Distributed Energy

Distributed energy and grid stability

National grid

- The electricity national extra high voltage grid connects to large power stations and offshore wind generation farms.
- It consists of 400 kV and 132 kV power lines and cables
- There are intercontinental connectors with ac/dc and dc/ac inverters to swop power at peak times

Distributed energy

- Consumers with self-generation are connected to the 33 kV and 11 kV power lines and with 415 V and 240 V local distribution
- Self-generation is mainly by solar PV, wind and anaerobic digestion
- The main advantage of this is that it makes better use of the existing power lines
- A consumer with a load of 10 kW with solar PV providing 5 kW will reduce its grid intake to 5 kW
- Local inputs reduce the overall load on the system

National grid control

- National grid has to balance inputs with demand
- If a major power station drops out of action it reduces temporarily the system frequency and the voltage
- The operator has to bring other generators on line to restore stability
- This usually is performed without a noticed disturbance
- If large generators drop out and standby generation fails, parts of the system may have to be isolated to prevent a national blackout

Effects on renewables of loss of a major generation input

- In August 2019 Little Barford gas-fired power station (698 MW) tripped, while moments later Hornsea offshore wind farm (Maximum 1.2 GW) shut down
- To avoid a complete national blackout a large section of the grid in Wales was shut down
- The effect was compounded when all the renewables' inverters in the switched off section lost their voltage and frequency references and shut off

Dropout section management

Renewables require network load and reference voltage and frequency for inverters

Connected mostly to 33kV, 11kV and 415/240V power lines

When major 400kV and 132kV sections are closed to maintain stability 33kV/11kV and 415/240V ring mains could be section-wise isolated and connected to standby generation per section (by automatic change-over ?)

This would keep renewables working and providing their share of the section load while major sections are closed.

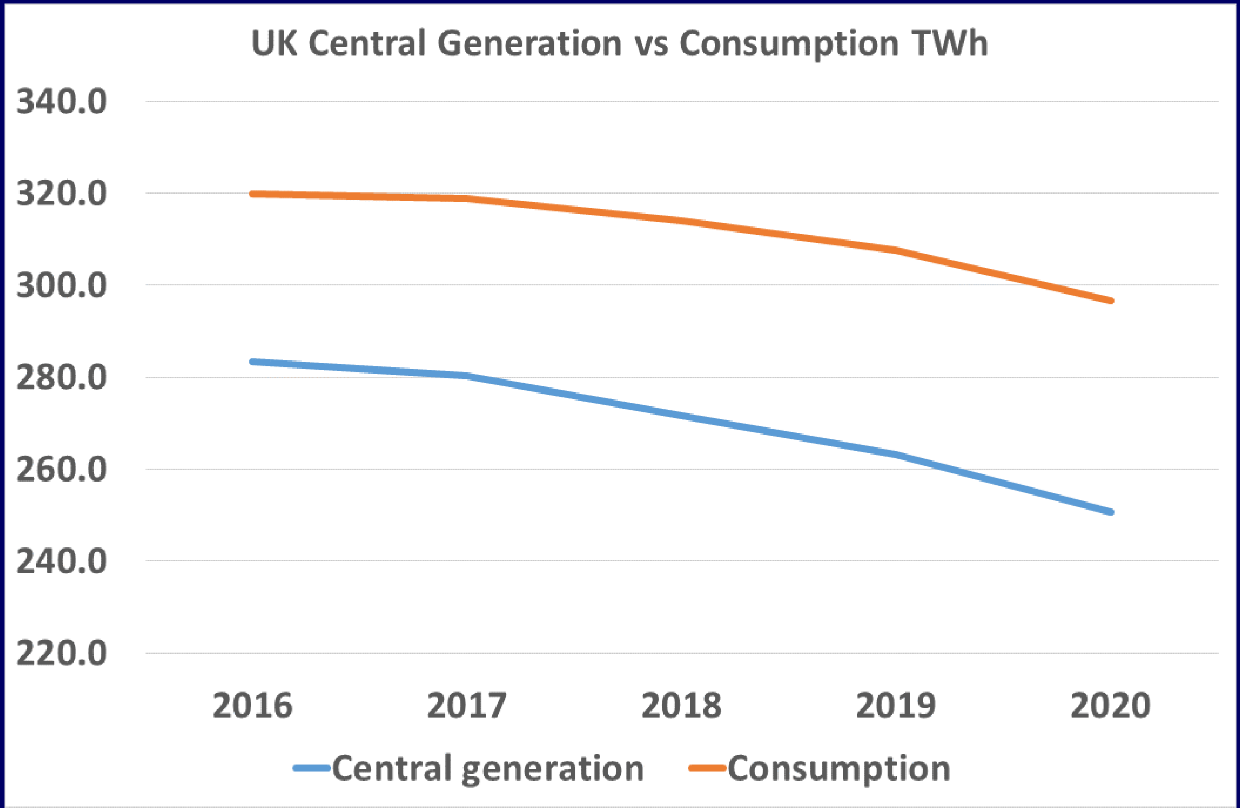
UK nuclear plants in operation

Sizewell B	1195 MWe
Torness	1205 MWe
Heysham 1 and 2	1240 & 1250 MWe
Hartlepool	1190 MWe
Hunterston B	830 MWe
Hinkley Point B	840 MWe
Dungeness B	1040 MWe

Coal-fired power plants

Drax 5 & 6	(Wood fired)	1290 MWe
West Burton A		2000 MWe
Kilroot		520 MWe
Ratcliffe on Soar		2000 MWe

UK Electricity Generation and Consumption 2016-2020



Central Electricity Generation and Consumption TWh

- Solar PV and anaerobic digestion is distributed, not central
- The UK's central generation on the grid has declined from 2016 to 2020 by 11% from 283 TWh to 251 TWh
- The UK's consumption has declined from 2016 to 2020 by 7% from 320 TWh to 297 TWh
- The additional 23 TWh between consumption and central generation is met by net imports/exports and by solar power

Electricity grid input power
See www.gridwatch.co.uk

- 2020 day averages in GW
- Power range:-
- Minimum 17.151 GW Maximum 47.275 GW
- Average 29.653 GW
- HPC 3.2 GW will provide 19 % input of minimum central power
- With SZB 1GW, SZC 3.2 GW and Hualong 2 GW nuclear will provide together 9.4 GW
- Nuclear would then provide 55% of minimum, 32% of average, 20% of maximum power

Electricity grid stability

- The bigger the input power the greater the effect on grid stability
- All the nuclear plants have to run 24/7 at a load factor of 90% to be viable
- Predominance of nuclear will cost inflate unaffordable “strike” prices per MWh
- Section closures will be essential to avoid a national blackout - it will be impossible to replace the output of a lost big input with multiple small units in time.
- Losing the HPC transmission line would require 2 or 3 major generator replacements
- SZC is not required

Section closure needs grid re-profiling

- 400 kV lines for major inputs
- 132 kV lines for major wind farms
- 33 kv lines for biomass and major solar
- 11 kV lines for large renewables
- 415/240 for small solar, wind and hydro

Small modular reactors

- Instead of SZC a number of distributed small modular (nuclear) plants, SMRs <300 MWe would be more appropriate for a distributed system
- Cooling in rivers is problematic in Summer as in France
- SMRs use fan air cooling systems, noisy and inefficient
- Communities are unlikely to accept SMRs
- Huge security problems with large numbers

My Conclusion

- SZC not required
- SMRs unacceptable and insecure
- Grid stability needs study
- Distributed energy a necessary concept
- Major inputs too big