**Project Title:** 'Optical Detection of the Degradation of Transformer Oil'
**Principle Investigator:** Dr J Spencer (University of Liverpool)
**Project duration:** 01/11/08 – 31/08/09
**Grant Value:** £74,121

Transformers are components in electrical networks which change voltages from one level to another. This allows for efficient transmission of the electricity from where it is generated to where it's needed (e.g. home, business, factory etc). However they fail from time to time resulting in a loss of power to the home and in rare cases have resulted in the death of those who maintain them. One of the main reasons these transformers fail is because the oil that serves to both cool and insulate them can lose its effectiveness over time.

This research will explore a cost effective optical technique to look for changes in the oil that might indicate it is losing its effectiveness with a view to scheduling its replacement during the next planned maintenance run. The traditional method for checking transformer oil is to draw a sample and have it chemically analysed, use of an optical technique would save both time and money compared to this method.

The proposed technique uses a number of photo detectors, which are light sensors, combined with an information extraction process known as chromaticity. Chromaticity is a process which involves looking at the lightness, brightness and hue of colour, in simple terms it does this to identify the colour of the oil. The project involved analyzing a number of different samples of oil taken from operational transformers to create benchmarks showing which colours represent each state for oil (new, aged etc) and which future samples can be compared to. Creating these benchmarks involved carrying out a chemical analysis of each sample in order to establish which colour output from the chromaticity process represents each state of oil.

A prototype of the system was created for the project which included a white light source, 3 light sensors, with the output being processed with a chromactic algorithm. The results from the tests using this prototype indicated a distinction between the different oil samples which could be used at a very basic level to indicate oil ageing. At a more advanced level, the results indicated that from the limited number of oil samples there was sufficient resolution to begin to identify possible contaminants. The light sensors were then replaced with a mobile phone camera and further tests carried out, these showed it is possible to distinguish new from aged oil but it could not discriminate between the lightly contaminated oils. Since then further work has been carried out to resolve this problem and the system produced is portable, robust and cost effective.

This project has led to a number of follow on projects for which further funding has been obtained, these include an extension to the original study for which ENW has provided a further £69,000 of funding. It has also led to a project investigating
This project has led to follow on work, for which £167 k has been obtained, in partnership with ENW Ltd and Ashridge Engineering Ltd which will focus on using these prototypes to identify contaminants in oil.

The original Joule Centre funded project was partnered with MHA IES and ENW, and led on to several follow on projects with further funding:

- The sample test carried out in the original project proved that optical analysis of transformer oils was feasible, so the project was extended to a larger scale study. ENW provided £69 000 of funding (IFI), and the study is currently ongoing. The technology is very promising and if it proves feasible would greatly increase the efficiency of ENW's operations (see ENW questionnaire).
- The non intrusive measurement approach from the optical analysis and collaborations formed during the Joule project led on to a project investigating an acoustic opto-electronic system (would need to confirm technical terms with Prof. Spencer!) for monitoring transformers. This project just starting with £185, 000 funding from ENW, and will have a 12 month timescale.
- Knowledge transfer project with the University of Liverpool and MHA IES, £96,000 ESPRC funding obtained.
- There is an additional project planned to develop a further application of the optical analysis method from the Joule Project, which is in its initial stages *(Darren Jones from ENW has not mentioned it to Prof. Spencer yet!)*, see ENW questionnaire.

JC funding: £74,121 Additional funding obtained: £330, 000