



Preparing for Low Carbon Technologies

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Doble History



100 YEARS OF SERVICE TO THE ELECTRIC UTILITY INDUSTRY



<p>1920 Doble Safety Portable Telephone</p> 	<p>1922-1923 Type A & B testers</p> 	<p>1928 Power factor test set</p> 	<p>1934 First Doble Client Conference</p> 	<p>1934 Frank Doble forms special ad. committee</p> 	<p>1936 Morgan Schaffler established in Montreal, Canada</p> 	<p>1949 Type MH power factor test set</p> 	<p>1951 First Doble survey of electric insulating mineral oils</p> 	<p>1972 TR-1 circuit breaker motion analyzer</p> 	<p>1978 Doble acquires Jonice Controls Corporation</p> 	<p>1982 Type F3F35 series</p> 	<p>1987 TR3000 circuit breaker analyzers</p> 	<p>1989 AM100 circuit breaker monitor</p> 	<p>1990 Doble Test Assistant (DTA) software</p> 	<p>1993 M4000 high voltage apparatus tester</p> 	<p>1994 AMS-500 on-line dissolved hydrogen monitor</p> 	<p>2000 F6 series</p> 	<p>2000 Intelligent Diagnostic Devices (IDD)</p> 	<p>2003 Doble Power Test opens in the UK</p> 	<p>2005 Nykos™ portable dissolved gas analyzer</p> 	<p>2007 ESCO Technologies, Inc. acquires Doble Engineering Company</p> 	<p>2011 dobleAPMS™ asset risk management system</p> 	<p>2012 Xtensible Solutions joins the Doble team</p> 	<p>2013 M7100 high voltage asset analyzer</p> 	<p>2014 Condition monitoring system</p> 	<p>2015 ENOSERV joins the Doble team</p> 	<p>2016 Transient Cyber Asset (TCA) program</p> 	<p>2017 Morgan Schaffler and Vanguard Instruments join the Doble team</p> 	<p>2017 NRG Systems joins Doble's Utility Solutions Group</p> 	<p>2018 Manta Test Systems joins the Doble team</p> 	<p>2021 F8 Series</p> 	<p>2021 Altanova joins the Doble team</p> 	<p>2021 Phenix Technologies joins the Doble team</p> 
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Our Solutions



Electrical Test Equipment

Essential for day-to-day maintenance tests of electrical assets. Useful in specific phases of the asset lifecycle:

- Procure
- Operate
- Maintain
- Decommission.

Professional Services

Diversified offer according to the electrical asset lifecycle:

- Installation and commissioning
- Diagnostic test
- Data analysis
- Consultancy
- Training.



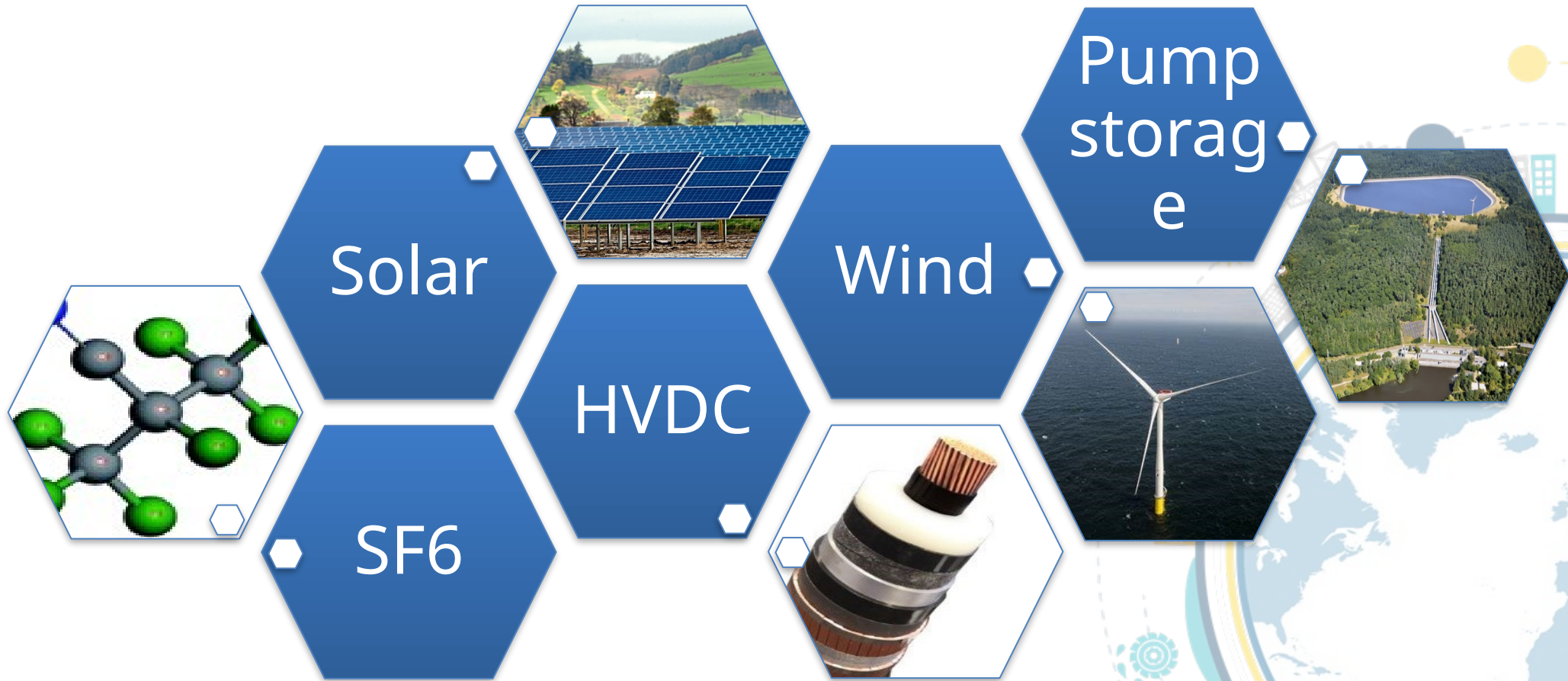
Monitoring Systems

Shift from a time-based maintenance to a condition-based maintenance.

Focus on predictive maintenance and shift in focus from electric asset value cost to network outage costs.

Strong evolution of digitalization trend in the power industry.

Where Are We Supporting the Energy Transition?



How Are We Supporting the Energy Transition?



Work all across the Asset Lifecycle

And more broadly within a larger asset management framework (ISO 55001)

Strategy and Planning

Procurement

Asset Management Decision Making

Condition Assessment reports

Data analytic tools

Asset Information

Databases

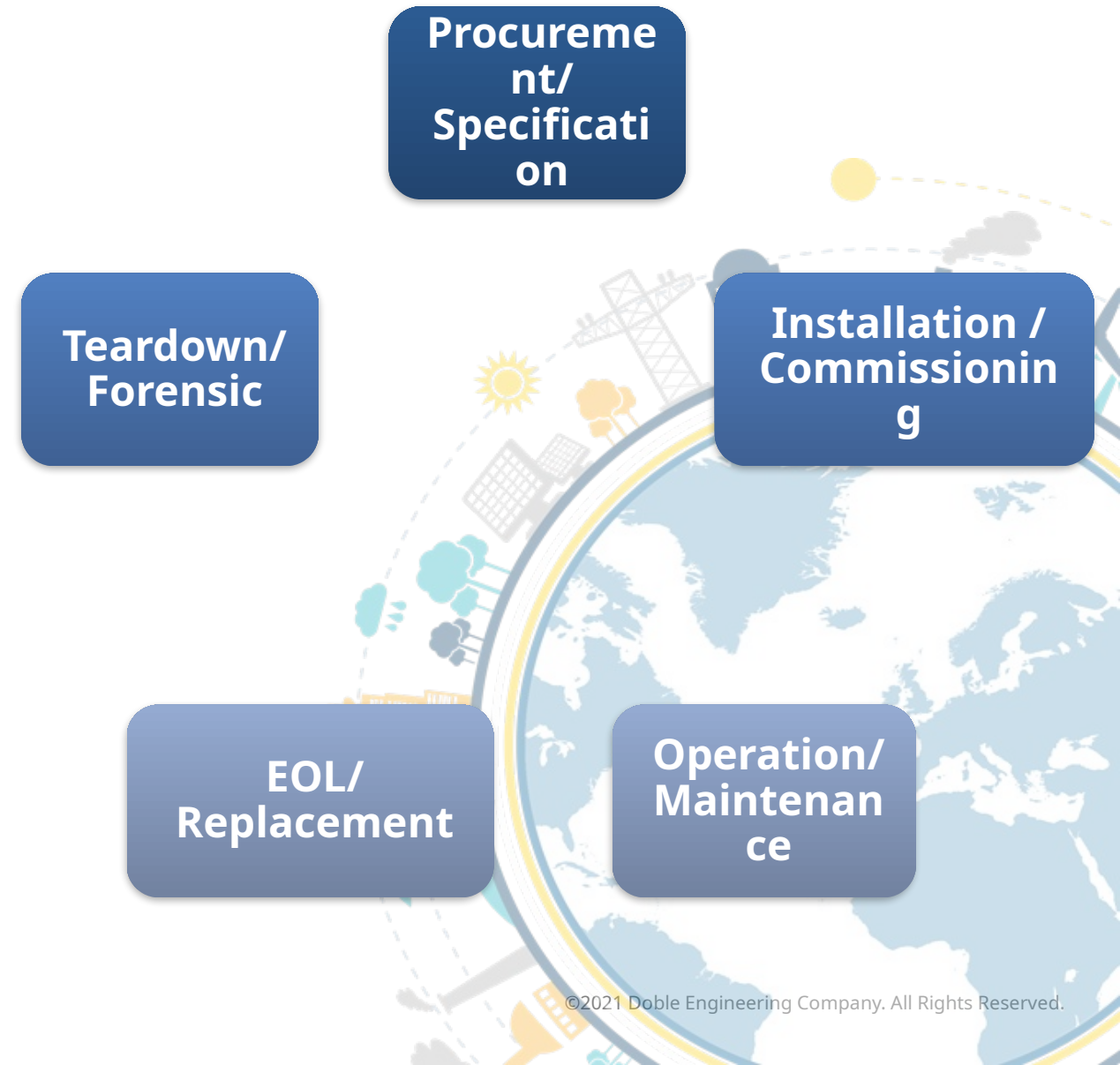
Risk and Review

Consulting services

Fleet management

Organisation and People

Training



Same Assets But....



Same assets as conventional T&D applications but

Different load profiles

Different installation environments

Different harmonics

Different connection configurations (e.g. arrays)

Different contractual/ownership arrangements

Leads to

Different patterns of thermal and electrical stress

Different view on risk



What Issues Do We See?



Problems caused from the outset

Contracting philosophy

Weak specifications leading to confusion between the asset owner and OEM

Assets installed in inappropriate environments

Poor CDM

Under rating

Not understanding the thermal environment

Not taking account of harmonics

Resonance and transient related failures

Asset owner sometimes lacks technical knowledge



Solar Farm



Supporting a solar farm operator with a large portfolio but little in-house engineering expertise

Company is committed to improving asset management and ultimately generation output

Wide range to transformer suppliers and designs (dry, oil, sealed) through acquisition

Started with desk-top asset health review of transformer condition across seven sites based on available data (mainly DGA)

Prioritised list of recommendations

Follow-up electrical testing on units of concern



Offshore Wind Turbines



Supported transformer supplier in dispute with turbine manufacturer following multiple failures of dry-type units

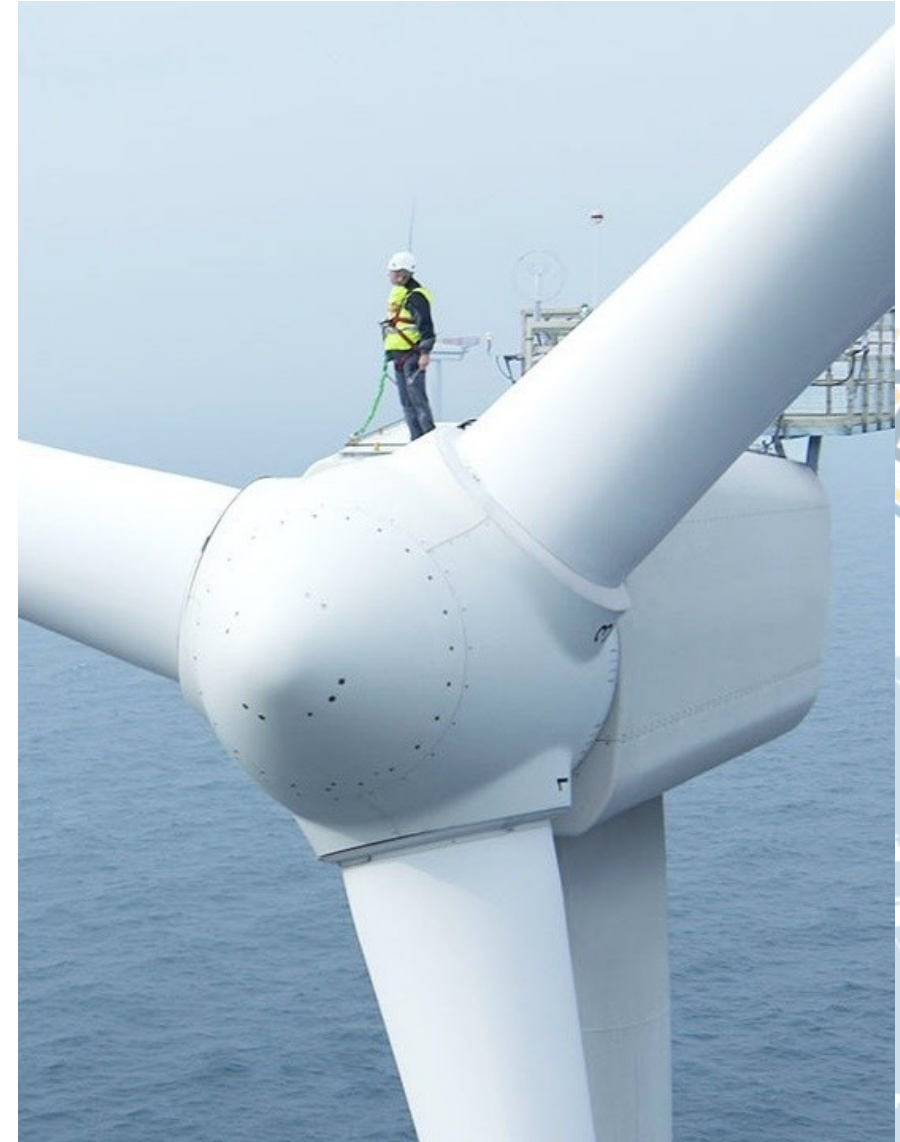
Dispute centred on potential overheating

Ambiguity in the specification

Exacerbated by ambiguity in the IEC standards

Definitions of ambient air and cooler inlet temperatures

Reviewed experimental design to prove transformers were fit for purpose



Onshore Wind Turbines



Following failures, carried out a programme of offline partial discharge testing on dry type transformers installed in onshore wind turbines

The results were used to create a fleet management plan and prioritise the replacement of the affected units

Replacements were aligned with maintenance outages
Minimised downtime and lost production



What to do?



First line of defense is to buy assets which are fit for purpose!

However, if things do go wrong either because of poor specifications or single asset issues

Offline testing

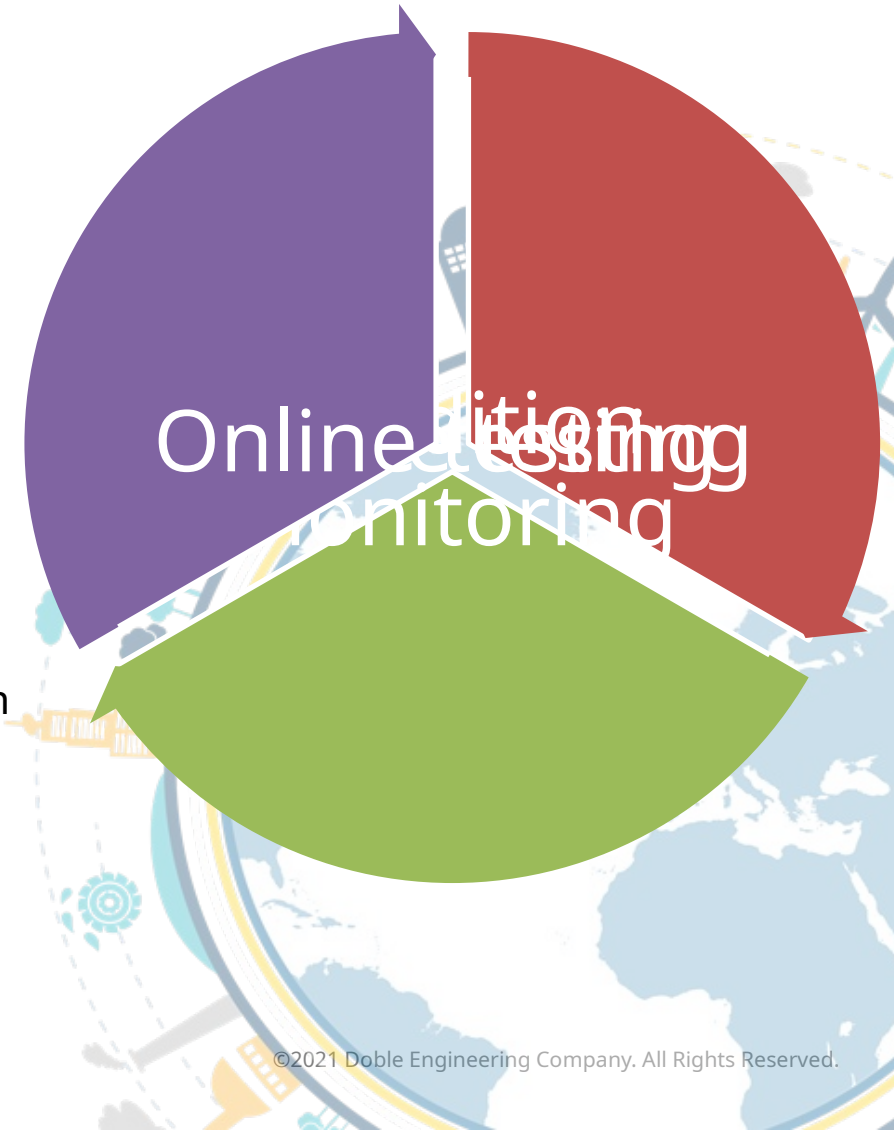
Outage required. Diagnostic tests to measure specific parameters

Condition monitoring

No longer the preserve of HV/EHV. Simpler/cheaper monitors available which can still give valuable condition information

Online testing (surveys)

No outage required. Screening techniques which can be used as part of routine maintenance

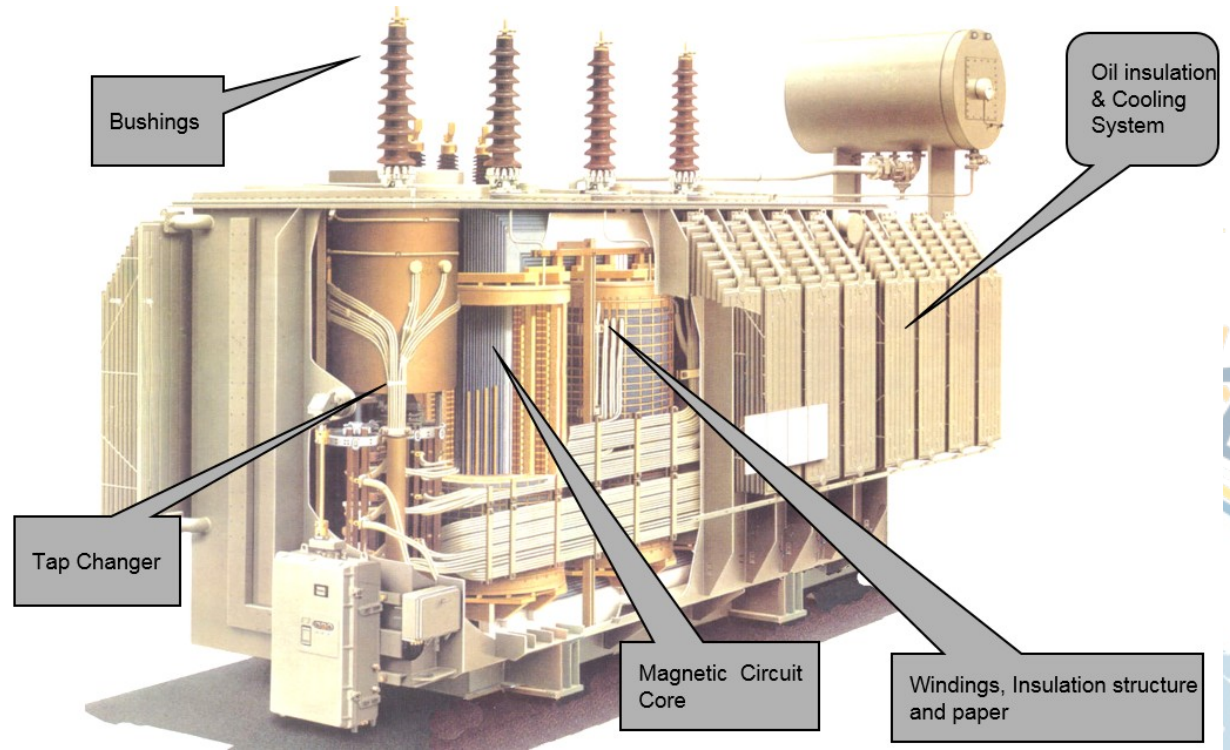


Offline diagnostics



Several methods to assess the condition of transformer:

- PF/Cap. for windings and bushings
- Excitation test
- Leakage reactance
- SFRA
- Turns Ratio (LVTR, HVTR)
- DC winding resistance



- Combined output of these tests provide a clear indication to condition of transformers

Condition monitoring



Solar farm at South Africa



Wind farm at Quebec



BUSHING LEAKAGE CURRENT

High, low, tertiary

Add voltage reference for true power factor

OPERATIONAL PARAMETERS

Tap position

Load

Voltage

Temperature

Pumps & fans status

Vibration

Oil level

PARTIAL DISCHARGE

Bushings

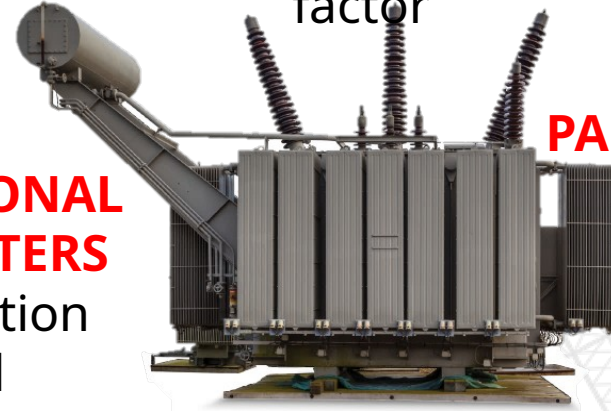
Main tank

Neutral

DGA

Main tank

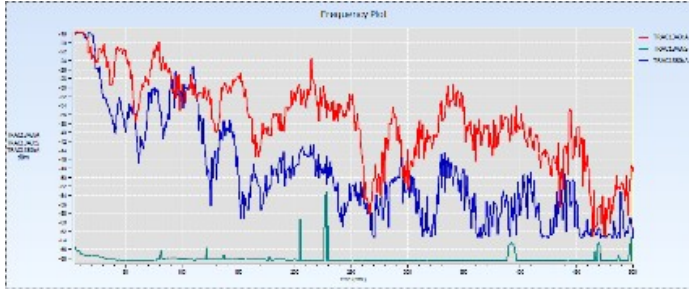
Optional tap changer



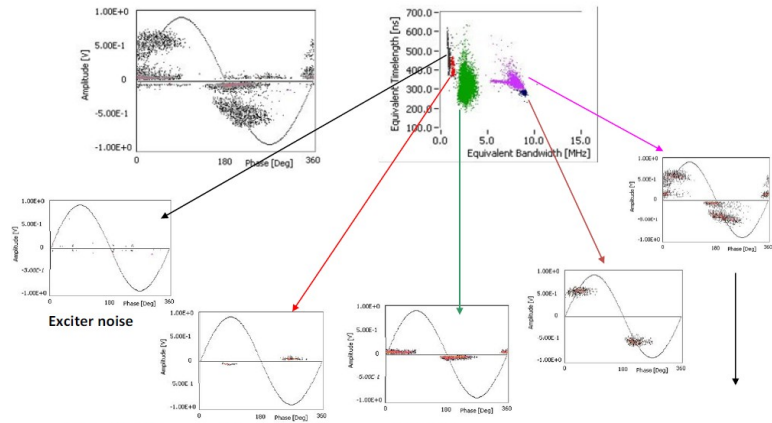
Online testing



Spark P3



Aquila



Summary



Same assets but need to understand the actual operating conditions and different stress patterns

Specifications are important

Failure to understand the thermal issues

Load profile

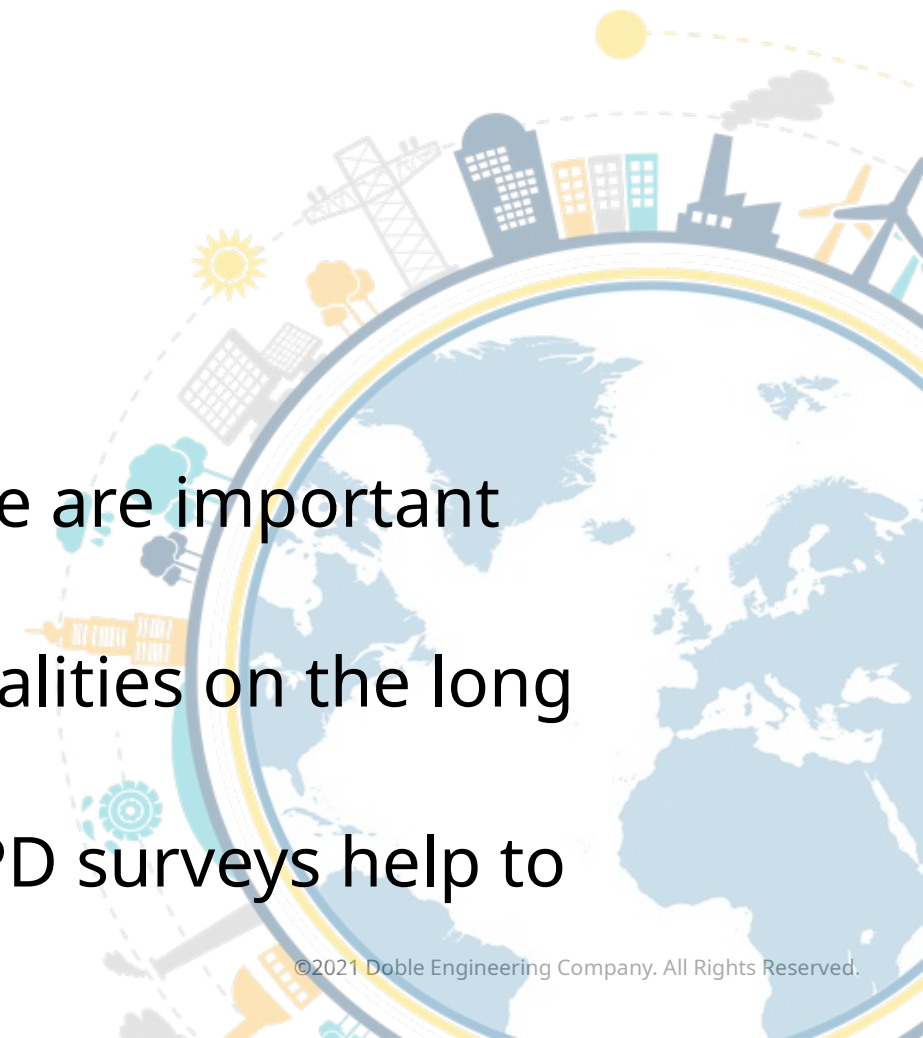
Additional heating from power electronic harmonics

Inadequate cooling

A strong asset management tools during lifecycle are important avoids major failures

Offline testing is always useful to detect abnormalities on the long term

In short terms, Online monitoring systems and PD surveys help to understand current condition of assets



Questions & Discussion

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