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Transformer Services

Asset Management View
Risk Reduction and Mitigation

Introduction

Most owners and users of Transmission and Distribution (T&D) assets increasingly consider the Total-Costs-of-Ownership for their assets. There are well known factors like the purchasing costs of new assets or routine maintenance as specified by the OEM. However, there is also a somehow "hidden" portion resulting from the operational risks of the assets. The following focuses on power transformers as very important assets inside the T&D grids.

Challenges

Power transformers are very reliable assets. Depending on the type of transformer the average failure rates (FR) are between 0.5% and 1% per year /1/. But as they have a high strategic relevance for Transmission & Distribution Grids the Costs-of-Failures (CoF) are quite high. Small FR and comparably high CoF lead to a significant impact on the transformer lifecycle costs (LCC).

The following qualified estimate shows the LCC impact of major failure scenarios for somehow typical generator step-up (GSU) and substation (SUB) transformers. The CoF are mainly influenced by a) costs for repairs and preliminary solutions, b) costs-of-energy-not-supplied (CoENS) and c) the probability of the respective failure scenario. The question arises by what means the LCC impact can be reduced. Our proposal is the stringent application of transformer online monitoring systems as described in /3/. This needs to be embedded into an Asset Management process according to ISO 55000.

Benefits of transformer condition assessments

Transformer Condition Assessments are part of the routine maintenance procedures of power transformers. The interval between condition assessments is 1 year. Acc. to /3/ 30% of all evolving major power transformer failure can be identified in advance. However, the result is just a snapshot.

Benefits of transformer online monitoring

Modern Transformer Online Monitoring Systems are capable to reduce the risk of major failures by additional 42% in comparison to conventional maintenance practices as described above /3/. This positive impact is due to a) the continuous monitoring of transformers and b) the early identification of critical trends or exceeding of limit values. Documented cases /4/ show how power transformers may get into critical conditions in less than two days.

Application	GSU		SUB	
Major failure ...	... with external effects	... without external effects	... with external effects	... without external effects
Costs-of-Failure, CoF				
Repair + Prel. solution	>3'0EUR	>1'5EUR	>2'0EUR	>1'5EUR
CoENS /2/	>10'0EUR	>10'0EUR	0	0
Life Cycle Cost (LCC) Impact				
Probability	0.22%	0.78%	0.12%	0.41%
LCC, 50yrs	>1'1EUR	>3'9EUR	>0'1EUR	>0'4EUR
	5'0EUR		**0'5EUR**	

Evolving failures

In case of an identified evolving failure the limitation of the damage depends on the efficiency of the owner's processes. The background is e.g. the long delivery time of certain spare parts or the limited availability of skilled resources, e.g. supervisors from the respective transformer factory. The indicated risk reduction potentials of Transformer Condition Assessments

Condition Assessments and Online Monitoring Systems can only be materialized if improving or corrective actions are triggered without further delay.

Strategic spare parts

Tab. 2 indicates shows the necessity to consider the preventive purchase of certain strategic spare parts, e.g. high voltage bushings. Their delivery times are comparable to the delivery time of the transformer itself.

To avoid unplanned downtimes related to the unavailability of spare parts we recommend their purchase and exchange the results of Condition Assessments or Online Monitoring indicated the need for action.

Availability of appropriate technical specialists & equipment

The execution of improving or corrective action, e.g. transformer repairs, often requires the availability of factory experts like supervisors or trained transformer technicians. Some preventive action like the regeneration of transformer oil requires a midterm planning to ensure the availability of the required technical equipment and service staff. We recommend agreeing on service contracts with the OEM to ensure the availability of staff and equipment when indicated by the results of transformer condition assessments or Online Monitoring. Examples are On-Call duty, strategic spares or KPI-based Operation & Maintenance contracts.

Financial benefits

With reference to the mentioned examples we estimate the financial benefits of the described process in table 3. We assume that the preventive character of the process reduces the repair costs by 80%, compared to a fully reactive approach. The indicated LCC-savings can only be materialized if the application of Condition Assessments and Online Monitoring is part of an efficient Asset Management process.

The preventive actions described above need to be initiated soon when somehow critical transformer conditions are identified. Therefore, fast emergency processes are required to minimize unplanned downtimes.

Our recommendation

- We recommend the application of condition assessments and online monitoring for early fault detection.
- Based on known market prices the application of these preventive techniques always pays off.
- Strategic spare part supply agreement with the OEM to avoid downtimes caused by the unavailability of spares
- Service contract with the EWM, e.g. 24/7 hotline, on-call duty, availability-based, to avoid downtimes caused by the unavailability of required technical specialists and experts
- These measures shall be embedded into an asset management process acc. to ISO 55000.

Spare parts	Est. life time	Importance	Probability	Delay times
Solid porcelain bushing	20 to 30 yrs.	+	-	> 8 weeks
Condensive bushing	10 to 20 yrs.	++	N	4 to 8 months
Off load tap changer	25 to 30 yrs.	++	N	4 to 8 months
Fans	10 to 15 yrs.	0	N	< 2 months
Oil pumps	10 to 15 yrs.	+	N	< 8 weeks
Buchholz Relay	10 to 15 yrs.	0	N	On stock
Pressure Relief Valve	10 to 15 yrs.	+	N	On stock
Winding/oil temperature indicator	10 to 15 yrs.	0	N	On stock
Oil level indicator	5 to 15 yrs.	-	N	On stock
Oil/water flux indicator	5 to. 10 yrs.	-	N	On stock
Gaskets	5 to. 10 yrs.	-	+	< 8 weeks
Rubber bag	10 to 15 yrs.	-	N	4 weeks
Valves	10 to 15 yrs.	-	+	4 weeks
Dehydrant air breezers	5 to. 10 yrs.	-	N	< 4 weeks

APPLICATION	GSU	SUB
LCC impact	5'0EUR	0'5EUR
Risk reduction enabled by Condition Assessments		
Detectable /3/	30%	
LCC impact	-1'5EUR	-0'15EUR
Additional Risk reduction enabled by Online Monitoring		
Detectable /3/	42%	
LCC impact	-2'1EUR	-0'21EUR
Overall Risk reduction enabled by applicati on of Condition Assessments and Online Monitoring		
LCC impact	-3'6EUR	-0'36EUR

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