Interconnecting North Sea Wind Power Plants

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www.ecn.nl
WPP export cables and interconnectors: Why not combine?

- Lower investments
- Higher reliability
- Less land use
- Dual income
- Hedging risks
- Integrated offshore grid

Source: EWEA.org
Case study for a UK and NL WPP: Is an Interconnecting Link feasible?

UK WPP: East-Anglia 1
NL WPP: Beaufort
IL: Interconnecting Link
Perspectives

1. Technical feasibility

2. Stakeholder interests
   - Interconnecting Link investor
   - WPP developer
   - TSO
   - Government

3. Legal feasibility

-- WORK IN PROGRESS --
Conclusions

• Technology
  – Combining Interconnectors and Export Cables is technically feasible
  – Experience with control and protection of Multi-Terminal DC grids is needed

• Economics
  – Marginal decrease LCoE of offshore wind energy in our scenarios: ≤ 3 €/MWh (3%)
  – Depends strongly on IL hurdle rate, WPP size, location and market price difference
  – Uncertainties of costs and benefits are large
  – Higher risk perception because of complexity in design and operation

• Legal
  – Legal framework is insufficient for IL permitting and operation

• Perspective is decisive
  – Stakeholders have opposing interests → different preferred scenarios
Recommendations

• Interconnecting Links are interesting:
  – If costs and risks of offshore DC technology are significantly lower
  – For large WPPs, far offshore, close to interconnector with high congestion rent
  – As a means to pre-finance export links for future WPPs

• Policy measures needed
  – Clear legal definition of Interconnecting Link and its operation
  – International coordination of renewable incentive and permitting schemes
  – Compensation mechanism for stakeholders that are negatively affected
Scenario definition: Topologies
Scenario definition:
Alternative topologies
Scenario definition: Technical implementations

IL1-AC

UK grid = NH WF

NL grid
Stakeholder interests

- Interconnecting Link investor
  - IRR

- WPP developer
  - Availability

- TSO
  - Market Integration

- Government
  - Social welfare
  - Land use
  - LCoE reduction

Note: Costs for onshore grid reinforcements are neglected
## Stakeholder interests

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>300 MW</th>
<th>1200 MW</th>
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</thead>
<tbody>
<tr>
<td><strong>IL investor</strong></td>
<td>IRR &gt; 10.9%</td>
<td>-</td>
</tr>
<tr>
<td><strong>UK WPP</strong></td>
<td>Availability</td>
<td>0</td>
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<td><strong>NL WPP</strong></td>
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<td><strong>GOVs</strong></td>
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**OVERALL SCORE**
Interconnecting Link investor: IRR

IC      -
IL1-AC   --
IL1-DC1  -
IL1-DC2  +
IL1-DC3  ++
IL2-DC1  ++
IL2-DC2  +

hurdle rate
-5% 0% 5% 10% 15% 20%
Interconnecting Link investor: IRR

P_WPP_NL goes up => IRR goes up

- IC
- IL1-AC
- IL1-DC1
- IL1-DC2
- IL1-DC3
- IL2-DC1
+ IL2-DC2

P_WPP_NL: 300 MW, 600 MW, 900 MW
Interconnecting Link investor: IRR

IC -
IL1-AC --
IL1-DC1 -
IL1-DC2 +
IL1-DC3 ++
IL2-DC1 ++
IL2-DC2 +
Interconnecting Link investor: IRR

-5% 0% 5% 10% 15% 20%

IC -
IL1-AC --
IL1-DC1 -
IL1-DC2 +
IL1-DC3 ++
IL2-DC1 ++
IL2-DC2 +

P_WPP_UK goes up => IRR goes DOWN

P_WPP_UK
900 MW
1200 MW
WPP developer: Unavailability

- Unavailability UK WPP >> unavailability NL WPP
- Unavailability UK WPP decreases by ≥ 45%
- Unavailability NL WPP decreases by 90%: T1-AC link (very expensive)
- Unavailability NL WPP increases for T1-DC links
TSO: Market Integration

Power transport between offshore grid and onshore grids (GWh/yr)

Best option: 1200 MW IC (E_trade = 9200 GWh/yr)
Second best: 1200 MW ILs (E_trade=4000-5200 GWh/yr)
## Stakeholder Interests

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<td><strong>T2-AC</strong></td>
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### IL Investor

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<td>++</td>
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### UK WPP

| Availability          | 0      | ++      |
|                       | 0      | ++      |

### NL WPP

| Availability          | 0      | ++      |
|                       | 0      | ++      |

### TSOs

| Market Integration    | +      | ++      |

### GOVs

| Social benefits EU    | ?      | ++      |
|                       | ?      | ++      |

### GOVs

| Social benefits UK    | ?      | ++      |
|                       | ?      | ++      |

### GOVs

| Social benefits NL    | ?      | ++      |
|                       | ?      | ++      |

### GOVs

| Land use              | -      | ++      |

### GOVs

| Δ LCOE UK             | +      | +       |

### GOVs

| Δ LCOE NL             | +      | +       |

### Overall Score
Government interest: Land Use

Interconnecting Link needs no space for onshore stations and cables
- Saves scarce space in cities
- Saves nature

Source: premierconstructionnews.com
Government interest: LCoE reduction

- Marginal LCoE reduction in our scenarios
  - up to 3%

- Depends heavily on many variables
  - Costs, WPP location, WPP size, IRR hurdle, market price differences

<table>
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<th>Scenario</th>
<th>WPP_NL Δ LCOE [€/MWh]</th>
<th>WPP_UK Δ LCOE [€/MWh]</th>
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<tr>
<td></td>
<td>T1_DC3</td>
<td>T2_DC1</td>
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<tr>
<td>Unavailability</td>
<td>+0.54</td>
<td>0</td>
</tr>
<tr>
<td>NPV surplus IL</td>
<td>-0.58</td>
<td>-1.6</td>
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<tr>
<td>Total Δ LCOE</td>
<td>-0.04</td>
<td>-1.6</td>
</tr>
<tr>
<td>Total Δ LCOE (relative)</td>
<td>0%</td>
<td>-2%</td>
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Legal feasibility

- **Construction** of an Interconnecting Link by a private party or TSO possible
- **Operation** not supported by existing regulations
- Issues to be solved include:
  - What is the legal status of Interconnecting Link?
  - Who is allowed to operate it?
  - Mandatory capacity auctioning of the interconnector capacity?
  - If so, how can priority access for the connected WPPs be guaranteed?
- Other regulatory obstacles:
  - National character of incentive programs and permit procedures for RES generation
  - Cost recovery of pre-financing
- Solutions have been suggested to solve these legal issues
Recommendations

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