

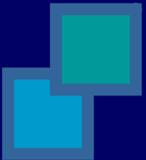
Distributed Energy



Distributed energy and grid stability

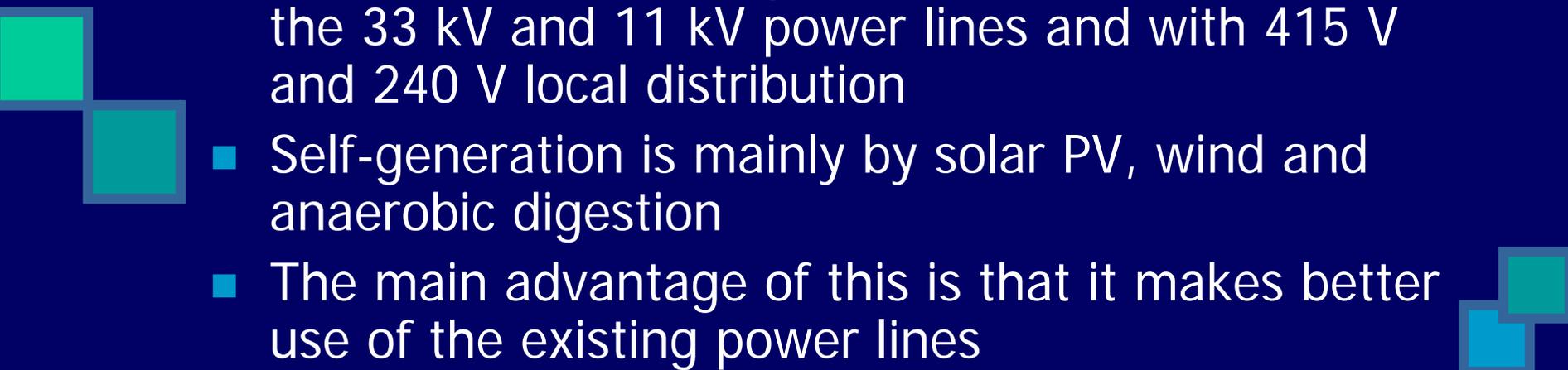


National grid

- 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
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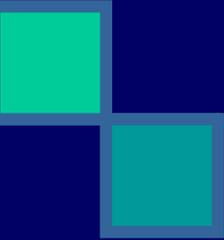
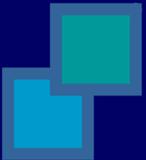


Distributed energy

- 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
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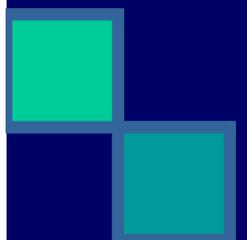


National grid control

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- 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
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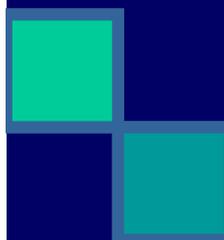


Effects on renewables of loss of a major generation input

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- 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
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Dropout section management



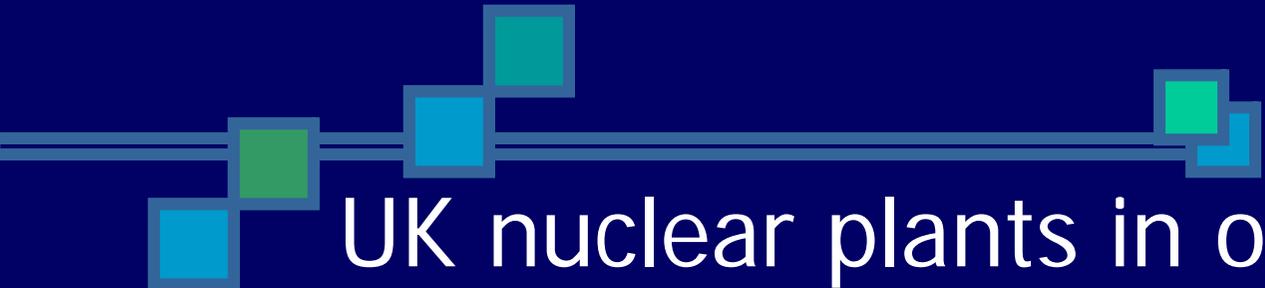
Renewables require network load and reference voltage and frequency for inverters

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

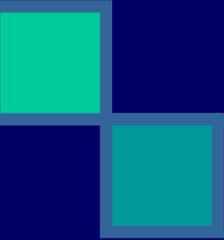
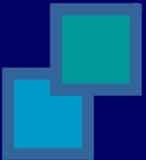
When major 400kV and 132kV sections are closed to maintain stability 33kV/11kV and 415/240V ring mains could be section-wise isolated and connected to standby batteries per section by automatic change-over



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

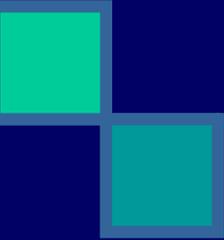
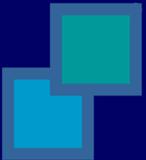


UK nuclear plants in operation

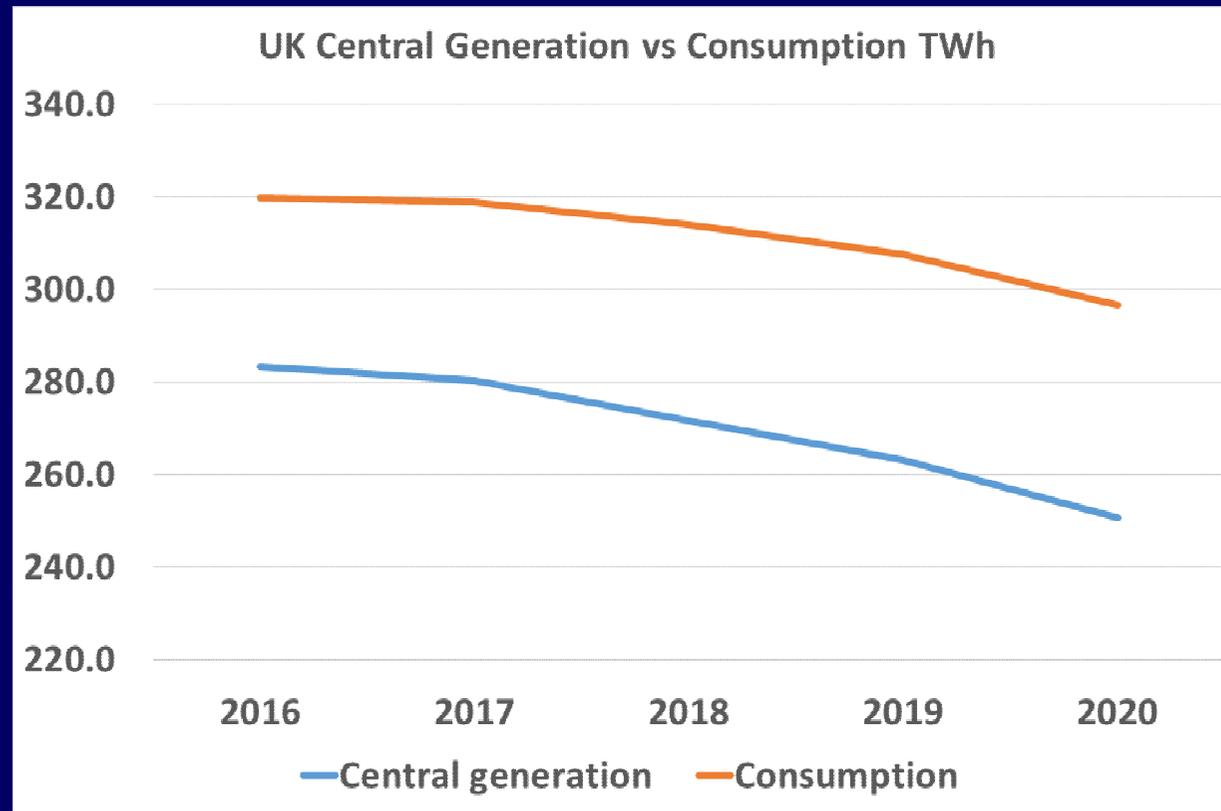
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- Sizewell B 1195 MWe
 - Torness 1205 MWe
 - Heysham 1 and 2 1240 & 1250 MWe
 - Hartlepool 1190 MWe
 - Hunterston B 830 MWe
 - Hinkley Point B 840 MWe
 - Dungeness B 1040 MWe
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Coal-fired power plants

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- Drax 5 & 6 (Wood fired) 1290 MWe
 - West Burton A 2000 MWe
 - Kilroot 520 MWe
 - Ratcliffe on Soar 2000 MWe
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UK Electricity Generation and Consumption 2016-2020



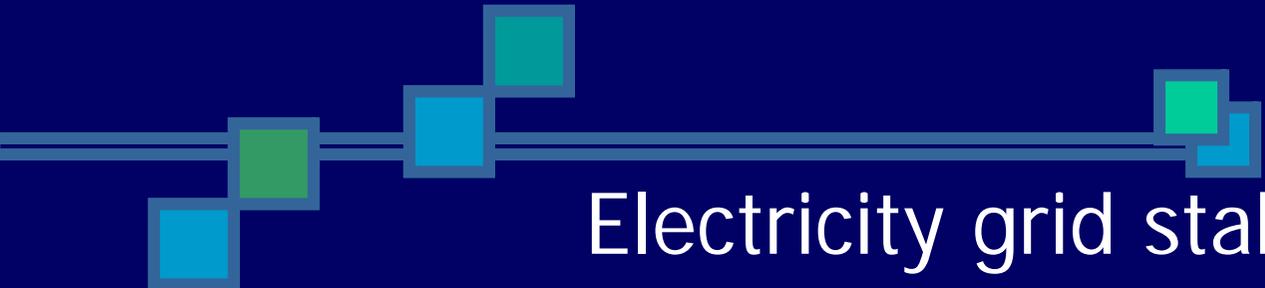
Central Electricity Generation and Consumption TWh

- 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

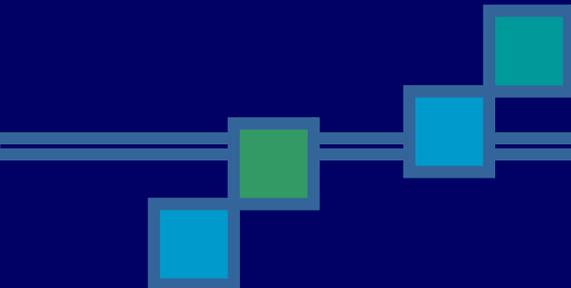
See www.gridwatch.co.uk

- 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

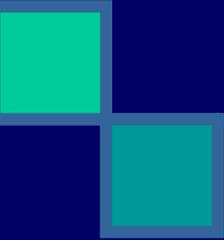
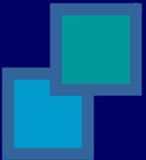


Electricity grid stability

- 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
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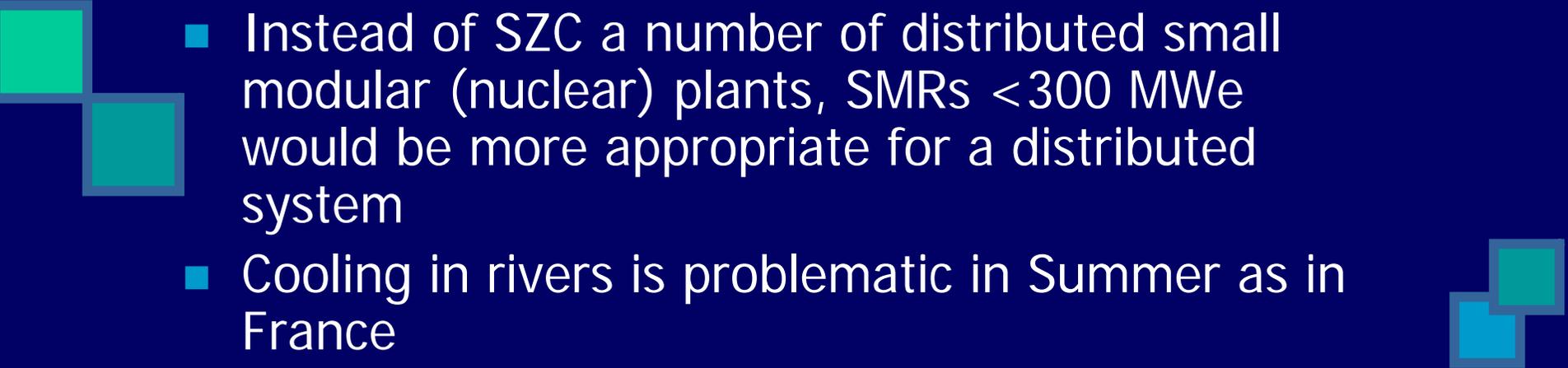


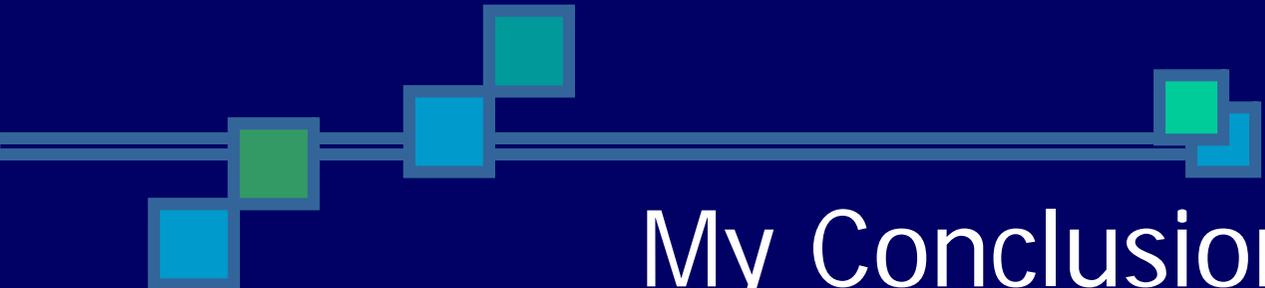
Section closure needs grid re-profiling

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- 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
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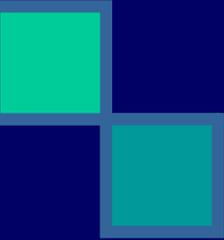


Small modular reactors

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- 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

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