Assessing the economic impacts for outages of HVDC-cables connecting the Nordic area and continental Europe

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13th INTERNATIONAL CONFERENCE ON THE EUROPEAN ENERGY MARKET
Porto, 6-9 June 2016 | Portugal
Outline

A motivation
Unavailability statistics
The case study
Some results
Status quo in Northern Europe

Implementation of CRM in Europe, as of June 2014.
Source: Eurelectric, "Renewable energy and security of supply: Finding market solutions.", 2014

New cables to Germany and the UK.
Source: Statnett, "Grid development plan 2015", April, 2015
Motivation

Value of capacity through HVDC cables?

- Provision of back-up capacity
- Capacity mechanisms throughout Europe
- Norway as green battery
- Reliability of HVDC cables
- Impact on market & system adequacy
Options for cross-border participation

Source: Eurelectric, "Renewable energy and security of supply: Finding market solutions.", 2014
Statistics Nordic HVDC cables

Unavailable exchange capacity ($E_U$) on average 12%

Average $E_U$ due to disturbance 4.7%

Highest $E_U$ due to disturbance 25% ~ 13 weeks

NorNed cable $E_U$ 19%, mostly due to disturbance outages

=> 3 disturbance cases: 4.7%, 12%, 25%

NorNed used as benchmark cable

Source: ENTSO-E Regional Nordic Group, "Nordic HVDC utilization and unavailability statistics 2013.", 2014
The power system model

- 75 climatic years (wind, solar, inflow, temperature)
- 2 hours resolution
- 52 areas
- About 1500 power plants
- 80 transmission corridors
- Stochastic optimisation
- Unit commitment and dispatch
Details for hydropower

Water-value calculation (SDP)

Market description

Water

Market data

Aggregation

Allocation

Market data

Stochastic weather

Detailed simulation

Probabilities

Scenarios

Market simulation (LP)

Energy demand curve

RES-E

Nuclear

Gas-power

Hydropower

Coal-power

Curtailment

Solutions

Results

Norwegian University of Science and Technology

NTNU
## Case study

### Study object

<table>
<thead>
<tr>
<th>Analysis of outages for the Nord.Link HVDC cable</th>
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<tr>
<td>• Connecting Norway and Germany</td>
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<td>• Planned to be commenced in 2020</td>
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<td>• 1.4 GW installed transmission capacity</td>
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<td>• Assumed to have same characteristics as the existing NorNed HVDC cable</td>
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Case study
Assumptions

- Outages with different duration: 1 week to 13 weeks
- Always assumed to occur at the begin of the year (highest probability of generation capacity shortage)
- Only one outage assumed during the year
- Comparison of transmission outage with equivalent outage of thermal production capacity
- Economic analysis of energy-only market vs. Capacity remuneration mechanism
Differences in climatic years

Wind production in Germany

Solar production in Germany
Impact on the exchange
Across Nord.Link – 3 weeks outage
Economic impact  
Sensitivity to outage length

Change in socio-economic surplus

- Mean
- Lineær (Mean)
- Worst year
- Log. (Worst year)
Economic impact  Sensitivity to outage length

Change in consumer surplus in Germany

- Mean
- Linear (Mean)
- Worst year
- Log. (Worst year)
Impact on consumers
Generation outage vs HVDC outage

Change in consumer surplus in Germany for 3 weeks outage

- Mean
- Worst year
- Median year

Production outage
Transmission outage
Impact on consumers
EOM vs CRM

Change in consumer surplus in Germany for 3 weeks outage

[Bar chart showing the change in consumer surplus for EOM and CRM.]
Conclusions

A transmission cable outage is expensive for consumers in continental Europe if it occurs during power capacity shortage. Consequences of outage are more sensitive to the initial power situation and the market solution in the affected area than the outage length.

An outage of one link is not covered by increased power flow in other interconnections during power capacity shortage, as these cables already are fully loaded due to price difference in such circumstances.

Cable outages have identical consequences like generation capacity outage for the continent. Hence, it is suggested that cross-border capacity should be included in foreign Capacity Remuneration Mechanism (CRM).