EPSRC
Engineering and Physical Sciences Research Council

UNIVERSITY OF Southampton

The Tony Davies High Voltage Laboratory
2002 – 2012: Celebrating 10 Years of Success

Condition monitoring and prognostic indicators for network reliability

Justin Steele-Davies, Stelios Christou, Paul Lewin, Steve Swingler
University of Southampton, Southampton, UK

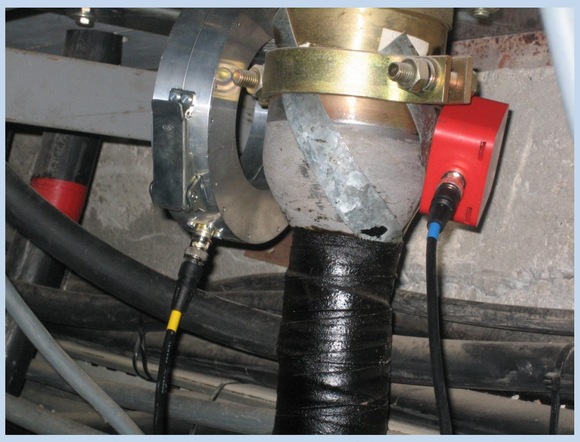
Abstract

Large-scale investment in transmission and distribution networks are planned over the next 10-15 years to meet future demand and changes in power generation. However, it is important that existing assets continue to operate reliably and their health maintained. A research project is considering the increased use of simulation models that could provide accurate prognostics, targeting maintenance and reduce in service failures. Such models could be further refined with parameters obtained from on-line measurements at the asset. It is also important to consider the future development of the research agenda for condition monitoring of power networks and with colleagues from National Grid, PPA Energy and the Universities of Manchester and Strathclyde, the research team are preparing a Position Paper on this subject.

Reliable measurements and prognostic models

Ensuring network reliability is a key driver behind condition monitoring, ideally being able to predict when an asset is likely to fail means that pre-emptive action can be taken. Obviously monitoring of assets on existing networks is already undertaken; here the research question is whether there is a subset of information that can be used within prognostic simulation models. Identifying this data is a key output of this project.

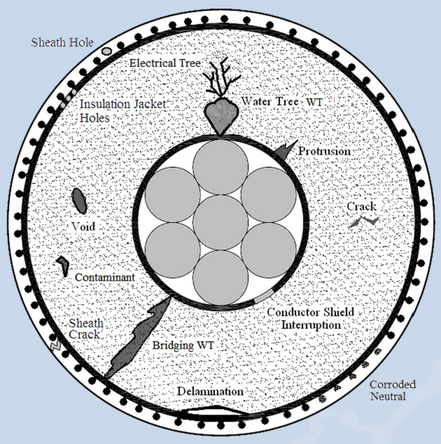
We have previously demonstrated a low cost solution for diagnosing leaks in oil filled cables [1]. By using existing measurements from a commercially available monitoring system, a model was developed that could identify the onset of an oil leak within the circuit. As well as using available data, this project will also consider the need for additional local measurements such as local ambient conditions or soil moisture content (for buried assets).



Monitoring of 11KV cable joint , courtesy of the University of Cyprus

Mechanisms of Cable Failure

Manufacturing Imperfections: Tend to increase the local stress leading to either initial failure or higher rates of aging.
Poor Workmanship: Damage caused during installation could increase the local stress leading to either early failure or higher rates of aging.
Overheating: Tends to accelerate thermal ageing of the dielectric. The impact can be restricted to short lengths (local) if the adverse thermal environment is localized.
Mechanical: Tends to lead to mechanical failure reducing the dielectric strength. The impact can be restricted to short lengths if the mechanical stress is localized.
Water Ingress: Tends to reduce the dielectric strength and increase the local stress. [2]

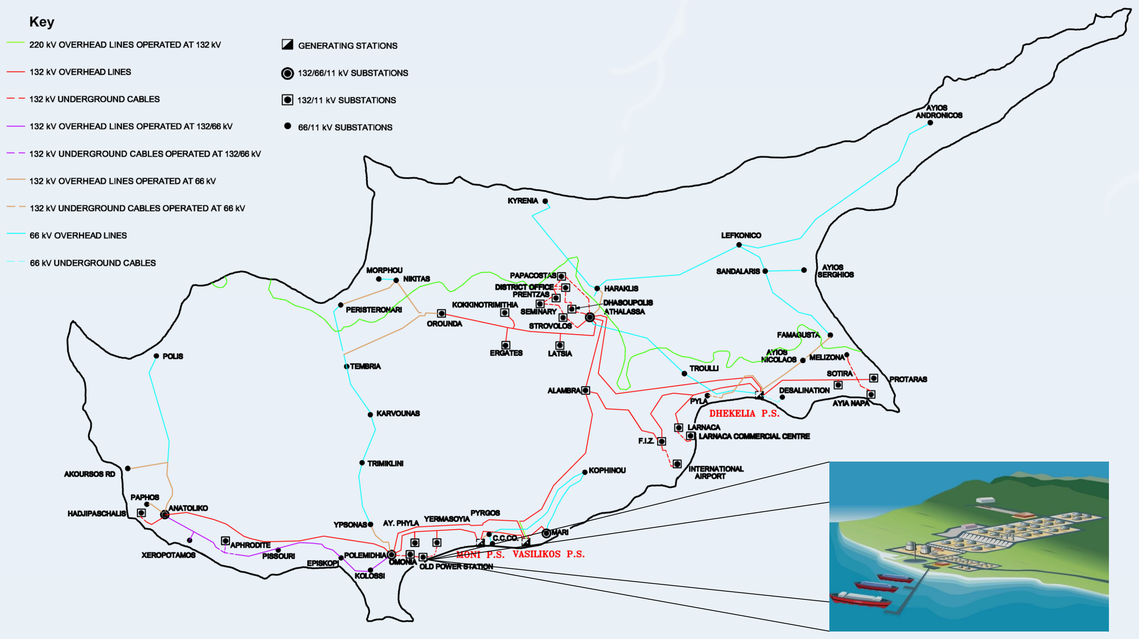


Cable cross-section [2]

A Network for Feasibility Studies

Cyprus represents an ideal system to study as it is an islanded network that sees heavy demand during the tourist season as well as being far smaller and less complex in design compared to UK distribution networks.

In addition, the Cyprus network operates at the same voltage levels as the UK and is similar in basic design. By collaborating with EAC it will be possible to rapidly assess the feasibility of providing additional local measurement data for prognostic modelling, before extending the research into UK networks.



Cyprus Network Map, image courtesy of EAC

Future Research Road Map for Condition Monitoring

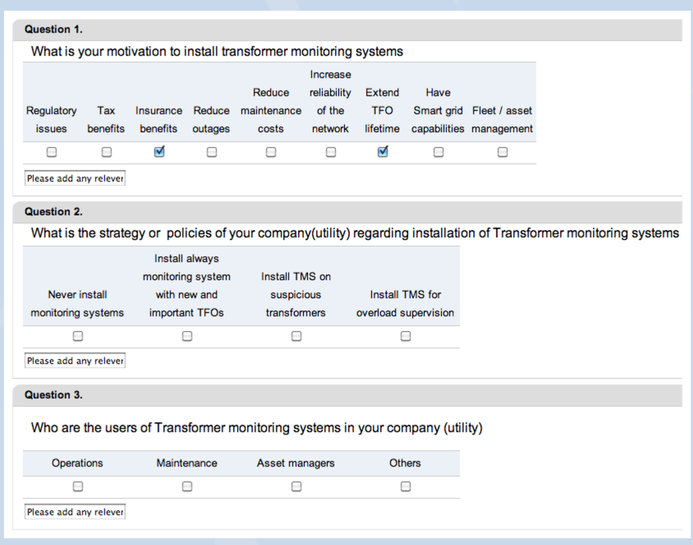
While there are many possible ways to measure the parameters of asset health in the laboratory and in field tests, these are often not practical for deployment throughout the network. This could be due to cost, reliability, quantity of data, the need for regular human interaction or measurement only being possible in an off line state. However, in the future improved measures are needed to monitor the overall health of the network than currently exist. Identifying which areas of network condition monitoring need to be further developed is one of the activities of the EPSRC's HubNet project. The outputs from this activity will inform policy and guide the strategic research agenda in this area with the aim of delivering new technologies to the sector.

Experts opinions count

Anecdotal evidence suggests that many of the existing condition monitoring systems are not being fully utilised. For example, data may not be analysed or arrives too late, or in some cases if the monitoring equipment fails it is not repaired or although installed it is not turned on. This could be an indication of many possible causes, including the perceived value of condition monitoring or loss of local expertise originally responsible for installation and operation.

Therefore it is important to survey asset managers, researchers and engineers to find out not only what is required for effective condition monitoring and where the greatest value can be achieved but also their attitudes and opinions on the subject. The results from this survey and consultation will be widely reported.

If you are an expert with something to contribute to the research roadmap for condition monitoring of network assets please feel free to contact us with your views



Question 1.
What is your motivation to install transformer monitoring systems

Regulatory issues	Tax benefits	Insurance benefits	Reduce outages	Reduce maintenance costs	Increase reliability of the network	Extend TFO lifetime	Have Smart grid capabilities	Fleet / asset management
☐	☐	☑	☐	☐	☐	☑	☐	☐

Please add any relever

Question 2.
What is the strategy or policies of your company(utility) regarding installation of Transformer monitoring systems

Never install monitoring systems	Install always monitoring system with new and important TFOs	Install TMS on suspicious transformers	Install TMS for overload supervision
☐	☐	☐	☐

Please add any relever

Question 3.
Who are the users of Transformer monitoring systems in your company (utility)

Operations	Maintenance	Asset managers	Others
☐	☐	☐	☐

Please add any relever

Image courtesy of Tony Davies High Voltage Laboratory

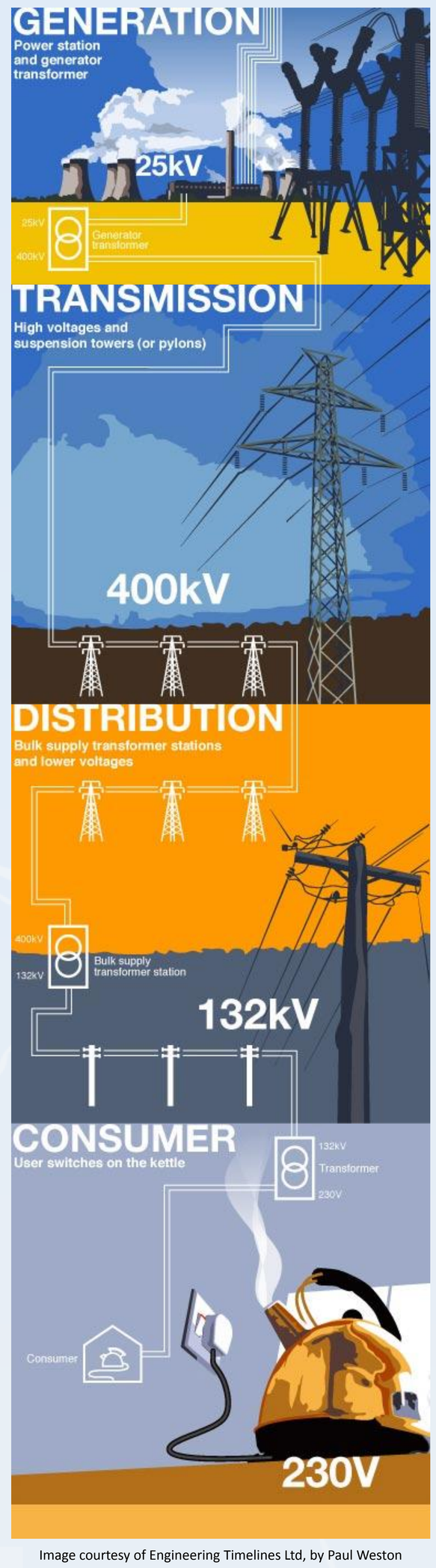


Image courtesy of Engineering Timelines Ltd, by Paul Weston

Monitoring the power network

Assets in the power network cover a very large range of scale and value, from generation transformers at power stations and towers for overhead lines to low voltage distribution cables. While the cost of condition monitoring at transmission levels represents a fraction of the asset value this is often not the case at distribution levels. The question being asked is, what really needs to be measured and how little data is required? The idea of making far greater use of simulation models that, for example, predict likely behaviour and then look for anomalies in future measurement data has not been tested but offers the possibility of providing a useful prognostic tool for all levels of the network.

Conclusions

The development of a system that will allow targeted use of resources for repair and replacement of network assets, whilst reducing the number of in-service failures per customer KWh will provide business benefits both in terms of reducing capital expenditure but also increased customers confidence. The area of condition monitoring is rapidly developing and additional benefits of this research are that not only will the feasibility of a 'model more measure less' approach be investigated but the power industry will be widely consulted about the future directions of UK research in this area.

Contact details : j.steele-davies@soton.ac.uk, sc10g09@ecs.soton.ac.uk
University of Southampton, Highfield, Southampton, SO17 1BJ, UK

References

[1] Hao L. , Lewin P.L. , Swingler S.G. , Bradley C. , " Leak detection for self-contained fluid-filled cables using regression analysis ", Electrical Insulation (ISEI), Conference Record of the 2010 IEEE International Symposium , 6-9 June 2010
[2] Hartlein R., et al., NEETRAC Miroslav Begovic, School of ECE, Georgia Institute of Techology J. C. Hernández Mejia, Universidad de Los Andes, Merida, Venezuela , *DOE Award No. DE-FC02-04CH11237 , (NEETRAC Project Numbers: 04-211 / 04-212 / 09-166) ,pp. 41-42, Publ. 2011*