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Thermal Capacity of Distribution Transformers Affected By Impact of Low Carbon Technologies

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Introduction:

Low carbon technologies (LCTs), for example solar panels and electric vehicles, are being introduced to the UK Power Network at a rapid rate.

The introduction of many LCTs shifts electricity generation from the transmission network to the distribution network. Further, some LCTs add load at the residential level.

Shifting this additional, unforeseen load onto the distribution network (specifically onto transformers at that level), stresses the assets. Figures 2 and 3 show plots of how transformer loading can be affected by these phenomena.

In order to properly manage the lifetime of the assets, and to avoid unnecessary costs, better understanding of the thermal performance of transformers is desired – unexpected failures cost more money!

The work shown here is an experimental plan which intends to focus on effects on transformers at high temperatures (i.e. distinct from thermal aging).

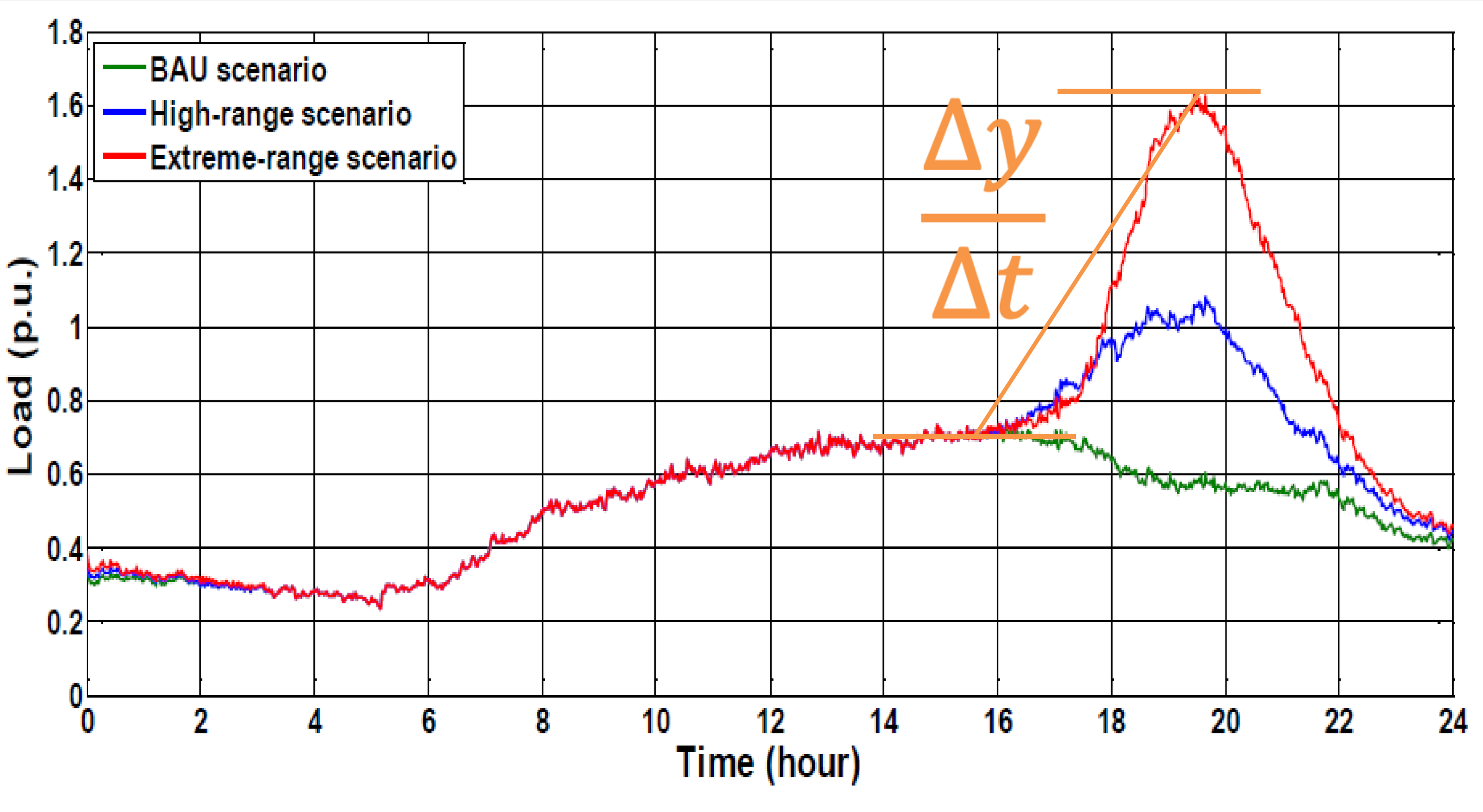

Figure 2 - Load profile showing potential variation in peak load due to electric vehicles [1]

Discussion

One of the main impacts of low carbon technologies on distribution transformers is the change in per unit (p.u.) load profile. The factor of main influence is the rate of change of the load profile.

Bubbling occurs only at high temperatures (for example, water will be liquid below 100°C, transformer rating is commonly designed as 98°C). However, operating at above 100°C is not the only factor to consider – a high rate of temperature change (caused by high rate of p.u. load increase) is also necessary. This is because there are relatively large forces for the gases to overcome in order for it to form a sufficiently large and stable bubble.

It can be seen from Figure 2 and Figure 3 that the load profile has indeed shifted in a manner that will exacerbate the rise time due to the introduction of low carbon technologies.

Figure 2 shows that (uncontrolled) electric vehicle charging leads to a higher peak usage value. Figure 3 indicates that solar output is high immediately before the peak, and drops significantly at the peak. This means that the midday values will be lower and peak values higher, increasing the Δy value, over the same time step.

[1] Adapted from Y. Gao, "Assessment of Future Adaptability of Distribution Transformer Population Under EV Scenarios," Faculty of Engineering and Physical Sciences, The University of Manchester, Manchester, 2016

[2] A. N. Espinosa, "Low Carbon Technologies in Low Voltage Distribution Networks: Probabilistic Assessment of Impacts and Solutions", Faculty of Engineering and Physical Sciences, The University of Manchester, Manchester, 2015

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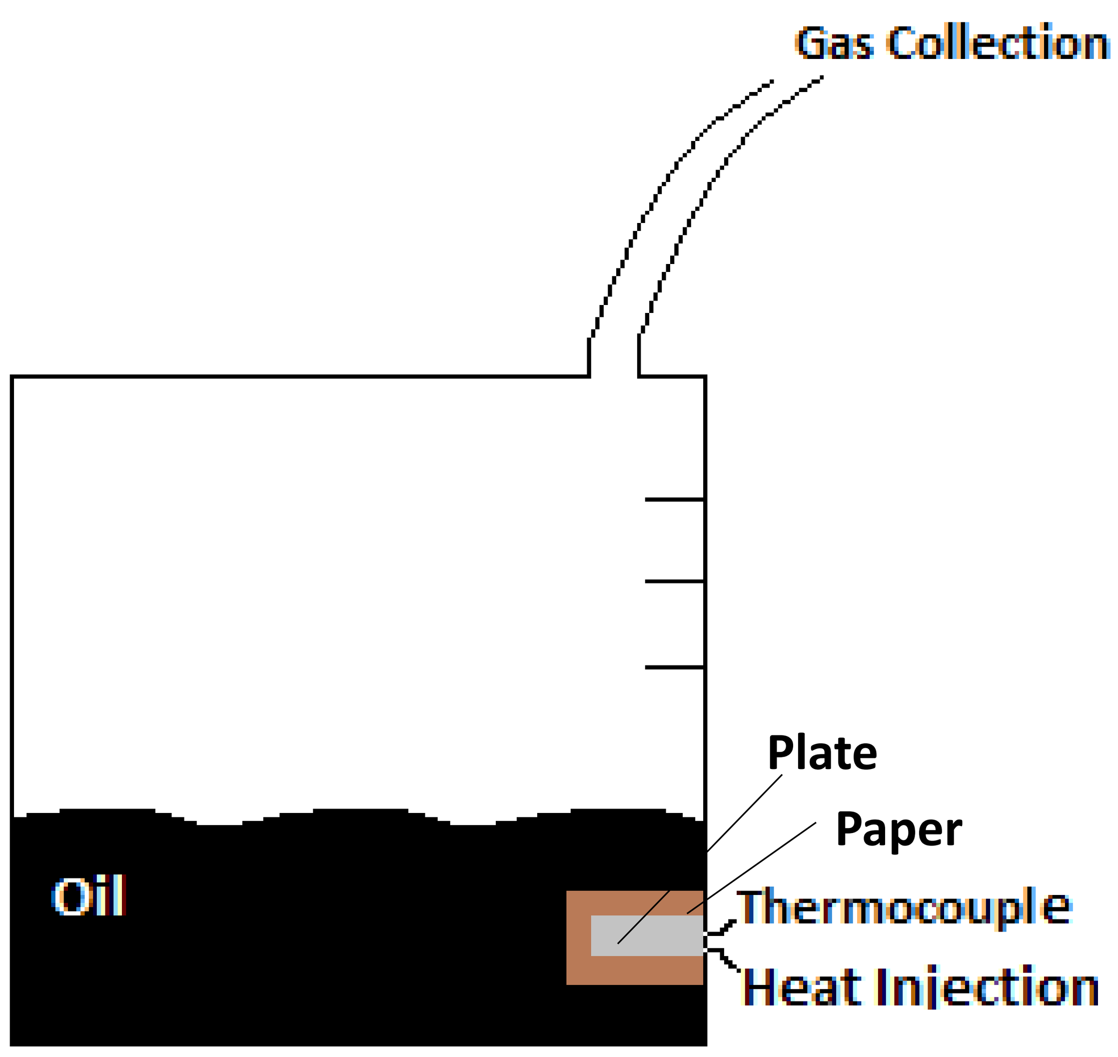

Figure 1 – Experimental Set Up

Experiment Methodology

The experimental set up is intended to be flexible, but at the same time to accurately replicate the situation found in an operational transformer.

The plate wrapped in paper / pressboard will be heated until a bubble is observed. The temperature at which this first occurs will be recorded.

Tests will be carried out for several variations, viz:

- Different age condition of paper / pressboard / oil
- Different relative position of the plate (to represent alternative hottest spot temperature location)
- Different rate of heat input (relating to change in p.u. load)

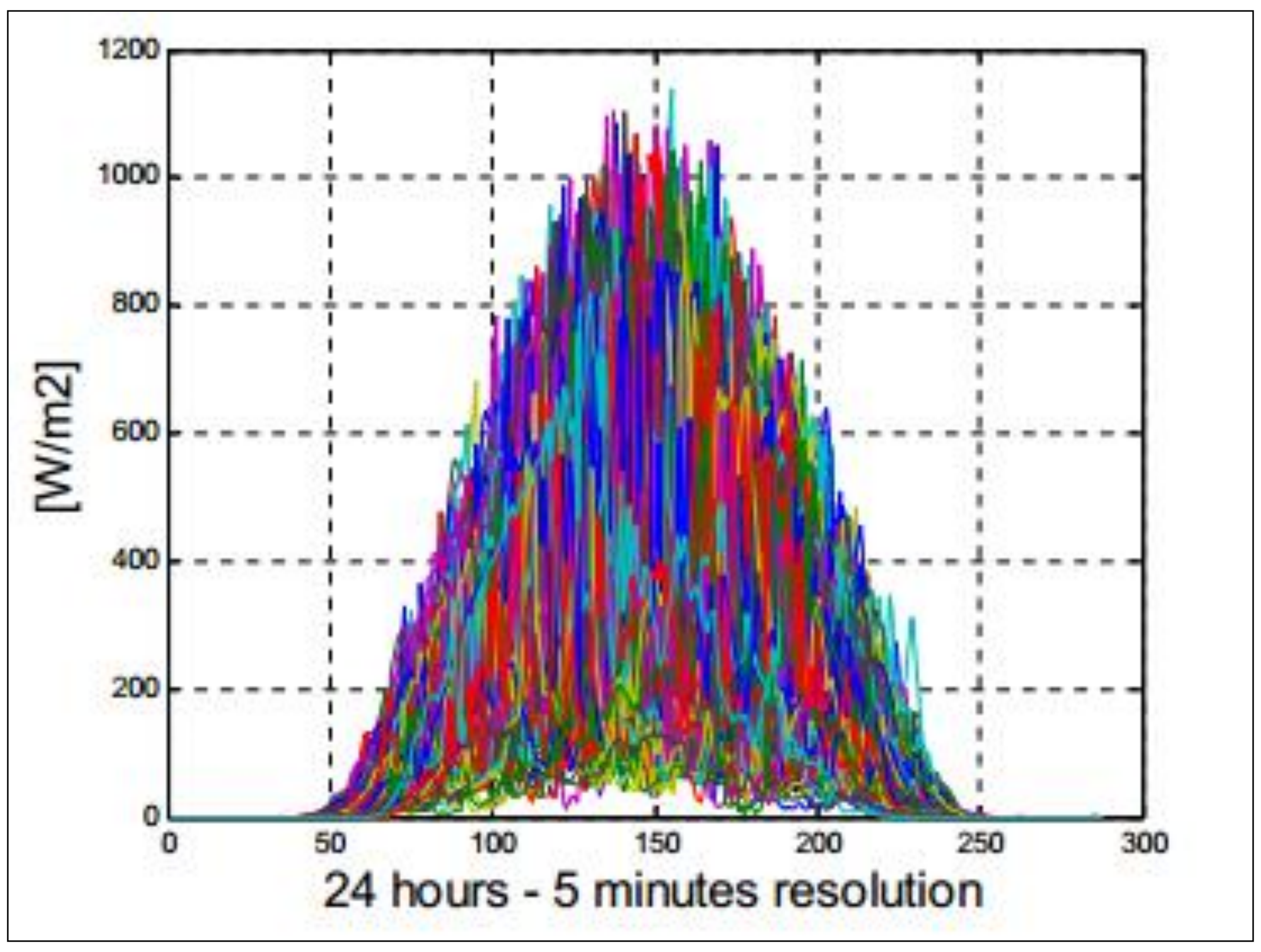

Figure 3 – Daily Solar Irradiance Profile (June 2012 – September 2012) [2]

Conclusions / Future Work:

Future work on this project is to carry out experiments with the aim of developing an understanding of the relationships between the variable conditions within a transformer than affect bubbling, and the temperature at which bubbling will then occur.

The *rate of energy input* is the most curious such variable condition in a network that is affected by low carbon technologies, as this can differ greatly from the changes witnessed in 'business as usual' scenario. Other conditions, such as relative paper age, are unlikely to be changed greatly from normal operation.