All Island TSO Facilitation of Renewables Studies

Work Package 3: Operational Strategy for 2020
Final Presentation

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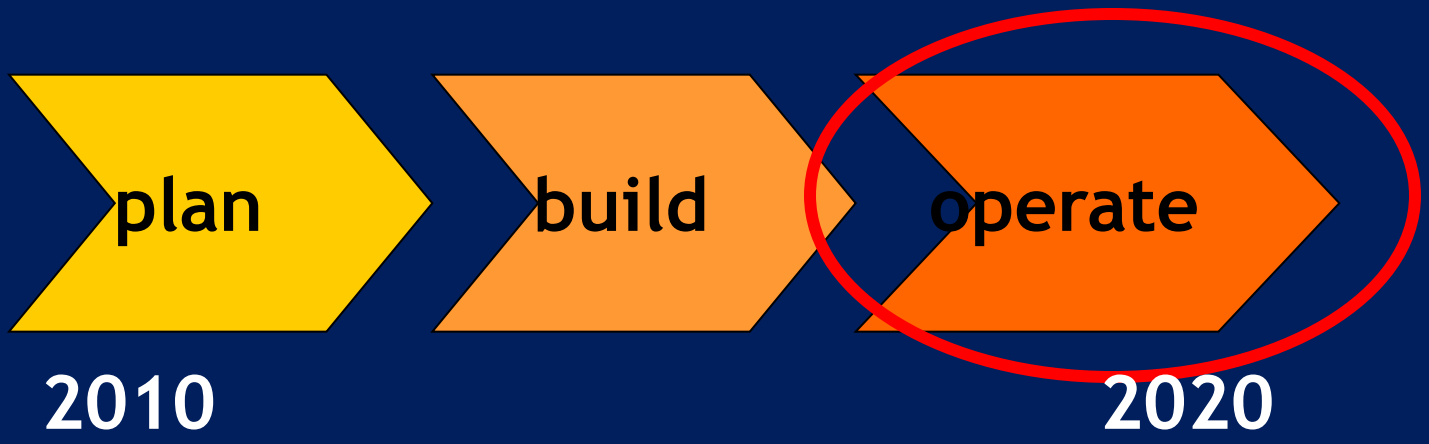
Scope



In a nutshell

- Instantaneous power from wind and import will have to be limited to 60%...80% of load and export in 2020

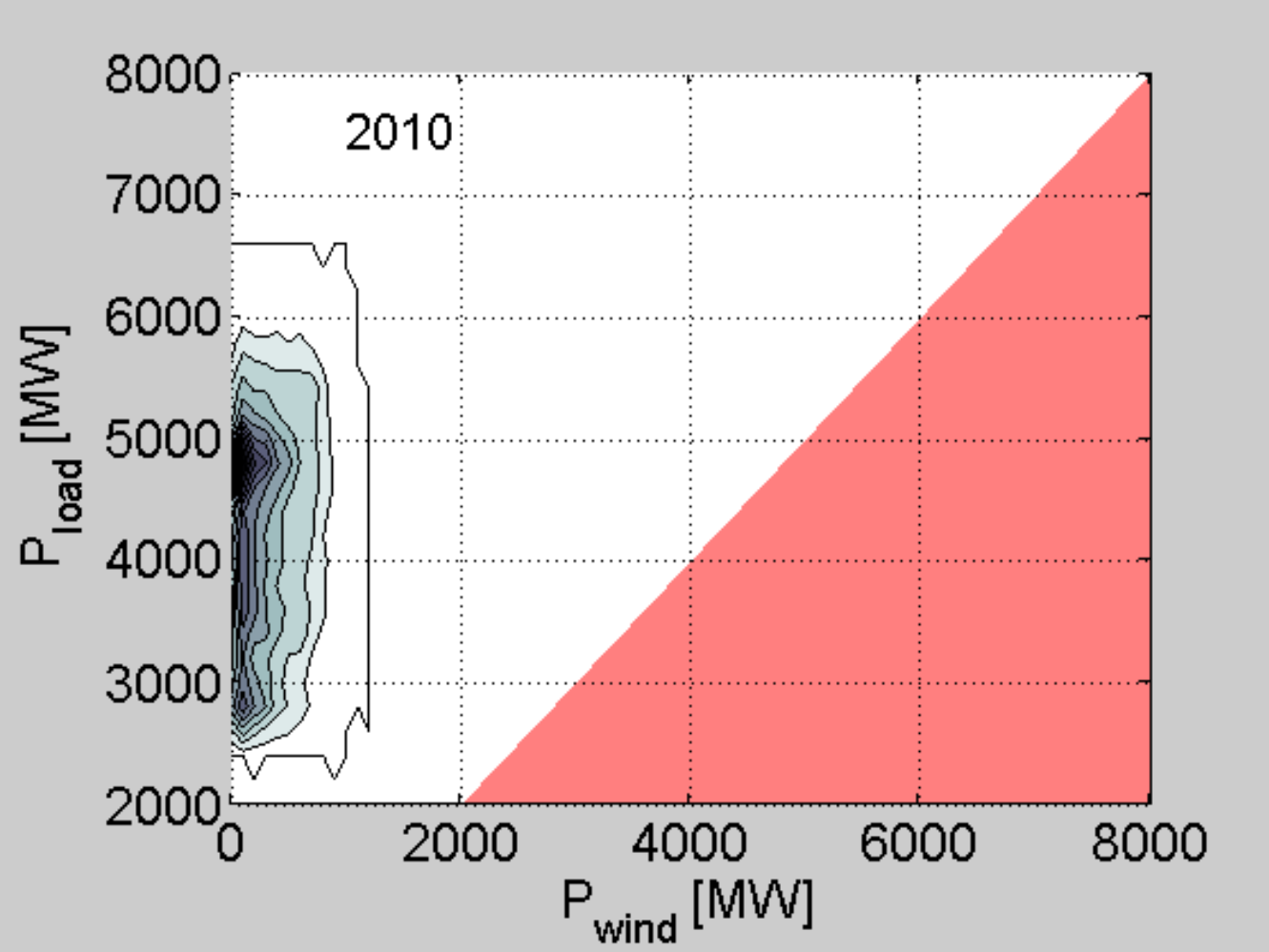
- This will still allow achieving the 2020 renewable electricity targets in Ireland

ECOFYS

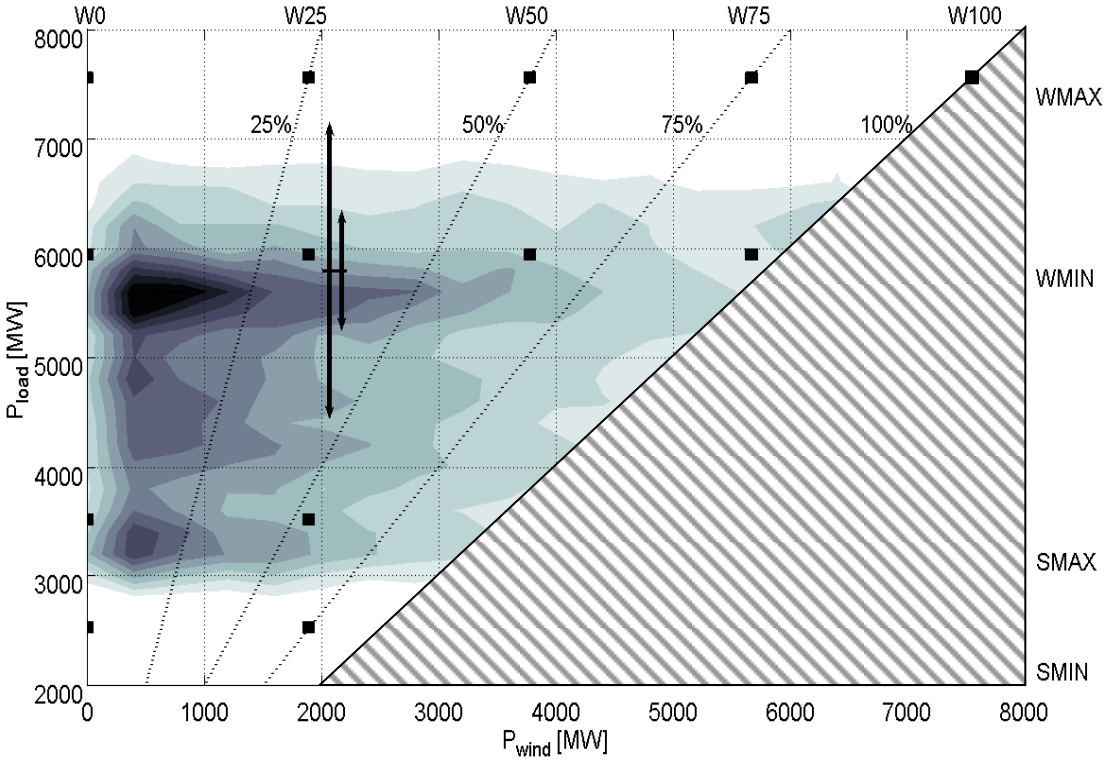
Content

- Methodology
- Overview of issues
- Selected key results
- Recommendations for an operational strategy
- Conclusions

Methodology



Methodology



63 dispatch cases, single bus model for frequency issues, multi bus model for other issues, statistical analysis based on 2007-2009 data

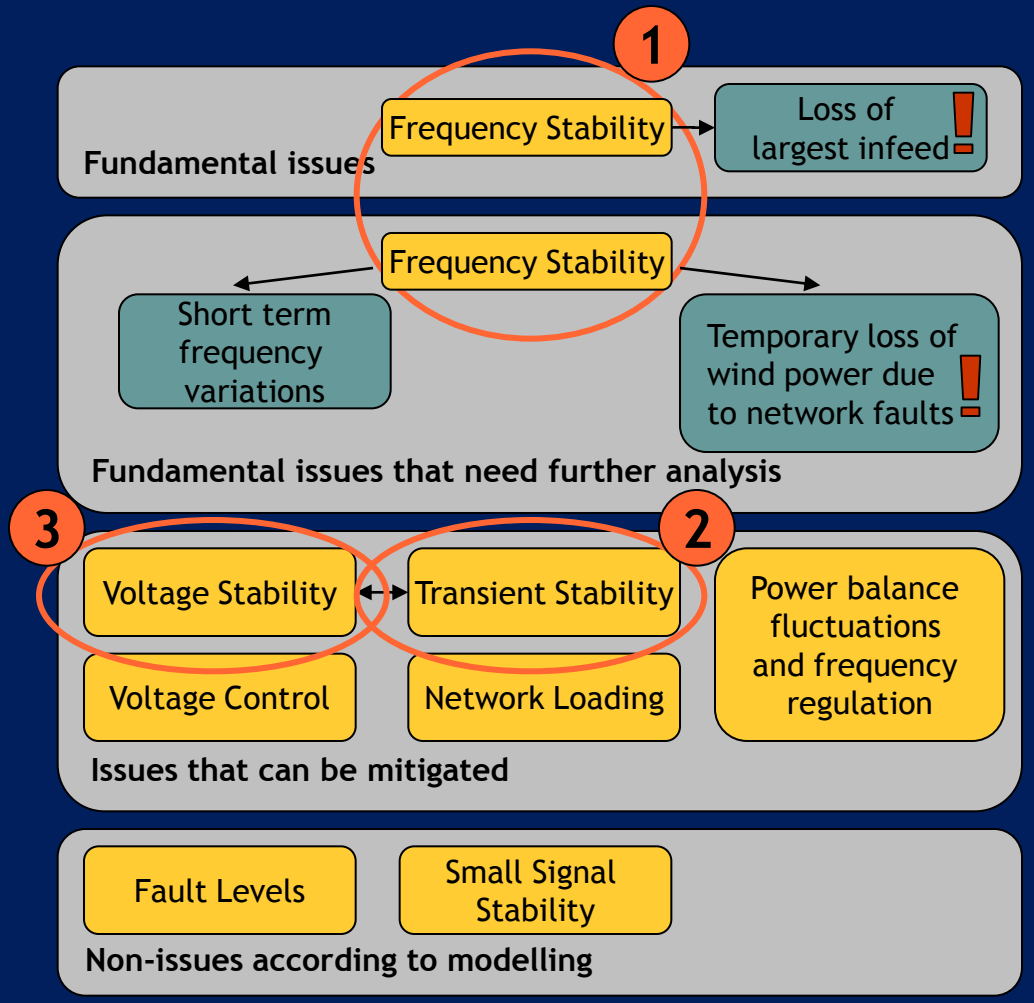
Overview of issues

Key issues are

- frequency stability after loss of generation
- frequency and transient stability after severe network faults

Transient stability can be mitigated.

Significant development of the power system is necessary by use of current technology.



Operational Metric

- „Operational metric 1“:
  Ratio of ‘inertialess’ power from wind plus import and instantaneous load plus export

$$\frac{P_{wind} + P_{import}}{P_{load} + P_{export}}$$

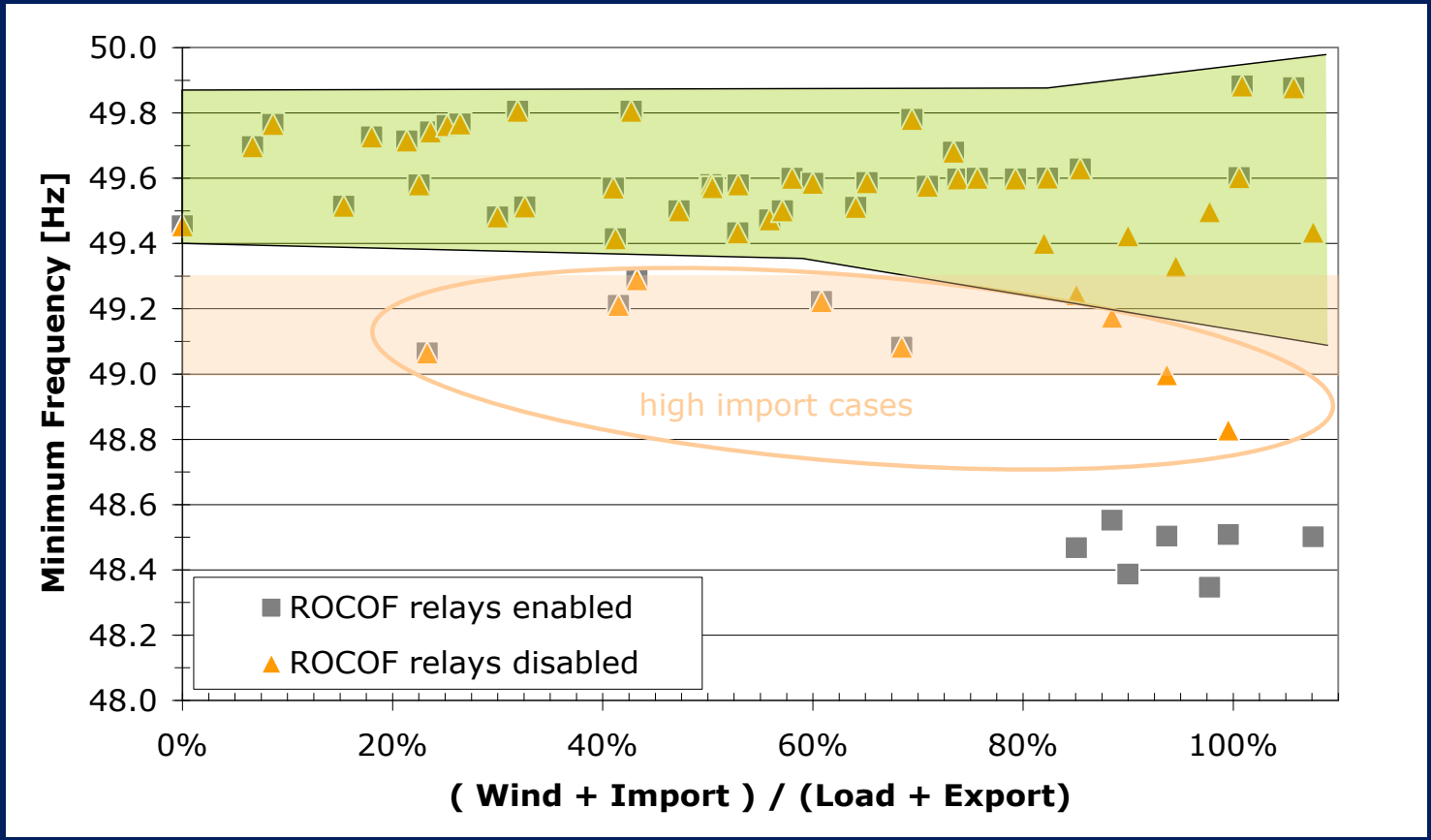
Selected key results

1. Frequency stability
2. Transient stability
3. Voltage stability

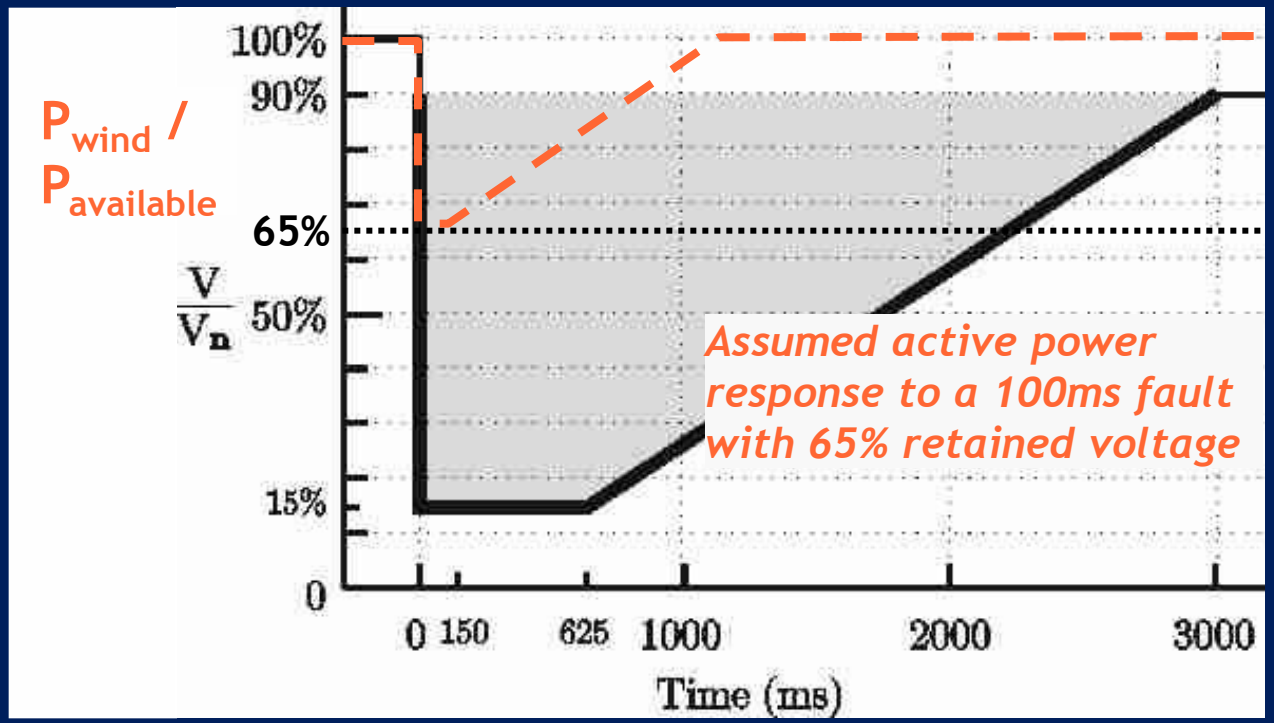
1. Frequency Stability – the issue

- Ability of a power system to return to an operating equilibrium following a severe system disturbance
  - loss of largest infeed
  - temporary reduction of wind power after network faults
- Frequency excursion triggers corrective actions
- Minimum frequency (nadir) as indicator

1. Frequency excursion following the loss of largest infeed - results



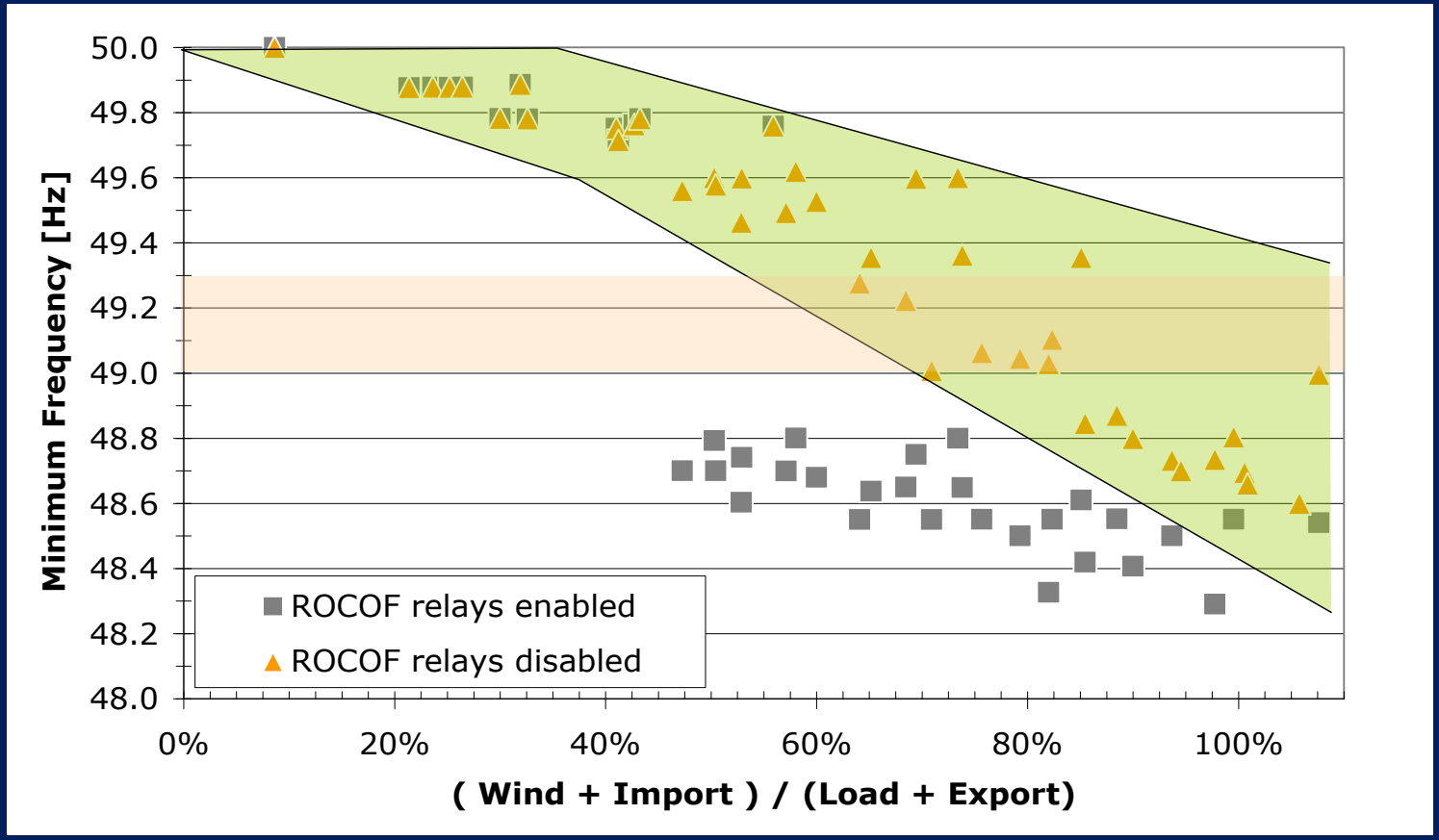
1. Frequency excursion after network faults - the issue



- Wind turbine generators assumed Grid Code compliant
- Faults can lead to voltage drops to 65% of nominal voltage throughout the system

In certain cases, wind power output temporarily is decreased by 1,000-2,000MW. This exceeds by far the largest infeed.

1. Frequency excursion after network faults - results



1. Frequency Stability – key conclusions

- The management of frequency following the loss of the largest unit will become progressively more difficult at high penetration of wind.

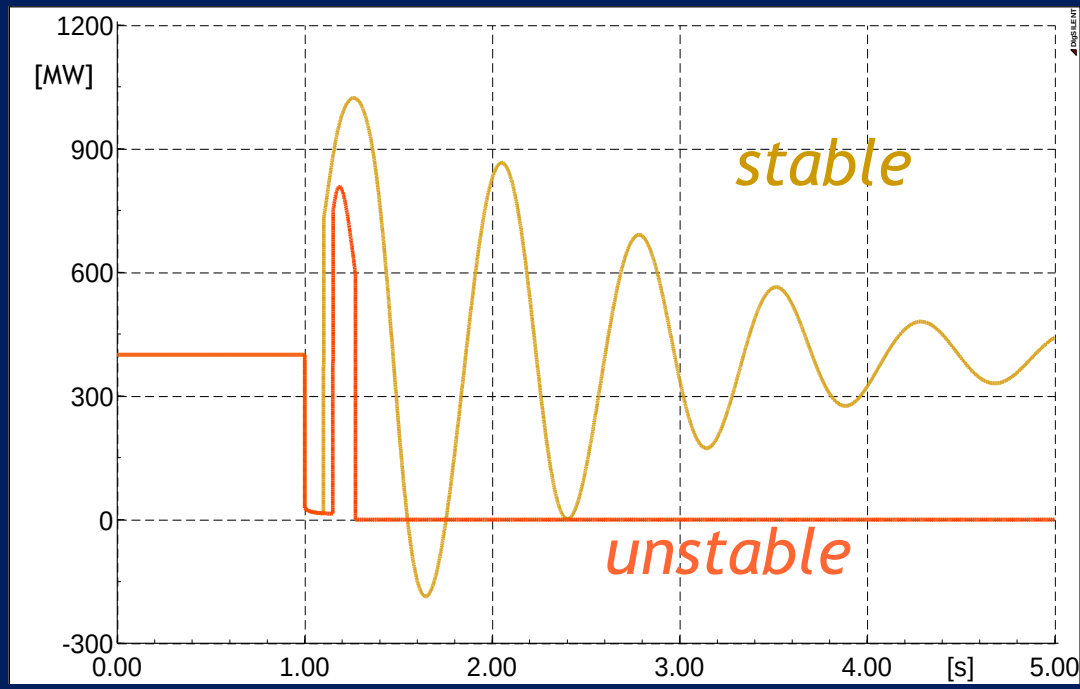
- In addition,
  - the use of ROCOF relays, currently employed on all distribution connected wind farms, and
  - the capability of **all** generators to ride through significant ROCOF

  need to be reviewed.

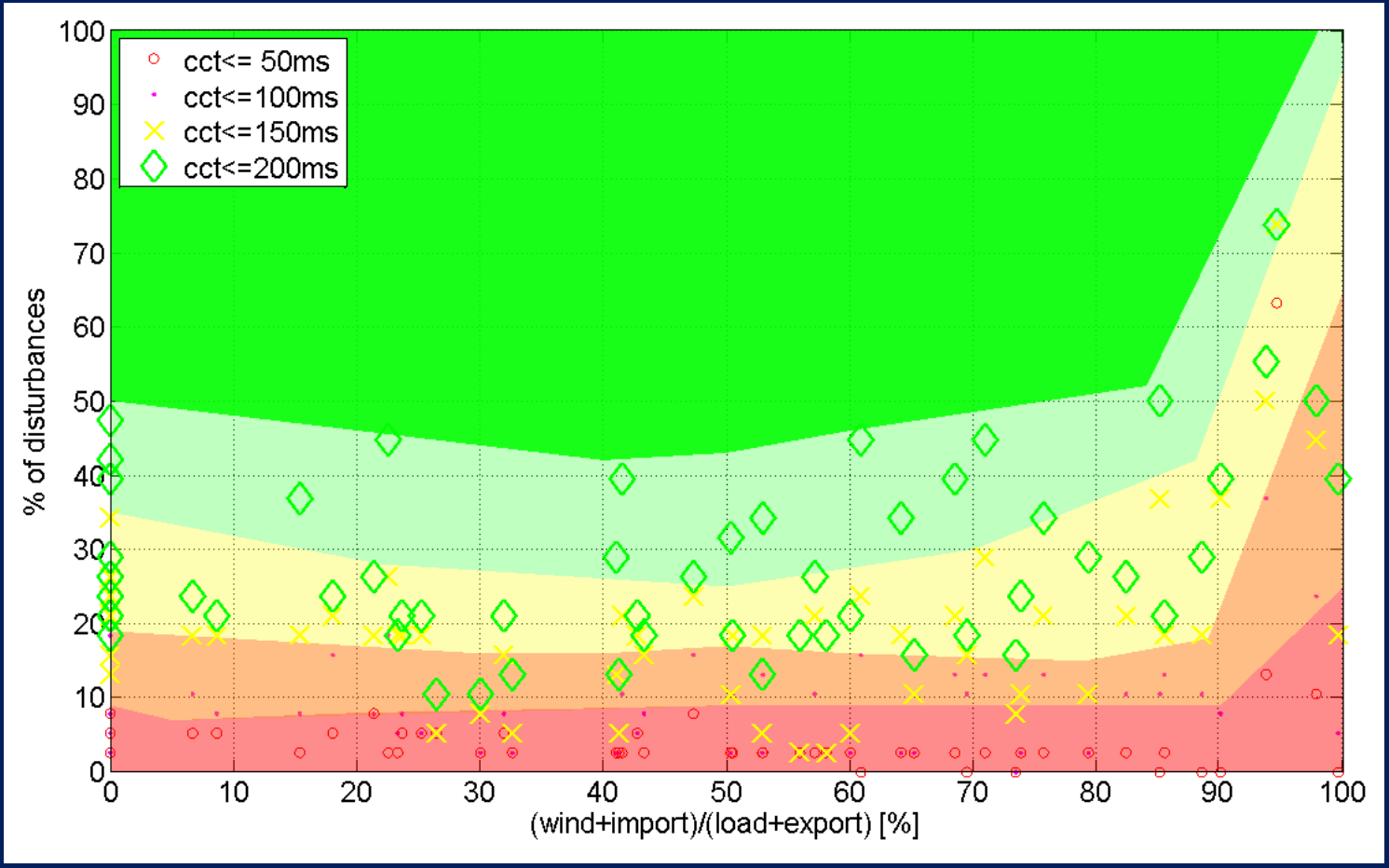
2. Transient Stability – the issue

- Ability (of synchronous generators) to maintain synchronism when subjected to severe network faults
- If large amounts of generation are lost, the power system may collapse
- Value of critical clearance times (CCT) and number of faults with certain CCT serve as indicators

Active power response to a fault with CCT ≤ 100ms



2. Transient Stability – results (number and nature of CCTs)



2. Transient Stability – key conclusions

- Moderate amounts of wind power improve transient stability.

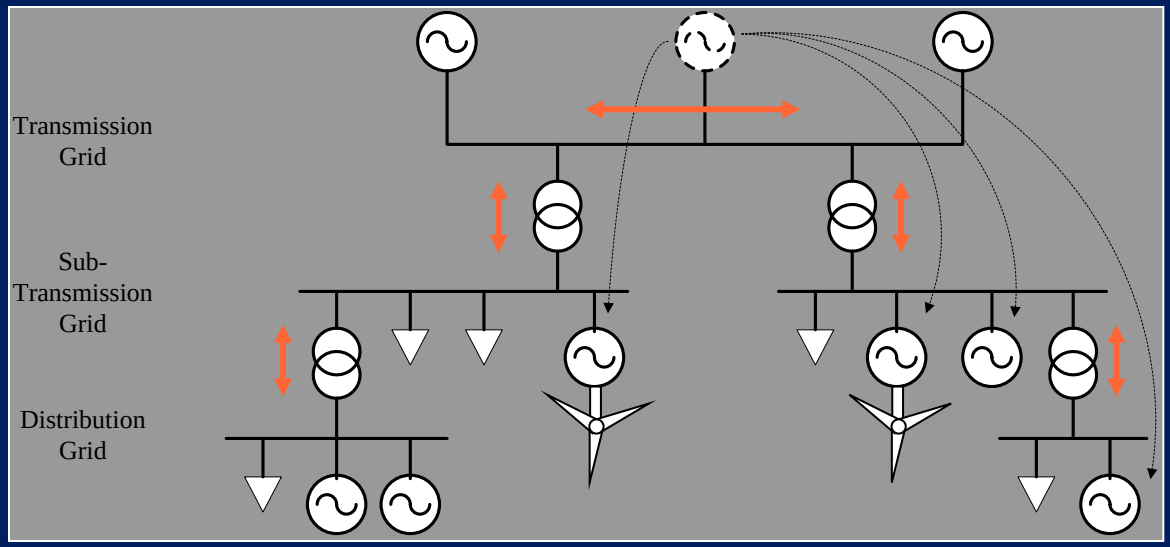
BUT:

- At high levels of wind power penetration, transient stability may deteriorate.

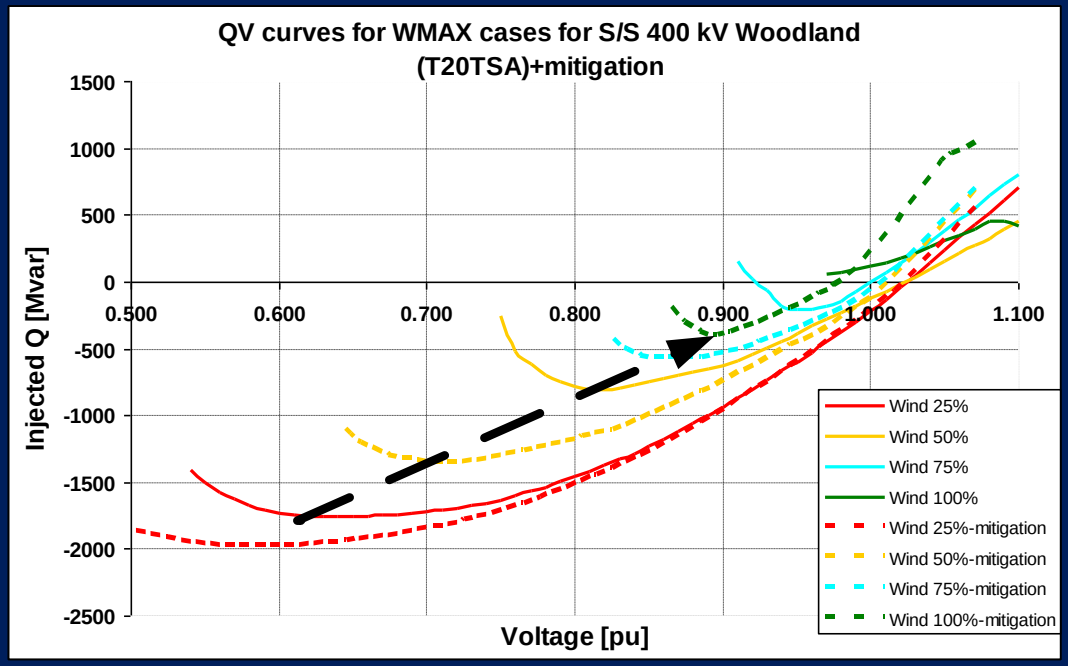
- Modelling results suggested that technical measures exist to further mitigate transient stability issues.

3. Voltage Stability – the issue

- ability of a power system to maintain acceptable voltages at all busbars in the system
- reactive power is key
- local phenomenon
- interrelation with transient stability
- minimum of QV curve as indicator



3. Voltage Stability – results

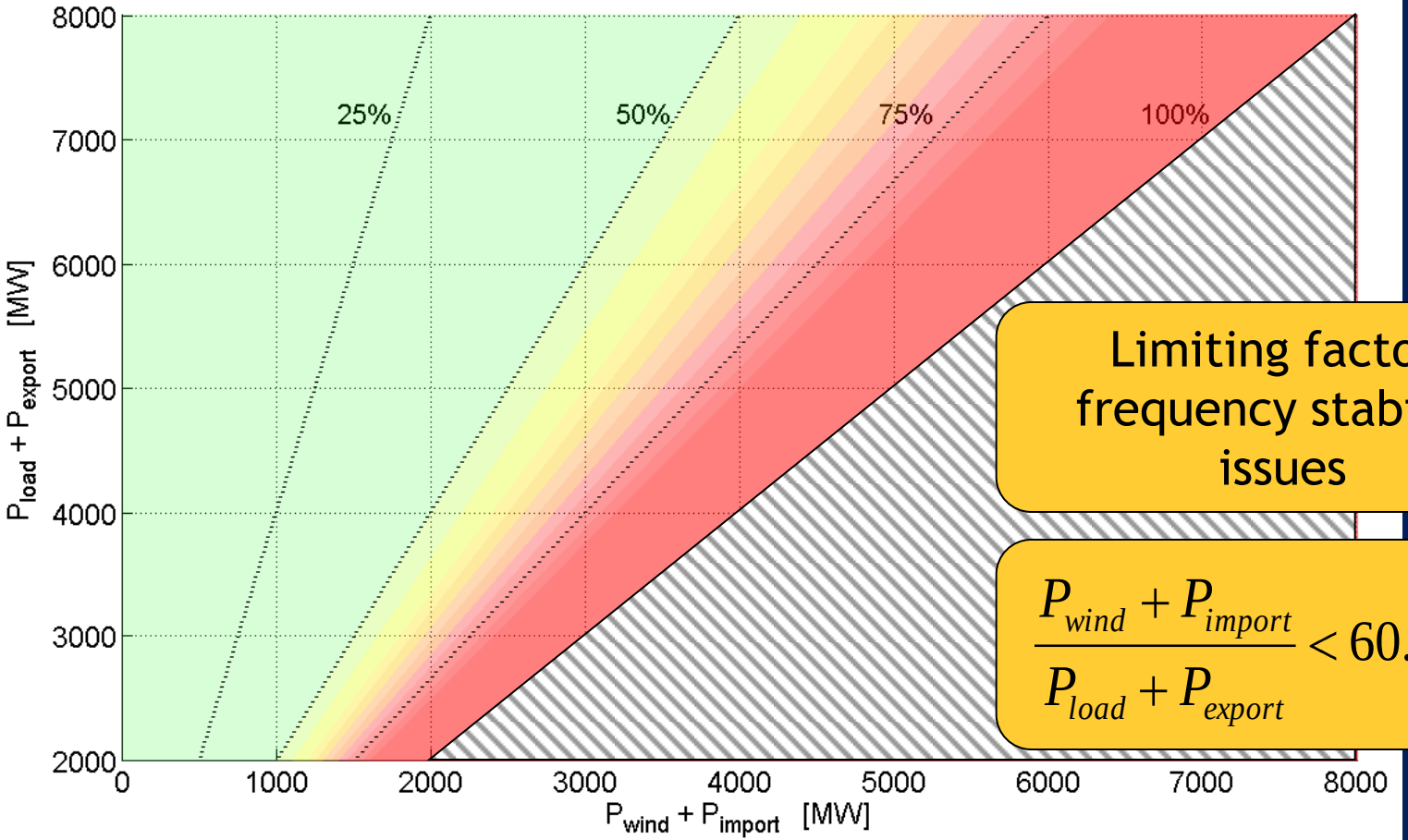


- Voltage stability may decrease if large amounts of distribution connected wind farms replace synchronous generators at transmission level.
- Methodology did not allow for quantification of stability range.

3. Voltage Stability – key conclusion

- The management of a secure voltage profile will become increasingly difficult.
- This will require the appropriate network planning, system operation and the static and dynamic reactive performance from all generators to achieve.
- Further investigations are needed to quantify reactive power requirements and locations

Recommendations for operational strategy



Limiting factor: frequency stability issues

$$\frac{P_{wind} + P_{import}}{P_{load} + P_{export}} < 60...80\%$$

Additional recommendations for operational strategy

- Limitation of imports via the interconnectors (500MW is ok)
- Redispatch of conventional units
- Integration of the system conditions in the real time system monitoring tools (state estimator)

- Replacement of ROCOF relays in distribution systems
- Adaptation of the Grid Code with regard to capability of **all** generators to ride through significant ROCOF

Conclusions

- Instantaneous power from wind and import will have to be limited to 60%...80% of load and export in 2020

- This will still allow achieving the 2020 renewable electricity targets in Ireland