Transmission Line Overloading Analysis using Probabilistic Dynamic Line Rating

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Steady-State Thermal Rating

for given weather parameters and maximum conductor temperature

\[ I_{\text{rating}} = \sqrt{\frac{q_c(T_{\text{max}}, T_a, V_m, \varphi) + q_r(T_{\text{max}}, T_a) - q_s}{R(T_{\text{max}})}} \]

Ref. “Guide For Thermal Rating Calculations Of Overhead Lines”, CIGRE
Rating compared to base case:
490 (A) at 40 °C, 0 wind, and sunny midday

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Increase</th>
<th>Rating</th>
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</thead>
<tbody>
<tr>
<td>20 °C</td>
<td>14.5%</td>
<td>718 (A)</td>
</tr>
<tr>
<td>0 °C</td>
<td>18%</td>
<td>896 (A)</td>
</tr>
<tr>
<td>Mid night</td>
<td>13%</td>
<td>654 (A)</td>
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<tr>
<td>1 m/s wind</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45 °</td>
<td>16%</td>
<td>770 (A)</td>
</tr>
<tr>
<td>90 °</td>
<td>17%</td>
<td>834 (A)</td>
</tr>
</tbody>
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Operational Risk
Overload Protection & DLR

- **Dependability:**
  The probability of not having a failure in protection operation under given conditions, in this case overloading

- **Security:**
  The probability of not having an unwanted operation like operation without overloading

- **Problem with classical overload protection:**
  Low security leading to high probability of unnecessary tripping or curtailment

  Making the addition of generation and load growth difficult
Amount of Curtailment versus Acceptable Probability of Overload

Hours with curtailment as a function of the acceptable probability of overload
Probabilistic Rating – Winter Day

Static rating (dashed line) and four different probabilistic dynamic ratings (solid curves) together with line current (green) for a winter day.
Probabilistic Rating – Summer Day

Static rating (dashed line) and four different probabilistic dynamic ratings (solid curves) together with line current (green) for a summer day.
Discussion

- Additional uncertainties
  - Such as emissivity, absorbtivity of the surface and loading profile
- Acceptable probability of overload
  - Deterministic DLR will be associated with a high probability of overload not being removed
  - A stochastic approach to DLR-based overload protection is highly recommended.

However

- What are the acceptable risks?
- Balance between dependability and security
Thank you