

Nordic Grid Model in PowerFactory

- Introductory study of the impact of future North-Sea HVDC converters in the Norwegian transmission system
 - Increased HVDC capacity between Norway, UK and Europe
 - Power exchange and connecting offshore wind farms
- A 24 node equivalent model of the Nordic grid is built in PowerFactory
 - Based on 23 node PSSE model
- Norwegian grid updated to year 2030:
 - Contains most of the 420 kV lines and some 300 kV lines
- Detailed line parameters
- Updated generator models
- Existing and planned HVDC converters
- Two future VSC's in Feda and Kristiansand
- Now: Steady state model
 - Dynamic model under development
- PowerFactory:
 - Power flow analysis
 - Electromechanical transient analysis
 - Electromagnetic transient analysis
 - Eigenvalue analysis
 - Flexible scripting languages
- FACTS
- HVDC, VSC
- MW- and MVar-controllers
- Virtual power plants

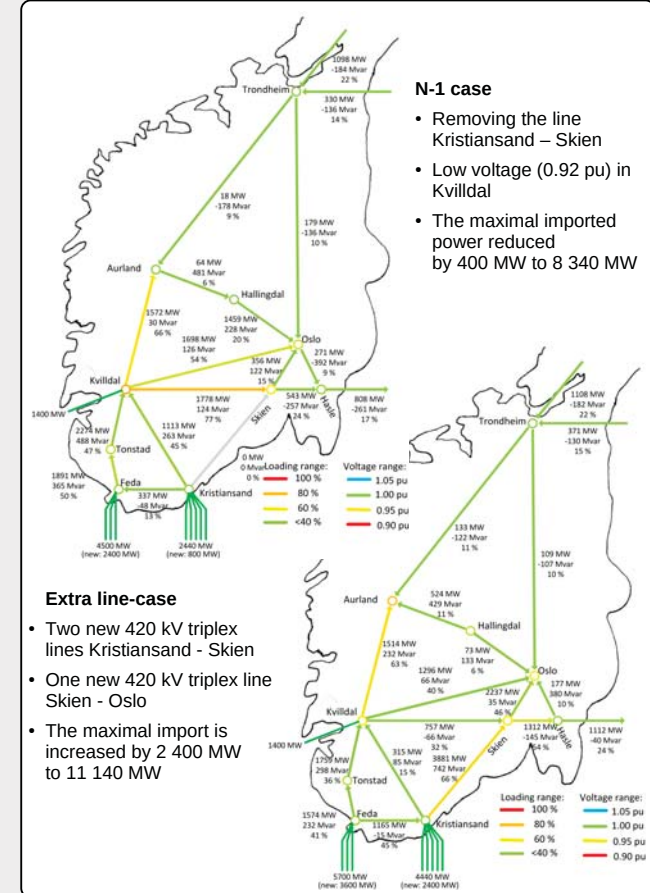
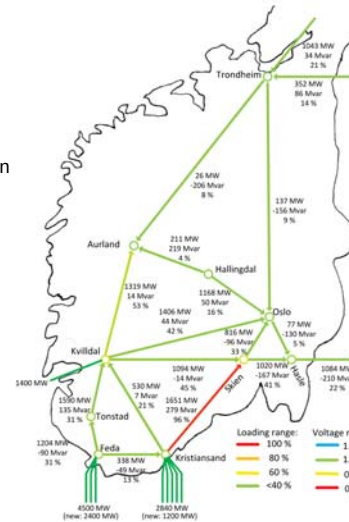


Power Flow Analysis

- Future scenario: increased HVDC import capacity
- Purpose:
 - Find the maximum HVDC import
 - Identify possible bottlenecks
- All existing and planned HVDC lines: fully loaded
- Future VSC's at Feda and Kristiansand: maximum load
 - Limited by power lines in the southern part of Norway
- Remaining production: hydroelectric power
- Southern Norway: High Import, low production

Maximum import case

- All power lines in operation
- 3 600 MW of new HVDC: total import of 8 740 MW
- Bottleneck: Kristiansand - Skien
 - Shortest way
 - Duplex



N-1 case

- Removing the line Kristiansand – Skien
- Low voltage (0.92 pu) in Kvitlidal
- The maximal imported power reduced by 400 MW to 8 340 MW

Extra line-case

- Two new 420 kV triplex lines Kristiansand - Skien
- One new 420 kV triplex line Skien - Oslo
- The maximal import is increased by 2 400 MW to 11 140 MW

Conclusion

- Maximum HVDC import is limited by the bottleneck: Kristiansand – Skien
- Maximum new imported power: approximately 3 000 MW (depending on the load, line and production situation)
- New lines Kristiansand - Oslo: Maximum approximately 6 000 MW new imported power

Future Work

- Prepare model for dynamic analysis (HVDC converter control systems, generator governor and turbine models)
- Run dynamic analysis to identify possible stability and operational challenges due to low inertia in the system
- Introduce new HVDC converter control concepts (virtual inertia, wide area control systems)