Session IV : Long term grid development – Technology and operations

Grid implementation : operation consideration

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Agenda

- Challenges for operation
  - New challenges for 2050
- Operation validation
  - N-1 overloads
  - Voltage profile (N-1)
  - Short-circuit current
  - Frequency Stability
  - Small Signal analysis
- Conclusion

Challenges for operation

- Grid adequacy
  - Avoid overload on lines, cables, transformers, etc.
  - Keep the voltage profile normal
  - Guarantee the security of the system in case of loss of equipment (n-1)

- New challenges for 2050
  - High penetration of RES
    - RES are localised in different areas than traditional generation and they behave differently (power electronics ≠ synchronous generators)
  - Increasing power exchanges
  - High number of HVDC, some being embedded in the AC grid

- These challenges require in-depth and innovative studies.
  - Some preliminary work was carried out in e-Highway2050 to provide recommendations for further studies

Studied issues in the project

- Steady state phenomena
  - N-1 overloads
  - Voltage limits (N-1)
  - Short circuit currents

- Dynamic phenomena
  - Frequency stability
  - Small signal stability

Test cases considered

- For each scenario at 2050:
  - Winter peak and summer low
  - Reinforcements with AC and DC lines

- Scope of the analysis: Continental synchronous area

- Inputs:
  - System simulations results at cluster level
  - ENTSO-E description of the full network at 2030

N-1 overloads

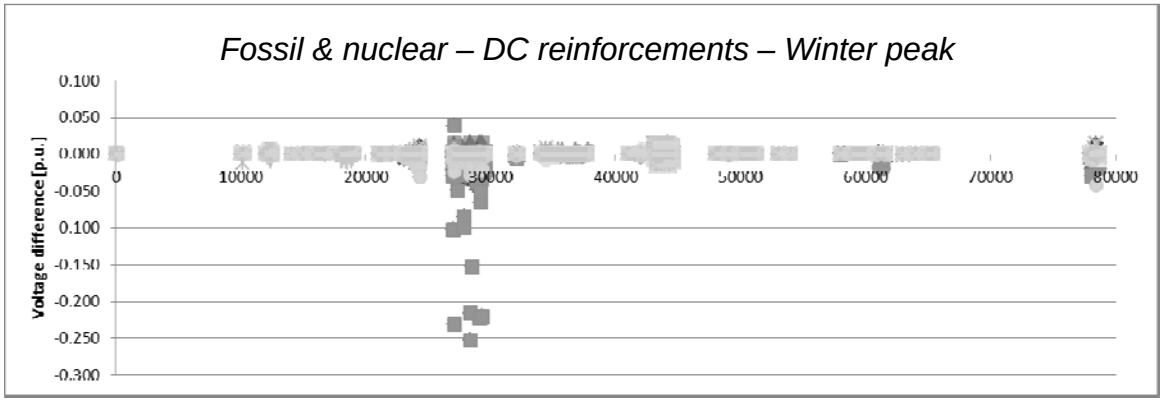
- The contingency of the reinforcement did not show any highly critical overloads.
  - Only minor additional reinforcements are required.

- The test cases facing the highest flows (Large Scale RES, 100% RES) could not be simulated
  - At cluster level, the system is feasible, but at nodal level advanced methods are required to study it.
    - See the methodology developed in the research part of the project (WP8)

- Tripping of DC connections creates more overloads than AC
  - The reason is that fixed setting points for DC were assumed.
  - Smarter control rules are necessary.

Voltage profile (N-1)

- The contingency list is the reinforcements for 2050
- In the majority of the cases, the system is secure (voltage drop <5%)
- Only one case shows a voltage drop of 25% :
  - loss of HVDC link between England and France with 6519 MW

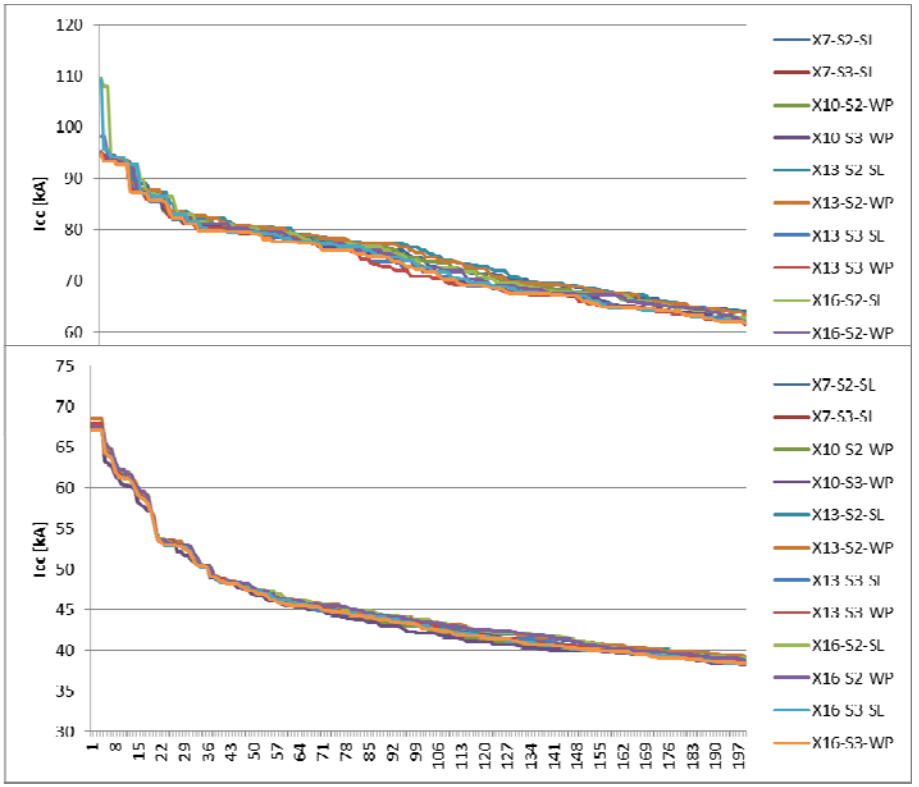


  - Solution is to split the size of the link.

Short circuit currents

- The 400 kV network reaches 109 kA (Small & local - summer low).
- The 220 kV network reaches 68 kA (Fossil & nuclear - winter peak).
  - These are the total short-circuit currents, not the contribution for each circuit breaker.

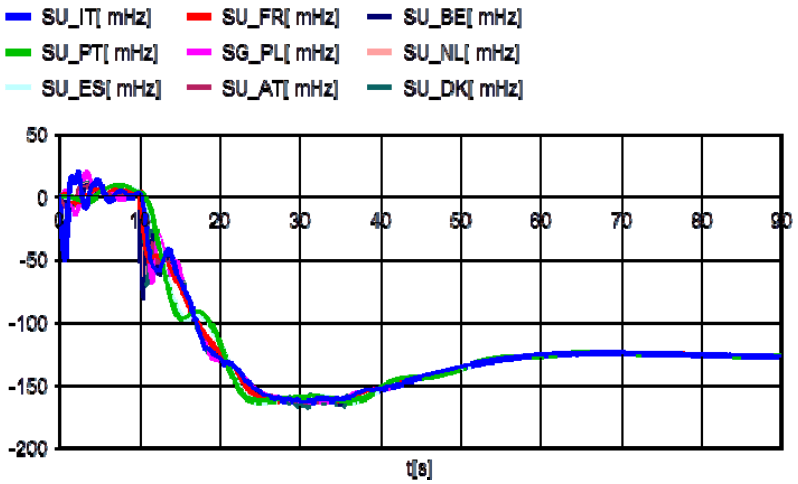
- Further studies could include :
  - Computation of the individual contribution of individual circuit breaker
  - Improvements of the datasets (RES modeling should be improved in current models)



Frequency stability

- All cases analyzed were stable.
  - Reduced model was used for Continental Europe
  - The wind generators were modeled with the capability to provide frequency control

- Example : 4503 MW HVDC outage between France and Great Britain in 100% RES – winter peak



- Cases with a higher share of inverter based generation need further studies (see the EU project to start soon)

Small signal analysis

- In the majority of the cases, the system is secure
  - Positive damping.
- Only one case show negative damping (-0.5)
  - Mode of frequency 0.3382 Hz, scenario Fossil & nuclear, strategy with DC cables, winter peak.

x13 – Nuclear & Large Scale Fossil Fuel							
AC Strategy				DC Strategy			
WP		SL		WP		SL	
f	ξ	f	ξ	f	ξ	f	ξ
0.2147	3.51	0.3187	1.83	0.1576	5.04	0.2600	3.59
0.3794	1.48	0.4333	1.82	0.3382	-0.50	0.3628	1.87
0.4053	2.02	-	-	0.3439	1.91	0.4665	0.51

- The low frequency oscillations are still on the range of the Power System Stabilizers.

Conclusion

- The European Network in 2050 will be more complex to operate
  - Different mix of generation technology
    - Less synchronous machines
    - Less inertia
  - Mix operation of HVDC with HVAC
    - Changes the dynamics of the system

- Big challenge to handle very high flows in Europe
  - Additional studies and improvements of methodologies/datasets are necessary

- Long distance transmission is limited by stability phenomena
  - WACS – Wide Area Control System in real-time is needed to preserve the security of the synchronous areas.
    - Small signal stability show the possibility of negative damping.

Thank you for your attention!

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