Energy Networks Innovation Process

Project Closedown Report Document

The voice of the networks

Date of Submission: 12/06/2024

Project Closedown Report Document

Notes on Completion: Please refer to the NIA Governance Document to assist in the completion of this form. Please use the default font (Calibri font size 10) in your submission. Please ensure all content is contained within the boundaries of the text areas.

Project Title (*This cannot be changed once registered*)
Net Zero Service Termination Project

Project Reference
NIA_SSEN_0055

Funding Licensee(s)

1. Electricity North West Ltd
2. Northern Powergrid (Northeast) Limited
3. Northern Powergrid (Yorkshire) plc
4. Scottish Hydro Electric Power Distribution plc
5. SP Distribution Plc
6. SP Manweb plc
7. London Power Networks plc
8. South Eastern Power Networks plc
9. Eastern Power Networks plc
10. Western Power Distribution (East Midlands) plc
11. Western Power Distribution (West Midlands) plc
12. Western Power Distribution (South West) plc
13. Western Power Distribution (South Wales) plc

Project Start Date
August 2021

Project Duration
25 Months

Year
2023

Nominated Project Contact(s)
Tim Sammon, Innovation Programme Delivery Manager at SSEN

1. Scope

The ENA LCT Working Group has identified a range of cut-out and service cable types, as well as a range of installation scenarios which will be tested and analysed by the project. The outputs from the project will provide important learning for other projects which are looking at how DNOs can accommodate a very high number of connection applications anticipated to transition to Net Zero. One such project which will benefit from this learning is the SPEN iDentify NIA project which is looking at the potential to digitise the process for applying to a DNO when a customer wants to connect LCT devices to their property. The iDentify project, has a primary purpose of employing Artificial Intelligence to identify the make and model of cut-outs, including their ratings and other information relevant to DNOs and also LCT devices, i.e. domestic EV charge points and HPs to be installed. The learnings from this project could improve project iDentify's outputs.

2. Objective(s)

The learning from this project will help inform the DNOs and LCT installers of the suitability of cut-outs and service cable types for the connection of LCTs, thus avoiding such equipment from being overloaded and damaged. A comprehensive analysis of the de-rating of LCT connections on service termination equipment and service cables will create an understanding of these issues and allow a standard planning approach to be adopted on a nationwide basis. The resulting ratings could also be applied to DNO Business as Usual activities, such as allowing certain service positions to be operated under LCT loads or justifying the expense of upgrading cables and cut-outs to allow connection of LCT loads. The output from the project will be disseminated in the form of a database that will be publicly available. A custodian for this database will be identified as part of the project.

3. Success Criteria

The outputs of this project can be used as learning by DNOs, customers and LCT installers to establish the suitability of cut-outs and service cable types for the connection of LCTs, thus avoiding this equipment from being overloaded and damaged. Publication of a database with recommendations on any changes to network design criteria will be published alongside a closedown report.

4. Performance compared to the original project aims, objectives and success criteria

Details of how the Project is investigating/solving the issue described in the NIA Project Registration Pro-forma. Details of how the Project is performing/performed relative to its aims, objectives and success criteria.

This project has met all aspects of the project aims which were as follows.

- Ability of existing service terminations to support the additional loads produced by LCT technologies.
- Ability of existing service cables to withstand loads produced by LCT technologies.
- Ability of cut-outs installed in customers properties and street furniture, which can be located in confined spaces subject to solar radiation, to withstand increased loads produced by these technologies,

But it has become clear that a second project is required to further investigate its outcomes.

5. Required modifications to the planned approach during the course of the project

The Network Licensee should state any changes to its planned methodology and describe why the planned approach proved to be inappropriate. Please confirm if no changes were required

It was concluded during the 11/01/23 meeting that the following two cable types should be removed from the test schedule for the associated reasons.
• 0.0225in copper PILC cable – Specimen provided for testing was of the incorrect type, and too large for direct termination within the domestic service cut-out types being tested; Actual samples of 0.0225in copper PILC cable would be nigh on impossible to source. Also, it is common for 0.0225in copper PILC cables to be terminated by alternative means when identified in service.
• LSOH cables – This form of cable is predominantly utilised in industrial/commercial/high-rise applications and is therefore not relevant to the scope of work.

6. Lessons learnt for future projects

Describe how the project (methodology, stakeholder engagement etc.) changed, or provided opportunities, from your expectation at the start of the project and therefore could be useful for a future project. In addition, please discuss the effectiveness of the research development or demonstration undertaken.

The significant levels of calculated de-rating depend on the use of constant 600W/m2 as the level of insolation. This was determined via the stakeholder engagement sessions held during the project. Further work is recommended to assess the validity of this approach and the results:
1) Theoretical study to better model daily radiation levels and temporal distribution.

   a. Outdoor testing with temperature monitoring and radiative flux measurements.

   b. Site tests to measure temperature rise times, possibly utilising ‘MyElectricAvenue’ facilities.

   c. Wider site survey using temperature indicator strips to verify scale of issues found.

   d. Review original approval testing of meter enclosures for comparison with the test and results in this report.

e. Depending upon the results of the previous points, it may be appropriate to perform laboratory tests to compare the constant irradiation implemented with an improved model.

f. Depending upon the results of the previous points, revise the de-ratings found in this report.

2) Further testing to cover a wider range of equipment may be considered:

a. Check effects of outdoor meter colour enclosure (and possibility of shielding or reflective coating).

b. Investigate wider range of domestic and streetlight cut-outs.

c. Investigate the effects of and on tariff meters and switched-isolators that generated heat and were excluded from tests.

d. Comparative testing of other types of service cables including 4mm2 CNE.

e. Streetlight looped service tests.

f. Other ex-service cut-outs, as those tested performed less well than the new cut-outs., these ex-service cutouts were used due to the fact they are no longer in production.

g. Investigate possibility of overheating of PVC meter tail at cut-out.

3) Investigate effect of high short loads such as showers combined with the LCT effect.

4) Further analysis of A2803/CEP025 report results to identify and resolve anomalies and out-of-scope issues arising.

5) Determine if any smart tariff meters measure their own temperature, possibly leading to survey of actual installations; or ongoing monitoring of temperatures; or inclusion in future requirement specifications.

6) Address the points raised in Conclusion C12 of Final report 'ENA CEP026 NET ZERO Termination Project - Final Report 2023'

7. The outcomes of the project

When available, comprehensive details of the Project's outcomes are to be reported. Where quantitative data is available to describe these outcomes it should be included in the report. Wherever possible, the performance improvement attributable to the Project should be described. If the TRL of the Method has changed as a result of the Project this should be reported. The Network Licensee should highlight any opportunities for future Projects to develop learning further.

Test rigs were constructed to test: domestic type cut-outs in various mock enclosures; streetlight type cut-outs in a mock galvanised steel streetlight; singles/looped service-cable specimens in mock domestic enclosures with internal (wall cavity) and externally mounted hockey sticks. For comparison a clipped-direct service cable installation test rig was constructed to test a single service-cable specimen. Solar gain was simulated on the rigs using a simulated solar radiation source with an intensity of 600W/m2.
Limit temperatures were taken from BS7657:2022: 90°C for Cross linked polyethylene (XLPE)and 70°C for poly vinyl chloride(PVC). PVC is used for the outer sheath of the XLPE cables.
The extent to which the different enclosure types affect the amount of de-rating required to prevent the permitted temperatures has been assessed:

1) In the case of domestic cut-outs:
   a. The de-rating required is higher for the higher current rated cut-outs (100A) than the lower rated cut-outs (60A/80A).
   b. An outdoor Glass reinforced plastic (GRP) meter cabinet enclosure, subject to solar radiation, required the greatest de-rating. Outdoors (non-solar) required the least demanding de-rating and the indoor enclosure lies between the two.
2) In the case of streetlight cut-outs:
   a. The analysis of all 4mm2 Separate Neutral & Earth (SNE) temperature data showed that none of the temperatures exceeded the BS7870-3.21:2011 maximum permissible temperature of 70°C, therefore, there was no requirement for de-rating.
   b. None of the cut-outs required de-rating when the enclosure was not subjected to simulated solar radiation.
   c. Most of cut-out types did not require de-rating even when the enclosure was subjected to simulated solar radiation. The two types of cut-out in table 13 in the final report 'ENA CEP026 NET ZERO Termination Project - Final Report 2023' that may warrant de-rating may require further investigation due to possible rogue behaviour of individual cutouts distorting the results. These are the Henley Type 5 and the Lucy Type 2.

Table 13 Summary of Streetlight Cut-out De-rating Factors Required For Enclosures Tested

De-rating Factors Required to Maintain Cut-out Component Part Temperatures Within BS7657:2022 Maximum Permissible Temperatures					
Streetlight Cut-out Type	Worst-case based on max cut-out final temps		Based on average cut-out final temps		Comments/Post-test Inspection Results
	Outdoor	Outdoor Solar	Outdoor	Outdoor Solar	
Henley Type 1 25A	100%	100%	100%	100%	Discolouration to terminal screws
Henley Type 2 25A	100%	100%	100%	100%	Discolouration around live termination
Henley Type 5 25A	100%	92%	100%	100%	Two Specimens ran approximately 10DegC hotter than the other three. Discolouration around live termination.
Lucy Type 1 25A	100%	100%	100%	100%	No visible degradation
Lucy Type 2 25A	100%	100%	100%	100%	No visible degradation. NOTE: During the outdoor solar test, one test specimen significantly exceed the permissible temperatures part way through the test but then cooled by the end of the test. See comments.
Lucy Type 5 25A	100%	100%	100%	100%	

d. In the case of the service-cables: (note that the ranges stated are the differences between the derating factors found for tests on combinations of solar/non solar, Combined Neutral & Earth (CNE)/SNE, external and internal hockey stick (HS) tube, and 25/35mm2 cables)
e. The cross-section of the copper neutral conductors was less than expected.
f. The most severe de-rating required was to 33%, of nominal (35A c.f. 105A), that is reduced by 67%. This was for 25mm2 CNE cable, single (not looped) service, external hockey stick with solar, based on the maximum temperature measured of the triple sets rather than the average. Based on average temperature {A}, the factor is 35%.
g. The de-rated (to) factors, average (and range) were: 25mm2 non-solar: 72% (66 to 78%); 35mm2 non-solar: 73% (66 to 81%); 25mm2 solar: 50% (35 to 64%); 35mm2 solar: 54% (35 to 65%). These are based on the temperature measurements averaged over the triple sets of thermocouples.
h. The single cable external conditions would be closest to the specified rating for cable in-conduit, clipped to wall; the calculated decreased ratings were down to around 72% to 79% of the specified level. This may be partly due to the extended loading time in these tests.
i. SNE cable performed better than CNE Cable by -1 to 11%.
j. External Hockey Stick (HS) cable performed better than internal (cavity) hockey stick by 2 to 12 % without solar; External HS performance was reduced compared to internal by 8 to 24% with solar irradiation.
k. Internal HS cable capacity was reduced by 7 to 10% by solar irradiation. External HS cable capacity was reduced by 22 to 37% by solar irradiation..
l. 35mm2 looped cables would not fit in the standard 39mm ID hockey stick, so a 50mm waste pipe was used. Two 25mm2 cables were a tight fit in the 39mm ID hockey stick, which may have produced better thermal conduction for the cable-generated heat. The other cables were not tight.

3) Solar gain was the factor that caused greatest derating of outdoor enclosures, to avoid cut-out component part temperatures exceeding the maximum permissible temperatures defined in BS7657:2022.
   a. The solar gain of the meter enclosures is heavily dependent upon the colour of the enclosure. Different de-rating factors may be appropriate depending upon enclosure colour.
   b. The degree of solar radiation depends on various factors, including latitude, weather, cloud cover, time of year, time of day, and the direction that the enclosure faces. Changes in ambient temperature and wind speed may also affect the temperature rise that takes place.
4) Solar radiation generally produced an increase in cut-out component parts of around 20- 25℃ in white outdoor GRP meter cabinets, and around 10-12℃ in streetlight enclosures, in addition to the heating caused by the electrical load.
5) The times to thermal stability (less than 1℃ change per hour) of the energised cut-outs in the various enclosures have been assessed. For domestic cut-out enclosures the time taken is typically 2 hours in free air; 4.5 hours in the indoor wooden cupboard, and 3 hours in the outdoor GRP meter cabinet. In the case of a streetlight cut-out mounted in a streetlight compartment, the time is around 1.5 hours. Considering LCT loads, these times are all within the plausible duration of an EV charge cycle. Cut-outs may reach the temperatures observed during the testing due to load current electrical heating during EV charging.
6) The solar gain heating thermal time constants have been assessed for each of the outdoor enclosure types. Solar heating will depend on factors including sunshine duration, the sun's azimuth relative horizontal position and elevation through the day, as well as any wind cooling.
   a. In the case of the streetlight, the time taken for the cut-out component parts to reach their final temperature as a result of solar gain is around 4 hours. A streetlight exposed to direct sunshine for more than a few hours is likely to reach maximum temperatures produced by solar gain. As streetlights will typically be tubular in shape, changes in the sun's angle of azimuth during the day will have minimal effect on the level of radiation received, so it is not unreasonable to expect extended periods of solar gain.
   b. The solar heating thermal time constant for the white outdoor GRP meter cabinet enclosure is significantly longer at around 10 hours, so real conditions may mitigate the derating factors found. This is important because outdoor enclosures exposed to solar radiation are potentially the worst-case scenario for domestic cut-out derating with LCT loads. Further work, including outdoor measurements in natural sunlight, would be required to quantify the degree of mitigation that might be expected. Limiting EV charging duration at certain times of the day may be another mitigating approach that could be adopted.

7) Tariff meters and switched-isolators in the domestic meter enclosures dissipated significant electrical power and may overheat themselves. In some instances, the meter and isolator dissipated more power and get hotter than the cut-out. The power dissipated by a switched-isolator may vary unpredictably with time: this may be due to fluctuations in contact resistance.

8. Data Access & Quality Details

A description of how any network or consumption data (anonymised where necessary) gathered in the course of the Project can be requested by interested parties. Please include a link to the publicly available data policy.

For information how to request data gathered in the course of this project, see Network Innovation Competition (NIC) and Network Innovation Allowance (NIA) Data Sharing Procedure at https://ssen-innovation.co.uk/innovation-strategy/.

9. Foreground IPR

A description of any foreground IPR that have been developed by the project and how this will be owned.

N/A

10. Planned implementation, recommendations or next steps

Please describe the next steps to implement this innovation project. What policies and standards need to be updated or created as part of this implementation.

A second project is required for more investigations into the findings of this one. The LCT working group have met to discuss this and decided that more information needs to be available to inform this work, including non-aggregated smart meter data.

11. Other comments

12. Standards Documents

Identify any industry standards that may require updating due to the outcomes or understanding developed from this innovation project. If no standards will need to be updated, please state - not applicable

BS7657:2022 is the standard to which this project relates to and may require updating from the results of this project.