Managing a Power System with 40% Wind

Dr Alan Rogers
EirGrid

Outline

- Current Situation
- Case study: August 26th 2009 > 40% Wind
- Power System Stability
- System Stability Tools
- Conclusions

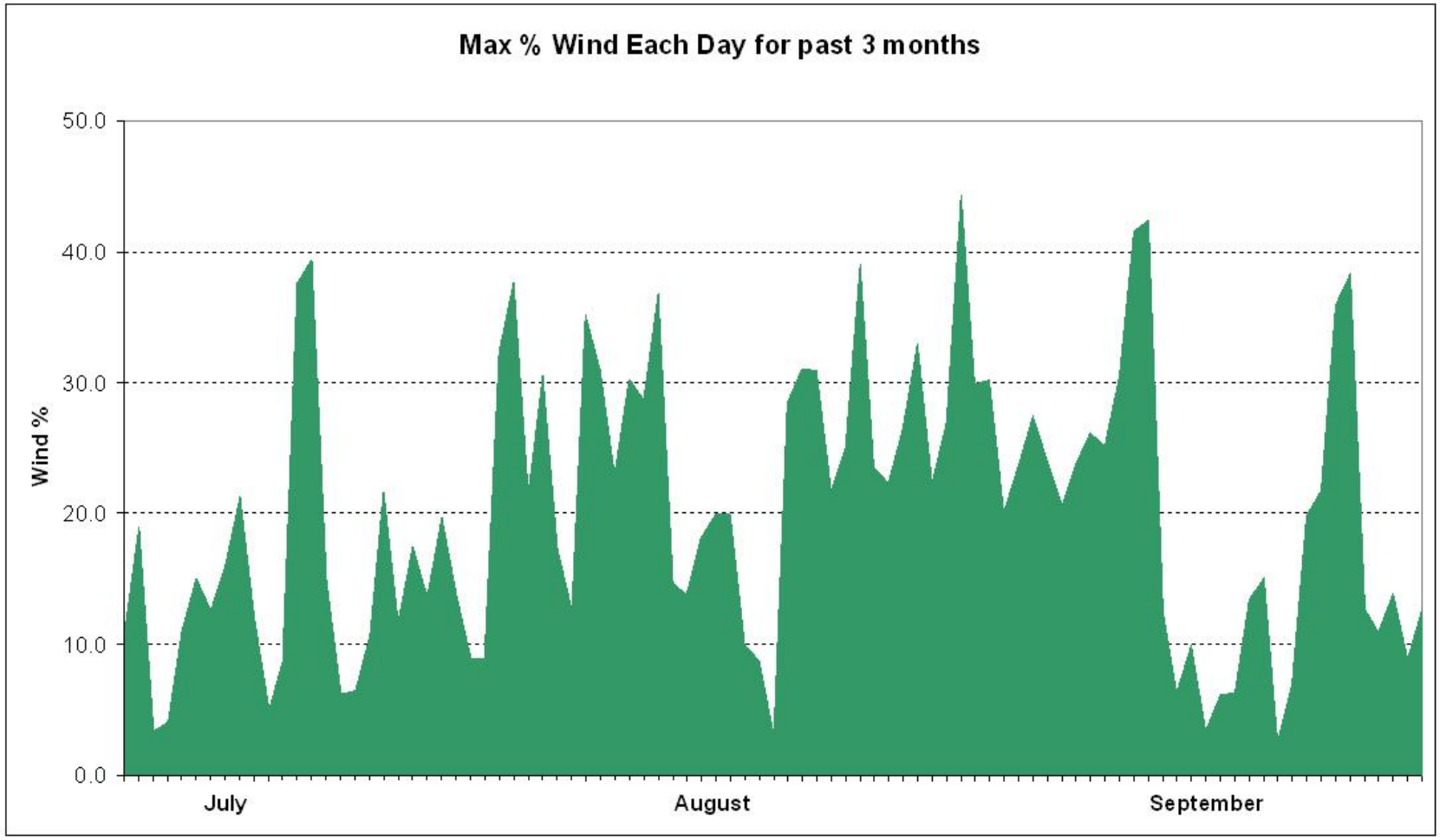
Current Status

- Oct 2009: 1119MW of wind generation connected
- End of 2009: 1250MW installed
- End of 2010: 1600MW installed

- Minimum Generation (August 2009): 1632MW exported
- Expected Winter Peak Load 2009: 4750MW
- Current Maximum Wind Generation: 999MW

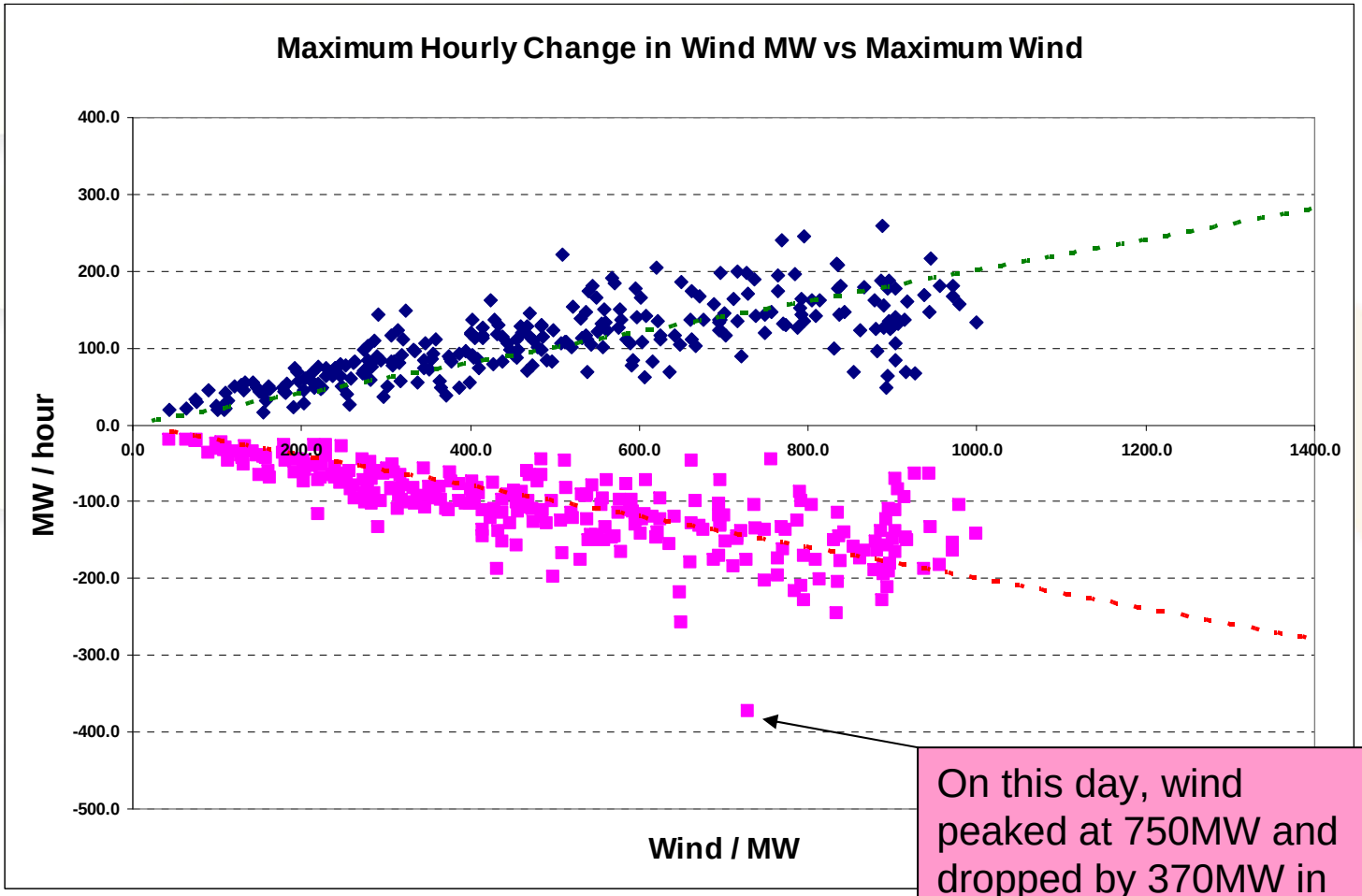
- Rapidly moving towards:
  - 50% instantaneous wind penetration
  - 33% capacity penetration (Installed Wind MW / Peak MW)

Maximum Percentage Wind during 2009



Hourly Wind Variability

Increased Wind needs more flexible conventional plant

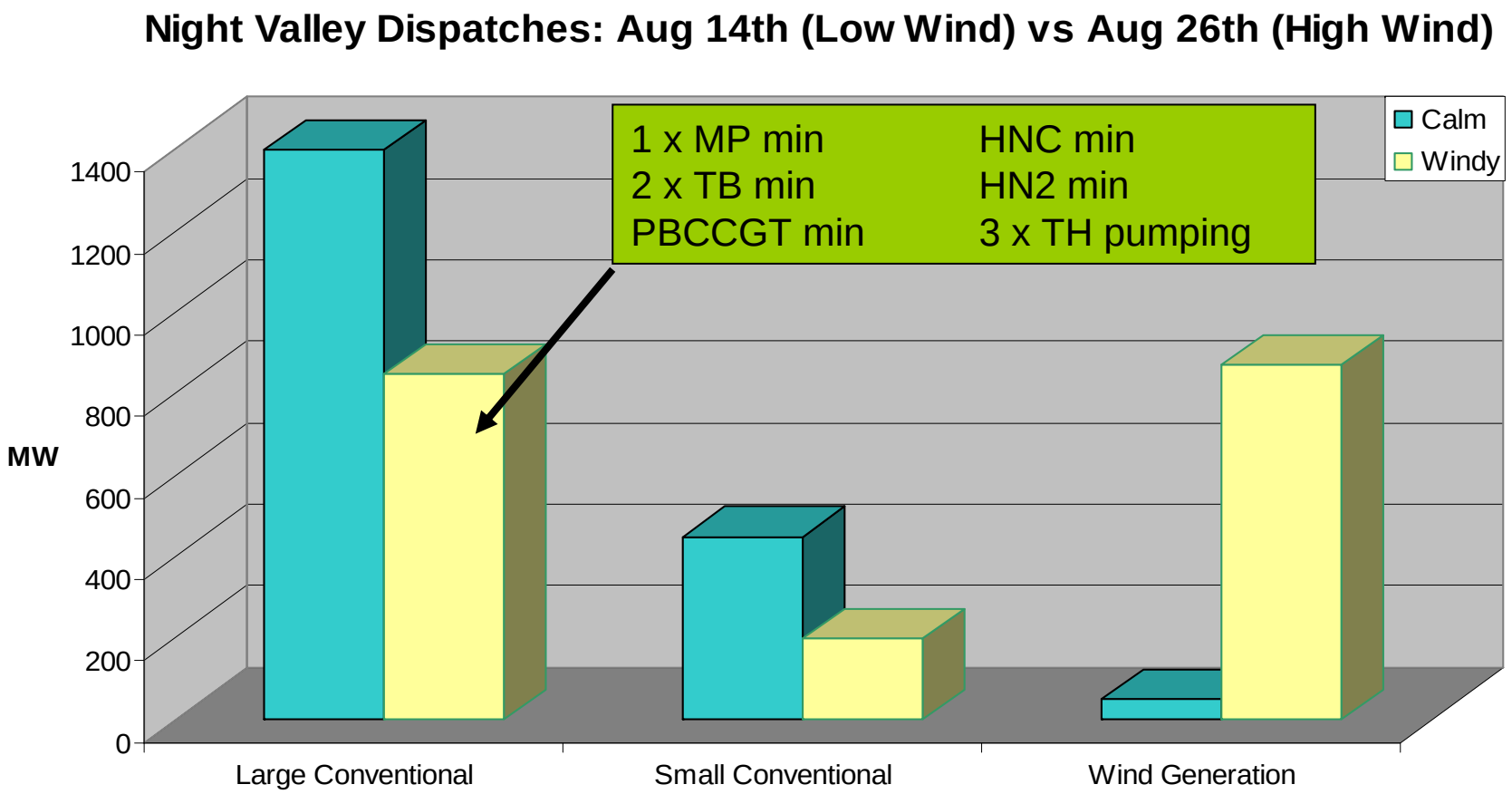


Case Study
August 26th 2009 3:45am > 40% Wind

- Wind generation now regularly exceeds 40% of demand
- Highest wind penetration in the world on a synchronous system
- Occurs during night valleys, when demand is at its lowest
- Conventional Generation Dispatch must be carefully managed
  - Geographical spread of generation for voltage control
  - Certain amount of flexible plant to cope with sudden changes in wind (e.g. hydro)
  - Large machines to provide inertia, synchronizing torque, and short-circuit power

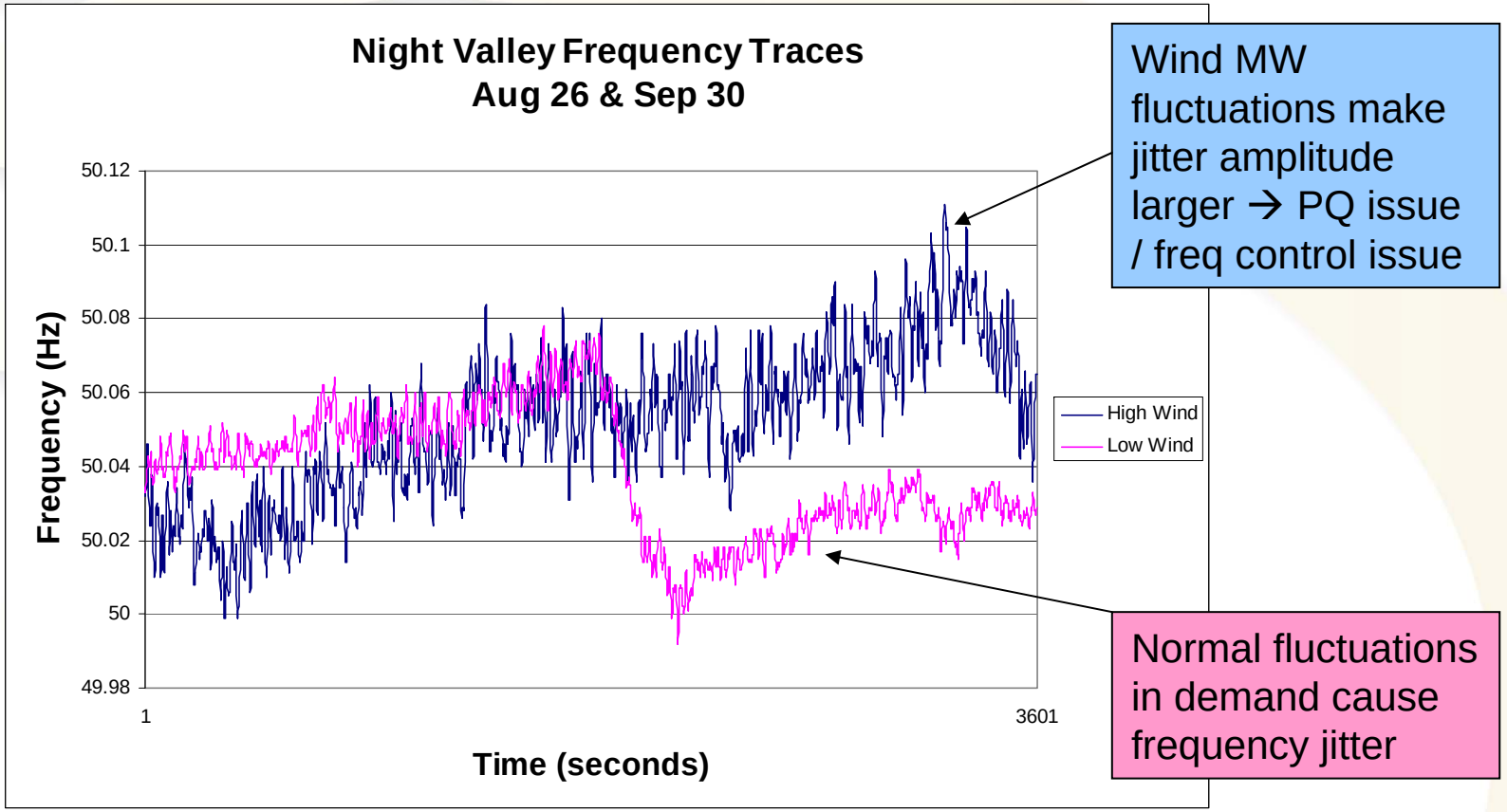
- Approximate Dispatch on August 26th:
  - 870MW Wind
  - 850MW Large conventional machines at minimum load
  - 200MW Peat / Hydro / Small-scale Gas

Change in Dispatch from Low to High Wind

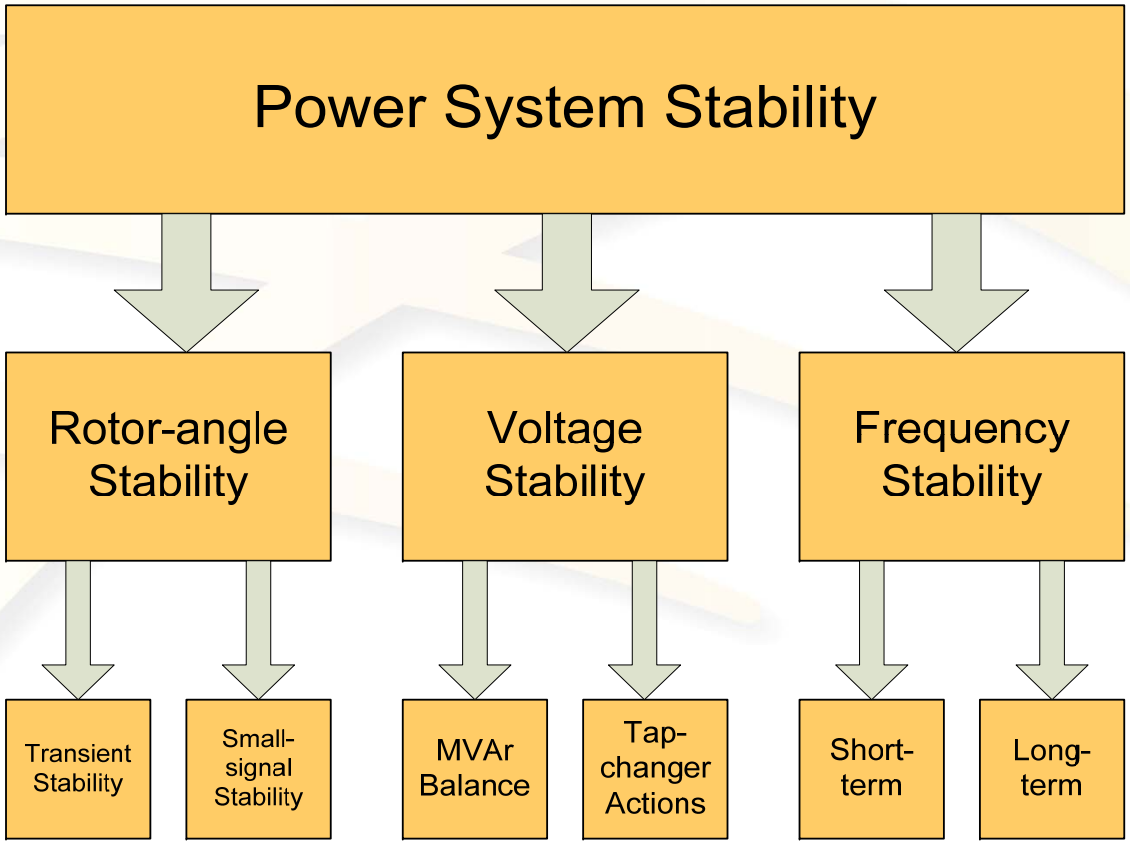


Case Study – Control Issues

- Wind generation peaked at 880MW on August 26th
- 30MW of non-firm wind was curtailed in South-West
- NCC expected severe contingencies in North-West, so SONI agreed to import 20MW at both Strabane and Enniskillen to alleviate contingencies



Power System Stability

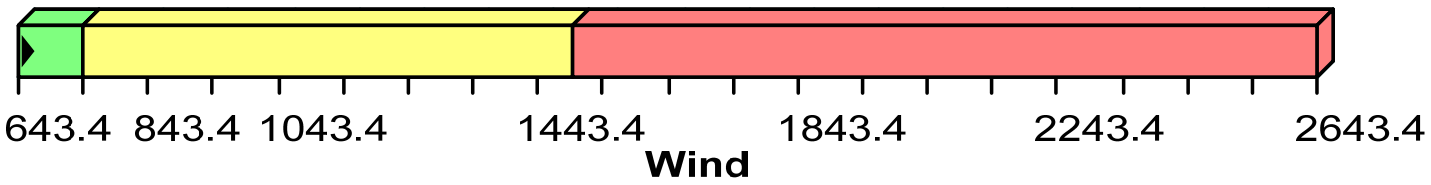


System Stability Tools

- Online Wind Security Assessment Tool (WSAT) in development: Real-time Analysis (every 30mins)
  - Transient Stability Analysis – Full Dynamic Simulation
    - Faults at every bus / Tripping of large machines / Relay Actions
    - Does the system remain as one synchronous area?
    - Do any machines trip unexpectedly?
  - Voltage Stability Analysis (Margin to Voltage Collapse / N-1 Contingencies)
    - Voltages in range / Overloads / Voltage Collapse
  - Frequency Stability
    - How low will frequency go / frequency recovery / system inertia ?
- Damping Monitor Relay
  - Analyzing low frequency modes 0.001Hz – 99Hz
  - Oscillatory Events / Magnitudes / Damping / Duration
  - Any systemic change in behaviour with high wind penetration?

System Security: August 26th

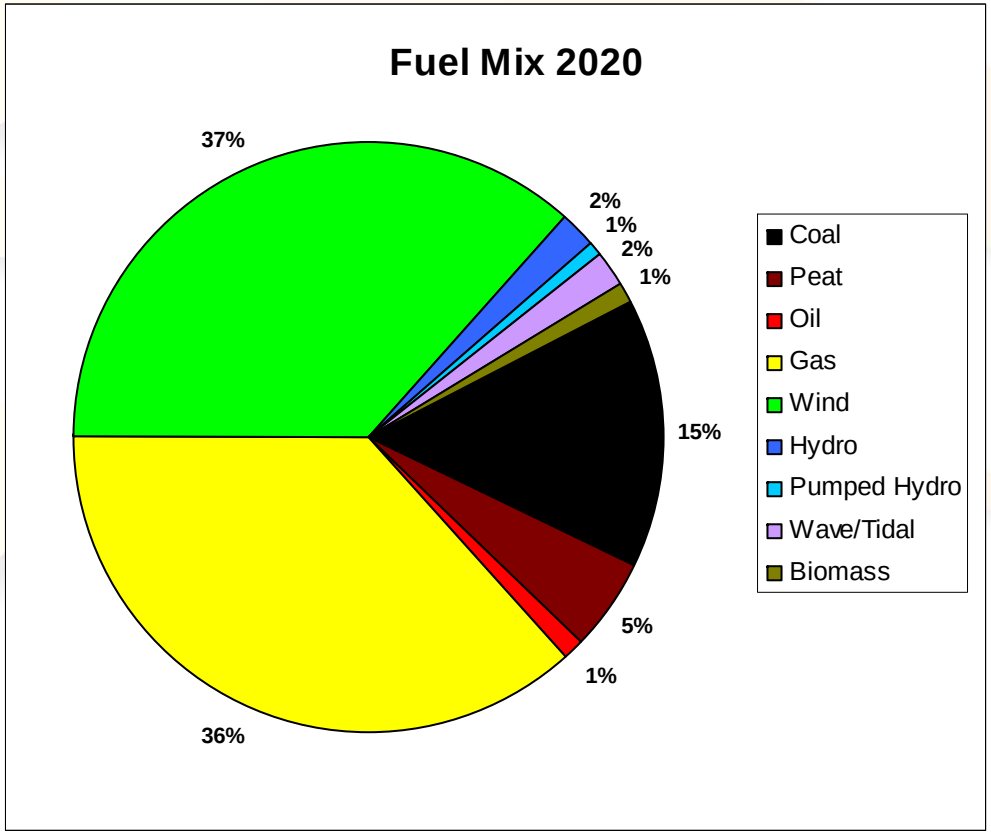
- Voltage Security Assessment – extra 500MW wind could be accomodated before voltage collapse / unsolved loadflow
  - Yellow region means secure but with some overloads if certain lines trip
- Transient Security Assessment showed that a large generator trip would cause a frequency drop to about 49.3 Hz
  - This is normal. No other problems were flagged
- No stability problem with 40% instantaneous wind during SNV as far as we can tell
  - Key limitations: Thermal Limits / Conventional Plant Constraints



Conclusions

- 40% instantaneous wind becoming more common
- Change in Dispatch / System Behaviour
  - Flexible Generation Requirements
  - Extensive dynamic simulations required
- Power System Stability Tools
  - WSAT
  - Damping Monitor
- 2020: 37% Average Wind Energy
  - Very high instantaneous penetration *in theory* (70/80%)
  - Careful study of stability limits will be required

Possible 2020 Fuel Mix

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