Customer-Led Network Revolution

A Review of Engineering Recommendations P15, P17 and P27 (Transformers, Cables and Overhead Lines)

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Executive Summary

The findings from the Customer-Led Network Revolution (CLNR) project have provided us with the opportunity to review the contents of a number of Engineering Recommendations. In this report the analysis from Real Time Thermal Rating (RTTR) equipment for Transformers, Overhead Lines and Underground Cables is compared to the contents of Engineering Recommendations P15 (Transformers), P17 (Underground Cables) and P27 (Overhead Lines).

A key finding is that the approaches and rating values in P15, P17 and P27 are not conservative. Particularly for overhead lines, often RTTR equipment produced values below those specified in P27. Through further analysis of the load curve at the CLNR trial sites, we have shown that the probability of exceedance using the generic ratings given in the Engineering Recommendations is low, so long as the correct site specific parameters are selected. We have therefore identified no case to change the generic ratings in these Engineering Recommendations.

In P15, P17 and P27 there is currently no explicit coverage for the use of localised site specific data (e.g. wind and load profiles) to calculate bespoke ratings or for the application of RTTR. We recommend that a separate application guide covering the rating of all distribution network asset types is produced, to assist engineers in deriving safe yet economical bespoke ratings and in using RTTR systems within control schemes.

An area of consideration for updating DNO thermal rating policies is based around our findings that application of site specific parameters within thermal models can have a significant impact on the capacity of distribution network assets. This has led to the definition of three distinct approaches to assess the capacity of distribution network assets:

- **Update generic ratings:** to gather better data for off-line analysis to change the parameters used in thermal models to derive a new generic rating. We have identified no case to change the generic ratings or the approach to rating assessment in the three Engineering Recommendations.
- **Create bespoke ratings:** to use site specific parameters to derive a more accurate rating for specific sites. For overhead lines and transformers we have identified that 10-15% additional capacity can be released, however for cables, measurements at our cable sites have led to 10% de-rating due to high soil resistivity values.
- **Apply RTTR:** to deploy RTTR equipment to calculate a rating in near real-time for input into a control scheme. This has been shown to release substantial capacity for overhead lines and transformers but this can only be realised where it is coupled with powerflow management.

It is therefore recommended that the Engineering Recommendations (P15, P17 and P27) are updated in line with the bespoke ratings approach and consideration is given to the production of an application guide for RTTR schemes.

Contents

Glossary

The key terminology used in this document is defined as:

- **Generic rating:** a rating value taken or derived from Engineering Recommendations P15, P17 or P27.
- **Bespoke rating:** a rating value that has been derived by taking site specific measurements to ascertain a more accurate rating than a generic rating.
- **Calculated RTTR (Real Time Thermal Rating):** a rating value that has been derived as an output of RTTR equipment.
- **Excursion %:** the proportion of time the rating of an asset has been calculated as being below the generic rating, as advised by Engineering Recommendations or manufacturer data.
- **Exceedance %:** the proportion of time a rating has been calculated as being less than the real-time demand for a circuit (i.e. the asset may be operated outside of its capability).

1 Introduction

The learning from the Customer-Led Network Revolution (CLNR) project has been assessed against the contents of Engineering Recommendations (ER) P15 (Transformers), P17 (Underground Cables) and P27 (Overhead Lines) to provide recommendations to update these three documents.

The work on ratings within CLNR has allowed us to define three distinct practices which have the potential to release capacity on networks:

- **Update generic ratings:** to gather better data for off-line analysis to change the parameters used in thermal models to derive a new generic (static) rating;
- **Create bespoke ratings:** to use site specific parameters to derive a more accurate bespoke (static) rating for specific sites;
- **Apply RTTR:** to deploy RTTR equipment to calculate a rating in near real-time for input into a control scheme.

The document also discusses implications for DNO ratings policy.

2 Key Findings from CLNR

This section provides a summary of the key learning from the application of RTTR systems on transformers, cables and overhead lines within the CLNR project. More detailed information is provided in the RTTR Lessons Learned Report [1]and the *Optimal Solutions for Smarter Network Businesses*[2] report, both available in the online CLNR project library.

2.1 General

Exceedance

On analysis of the output of the monitoring devices deployed in CLNR, an overall (i.e. across all asset types) observation is that the calculated RTTR was lower than the generic ratings defined in ER P15, P17 and P27 for a material proportion of time (excursion). However, further analysis was conducted to understand the coincidence of the excursions with high demand. Using the load profiles of the CLNR test cell network areas and scaling the values to simulate a stressed network (e.g. setting the peak demand at the generic rating), it was shown that applying a rating consistent with current Engineering Recommendations would unlikely lead to exceedances i.e. demand was almost always lower than the calculated RTTR.

We have therefore identified no reason to recommend a change to the present generic ratings or the approach defined to establish ratings in any of the three Engineering Recommendations.

[1] CLNR-L164: Lessons learned report - Real Time Thermal Rating
[2] CLNR-L248: Optimal solutions for smarter network businesses

We did however identify that the calculated RTTR for assets at some sites was materially different from the generic rating (both higher and lower) which leads us towards the view that there is benefit in taking care to select the correct parameters as inputs into asset thermal models for a site as they can have a significant effect.

Thermal Models

The project has shown that use of the following standard thermal rating models is satisfactorily accurate:

- Overhead Lines: Cigré WG B2.43
- Transformers: IEC60076-7:2005
- Underground Cables: CRATER[3]

These models are sensitive to local environmental or topographical conditions (e.g. wind shelter, soil resistivity and ambient temperature) and therefore it is recommended to derive bespoke ratings, where necessary, by applying site specific parameters based on a study of the assets' local environment.

For transformers, real-time models measuring the load current (for example, using 30 minute current averages), tap position and cooling air temperature are adequate.

For overhead lines, wind speed is the most important variable. Our analysis shows that a fixed wind direction can be used in models, as this has a negligible effect at low wind speeds. This is discussed in more detail in the *OHL RTTR EHV and HV Trial Report*[4] available in the CLNR online library.

2.2 Overhead Lines

For overhead lines there are issues in being able to safely rely on an uplifted rating. RTTR equipment reliability and communications reliability are a key concern as applications of RTTR can be considered a safety critical system. Therefore a form of feeder overload protection would be required to apply RTTR as a Business as Usual tool.

For overhead lines, in line with many other reports on the benefits of RTTR, additional capacity of the range 10 - 40% above the generic ratings can be released for substantial periods. However, releasing this capacity without deploying a RTTR control scheme cannot be achieved without accepting that assets will be overloaded (exceedance) for a material proportion of time.

The additional capacity can only be released where powerflows can be controlled (e.g. through the application of Demand-Side Response, controlling embedded generation or Energy Storage) to mitigate exceedances. In this context, our research suggests that using RTTR equipment rather than generic ratings as a trigger can reduce the energy required to be delivered by DSR or Energy Storage by around 30%.

[3] CRATER, developed by EA Technology, is freely available to all GB DNOs.
[4] CLNR-L127: CLNR Trial Analysis - EHV and HV for Real Time Thermal Rating

2.3 Transformers

Similar benefits were found for RTTR for transformers compared to overhead lines, i.e. that 10 – 40% capacity can be released for substantial periods. The same argument applies: that releasing this capacity without a form of powerflow control would lead to a high risk of exceedance.

2.4 Cables

Our research suggests that RTTR is neither effective nor economic for underground cables as the insulation of the soil means that temperatures change very slowly and thus the calculated RTTR values were close to the bespoke ratings as derived by using CRATER.

Our application of RTTR for cables involved the installation of soil temperature and soil resistivity sensors with values updated near real-time to a rating calculation engine. In practice, the measurements varied little, which questions the benefit of continuous measurement. It is recommended that rather than applying RTTR, for a more detailed understanding of cable ratings, one-off soil analyses are conducted to provide site specific data that can be used in the CRATER model offline.

For our cable RTTR applications, sheath temperature measurements were consistent with the predictions by CRATER when site specific data was used in the model. The research has highlighted that cable ratings are sensitive to soil resistivity which, from site to site, varies considerably depending on the backfill and native soil surrounding the cable.

2.5 Comparison with the Engineering Recommendations

In the CLNR project we identified the following when we compared our results with the current Engineering Recommendations:

1. **Updating Generic Ratings:** through having a better understanding of the correlation between high demand and unfavourable weather/ambient conditions, we have identified that:
   a. P15 – the thermal models and the recommendations in P15 remain valid;
   b. P17 – the rating values have been verified as appropriate. At CLNR sites there was a case for de-rating cables by 10% based on high soil resistivity. This de-rating is in line with the correction factors given in P17;
   c. P27 – the rating values have been verified as appropriate.

2. **Creating Bespoke Ratings:** use of an offline thermal modelling tool and local data to calculate a bespoke rating:
   a. P15 – additional capacity of up to 15% can be obtained by using site specific data for load curves and ambient temperature. It may be possible to release capacity by removing the nominal 150% load limitation advised in P15 if the capability of ancillary components is not exceeded;
   b. P17 – no additional capacity release was identified for EHV and HV cables, up to 10% could be released for LV cables;

c. P27 – additional capacity release of up to 10% was identified, noting that sheltered sites may be marginally de-rated.

3. **Applying RTTR:** Use of RTTR equipment combined with powerflow management such as Demand-Side Response or Energy Storage:
    a. P15 – additional capacity of up to 40% can be obtained. Also reduces the energy required from DSR or Energy Storage by up to 30%;
    b. P17 – no additional benefit beyond that identified above;
    c. P27 – additional capacity of up to 40% can be obtained. Also reduces the energy required from DSR or Energy Storage by up to 30%.

3 Thermal Rating Policy Principles

This section sets out where the learning form the CLNR project can be used to feed into proposals to update policy for the thermal rating of transformers, overhead lines and underground cables.

The learning described above has highlighted that there can be significant benefit in deriving bespoke ratings for assets where generic ratings are below the required capacity.

It should be noted that the application of this learning is dependent upon a tool being developed that would allow a planning engineer to input site specific parameters, characteristics of the asset and the demand curve to generate, through inbuilt algorithms, a revised rating. It is recommended that further work is undertaken to develop these tools for the benefit of all GB DNOs.

Thermal modelling should be based on the following models with load curves and the key input parameters as described:

- Overhead Lines: CIGRE WG B2.43;
    - Wind speed profile
    - Ambient temperature
- Transformers: IEC60076-7;
    - Ambient temperature
    - Capability of ancillary equipment
    - Manufacturers design data or temperature rise test data
- Cables: CRATER;
    - Laying details: backfill, depth of burial, ducted sections etc.
    - Soil temperature
    - Soil resistivity
    - Proximity of and loading on adjacent cables

For the rating of transformers, lines and cables, the following broad approach is recommended:

- Use the generic ratings as defined by the relevant Engineering Recommendation, taking care to select the correct parameters as above. Where there is concern that load may exceed the rating, then;

- Analyse the load curve and gain a better understanding of the asset and local site conditions. The following principles would be followed:
    - Use of site information to make better assumptions (e.g. transformer housing linked to ambient temperature and topology of network);
    - Use of equipment to take temperature and load measurements;
    - Combine the load curve with load and temperature data.
- Using a set of modelling tools, perform a more detailed assessment to establish exceedance and define a bespoke static rating for the asset.

For underground cables, there is no benefit in measuring the cable surroundings in real-time, however, it is worth gaining knowledge of the soil types and backfill surrounding the cable to ensure models can make the most accurate estimates of the extra headroom which may be available.

For overhead lines and transformers, substantial benefits can be achieved by applying bespoke ratings based on better information. The sites that should be considered for this bespoke treatment are as follows:

- Where demand on assets is approaching capacity limits as defined by generic ratings;
- Where transformers are likely to have short term (less than two hours) demand in excess of their generic rating.

Where these sites are identified, a site specific evaluation should take place which would involve using a modelling tool with site specific data to create a bespoke rating.

RTTR (as an input into a control scheme) should be investigated as a method of reducing the operational cost of DSR where this is being considered.

4 Implications for P15, P17 and P27

This section sets out the implications on the Engineering Recommendations for rating of transformers, cables and overhead lines (P15, P17 and P27 respectively) resulting from the findings of the work on RTTR as part of the CLNR project.

The trials and analysis performed has provided us with learning that will assist in making improvements to generic ratings, the development of bespoke ratings and the development of RTTR in conjunction with a form of powerflow management.

4.1 Review of P17 – Cables

Engineering Recommendation P17 consists of three parts:

- Part 1: issued in 1976, provides distribution ratings and correction factors for a range of 11 kV cable types;
- Part 2: issued in 1976, provides distribution ratings and correction factors for solid type 33 kV cables;
- Part 3: issued in 2004, provides distribution ratings and correction factors for 11 kV and 33 kV cables having extruded insulation.

P17 provides a basis for estimating the ratings of cables for particular environmental and operational conditions, and gives tables of ratings for a stated set of conditions that have been selected as typical for distribution cables. Also, a set of correction factors are provided to allow adjustment where environmental conditions differ from those assumed in the guide.

Several of the following recommendations note areas where the underlying assumptions in P17 require review and may be optimistic for many sites.

4.1.1 Review of Standard Environmental Conditions

Based on the measurements taken during the CLNR project, the standard cable installation environmental conditions used in P17 were reviewed. For example, measurements for both soil thermal resistivity and soil ambient temperature significantly differ from the default values assumed in P17. Soil thermal resistivity and ambient temperature were measured over an extended period at the Rise Carr site in Darlington.

Soil Resistivity

Data collected during January and July 2014 are shown below in Figure 1 and Figure 2, respectively. Note: the graphs show data for soil conductivity, which is the reciprocal of soil resistivity. Soil thermal resistivity was measured to peak at around 1.5 m.K/W during January and 2.0 m.K/W during July.

In all three parts of P17, soil thermal resistivity of 0.9 m.K/W is used as a default value.

Based on the data collected during the CLNR project, the soil resistivity assumptions in P17 appear too optimistic. Adopting the resistivity values from the CLNR trial instead of the generic P17 value would de-rate cables by between 5 and 10%.

From our cable RTTR sites, our data suggests bespoke values of soil resistivity would be:

a) 1.5W/K-m for winter, which leads to a reduction in rating of around 10%; and
b) 2.0W/K-m for summer, which leads to a reduction in rating of around 16%.

Figure 1 and Figure 2 show plots of winter and summer soil temperature and soil conductivity. This shows that soil conductivity varies little over the course of a month, which has helped form our view that real-time continuous measurement offers no value.

Soil Temperature

In P17, default soil temperatures of 10°C and 15°C are suggested for winter and summer respectively. During the CLNR trials, peak temperature was measured at 8°C in January and 17°C in July for both sites. There may therefore be a case to increase the summer value.

This would be particularly relevant for networks dominated by generation or where peak demand is in summer. However, further work is required to assess whether the findings of the CLNR trials are representative for sites across Great Britain; it is unlikely that the small number of sites used within the CLNR project represent the true worst-case scenario.

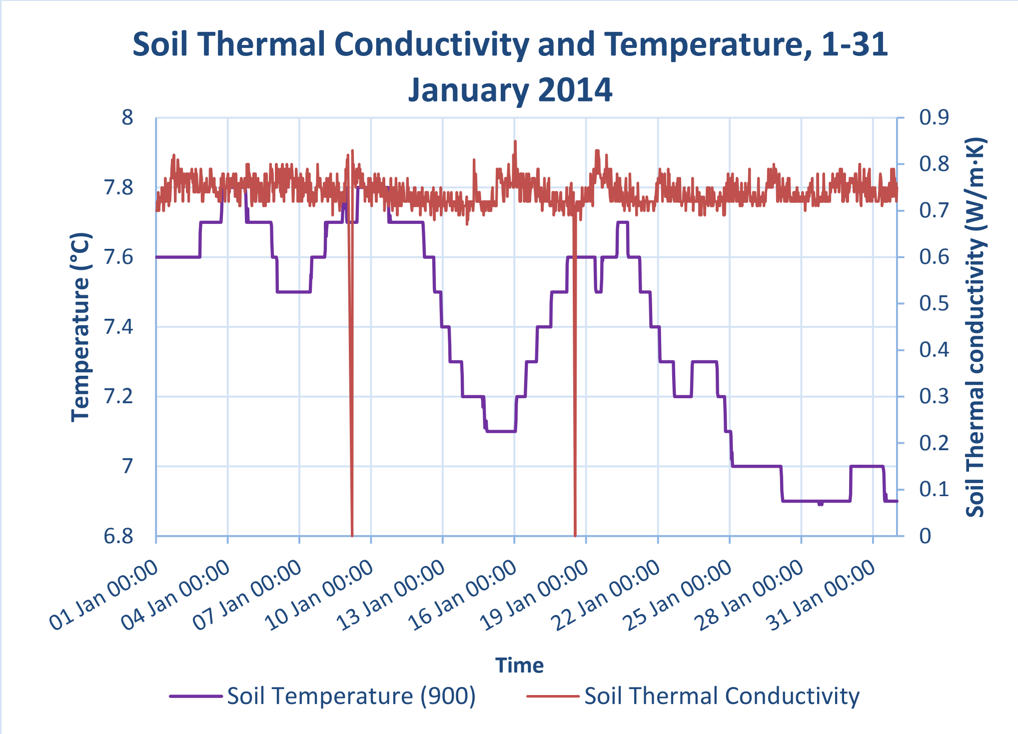

Figure 1: Measured Temperature and Soil Thermal Conductivity during January 2014 at the Darlington Site

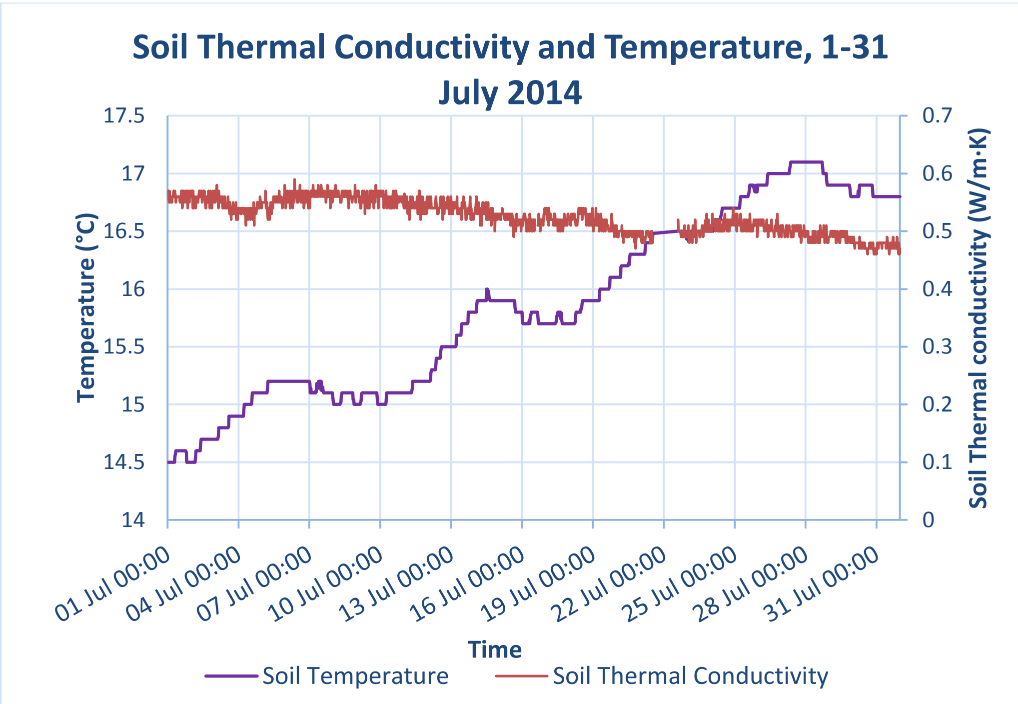

Figure 2: Measured Temperature and Soil Thermal Conductivity during July 2014 at the Darlington Site

4.2 Review of P27 – Overhead Lines

P27 gives the assumptions made for the derivation of ratings using a probabilistic approach. Given the short thermal time constants of overhead lines and the fast variation possible in environmental conditions, the tables in P27 are effectively intended as a pragmatic static rating, likely to be suitable for the majority of scenarios. Separate treatment is given for Single Circuit and Multi-circuit supply systems, reflecting the lower likelihood of high load on the latter.

4.2.1 Ratings in Sheltered Areas

Compared to data generated from overhead line RTTR equipment in CLNR, the ratings in P27 would appear to be optimistic for heavily sheltered areas. This is shown in Table 1, which gives the proportion of the calculated RTTR values which are below the P27 static ratings. It is shown that there is a wide variation between the sheltered and open sites. Although it is necessary to understand the correlation between periods of low RTTR values (i.e. below P27) and high demand to calculate risk of exceedance.

Wind speed data was analysed to understand the correlation between wind speed levels at open and sheltered sites in close proximity (within 10km). It was shown that there is a correlation but it is weak. Should data be available for an open site and it is desired to use it to rate a sheltered site, a value of only 10% of the wind speed can be assumed. This highlights the substantial effect of localised sheltering.

As an example, a wind speed of 5m/s at an open site would, with acceptable confidence, allow a wind speed of 0.5m/s to be assumed. For our data, this assumption is valid for sites up to 10km from each other.

4.2.2 Exceedance Levels

Table 1 indicates that if the lines used in the trial were operated at continuous (P27) rated load then the conductor temperature would exceed the design temperature between 4.2 and 19.6% of the time.

	Broxfield (Open)	*Whitehouse (Sheltered)*	*Eglingham (Open)*	*Scar Brae (Sheltered)*
Percentage of RTTR > P27 Static Rating	**95.8**	**80.9**	**94.0**	**80.4**
Percentage of RTTR < P27 Static Rating	**4.2**	**19.1**	**6.0**	**19.6**
Amount of complete data (%)	**76.9**	**86.1**	**86.7**	**86.9**

Table 1: Proportion of winter monitoring period where RTTRs exceed P27 static ratings

However, as the load curve is not continuous, this does not give an accurate representation of the risk of exceeding the design temperature of the line.

As part of the analysis, the winter peak load curve was scaled to assess whether the rating values could be increased without risk of exceedance. This was achieved by convolving the load profile of circuits with the RTTR data. This research accounts for any expected correlations between higher ratings and higher demand (e.g. lower temperatures can increase demand but also increase capacity). Figure 3 shows the resulting exceedance curve for the four HV (20kV) overhead line sites.

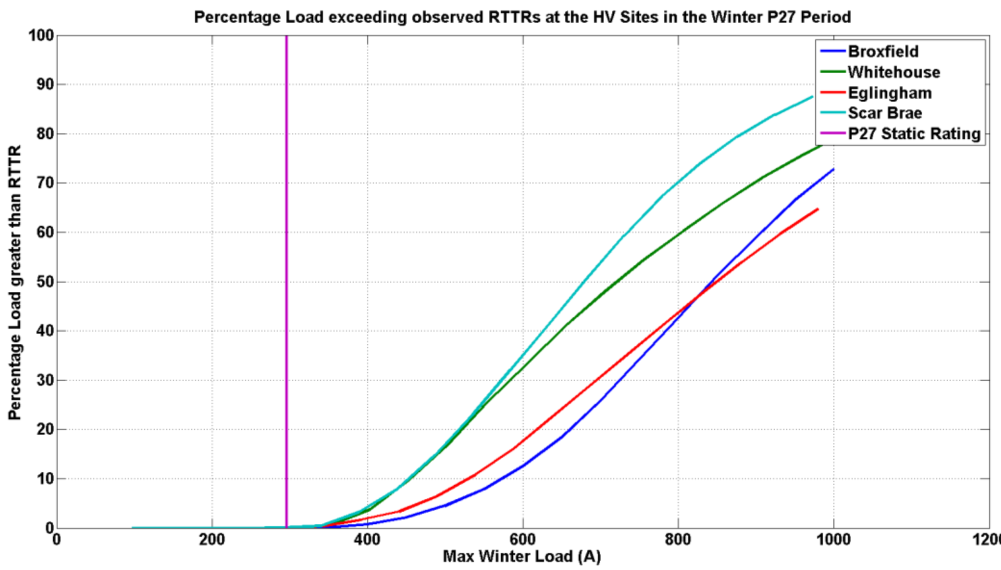

Figure 3: Exceedance curve: max winter load vs. calculated RTTR values

This analysis has revealed that compared to generic ratings in P27, RTTR values are often lower, however, on assessment of the typical load profiles on the CLNR test cell circuits, the risk of exceedance as shown in Figure 3 is negligible. We therefore have no reason to suggest the ratings in P27 are changed.

4.3 Review of P15 – Transformers

P15 references the thermal models of transformers in IEC 354 (now superseded by IEC 60076-7:2005), describes the thermal limits under which premature aging is unlikely to occur and provides limits for emergency ratings. Equations are provided to allow estimation of transformer winding temperature given a range of fixed parameters, ambient temperature and a load profile.

For transformers, the maximum rating we can apply changes according to the limiting factor chosen and upon the shape of the load curve. Given that lifetime is not a concern for the majority of transformers, particularly those supplying demand customers, ratings will be limited by the winding hot spot temperature. This is confirmed by the approach of ENA-TS 35-2, continuous emergency rated transformers. This is the specification against which the majority of primary transformers are bought. The ratings in that specification are set explicitly for a 140°C hot spot with no account for ageing.

Our research in CLNR suggests that, for typical load curves:

- applying a 130°C hot spot gives an uplift of 120-130% over nameplate (CMR/IEC60076-7); and
- applying a 140°C hot spot gives an uplift of 130-140% over nameplate.

These values are consistent with the 130% uplift of P15. As P15 presently refers only to transformers with primary-side voltages at 132kV or above, essentially those covered by ENA-TS 35-3, we recommend a future update to P15 extends the scope to at least ENA-TS 35-2 (transformers with a primary-side voltage at 66 or 33 kV) and preferably to ENA-TS 35-1 (distribution transformers).

Our research also shows that, for the unusual load curve supplied by our Sidgate Lane distribution substation, an uplift of over 50% over nameplate was possible by the transformer. This confirms the importance of the load curve on asset rating.

To establish a bespoke rating, using the IEC model, requires parameters for the transformer. These may be obtained from manufacturers' data if available or a temperature rise test in accordance with IEC 60076-2 will reveal the key parameters of the unit. Given the thermal time constants involved, using half-hourly demand profiles is adequate. It should also be noted that an assessment of the rating of auxiliary equipment (for example tap changer, bushings and CTs) should be conducted before ascribing an enhanced rating to the transformer.

The CLNR trials observed that the majority of RTTR calculations for the transformers studied show capacity beyond the rating calculated in accordance with P15. This was for two primary transformers (66/22kV, 20/25MVA ON/OF and 33/11.5/6.4kV dual winding 15MVA) and a range of ground mount distribution transformers.

4.4 Engineering Recommendation for Real Time Thermal Rating of Assets

Across Engineering Recommendations P15, P17 and P27, as may be expected given the vintage, no coverage is given for the application of RTTR to feed into a control system. Given that any circuit will comprise of a number of assets, it is proposed that one Engineering Recommendation should be developed for the application of RTTR for all distribution asset types.

The following sections describe potential content for a RTTR Engineering Recommendation; it is not intended to be comprehensive and discusses only the areas which have been informed by the learning from the CLNR project.

4.4.1 Communications

The CLNR project deployed a number of communication methods, including GPRS, fixed line ADSL and microwave point-to-point links (SCADA BaU). As a high level summary, the performance of each is described:

- GPRS: unacceptable in terms of both 'outages' and latency;

- ADSL: reliable and fast backhaul system (Openreach) but the local communications equipment (DNO owned) has shown to have inadequate reliability. This is discussed further in the *GUS Lessons Learned*[5] report on the CLNR online library;
- Microwave: very reliable with low latency.

GPRS, usually being the cheaper option, is adequate to use to bring back measurement data that is not required in an operational timescale, as there are latency and data transmission issues. It is not suitable where a control scheme is using the real-time rating to make powerflow management decisions.

From analysis of the time constants and the rate of change of load, the RTTR refresh rate, and therefore minimum communications requirements can be specified. Noting that we do not propose to deploy RTTR for cables, the sampling rate requirements for overhead lines and transformers are:

- Overhead lines: 5 minutes;
- Transformers: 30 minutes.

With any RTTR scheme which is used for control purposes, an operator should have the ability to request a refresh at any time.

It is recommended that a RTTR Engineering Recommendation provides reliability requirements and sampling rates to feed into the design of communications systems.

4.4.2 RTTR Application on Underground Cables

Based on the CLNR RTTR results, we recommend that RTTR is not applied as no additional benefit is achieved above those of a bespoke rating.

4.4.3 Overhead Lines

Figure 4 and Figure 5 show the calculated RTTR values and the probability of excursion against P27 values of four HV overhead line sites for winter 2013/14. The former uses measured wind direction and the latter assumes a fixed wind direction of 12°. It can be seen for RTTR values below 350 A, there is little difference between the calculated values regardless of whether the wind direction was fixed or variable. This is due to reduction in sensitivity to wind direction at low wind speeds, leading to reduced RTTR values. It is also noted that at low wind speeds, wind direction varies rapidly.

The measured wind direction has been observed to be highly variable between sites within relatively short distances due to sheltering. Figure 6 and Figure 7 show the frequency and direction of wind speeds measured at two different sites within 5km of each other. The topography and local sheltering of the sites has a significant impact on the wind direction, therefore it is unlikely that wind speed or direction will be consistent along an overhead line.

[5] CLNR-L167: Lessons learned report - Grand Unified Scheme

It is recommended that wind direction is not measured for future RTTR schemes and a default value of 12° is used for future modelling and RTTR applications. This finding is described in the *CLNR Trial Analysis – RTTR for EHV, HV Overhead Lines* report.

It has also been shown that insolation (solar gain) has a negligible effect at times of high demand when the conductor temperature is higher. It is therefore recommended that insolation is not measured in RTTR applications.

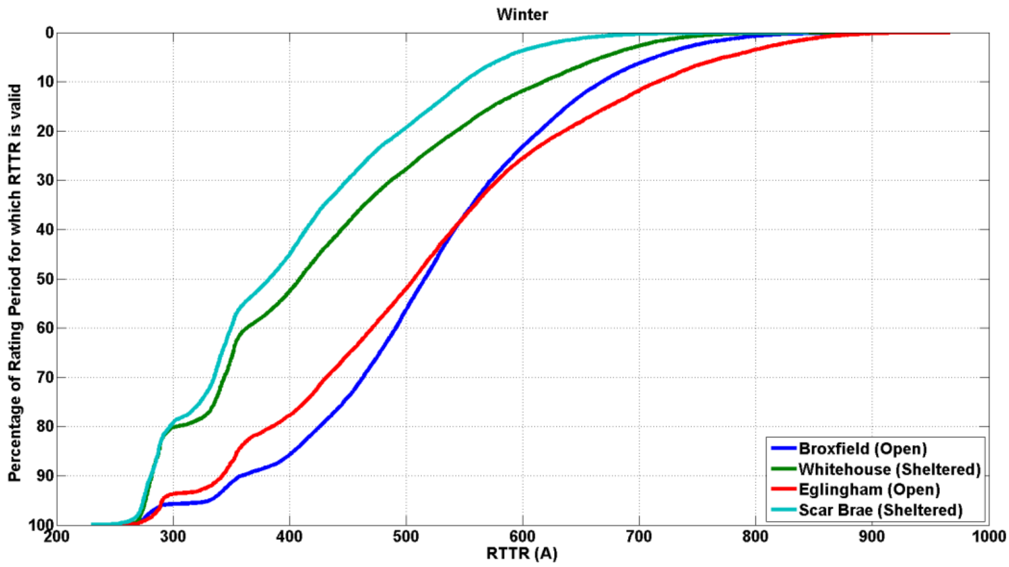

Figure 4: RTTR Cumulative Distribution Function for HV Sites, Winter 2014

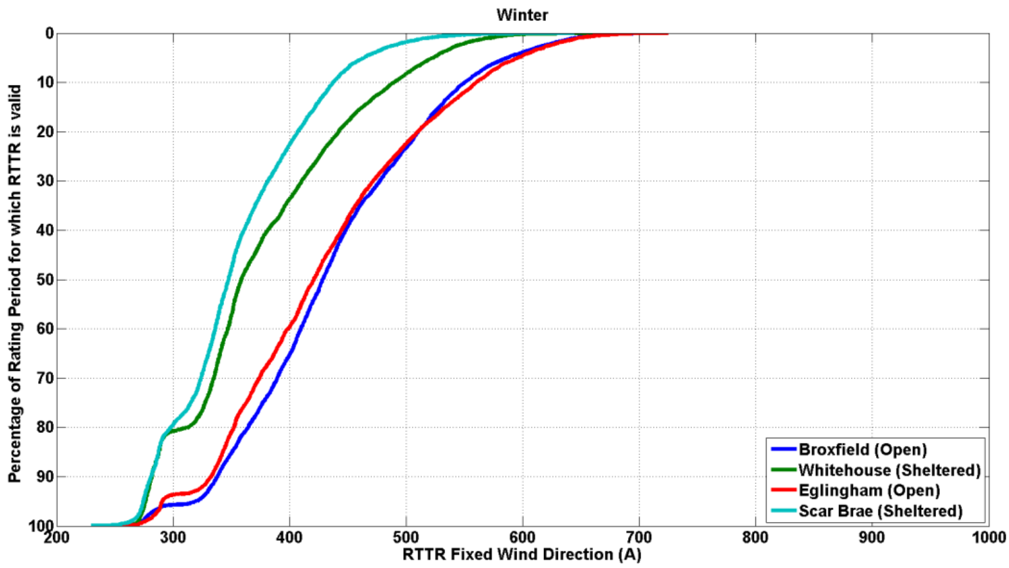

Figure 5: RTTR Cumulative Distribution Function - Assuming Fixed Wind Direction - for HV Sites, Winter 2014

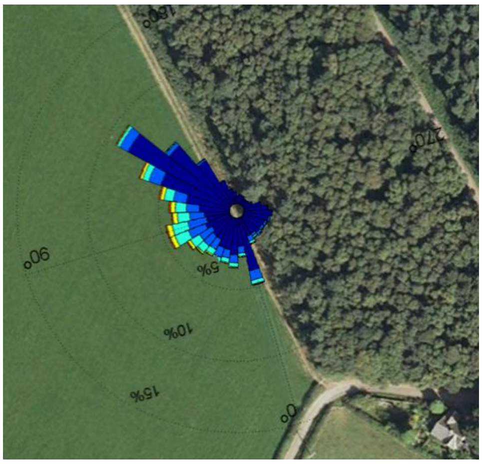

Figure 6: Wind Rose at Whitehouse HV Pole with satellite image (March 2012 – June 2014)

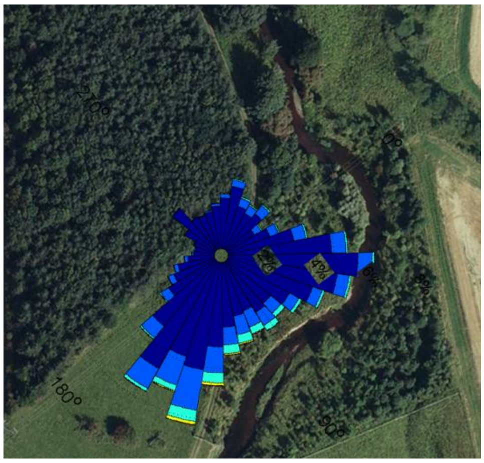

Figure 7: Wind Rose at Scar Brae HV Pole with satellite image (March 2012 – June 2014)

As shown in Table 1, the minimum rating is likely to occur at a shaded or sheltered location. This could change due to tree growth or construction of new buildings. It is recommended that an RTTR Engineering Recommendation includes a recommendation to check overhead line routes where RTTR is applied for tree growth and new construction (e.g. via inspections of local planning portals).

4.4.4 Transformers

An RTTR Engineering Recommendation should describe how RTTR for transformers can be used with active management schemes to allow more generation or load to connect without exceeding winding temperature limitations. For new transformers with primary winding at 33kV and above, the specification of a distributed temperature sensor close to the winding may be a prudent future-proofing measure to allow more accurate and less intrusive measurement of winding temperature for future RTTR applications. An RTTR Engineering Recommendation should also describe how these devices may be used to derive more accurate ratings.

Other loading constraints may apply to the transformer and it should be recommended that they are investigated during the design phase of an RTTR system to ensure voltage and thermal limits of all the transformer components including the tap changer, bushings and CT are not breached.

4.5 Recommendations

Recommendations for updates to Engineering Recommendations P15, P17 and P27 are made in light of the findings from RTTR trials under the CLNR project. In addition, recommendations are given for the content for a new Engineering Recommendation for the application of RTTR across all assets.

The main recommendations are:

Underground Cables (P17):

1.1. That P17 recommends the use of a standard model (perhaps based on CRATER which is available to all GB DNOs) for calculating bespoke ratings.

Overhead Lines (P27):

2.1. That a standard model be developed such that it can be used to calculate bespoke ratings, P27 would be updated to describe the approach;

2.2. That a fixed wind direction of 12° and zero insolation is assumed, so only wind speed need be measured. This may be taken from a remote site, however, the data should be from a site within 10km with values reduced to 10% to reflect the effects of sheltering.

2.3. That critical spans of uprated overhead lines are identified and then routinely monitored for changes in shelter from the wind.

Transformers (P15):

3.1. That P15 is extended in scope to include EHV/HV and HV/LV transformers.

3.2. That on-site tests in accordance with IEC60076-2:2005 be carried out to establish transformer specific parameters in P15 to reflect their variation according to size and design of the transformer, unless equivalent data is available from manufacturers

3.3. That only load current, tap position and cooling air temperature need be measured to derive a satisfactorily accurate estimated winding temperature.

RTTR:

4.1. Develop an Engineering Recommendation for the application of RTTR systems.

Customer-Led Network Revolution

For enquires about the project
contact info@networkrevolution.co.uk
www.networkrevolution.co.uk