Energy and climate modelling: the perspective of a power system researcher and former investment planner

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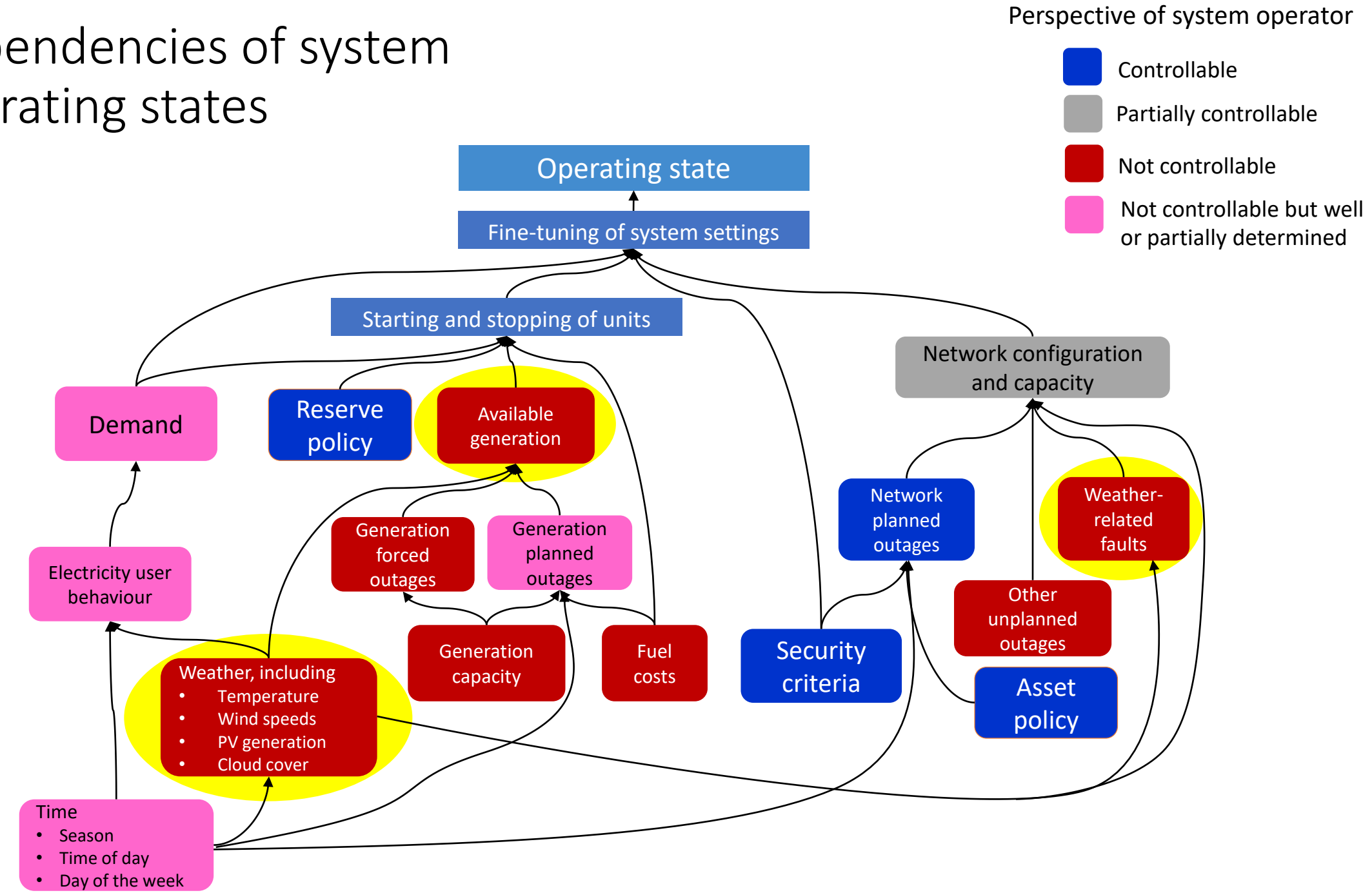
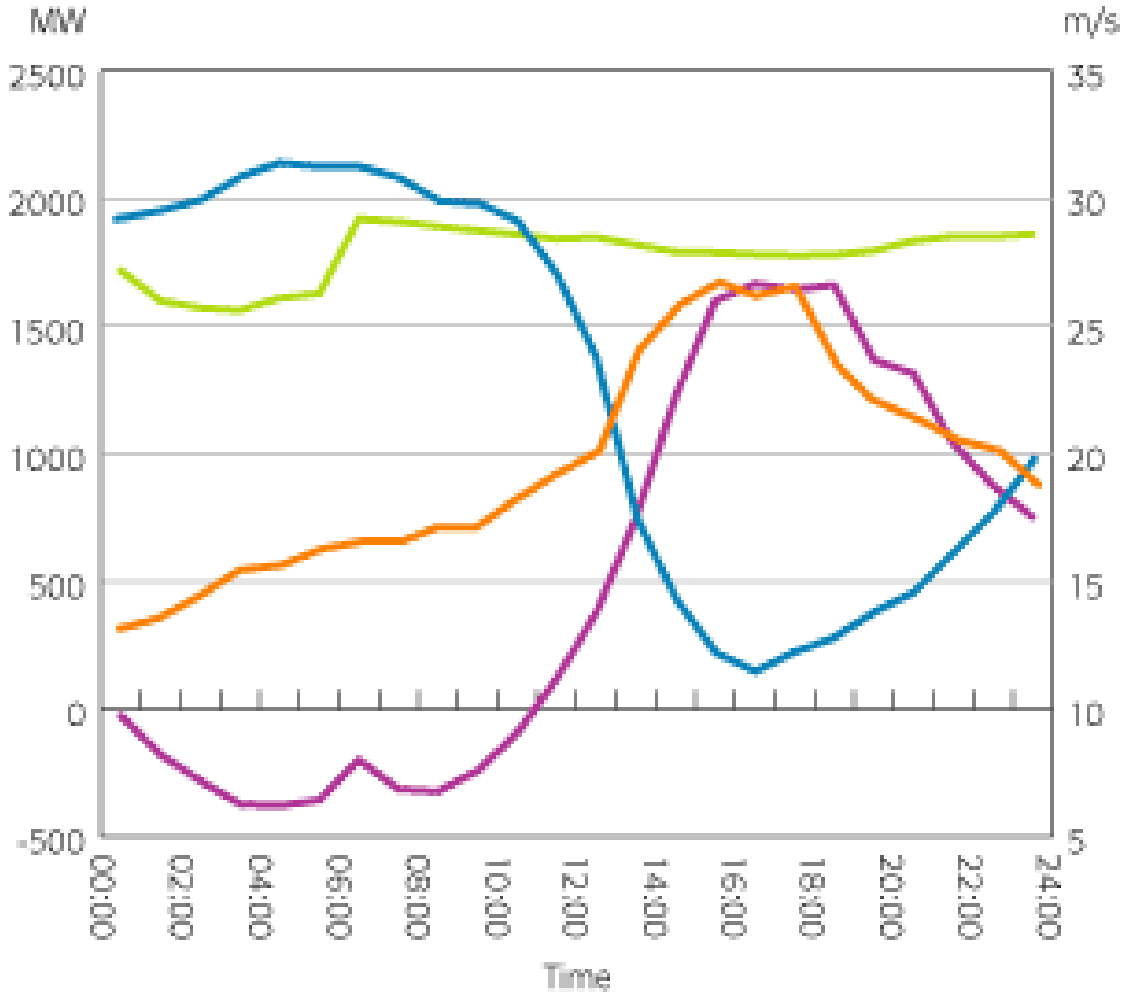
https://www.strath.ac.uk/staff/bellkeithprof/

Dependencies of system operating states



High wind speed shutdown

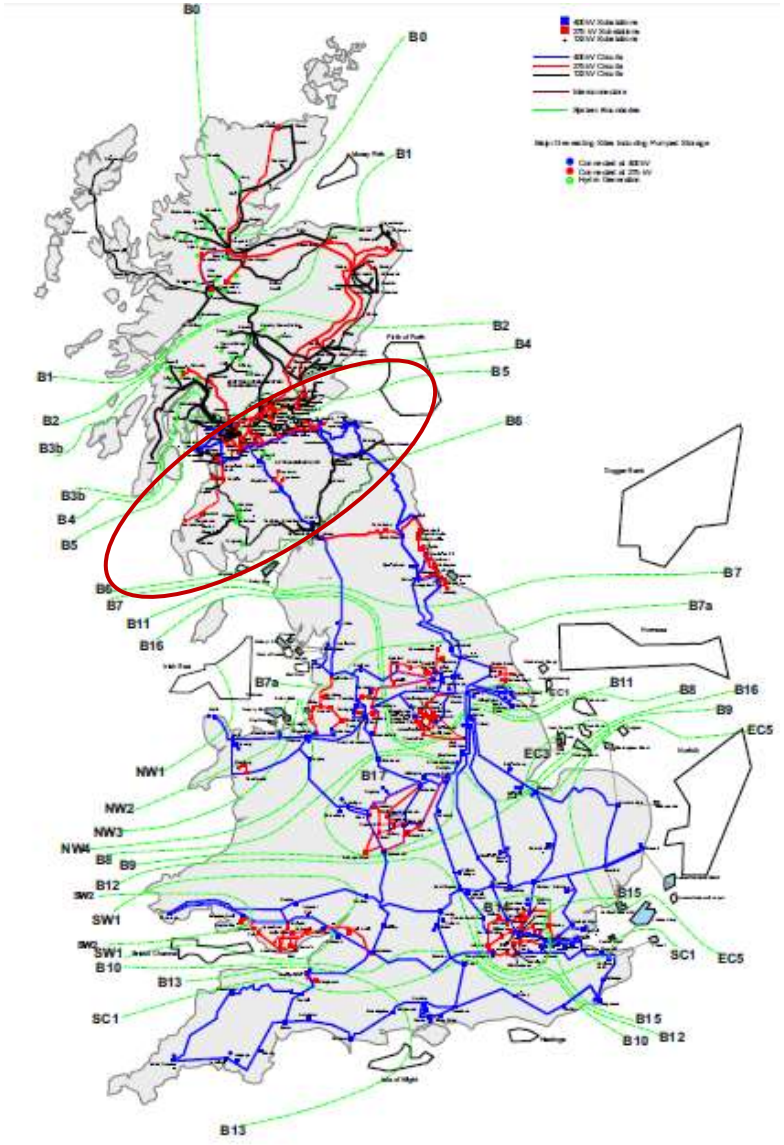


Unexpected hurricane
Denmark, January 8th 2005

- Will a high wind-speed shutdown happen?
- When will it happen?
- By how much will wind power drop?
- How quickly?

Source: Eltra
See http://www.eltra.dk/show.asp?id=15783

Weather-related transmission network faults in Southern Scotland



Analysis focussed on the Scottish Power Transmission area (Southern Scotland)

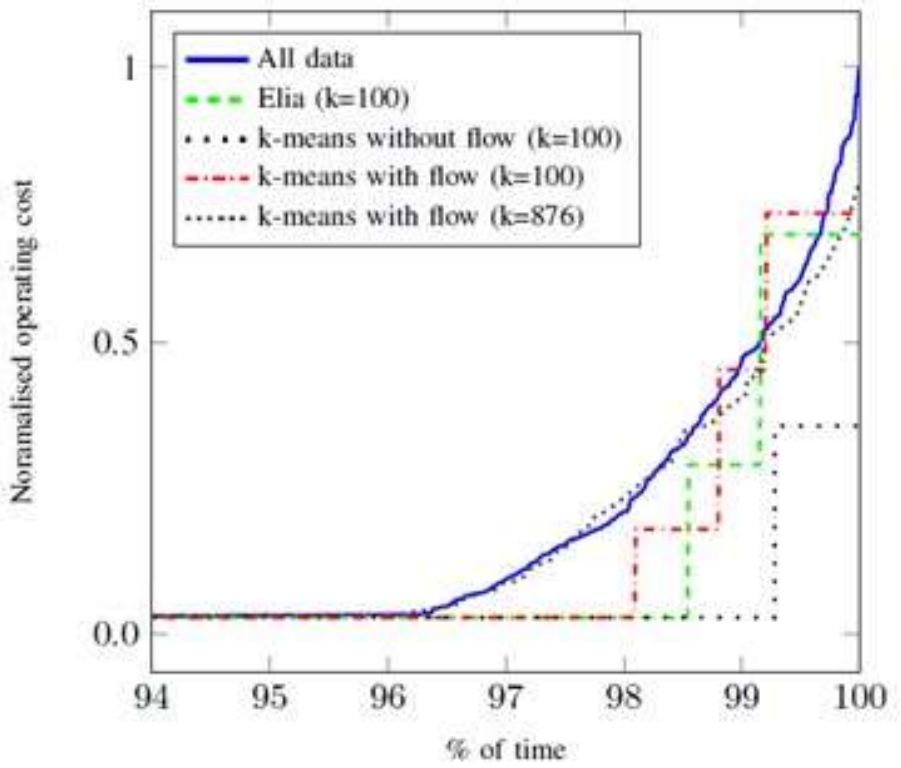
- Records of faults, 1984-2012 (28 years)
- Clusters of weather-related faulted identified

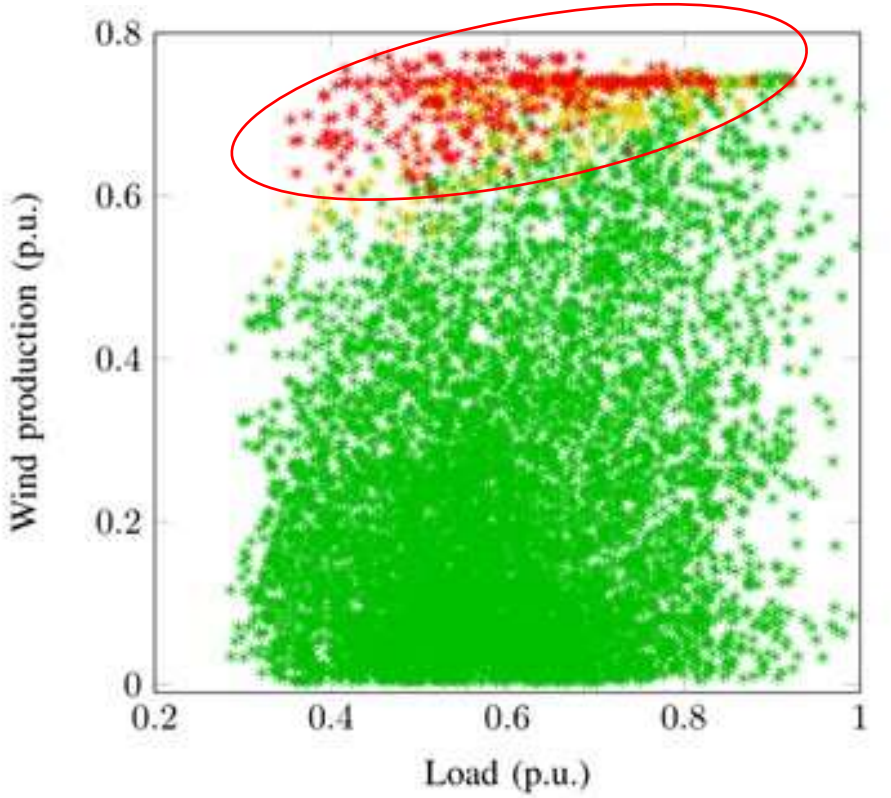
Year-round average: 0.006 faults/hour

Weather type	Faults/hour
“Ice, snow, sleet and blizzards”	11.4
Lightning	8.4
“Wind, gale, and windborne object”	18.6
“Corrosion, condensation and salt”	6

Work by Euan Norris

Network development: assessing possible future system states





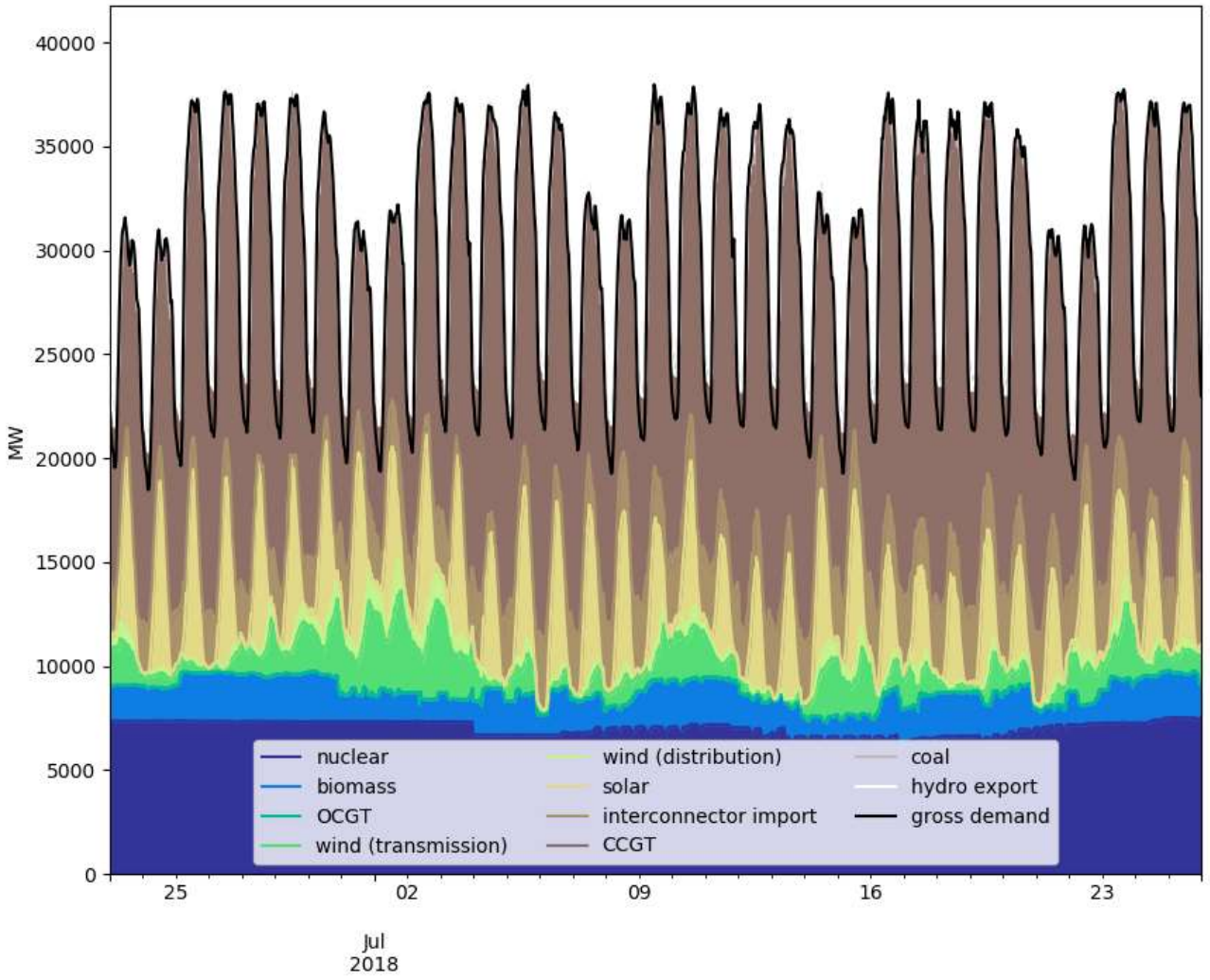
- How many of these cases will there be?
- How many should be satisfied?

OK in N and N-1
OK in N but not in N-1
Not OK in N

Some clustering methods better than others
None catch the HILP scenarios

Peak demand is not the worst condition

Wind ‘drought’ for extended periods



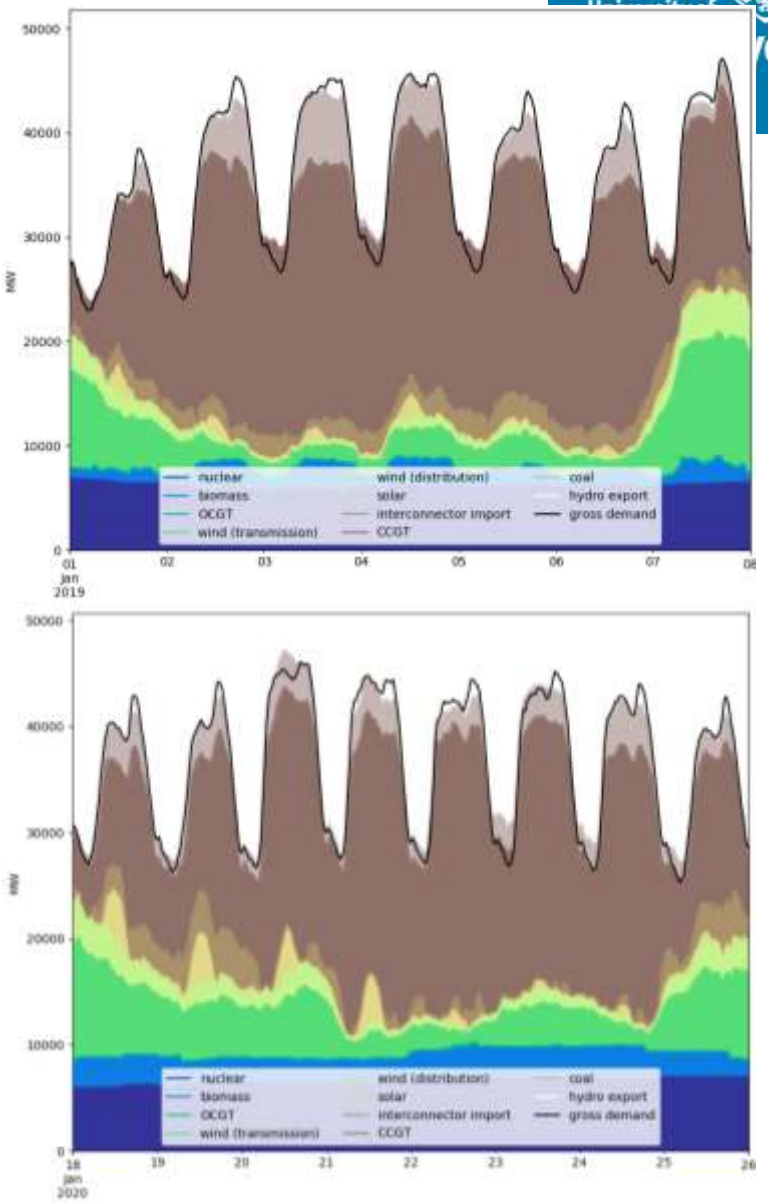
Start Date	23rd June 2018	
Duration	33 days	
Peak gross demand	38.0 GW	
Average gross demand	29.5 GW	
Total gross demand	23,445 GWh	
Total wind output	1,448 GWh	**2018 Mean**
Average wind CF	8.4%	28.1%
Average wind output	1.8 GW	6.0 GW
Demand met by gas-powered generation	46.1%	37.9%

(wind index for 2018 = 99% of long term average)

Need not just MW capacity of schedulable, flexible generation, demand or storage but MWh capacity, i.e. persistence of output

…but not just in summer

Start Date	2nd Jan 2019	21st Jan 2020
Duration	5 days	4 days
Peak gross demand	45.7 GW	45.2 GW
Average gross demand	36.2 GW	37.5 GW
Total gross demand	4,361 GWh	3,615 GWh
Total wind output	337 GWh	342 GWh
Average wind CF	12.8%	16.2%
Average wind output	2.8 GW	3.5 GW
Demand met by gas-powered generation	56.4%	54.2%



Substantial volumes of energy that cannot be supplied by traditional peak-shifting or diurnal storage, and may occur at times when heat demand is at a peak and able to offer little flexibility

System operation questions

- What will be the future correlation of demand with weather?
  - Increased cooling demand? More electrified heating?
- How to meet demand during long lulls in wind power?
  - How big would ‘essential’ demand be anyway?
- How to manage high wind speed shutdowns?
  - How deep would be the drop in wind output?
  - How fast might it happen?
- How many faults will there be during storms and how long will a storm last?
  - How many will involve equipment damage, e.g. due to high winds or flooding?
  - Will the system operator be able to operate defensively when a storm is coming?
- (The system operator depends on facilities made available by the investment planner)

Investment planning questions

University of Strathclyde Engineering

- How often will ‘wind droughts’ occur?
  - What will the peak demand be for ‘essential’ services? (MW question)
  - How long will the drought last and how much energy will be demanded? (MWh question)
- What will the long-term average capacity factors of renewables be? (MWh question)
- What is the right mix of assets to meet demand for electricity?
  - Renewable generation capacity
  - Other low carbon generation capacity
  - Storage capacity (of different types)
  - Interconnector capacity
- How much network capacity will be needed to
  - accommodate the mix of generation, storage and interconnector capacity?
  - enable the system to survive faults and unavailability of generation?
- What equipment, personnel and communications facilities will be needed to recover from major disturbances?
- What can be assumed for the thermal ratings of equipment?