Distribution Congestion Management by Using CVSR Devices: Optimization and Clustering

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INTRODUCTION:
- A continuously variable series reactor (CVSR) is a series of line reactor for power-flow control in meshed power grids.
- High load density networks (i.e., spot networks, secondary networks) should be highly reliable to sustain the system following a contingency.
- Grid network transformers play an important role for these spot networks.
- Relief overload power on supply transformers can be accomplished via CVSRs.

PIECEWISE OPTIMIZATION AND CLUSTERING APPROACH
- Calculations by linear optimization may give large errors since assumption is made on the sensitivity curves.
- Therefore, piecewise linearization can be a solution for more accurate transformer sensitivities.
- System can be divided into clusters as seen in the figure.
- Increasing the electrical distance, transformers with CVSR do not affect the other transformer loading significantly.
- Results from Table I are very close to the benchmark results.

Table I: 4-Segment Piecewise Optimization Results for IEEE 342 Test System

<table>
<thead>
<tr>
<th>Xhi23 (ohm)</th>
<th>Xhi24 (ohm)</th>
<th>P23 by OpenDSS</th>
<th>P23 by Sensitivities</th>
<th>P24 by OpenDSS</th>
<th>P24 by Sensitivities</th>
<th>Transformer Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.76</td>
<td>4.76</td>
<td>1133.96 kVA</td>
<td>1133.96 kVA</td>
<td>944.72 kVA</td>
<td>944.72 kVA</td>
<td>No Limit</td>
</tr>
<tr>
<td>4.76+1.283</td>
<td>4.76+0</td>
<td>999.11 kVA</td>
<td>1000</td>
<td>981.11 kVA</td>
<td>980.757</td>
<td>1000</td>
</tr>
<tr>
<td>4.76+1.997</td>
<td>4.76+0.529</td>
<td>947.48 kVA</td>
<td>950</td>
<td>947.07 kVA</td>
<td>950</td>
<td>950</td>
</tr>
<tr>
<td>4.76+2.88</td>
<td>4.76+1.364</td>
<td>892.84 kVA</td>
<td>900</td>
<td>891.88 kVA</td>
<td>900</td>
<td>900</td>
</tr>
</tbody>
</table>

CONCLUSION
- Transformer sensitivity analysis helped us to determine the device specifications.
- Piecewise optimization results are close to the benchmark results.
- Optimization results shows the effect of CVSR devices.
- Clustering approach reduces the computational time.