Determining the capacity value of interconnectors, and implications for capacity markets

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joint work with Matt Woolf, Goran Strbac

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Increased electrical interconnection within the EU

- European Commission aims are to have at least 10% interconnection by 2020, for each member state, and 15% interconnection by 2030.
- Interconnection is an essential element of the Energy Union policy package.
- Capacity markets are being established in various EU countries
- EC wishes to enable cross-border participation in capacity markets

Table 9: Capacity Levels for Interconnection (in GW)

<table>
<thead>
<tr>
<th>Capacity GW</th>
<th>2017/18</th>
<th>2018/19</th>
<th>2019/20</th>
<th>2020/21</th>
<th>2025/26</th>
<th>2030/31</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Case</td>
<td>4.2</td>
<td>4.2</td>
<td>5.2</td>
<td>7.6</td>
<td>13.5</td>
<td>14.9</td>
</tr>
<tr>
<td>Gone Green</td>
<td>4.2</td>
<td>4.2</td>
<td>5.2</td>
<td>7.6</td>
<td>19.4</td>
<td>23.3</td>
</tr>
<tr>
<td>Slow Progression</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>13.5</td>
<td>14.9</td>
</tr>
<tr>
<td>No Progression</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>4.2</td>
<td>9.6</td>
<td>11.0</td>
</tr>
<tr>
<td>Consumer Power</td>
<td>4.2</td>
<td>4.2</td>
<td>6.6</td>
<td>8.6</td>
<td>20.1</td>
<td>23.3</td>
</tr>
</tbody>
</table>

National Grid 2016 Electricity Capacity Report
Interconnection in UK capacity market

Interconnectors are eligible to participate in CM auction from delivery year 2017/2018 (T-1) and 2019/2020 (T-4)

Split methodology:

• For the **analysis of capacity to secure**, interconnector contributions are modelled probabilistically (distributions from market model)

• The **allocation of capacity value** is based on the formula

  \[ \text{de-rated capacity} = \text{nameplate capacity} \times \text{technical availability} \times \text{country factor} \]

### Table 1: De-rating factor ranges

<table>
<thead>
<tr>
<th>%'s</th>
<th>France</th>
<th>Netherlands</th>
<th>Ireland</th>
<th>Belgium</th>
<th>Norway</th>
</tr>
</thead>
<tbody>
<tr>
<td>2017/18 High</td>
<td>86</td>
<td>82</td>
<td>58</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2017/18 Low</td>
<td>45</td>
<td>70</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2020/21 High</td>
<td>88</td>
<td>82</td>
<td>50</td>
<td>92</td>
<td>96</td>
</tr>
<tr>
<td>2020/21 Low</td>
<td>45</td>
<td>70</td>
<td>25</td>
<td>65</td>
<td>76</td>
</tr>
</tbody>
</table>
Aims

What this work **doesn’t do:**

- Model the ‘real’ system
- Predict actual (xxx.yy MW) capacity contributions
- Produce results for meshed systems (> 2 zones)

What it **does do:**

- Support work on definitions for capacity contributions
- Provide qualitative insight into capacity contribution of interconnectors
- Identify areas of concern for the development of coordinated/integrated capacity markets
Major sources of uncertainty

Asset and load scenarios

Markets
• Real time markets (who controls the interconnector in real time?)
• Capacity markets (investment and allocation)

Security standards
• Different values (3 hours LOLE vs X hours LOLE)
2014 demand profiles
2014 wind power profiles
most significant generators (66 GW; 97 GW) + generic availabilities
additional load/generation offset to hit LOLE target
capacity contribution computed as ELCC \(=\text{capacity displaced}\)
Computational approach

1D PDF of conventional generation in system A

1D PDF of conventional generation in system B

2D PDF of historical load (A&B)

2D PDF of dependent wind model (based on Gaussian copula)

hindcast PDF

data driven copula model

2D PDF of margin

aggregation with IC constraints + policy

LOLP A

LOLP B

LOLP as function of 2-area ELCC

correlation parameter
Displacement of generation in zones A and B is not independent.

There is no unique capacity value, but a *Pareto frontier* of possible answers: the **capacity allocation curve**.

We need a mechanism for capacity allocation (markets or multi-lateral agreements).
Capacity allocation

- Three (aggregate) capacities: 1 GW, 3.5 GW, 10 GW
- **Qualitative** difference between small and large interconnector capacities
- **Asymmetry** between GB/FR contributions
Range of real-time market policies is bracketed by four operational policies:

- **veto**: both areas have veto power over exports
- **helpA**: always assist A
- **helpB**: always assist B
- **share**: shared shortfalls

The *share* policy provides a conservative capacity estimate.
Different security standards

Test case: GB relaxes its security standard to from LOLE = 3 hr/year to 10 hr/year
Very preliminary: High wind & flat load profiles

- Installed wind capacity has **very little influence** on interconnector capacity value [*disclaimer: wind model trained on single-year hindcast and independence of load]*
- Flattening the load profile **boosts** the capacity contribution

![Graph showing capacity value A vs capacity value B for different load profiles and wind percentages.](image-url)
Impact on capacity values

Assumption: equal allocation of capacity
Conclusions / discussion

- The capacity contribution of interconnection is strongly affected by
  - other interconnectors
  - real-time power flows
  - security standards [+ details...]

- The capacity allocation curve relates capacity contributions in neighbouring areas
  - Limited interconnection: approximately independent
  - Significant interconnection: highly dependent

- Who coordinates capacity contributions? Do we need a single European clearing of capacity markets, or independent verification by ENTSO-E?

- The big question: who should benefit from capacity contributions? [interconnector owners, the public, remote generators]