Overcoming operational challenges in large power transformers for offshore platforms
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Abstract
Offshore platforms for windfarms represent an important piece of the total project investment cost, these are large structures dealing with numerous equipment types and systems, relating to grid interconnection and control tasks. Large oil immersed power transformers are also located on these offshore platforms and they are used to increase the generated voltage level for long distance power transmission. These transformers will experience particular requirements when they are compared to standard on-land units.

Compact solutions
Transformer size and weight are crucial parameters regarding overall installation and equipment expense, specially regarding platform costs. The following graph shows qualitative impact in case of using standard insulation material (unitary reference) or high temperature aramid material.

Spare strategies
In case of a failure on a collector step up transformer, a redundancy strategy needs to be established in order to minimize the loss of generation capacity and thus, the related benefits. Three possible trends are observed: on-shore traditional (blue), current off-shore (green) and new off-shore alternative (yellow):

<table>
<thead>
<tr>
<th></th>
<th>Conventional Insulation</th>
<th>Hybrid Insulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal Operation</td>
<td>50%</td>
<td>100%</td>
</tr>
<tr>
<td>Emergency Operation</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Max. Load</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Loss of Life</td>
<td>NO</td>
<td>YES</td>
</tr>
<tr>
<td>Restriction</td>
<td>HIGH &amp; HIGH</td>
<td>LOW &amp; LOW</td>
</tr>
<tr>
<td>Cost &amp; Size</td>
<td>HIGH &amp; HIGH</td>
<td>MEDIUM &amp; LOW</td>
</tr>
</tbody>
</table>

The use of hybrid insulation for off-shore designs can help to reduce the transformer life ageing or loading restrictions at an attractive investment cost, enabling an efficient emergency spare strategy without special actions on site.

Corrosion
To achieve a superior corrosion protection, some of the following actions are recommended based on successful previous experience regarding offshore transformers:

- CSM-H corrosion protection level for main tank
- Radiators are recommended to present 1.2 mm thickness
- No rotating equipment is recommended to avoid early corrosion

Maintenance
Maintenance activities on an offshore platform are costly and time consuming due to difficulties in accessibility to the affected platform, safety reasons and weather conditions.

In order to avoid maintenance and service needs, the following recommendations are presented:

- ONAN cooling is a preferred strategy: radiators
- Minimizing accessories for cooling equipment: no pumps & no fans
- On line monitoring: DGA, ETM, Oil level, Bushings. OLTC...
- Maintenance free devices: Vacuum OLTC, air breather...
- Accessories should be provided with ambient protection

Conclusions
From an operative point of view, lighter transformers and reduced footprint area units can be obtained, showing very attractive cost reductions in terms of platform structural material expenses. Also, thanks to a high overloading capability in case of failure, urgent repairs are no longer needed, allowing a better and more economical repairs planning. Regarding maintenance activities optimization, the maintenance personal presence in the offshore platform is minimized, at the same time that the reliability of the unit is increased by providing continuous monitoring actions and early warning.

References
1. Compact transformers for offshore wind power plant applications (418.14), IREPO, Grinda – 2014
2. Optimisation of offshore platform transformers (PO887), WindEurope, London - 2017