ABSTRACT

A comprehensive, detailed report covering European distribution grids [1] makes one thing very clear: huge improvements and investments are needed to renovate the continent's ageing electric grid. Tim Martin, sales director for MIDEL in Europe, Middle East and Africa, takes a look at the report and points to a clear role for ester transformer fluids in the upgrading of European grids.

KEYWORDS

ester, fluids, modernisation, retrofilling

The role of ester fluids in Europe's ageing grid infrastructure

European distribution grids will need investments of €375-425 billion until 2030, concludes a study [1] by Eurelectric, Monitor Deloitte and smart grid organisation E.DSO. Based on detailed empirical data from ten European countries, Connecting the Dots: distribution grid investment to power the energy transition suggests investments in distribution grids will

need to increase by 50-70 %, from 2020 to 2030, compared with the previous decade. That is equivalent to €34-39 billion a year.

The single biggest investment driver is modernisation of ageing infrastructure. The study found that a third of the EU's grids are already over 40 years old, a figure increasing to fifty percent by 2030.

Transformers, designed to step power up or down, are a critical component of any power grid. Upgrading or replacing these assets constitutes a key aspect of any grid modernisation investment programme.

Liquid filled distribution transformers are used in medium voltage (MV) and high voltage (HV) applications - historically using mineral oil as the dielectric insulating and heating media fluid. Liquid filled transformers are robust assets, with low load losses and long service lifetimes of around 35 years [2], making them a popular option for outdoor as well as indoor environments, compared with dry type, or air cooled, transformers, which require more maintenance. However, in our experience, there is a growing awareness of two critical flaws in the use of mineral oil as an insulating fluid – its potential flammability and its poor biodegradation characteristics in case of a major failure.

For any distribution network operator (DNO), or utility, transformer fleet upgrades can potentially be a costly undertaking, especially from a capital expenditure (Capex) perspective. Utilities will want to consider solutions that can safely

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extend asset life and optimise loading performance. Retrofilling transformers with natural or synthetic ester fluid to replace mineral oil is a perfect example of such a solution.

This practice of retrofilling provides several key benefits, including:

- Ester fluids have a higher fire point than mineral oil that virtually eliminates the possibility of a transformer fire.
- Being readily biodegradable, unlike mineral oil, ester fluids offer a high level of environmental protection.
- Ester liquids can allow higher operational temperature of a transformer due to their higher flash and fire points as well as different chemical structure which allows a longer lifetime of cellulose materials. This phenomenon can be found in IEC 60076-14 and IEEE C57.154. Based on that it is possible to run transformer at higher power rate and at the same time also run at higher operational temperature [3]. Synthetic ester fluid is more hygroscopic than mineral oils. It is capable of absorbing more moisture from the solid insulation system used within the transformer (without a reduction in its breakdown voltage). Doing so slows down moisture degradation of the winding paper and extends operational life.
- Retrofilling liquid filled transformers using an ester fluid is a straightforward process, usually being performed in-situ and with minimal transformer downtime.

Certain forward-looking utilities and transformer OEMs have already been pursuing ways to address the challenges echoed in *Connecting the Dots* report. A recent project undertaken by Scottish Power Energy Networks (SPEN) identified several capital expenditures (Capex) and operational expenditure (Opex) cost savings derived from the use of ester transformer fluids in its transformer fleet for 132 kV grid, 33 kV primary and 11 kV secondary assets [4]. Considerations in SPEN's cost-benefit analysis included capital cost, operation and maintenance cost, firewall necessity and fire suppression system necessity. They found that ester-filled transformers offer a significant unit cost saving, particularly for indoor applications where most saving originates from the exclusion of a firewall or fire suppression system.

SPEN found that average unit cost savings were found to be around £235,000 per indoor installation.

In another example, German transmission system operator TransnetBW tasked OEM Siemens with supplying a power transformer with two critical criteria; namely, the transformer was to be filled with natural ester fluid rather than mineral oil. In addition, the transformer had to demonstrate robust cold start capability. The use of a rapeseed ester fluid satisfied the local authority's mandate for the transformer materials to be locally sourced, the rapeseed being grown in central Europe. Importantly, the manufacturer independently acknowledged the superior cold weather performance of rapeseed ester fluid, with its pour point of -31 °C, over soya-based ester fluid that has a pour point of around -18 °C.

Dr Beatrix Natter, CEO of Siemens Energy Transmission commented on this project, saying *"The innovative cold start technology in this transformer demonstrates Siemens' expertise in combining industry leading innovations with eco-friendly solutions for the benefits of our customers and society"* [5].

Accommodating more capacity based on distributed sources of clean electricity, while ensuring networks can supply demand for recharging electric vehicles and for heating, inevitably requires investment in new physical infrastructure, including transformers. In densely populated cities and urban areas, where utilities may have to install transformers closer to where people live and work, ester transformer fluids, with their high fire point, clearly strengthen mandated fire safety protocols. In addition, the fluids' biodegradability means they can be used in transformers installed closer to waterways and other environmentally sensitive areas.

Increases in renewable energy generation, electrification of transport and electrification of heating and industrial activity are identified in the *Connecting the Dots* report as other key drivers for investment in European distribution grids to 2030. Ester fluids have a long and proven track record in offshore / onshore wind farms where fire safety and environmental credentials are paramount. Ester fluids' uptake in the world of solar power – in particular the growth we see in floating solar – is increasing at pace. The correlation is clear: ester filled transformers constitute a wise investment for balance of plant (BoP) electrical equipment at solar photovoltaic (PV) power plants and wind farms. BoP equipment is the critical link for delivering electricity generated by these renewable energy plants to the grid. Increasingly wind and solar plants are being built without subsidy, earning their income through electricity sales. Meanwhile, owners of these assets are also focused on reducing levelised cost of energy (LCOE) through reducing BoP equipment Capex and Opex. Ester fluid transformers can operate at higher temperatures, maximising the

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amount of power distributed and ensuring uptime of BoP equipment and helping to maximise the operator's return on investment.

The *Connecting the Dots* report sets out clearly, and in granular detail, the level of investment and work necessary in the near future for European distribution grid operators. There are complex challenges ahead, to be sure. However, by embracing proven technology such as ester transformer fluids in parallel with deploying smart grid processes and innovations, forward-looking operators and OEMs will survive, thrive and ultimately materially contribute to a pan-European landscape of greener, safer, more reliable and better performing power networks.

Bibliography

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Authors

Tim Martin is the EMEA Sales Director for MIDEL ester transformer fluids at M&I Materials. He has held various senior board level positions throughout his career in leading technology providers in both publicly listed Fortune 500 corporations and SME entities in the UK, Middle East and Asia Pacific region.

He has experience of the latest technology developments in the global power and electrical transmission and distribution markets and is regarded as an expert in Ester Dielectric Fluids used within these systems. His passion for Corporate and Social Governance and the green economy is the driving force behind Tim's vision for all transformers to be green, safe and ultimately more efficient for operators and the environment.