Implications of Fault Current Limitation for Electrical Distribution Networks

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The future need for fault current limitation

An approach has been developed for estimating the number of UK substations that may require fault current limitation. It is based on the statistical analysis of existing fault level headroom, combined with the potential future presence of distributed generation (DG) and energy storage.

### Establish a generation scenario that satisfies an 80% drop in CO₂ emissions by 2050:

<table>
<thead>
<tr>
<th>Property</th>
<th>% Required</th>
<th>Total Energy Required</th>
<th>Peak Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>60%</td>
<td>22.7 GWa</td>
<td>64.9 GWa</td>
</tr>
<tr>
<td>Total</td>
<td>20%</td>
<td>7.8 GWa</td>
<td>18.6 GWa</td>
</tr>
<tr>
<td>Wave</td>
<td>10%</td>
<td>4.1 GWa</td>
<td>11.7 GWa</td>
</tr>
<tr>
<td>Solar</td>
<td>5%</td>
<td>2.7 GWa</td>
<td>22.2 GWa</td>
</tr>
<tr>
<td>Despatchable renewables</td>
<td>5%</td>
<td>1.9 GWa</td>
<td>3.1 GWa</td>
</tr>
<tr>
<td>Storage</td>
<td>n/a</td>
<td>5.1 GWa</td>
<td>20.5 GWa</td>
</tr>
</tbody>
</table>

### Determine statistical fault level contribution for future generation mix (based on typical interfaces and their fault current contributions)

### Account for "independent nodes"

### Scale to number of UK substations

### Combine normal distributions: provides probability (or percentage) of substations with fault level violations

### Multiply by the number of substations in the UK, for each voltage level

### Conclusions:

- Suggests a worldwide market for fault current limitation, for countries facing similar future DG connection
- Does not include the potential “intangible” benefits of SFCLs: increased interconnection; increased security of supply; increased power quality; and reduced losses

Technical issues with fault current limitation

During a fault, the superconductor in a resistive superconducting fault current limiter (SFCL) will rapidly transit from the superconducting state to a resistive state. However, up to several minutes may be required for recovery to the superconducting state, which leads to several issues.

Remote faults, such as F₁, may cause undesired operation of an SFCL; the DG must “ride-through” until the appropriate protection operates.

Auto-reclosure schemes (e.g., after a transient or semi-permanent fault at F₂) may be complicated by the presence of SFCLs in the network: the dead time may be unduly increased by an SFCL’s recovery time.

Non-fault transients, such as transformer inrush, may cause spurious operation of SFCLs. Hence, SFCLs located at the grid infed must be rated to operate only for “near” faults:

Potential solutions include:

- The use of SFCLs that can recover immediately after a fault, or under load
- Network automation could manipulate normally-open/closed points to reduce the fault level
- Islanding may help to supply loads during SFCL recovery
- Islanding can help keep transformers energised, minimising the risk of SFCL operation due to inrush

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