Effects of Embedded Generation on Sydney CBD’s 11kV Distribution Network

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Introduction

There is an ever increasing interest in connecting embedded generation (or distributed generation - DG) onto the power network. This project aims to model the connection of embedded generation onto Sydney CBD’s 11kV distribution network. The network is owned and operated by Ausgrid and is known as a triplex network and is unique in the world.

Different penetration levels of generation are connected to the network and three major effects are analysed: potential for reverse power flow, magnitude of any fault level increase and any possible problem with a voltage regulation (VR) maloperation.

Model Design

The network was simplified using some assumptions:
• 5 equal loads on the feeder
• Distribution transformers are identical
• DGs used: 0.5, 1, 2.5, 5, 6MVA

The system is modelled in PSS/E and is loaded with 2 different loading conditions: fully loaded (30MVA) and half loaded (15MVA) and with 2 different power factors: 0.8 and 0.9 lagging.

Reverse Power Flow Results

Reverse power flow will not occur when the system is operating under normal conditions with any penetration level of embedded generation used for this project. The high impedance distribution transformers cause a much larger impedance to be seen at the point of connection so power flows back up the feeder to the zone rather than through the LV busbar.

Fault Level Results

3-phase fault levels increase as the penetration level of DG increases. The further from the zone substation the DG is connected, the smaller the fault current measured at the zone substation busbar, however it is always greater than the existing fault level. Line-ground fault currents also increase but they are much more dependant on the generator construction style because of zero sequence current flows.

<table>
<thead>
<tr>
<th>RC%</th>
<th>DG 0.5MVA</th>
<th>DG 1MVA</th>
<th>DG 2.5MVA</th>
<th>DG 5MVA</th>
<th>DG 6MVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-Phase</td>
<td>0.0828kA</td>
<td>0.2009kA</td>
<td>0.1783kA</td>
<td>0.1505kA</td>
<td>0.1669kA</td>
</tr>
<tr>
<td>Line-ground</td>
<td>0.1157kA</td>
<td>0.2015kA</td>
<td>0.1701kA</td>
<td>0.1443kA</td>
<td>0.1605kA</td>
</tr>
</tbody>
</table>

Voltage Regulation Results

As the penetration level increases, the voltage at the zone busbar decreases as more reactive power is pulled through the transformer. At a penetration level of 5MVA or 6MVA, the VR scheme will operate and enact a tap change. However, the zone busbars will become unbalanced. The voltage imbalance on each transformer winding can be corrected by adding the same size generator onto the other winding.

Conclusion

Connection of DG to the network causes some problems. The fault levels increase for both ground and 3-phase faults and the zone busbar voltages will become unbalanced possibly causing a maloperation of the VR scheme. However these problems are insignificant for a penetration level of 0.5MVA or 1MVA provided the power factor follows the load power factor.