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Experience with electric vehicle loads and substation capability

As more EV's are introduced the power system charging loads will increase and public chargers will become more common. These public chargers can have a power rating of several hundred kW's, which is substantial compared to a distribution substation having a rating of a few hundred kVA. Given the low proportion of EV's currently in New Zealand, it would be uneconomic to reserve transformer capacity now, which is not be used until when mass EV take-up occurs and charging demand warrants it.

A better option could be to safely allow a transformer in an existing substation to operate higher than its rated load for short periods of the day, until community charging behaviour is well understood and planned for. The key benefit is to defer network augmentation costs by keeping existing assets in service for as long as feasible.

A transformer within the substation is given operational temperature limits. As the substation has N-1 redundancy, and/or backstopping contingency, how hot the remaining transformer will become during service is of interest. However, the volume of oil, and internal mass of a transformer, results in a large thermal inertia which will take many hours to heat up when loaded. As a typical EV charging cycle will be complete in an hour, the transformer temperature will not rise much due to its thermal inertia and will cool down soon after. Relying on this heating and cooling cycle while the daily number of EV charges is low warrants further investigation, to predict expenditure for substation upgrades undertaken in the future once the charging cyclic demand has reached a certain threshold.

The goal of this study was therefore to investigate, using a public EV charger in Whangārei, how different charging patterns will impact the life of two existing distribution transformers, by monitoring and simulating performance with thermal models. The residual life of transformer insulation is related to temperature and environmental factors. LV monitoring is used to dynamically track long-term ageing of insulation and use this to oversee when the transformers should be replaced. The IEC 60076/7 loading guide provides advice for normal cyclic, long-time, and short-time ratings.

It was found that network augmentation costs may be deferred using LV monitoring of transformer EV loading. And that by applying LV monitoring to network areas of differing EV population uptake opportunities, LV monitoring deployment could be targeted for analytical investment decisions without it being required across the entire network of distribution transformers.

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