Status, Concept and Way Forward for Nordic Electricity System

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Nordic production system

Total generation in 2015

<table>
<thead>
<tr>
<th>Country</th>
<th>TWh</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nordic</td>
<td>397</td>
<td></td>
</tr>
<tr>
<td>Baltic</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Fossil fuels</td>
<td>32</td>
<td>8</td>
</tr>
<tr>
<td>Nuclear</td>
<td>77</td>
<td>19</td>
</tr>
<tr>
<td>Biomass</td>
<td>23</td>
<td>6</td>
</tr>
<tr>
<td>Solar</td>
<td>1</td>
<td>0.2</td>
</tr>
<tr>
<td>Wind</td>
<td>35</td>
<td>9</td>
</tr>
<tr>
<td>Hydro *</td>
<td>229</td>
<td>58</td>
</tr>
</tbody>
</table>

Nordic net export 16 TWh
Baltic net import 8 TWh

Source: ENSCO-E preliminary data 2015

*) Normal annual Nordic hydro generation 208 TWh, variation +/- 40 TWh.
Nordic solution

Nordic cooperation
– A long history

> Nordel from the beginning of the 60’s to 2009

> Many Areas
  > Planning, Market, Operation, R&D, Maintenance etc

> Coordinated Planning
  > Common dimensioning criterias
  > Requirements for generators
Baltic region included

- 2007 - 2009 a Multi-regional study was performed including Nordel, the Baltic states (BaltsO) and Poland (PSE Operator)

Identifying three major interconnections:

- Lithuania - Poland
- Estonia - Finland
- Lithuania - Sweden

- The Baltic states
  Estonia, Latvia and Lithuania part of NordPool

Market based analysis of interconnections between Nordic, Baltic and Poland areas in 2025
Benefits of interconnections

- Security of supply
- Value creation
- Promoting renewables
Benefits of interconnections

Security of supply

Consumption, wind generation and exchange (January 22 – 25)

Source: Energinet.dk

(+ export to Denmark)
Benefits of interconnections

Price difference between Germany and Norway

Spot prices in Germany and Norway 2009-2014 – average week

€ / MWh

Week day

Weekend

Norway
Germany
Development of interconnection capacity
Nordic electricity market

- Forwards / Futures
  - Hedge against price risk
  - Several years or months ahead

- Day-ahead
  - Hourly schedule for next day
  - Needed by slow plants

- Intra-day / Balancing
  - Allows schedule changes
  - Important for variable renewables

- Regulating
  - Ensures real-time supply/demand balance
  - Important for compensating demand calculation errors

Source: IEA Nordic Energy Technology Perspectives 2016
Crossborder electricity trading increasing
Positive development of prices
Typical operation of the Nordic System

- Nuclear: 7370 MW
- Heat: 1427 MW
- Wind: 4203 MW
- Hydro: 11331 MW
- Unspec: 591 MW
- Tot Prod: 24922 MW
- Tot Cons: 20736 MW
- Export: 4186 MW
Interconnections reduce consumer prices, NordBalt

- ~ € 90 million can be saved in the first year with minimum risk

Daivis Virbickas, Litgrid CEO:

- Nasdaq OMX and Platts Forward Assessments indicate positive impact on consumer prices already today
Interconnections are good investments, NorNed

Source: Statnett
Going forward, new interconnection capacity

NorthConnect
- Length: 650 km
- Power: 1400 MW
- Voltage: ±500 kV bipolar
- Expected: 2025
- Cost: €1.5-2 billion

NSN Link
- Length: 730 km
- Power: 1400 MW
- Voltage: ±550 kV bipolar
- Expected: 2021
- Cost: €2 billion

Norger
- Length: 630 km
- Power: 1400 MW
- Voltage: ±500 kV bipolar
- Expected: 2028
- Cost: €1.5-2 billion

Nord.Link
- Length: 500 km
- Power: 1400 MW
- Voltage: ±500 kV bipolar
- Expected: 2018
- Cost: €1.5-2 billion

Source: JRC 2015
Going forward towards 100% renewable production

Nordic Countries

Source: NEPP 2015
How much wind can you have in the system?
2016-08-09

Nordic
- Wind 18 – 25 %
- Thermal
- Nuclear
- Hydro

Sweden
- Wind 20 – 32 %

Denmark
- Wind 70 – 83 %
Going forward,
Integration of national wind resources
Going forward, increase in interconnection capacity

Source: IEA Nordic Energy Technology Perspectives 2016
Going forward, net export of clean electricity

Source: IEA Nordic Energy Technology Perspectives 2016
2015

5 GW capacity to Europe
28 TWh trade activity with Europe
14 TWh net export to Europe

2050

23 GW capacity to Europe
125 TWh trade activity with Europe
53 TWh net export to Europe

Source: IEA Nordic Energy Technology Perspectives 2016
An interconnected renewable electricity system ensures low and stable prices

Source: IEA Nordic Energy Technology Perspectives 2016
Summary

• The Nordic Electricity System is based on physical and market integration that ensures:
  • High penetration of renewable energy
  • Efficient use of the collected production resources
  • Positive development of prices and reduced price volatility

• The interconnections are characterized by:
  • High capacity
  • Good return on investments

• Future electricity system characteristics:
  • Close to 100% renewable
  • Increased interconnection capacity
  • Low prices
Status and concept of Nordic Grid

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