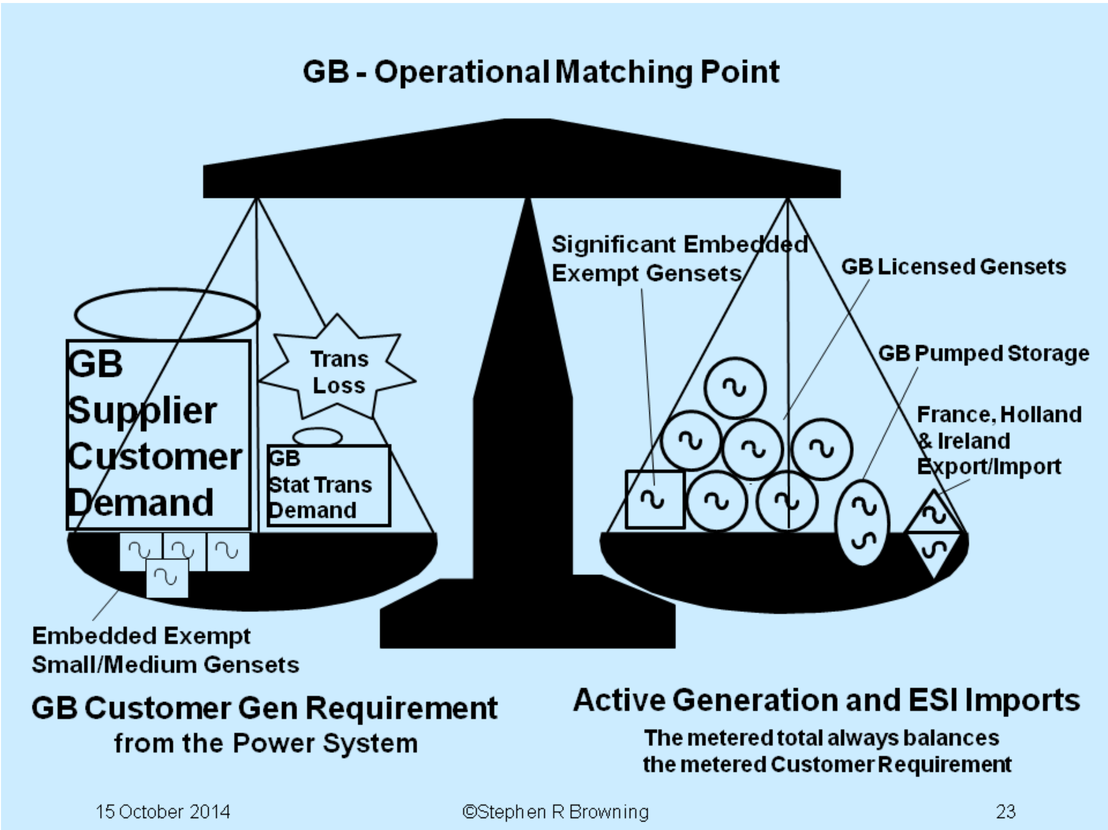
Generation and Demand 'accounting' for matching

A large system will carry a range of generating units, from big main units (500/660MW individual), right down to (increasing amounts of) microgeneration. To adequately and efficiently 'match' Generation to Demand the market and operator do not need a precise view of all the very small plant, as long as, individually or in aggregate, it does not form a large percentage of demand or always runs in a 'stable' manner.

However, for total and nodal demand prediction to be accurate, the metering must not be 'distorted' by omission of large amounts of embedded generation meters from the generation summation.

We model the 'match point' as the output required from the all significant Generating plant, plus Interconnector Imports less Interconnector Exports and Pumped Storage Demand, to meet the GB Customer and Power Station demands plus Transmission losses. We model Active against Passive.

So, the 'actual' view of the Generation-demand 'matching point' looks as follows. Note that the scales are always 'level' as the system is always in balance.

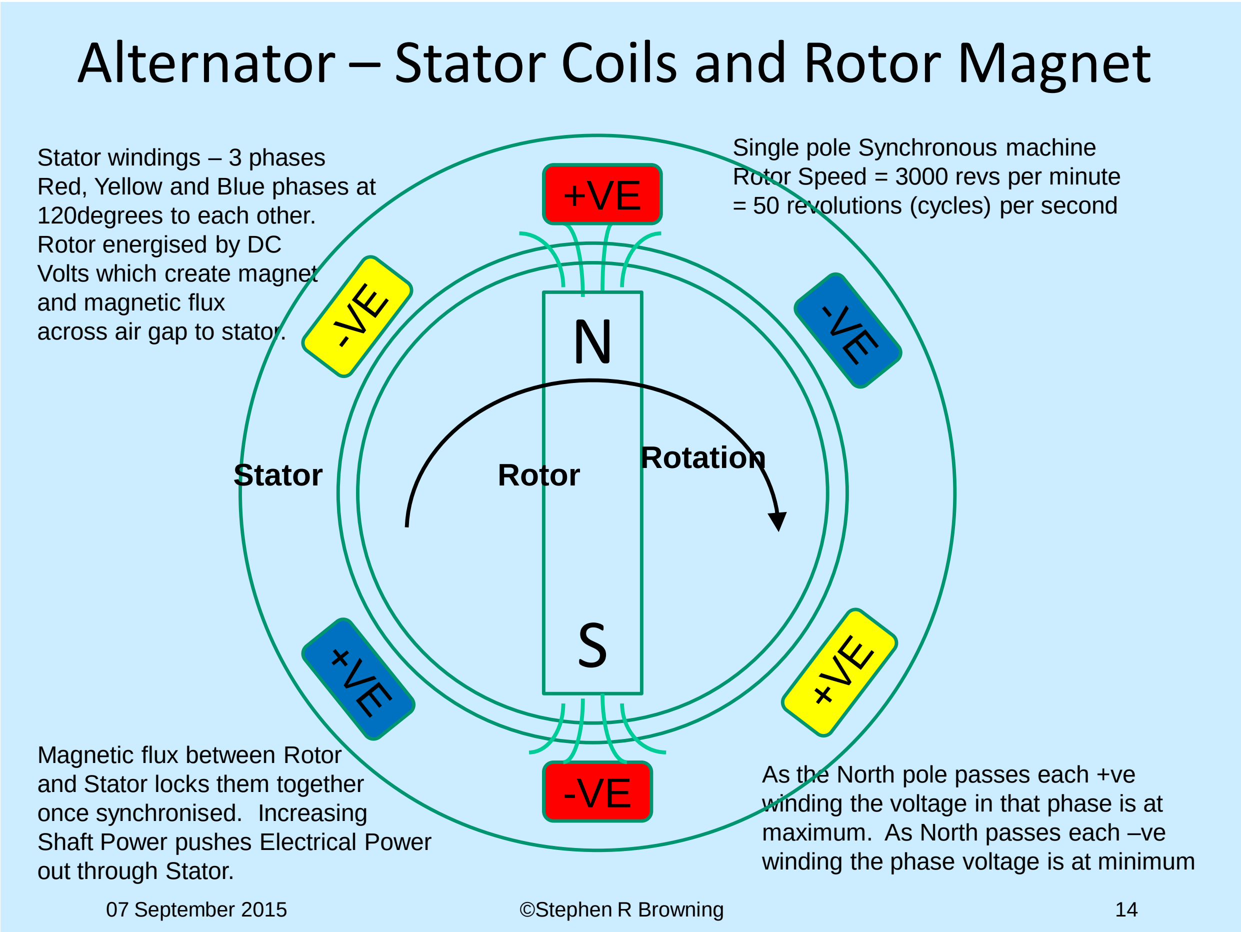


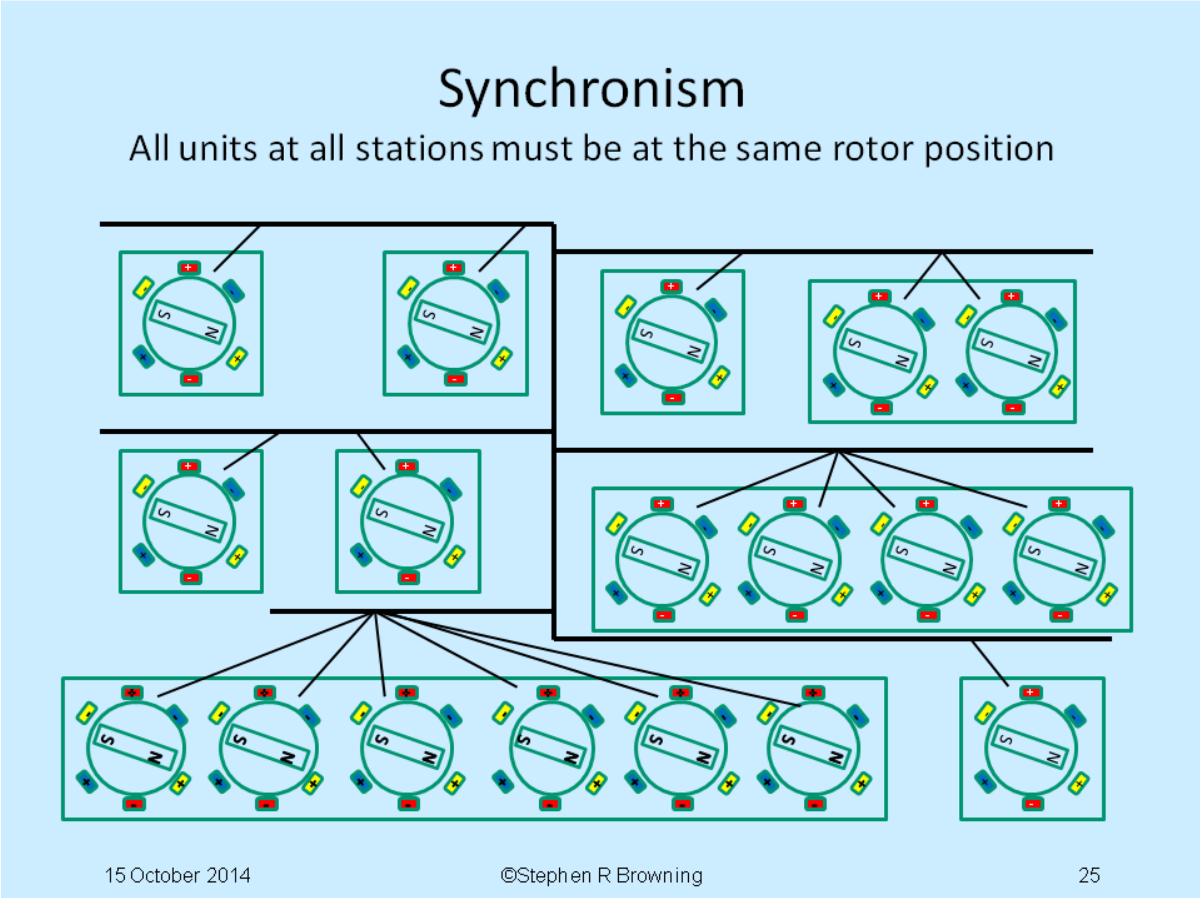
Future Power Systems 2 - Matching Monitoring and Predicting Generation and Demand

Synchronism

Please read together with FPS 3 Pages 8 and 9

Each system is of course in 'dynamic' balance. All generating units are 'locked together'; the voltage on each phase must of course maximise then minimise at the exactly the same time at all points on the system. Thus the 'magnets' within the rotors on all synchronous generating units are always at the same relative position.





It is a sobering thought that, at the annual peak of 60GW, the combined set of running generating units is pushing over 80 million brake horsepower into the wires as the demand appliances 'pull' exactly the same amount out.

All those Generating Units and the Demand are dynamically (Electromagnetically) 'locked' together.

Thus Electricity systems are the biggest machines on the planet.

Future Power Systems 2 - Matching Monitoring and Predicting Generation and Demand

As each Machine is brought up to Speed a Synchronising Clock is energised which shows the Waveform position of the machine in relation to the system.

When the Pointer is at Top Dead Centre the Machine Waveform exactly matches that of the System. Only then can the Circuit Breaker be closed to connect. The Alternator is then 'locked' to the System Waveform and any increase in Power input to the shaft causes an Export of Electrical Power to the System