EA15298 – LCT Harmonics Effects, Model Structure

Ground Mounted Substation/Urban Substation

There are two aspects worthy of investigation, the effect on the transformer and the effect along feeders of increased penetrations of Low Carbon Technologies. Within the LV feeders there are different ways of looking at the problem:

- What are the conditions required that will permit maximum connection of these technologies to a Low Voltage feeder?
- What will be the effects of increased penetrations of these technologies on the network parameters along the feeder?

The answers to the first question will inform what changes might be necessary to existing design policies to facilitate maximum connection of these technologies on new networks, whilst the second question is more concerned with addressing at what point connection of these technologies may require some mitigation or remedial action to either maintain conditions within limits or facilitate further connection.

To address both of these areas of concern it is proposed that the model for ground mounted substation 'urban' scenarios have up to 5 feeders with each LV feeder modelled to represent different design philosophies that have been applied over the life of the networks. In this way the effects of the total load on the transformer will be addressed and the conditions where individual network types may expect to reach limits with increased LCT penetration will also be established. To this end it would be useful if NGED could identify a range of network designs that reflect the kinds of LV networks which have been deployed in the 4 licence areas at various times in the last 80 years. Below are some suggestions of the kind of circuits that might be worth exploring.

- Feeder 1 – CNE Main 300sqmm – 240sqmm new development
- Feeder 2 – Tapered PILC
- Feeder 3 – Half Size Neutral PILC
- Feeder 4 – CNE Main 300sqmm – 240sqmm existing housing stock
- Feeder 5 – Overlaid CNE main picking up old main as branches.

Issues to consider in the modelling:
Heat pumps

Diversity of manufacturer in the heat pumps, existing private housing stock with retrofit probably a bit more random, although there may be some element of recommendations skewing this, existing housing association stock might be more likely to have the same unless this study shows that they need to be encouraged to mix it up

Effect of housing stock, existing housing stock will likely need larger capacity heat pumps due to reduced thermal efficiency, whereas new developments might be expected to have smaller capacity pumps, new developments might also be expected to have less/no diversity of manufacturer unless this study shows a need to encourage that.

Penetration rates and clustering

Penetration rates for new LCTs are to be determined based on variations in the Distribution Future Energy Scenarios.

Clustering could be set manually at the remote ends of the feeders which will likely give the worst results.

Plan is to carry out repeated studies with various 'random' deployments based on average penetration rates, the studies would flag where problems occurred and on which feeder(s) and under what conditions.

Transformer impedance and losses

Carry out comparative studies of a limited number of conditions to establish what effect the new transformer standard will have on losses and distortion.

Pole Mounted Substation/Rural Substation

For the Rural substation we need to consider the larger end of the capacity to see changes as the penetration increases, with small customer numbers the number of combinations will be too limited. For this analysis NGED have suggested the use of a specific example substation as the source for a model Springers Hill 161806.

Issues to consider

Larger and/or older houses might be typical of these types of network tending to require a larger capacity heat pump.

More affluent areas might be expected to see more rapid uptake of EVs etc. so perhaps consider this with the DFES assumptions used

In terms of the penetration rates and locations the planned method for study is as for the urban scenario above.

Common Issues

The initial model will be developed with a voltage harmonic source deployed at the network source to set the background levels.

Harmonic profiles for the various devices to be considered will be modelled as current source inputs based on the manufacturers' data. This can be anonymised within the model as manufacturer A, B C etc and either selected at random or a worst case considered. Load profiles will be set to reflect the normal operation of the technology for the random allocation studies but will have variations in profile available to explore the effect of supplier price signals which may drive customer behaviour to establish whether this may result in adverse effects on the distribution network.