Study Committe C4

Power System Technical Performance

Paper ID: 1016

Stability Analysis on the Power System of Ireland and Northern Ireland for Operation with 75% Inverter-Based Resources.

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Motivation

- **80%** renewable electricity generation by 2030.
- System Non-Synchronous Penetration

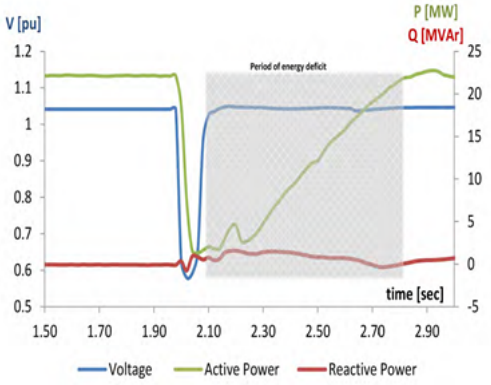
$$\frac{\text{Non Synchronous Generation + Net Interconnector Imports}}{\text{Demand + Net Interconnector Exports}} \times 100$$

- Secure, reliable operation of power system guaranteed up to a certain SNSP level.
- A limit on SNSP ⟶ wind dispatch down

Methodology/Approach

Preparation of snapshots	Studies	Mitigation (Step-Back)
• Selection of snapshots from the last 12 months - historical cases with SNSP >=60% . • ~3000 of the initial snapshots were selected and wind were scaled up to give us 75% SNSP. • Machine learning based on data clustering to reduce the number of representative study snapshots from ~3000 to 300 and further to 89. • Based on selection refinements and with extreme snapshots the final batch of 137 study snapshots were compiled.	Voltage security studies through VSAT focusing on: Divergent contingencies Voltage issues RMS dynamic studies using TSAT and focusing on: Frequency/rocof insecurities Swing margin insecurities WECC 2 models used to simulate the effect of Voltage Dip Induced Frequency Dip (VDIFD).	A number of different mitigations and their combinations is considered: 1.Large Energy Users (UPS disconnections). 2.Batteries connected by the 1st of April 2021. 3. Adjustment to tie-line flow. Option 3 only as the last resort if 1. and 2. or their combination is insufficient.

Voltage Dip Induced Frequency Dip Phenomenon



- There will be some MW loss straight after the fault (=>ROCOF impact) – low voltage will propagate throughout the affected area; wind power output might need some time to recover and trigger VDIFD.
- Low voltage propagation drives the effect of VDIFD.

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Assumptions

Assumption	Without VDIFD	VDIFD
75% SNSP	✓	✓
Min 8 Units	✓	✓
23 GWs inertia floor	✓	✓
ROCOF 1 Hz/s	✓	✓
Batteries react to frequency (1/4/2021: 166 MW)	✗	✗
Data Centres react to frequency	✗	✗
WECC 1 Wind Farm models	✓	✗
WECC 2 Wind Farms models	✗	✓

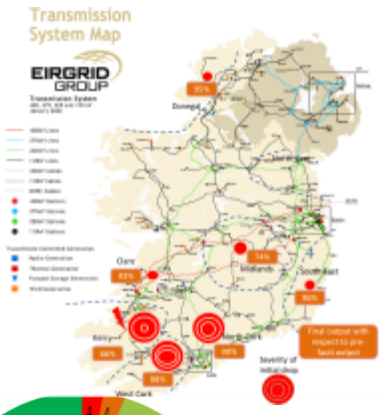
Prudent Assumptions

- 2 Study streams:
  - Without VDIFD
  - VDIFD (voltage dip induced frequency drop)

Low Voltage Propagation and VDIFD Impact

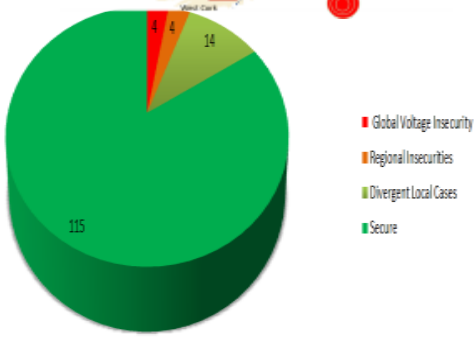
A three-phase fault in the South West region showing the impact of:

- The initial active power drop in every single region using the red concentric circles (the more concentric circles the bigger the impact is).
- The final active power recovery- where the percentage of the recovered active power, with respect its pre-fault values, is denoted by orange rectangles for different regions.



Voltage Security Studies

- High wind power output at two different weekly connected nodes are the main drivers of the observed voltage insecurities. These are known issues and are being managed in real-time operations.



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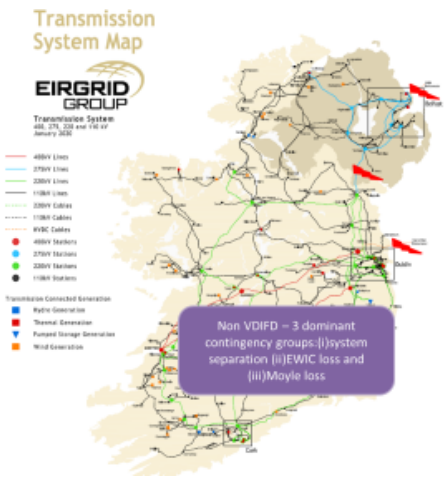
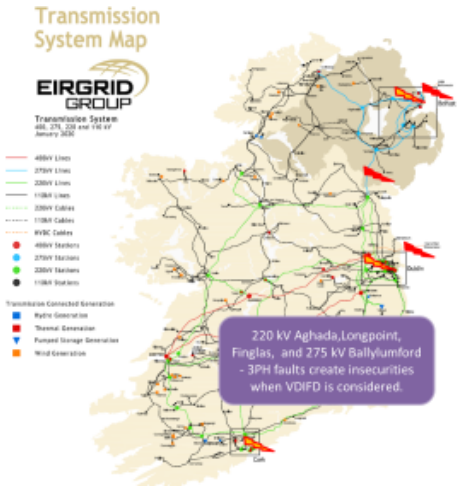
continued

Transient Stability Studies -Summary





Conclusion

- This study used a novel modelling approach (IBR model with VDIFD Phenomenon) and represents a significant step-change in methodology.
- Used VDIFD and machine learning.
- There were frequency insecurities which increased due to VDIFD impact, but there are mitigation options (mainly fast frequency response from batteries) for all of them.
- Study was completed in April 2021 and it was recommended to the EirGrid Group's Operational Policy Review Committee to move forward with the 75% SNSP trial.
- A successful operational trial took place between April 2021 and March 2022, and a limit of 75% SNSP is now operational policy.
- We are aiming to increase the SNSP further, with a goal of 95% by 2030.