HV Pilot

WP1 D1 Network Data Assessment Report

Version 1.0

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Prepared by:

Andrew Urquhart and Murray Thomson

CREST, Loughborough University

Prepared for:

David Penfold

National Grid Electricity Distribution

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1. Introduction

1.1 Project overview

The HV Pilot aims to identify the phases to which two-wire sections of HV overhead line are connected. This will enable more accurate power-flow modelling of the HV feeders and may ultimately lead to changes in the phase connections to minimise phase unbalance. Two techniques will be used. Smart meter voltage data will be used, building on the learning of the SMITN project. The other technique will use helicopter survey data to build a virtual model of the network to enable the connection of wires to be physically traced. These techniques will be developed and tested to determine accuracy and cost effectiveness compared to site inspections.

1.2 Document purpose

The purpose of this document is to summarise the review of information sources available to support the phase identification method using smart meters. The document also reviews information provided by NGED to assist in the selection of a sample area for the project research.

Several sources of monitoring data have been reviewed, as described in section 3, with the LV monitoring data appearing to be the most useful. Two innovation projects may also provide data that could be used for validation. There may be scope to use substations selected for these other projects within the HV Pilot analysis, which would be desirable as an opportunity to re-use existing practical knowledge of the feeder topology and to make the best use of the additional monitoring equipment.

1.3 Sample feeder selection process

NGED HV planning teams have identified a list of priority HV feeders with possible concern for phase unbalance. These are reviewed in section 4. Some of these are less suitable for use within the project due to either a low uptake of smart meters, or are not preferred as there are no substations with monitoring that can be used for validation of the phase identification results.

Most of the feeders identified as high priority are unusually long and section 4 compares these feeders with a more typical distribution of HV feeders. For the purposes of the HV Pilot project, it has been decided to include some of the long high-priority feeders, but to also includes feeders with a more typical topology and length.

The two project methods, one using smart meter data and the other using helicopter survey data, will both use the same sample feeders so that the results can be compared. It is therefore necessary to identify feeders where the data quality is appropriate for both methods. This document covers the data assessment from the perspective of smart meter data, and this will be combined with the results of the visual data assessment (WP1 D2) to arrive at a final proposal for the selected primary substations and HV feeders.

2. Network data

Data describing the topology of the HV network and the cable impedances associated with each feeder may be needed for the HV Pilot project.

The topology and layout data will likely be used to confirm the geographic routes of underground cables and overhead lines, and also to confirm which substations are connected. The associated cable types will indicate whether a three-phase cable or a two-wire cable are expected, although it is recognised that this data is not always fully correct.

This data is held in the NGED Electric Office GIS database, and it is understood that all other NGED geographic network data is derived from this Electric Office master reference.

Although it was initially expected that a bespoke extract of the Electric Office data would be needed for the HV Pilot project, it has been agreed that the project team will use the same data extracts that are routinely provided to HV planners. This ensures that the analysis will make use of the same data that planners would see, saves working time as these data extracts are already being created, and ensures that the content of the data will be appropriate to fully define the HV network topology.

3. Monitoring data

3.1 LV monitoring

NGED have installed LV monitoring at a number of distribution substations. This data can assist in phase identification as it provides a time-series voltage data for each of the three phases. The HV Pilot phase identification process will ideally not rely on substation monitoring data as this is not available for the majority of substations, but the data can be used where it is available. In the absence of this data, reference voltages will be identified from smart meters on each of the three phases and the substation monitoring data can be used to assess whether the algorithms to select these reference voltages have operated successfully.

LV monitoring data is available from instrumentation provided by three manufacturers. These devices report time-series data back to the NGED iHost repository, and data from selected devices is made available on the public portal for download. Some of the devices are excluded from this list, either due to problems with the data communications or errors in the configuration to identify where the devices have been installed.

The NGED iHost management team maintain an inventory of the substation sites with LV monitoring installed and this has been made available for use in the HV Pilot site selection analysis.

LV monitoring is not usually installed on pole-mounted transformers and so is less likely to be available on the rural overhead lines that are the highest priority for the HV Pilot project. However, the analysis does not require every substation to have monitoring installed. Preferably, each HV feeder considered for the analysis would have at least one three-phase distribution substation with LV monitoring.

The three groups of LV monitoring devices are as follows:

Lucy Electric GridKey

968 installations, of which 800 are working, identified on the basis that are recorded in the inventory with ‘Communication status’ as ‘Successful’

EA Technology Visnet

3,891 installations, of which 3,232 are working, identified on the basis that they are recorded in the inventory with ‘Communication status’ as ‘Connected’

PRESense

2,122 installations, of which 1,933 are working, identified on the basis that they are recorded in the inventory with ‘Communication status’ as ‘Successful’

In total, 2,622 HV feeders have at least one distribution substation with working LV monitoring installed, which is around one third of the total of 7,732 HV feeders across the four license areas.

Each type of device provides three-phase voltage, current and power monitoring at 10-minute resolution.

3.2 Business-as-usual HV monitoring

The project team have investigated whether further monitoring data is available from measurements at HV. Based on a number of discussions with the NGED project stakeholders, we understand the position to be as follows:

- There is no business-as-usual monitoring on HV feeders that would provide time-series voltage data

- Single-phase time-series voltage monitoring data is available and held in the NGED Time Series Data Store. This data typically provides half-hourly mean values from monitoring installed using current transformers and voltage transformers at the primary substation. Voltage data is available for the transformer HV busbar, and current amplitude (or apparent power) data is available for each HV feeder. It is common practice for the single-phase data to be measured on the yellow phase, which we expect will be the most lightly loaded if there us unbalance between phases. Since these data logs are single-phase only, they are not of high priority value to the project analysis.
- If a customer voltage complaint is investigated and if there is no reason to suspect that over-voltages or under-voltages relate to the LV assets, then the high voltage drops on the HV feeder might be suspected as a cause. To investigate this, additional monitoring may be temporarily installed at the distribution substations, and this would provide time-series voltage data. This instrumentation would provide additional time resolution and harmonic power quality information not usually available from permanently installed LV monitoring. While this monitoring is not routinely available on HV feeders, it could be argued that it is valid to include it in the project analysis if it is routinely installed whenever an HV phase unbalance is suspected.

  We understand that there may be scope for this type of monitoring to be fitted for a short period on the selected project feeders, subject to funds for the installation work being available.

  Sample data from this instrumentation has been requested, although this is not seen as a high priority task.

3.3 HV Pre-fix monitoring

Additional monitoring has been installed on some feeders for the HV Pre-fix NIA project, comprising:

- Smart Navigator 2 units, self-powered overhead line monitoring

- NX44 units, a smart fault passage indicator that is mounted upon a ring main unit

- PQube units, an LV monitoring instrument installed at primary substations to monitor the HV line via voltage and current instrumentation transformers

The Smart Navigator and NX44 devices are understood to capture high resolution data in the event of a fault being detected, but not to provide time-series monitoring data on a regular and on-going basis. Event data cannot easily be utilised for the HV Pilot project as it will not be available for the same time intervals throughout the HV feeder.

However, the PQube data from primary substations is likely to be useful as it will provide a three-phase voltage reference, in the same way as the LV monitoring at distribution substations.

PQube units are fitted at primary substations

East Midlands

- 930016 Whitley (to be confirmed)
- 930027 London Road (to be confirmed)
- 930031 Cox Street
- 930033 Courthouse Green (to be confirmed)
- 930038 Holbrook Lane
- 930040 Sandy Lane
- 930041 Spon Street (at 935791 Spon Street distribution substation)
- 930042 Dillotford Avenue (at 930623 Dillotford Avenue Primary distribution substation)
- 930047 Walsgrave
- 930048 Claverdon
- 930067 Hillmorton

South West

- 310011 Witheridge
- 310015 Crediton
- 310016 Folly Bridge
- 340011 Chudleigh Knighton
- 340012 Moretonhampstead
- 350050 Okehampton

South Wales

- 590161 Llanllwni
- 600184 Nevern

3.4 Arc Aid monitoring

The NGED BAU project Arc Aid plans to install MetrySense 5000[1] monitoring on HV feeders in Cornwall. These devices are capable of time-series voltage and current monitoring with a 15-minute resolution.

The stage 2 installations will arrive too late to be of use within the HV Pilot project but the stage 1 installations could provide useful additional voltage data. The stage 1 installations are due in July or August 2025 and would include the following primary substations:

- 457290 Liskeard
- 417140 Truro Shortlanesend
- 417050 Helston
- 417110 Redruth
- 437230 Bodmin
- 437550 Polzeath
- 417020 Camborne Carn Brea
- 457250 Launceston
- 552790 St Ives
- 437610 Newquay Trencreek Lane

[1] https://www.megger.com/en-gb/products/ms5000

- 417600 Truro Treyew Road
- 437430 Padstow
- 457300 Looe

Further information on the Arc Aid installations has been requested.

The sample feeder selection for this project does not yet reference the Arc Aid installations but further feeders could be added once details of the monitoring configuration are available.

4. Priority HV feeders

NGED have provided a list of feeders that have been suggested by HV planners as being of possible concern for phase unbalance. For each HV feeder, the list identifies:

- Name of the HV planner
- Primary substation
- HV feeder
- Total length of the circuit, including all lateral branches
- Total length of underground three-phase
- Total length of underground not-three-phase
- Total length of overhead three-phase
- Total length of overhead not three-phase
- Number of LV smart meter customers
- Number of LV customers with non-smart meter

The feeders identified as high priority for investigation are typically extremely long, as shown in Figure 1, with total circuit lengths of up to 130 km. It should be noted that this does not imply a linear extent from the primary to the furthest distribution substation of this length, and this is the total length including all side branches. It is likely that load-related voltage drops along these circuits could dominate the voltage variations seen at individual smart meters, masking the variations at the primary substation busbar that differ between phases. The phase identification methods may perform poorly on these feeders, with the risk that the analysis techniques are not taken forward for development, even though they may have worked well on the much more commonplace examples of shorter HV feeders.

Figure 2 compares the lengths of these feeders using underground cable or overhead line (both three-phase and single-phase). The majority of priority feeders have less than 10 km of underground cable, with the length of overhead line varying between zero, and over 120 km. There are no feeders that are entirely overhead, without having any underground cable at all, suggesting that the phase identification method will be required to handle partial visibility of the feeder. Feeders with a long total circuit length typically have a high proportion of overhead line.

Where there are long lengths of overhead line, a significant proportion of this is ‘not three-phase’, with this being taken as meaning two-wire line-to-line HV conductors, and so only enabling connection of single-phase line-to-neutral LV transformers, as shown in Figure 3. Around 10% of the priority feeders have no two-wire overhead line, but most have at least 10% two-wire line, and for those with longer overall circuit length, there is typically between 30% and 60% two-wire line.

The proportion of LV customers with SMETS meters, shown in Figure 5, has a slight decrease for the longer HV feeders. This may be due to a reduced proportion of new-build housing on the longer feeders or could simply indicate a lower willingness to adopt smart metering. Regardless, this raises a potential concern for the project analysis as it will be necessary to select feeders where there are sufficient smart meters at each of the distribution substations included to enable the use of the voltage correlation methods.

Figure 4 and Figure 5 below show details of the LV customers served by the priority HV feeders. The total number of customers in Figure 4 does not appear to increase for longer HV feeders, suggesting that these feeders are serving more remote areas, rather than an area with a uniform population density, such that the number of customers would increase with the length of the feeder.

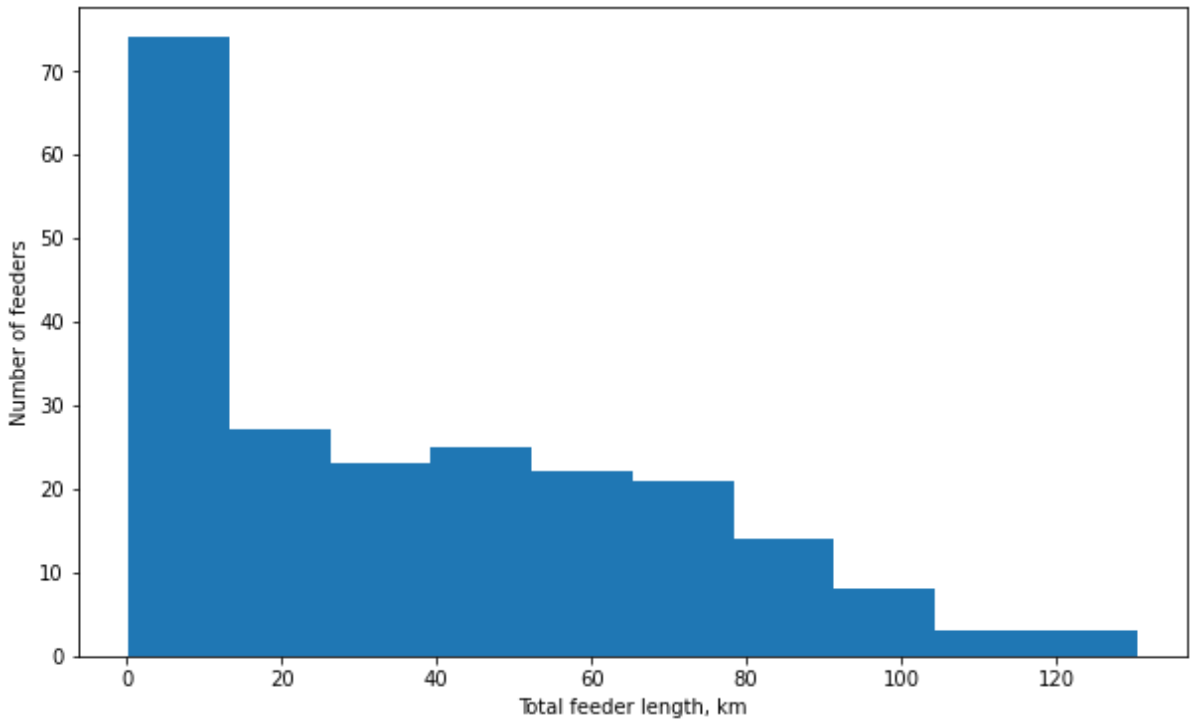


Figure 1: Total circuit length of priority HV feeders

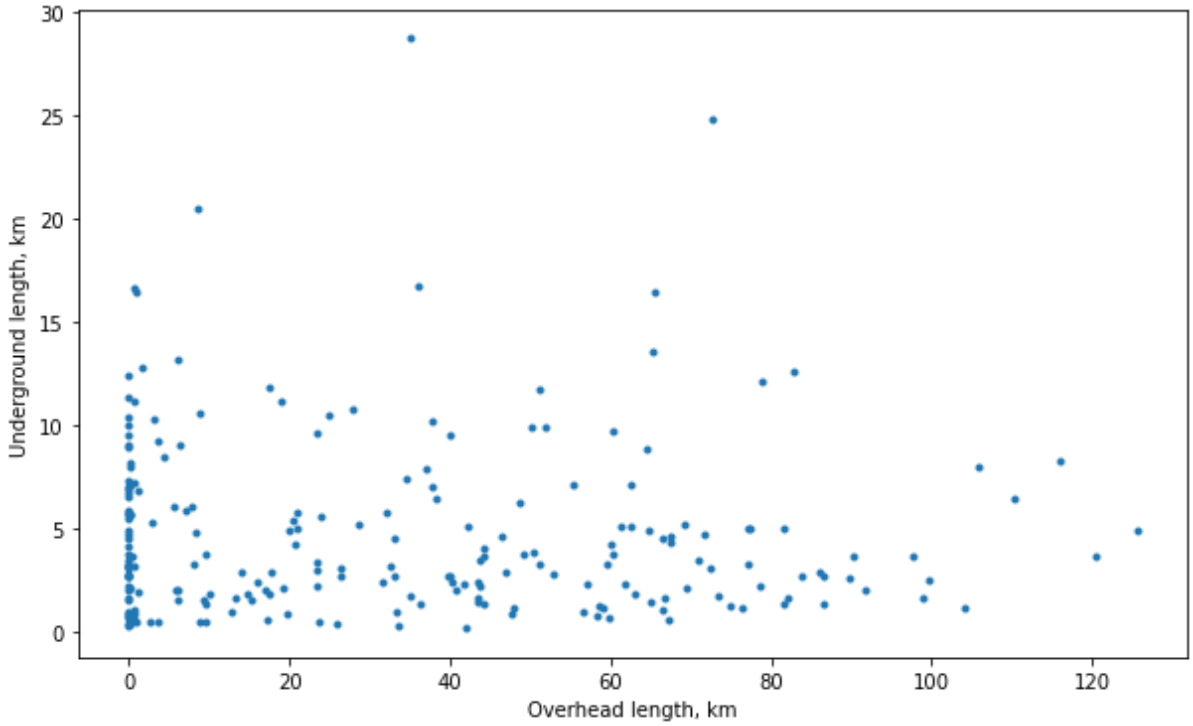


Figure 2: Underground and overhead lengths of priority HV feeders

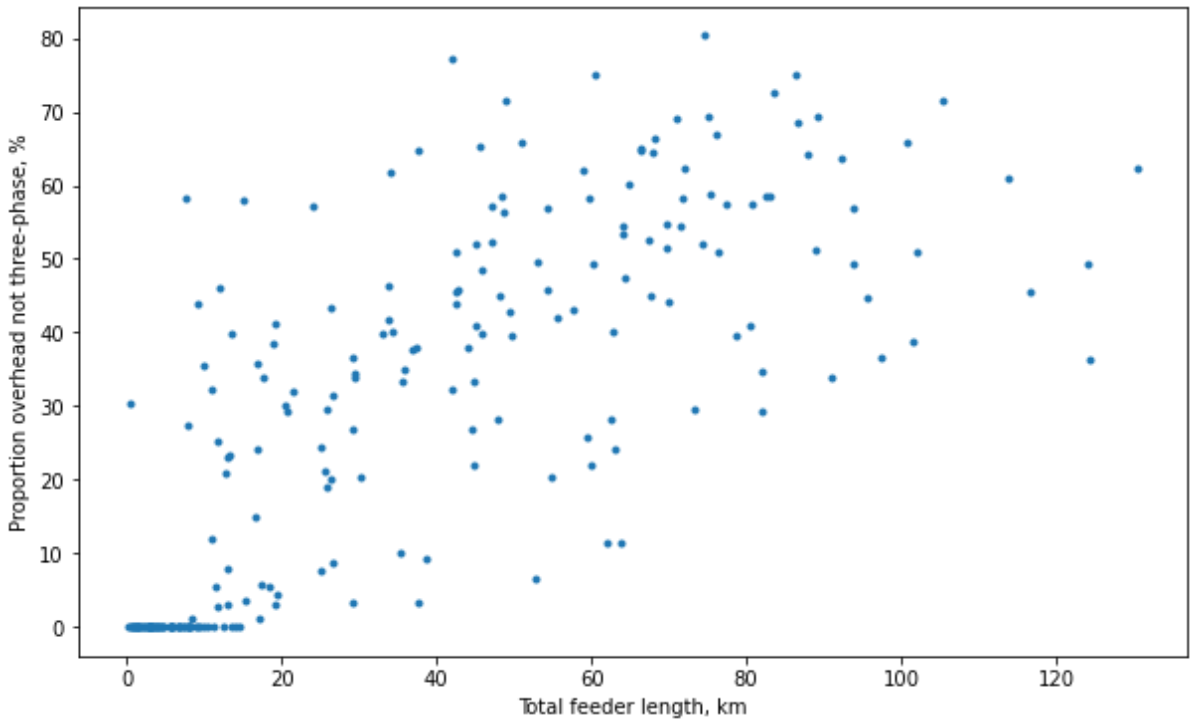


Figure 3: Proportion of two-wire overhead on priority HV feeders

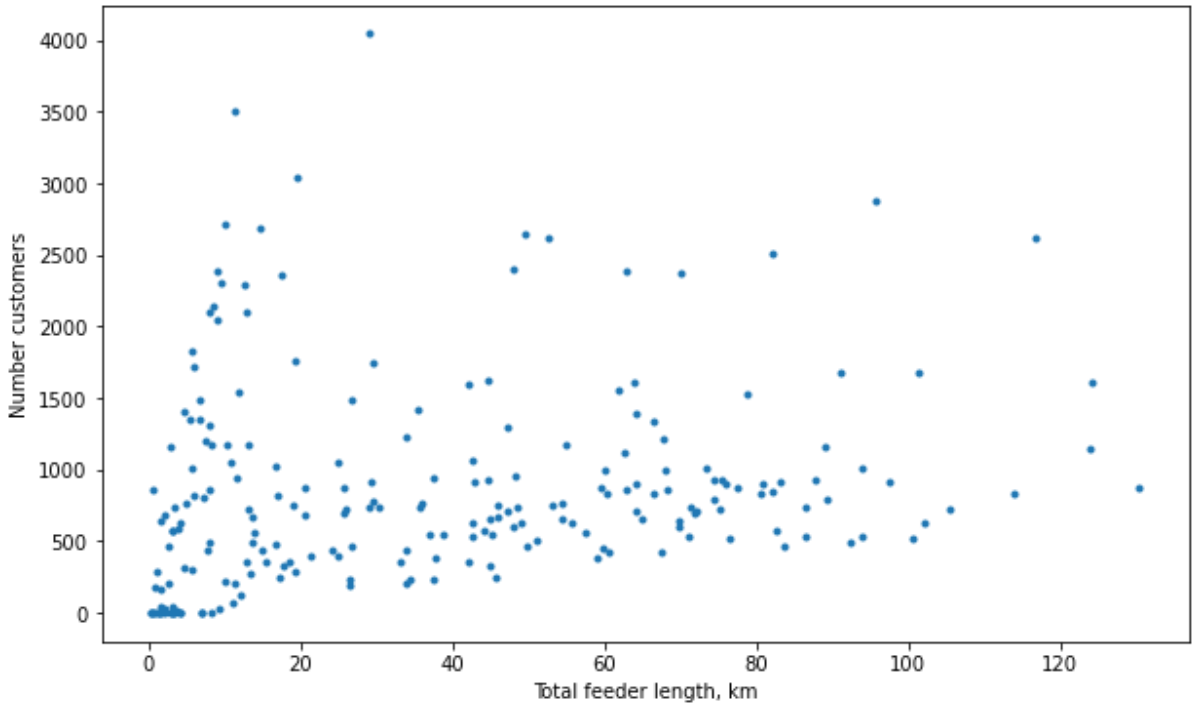


Figure 4: Numbers of LV customers on priority HV feeders

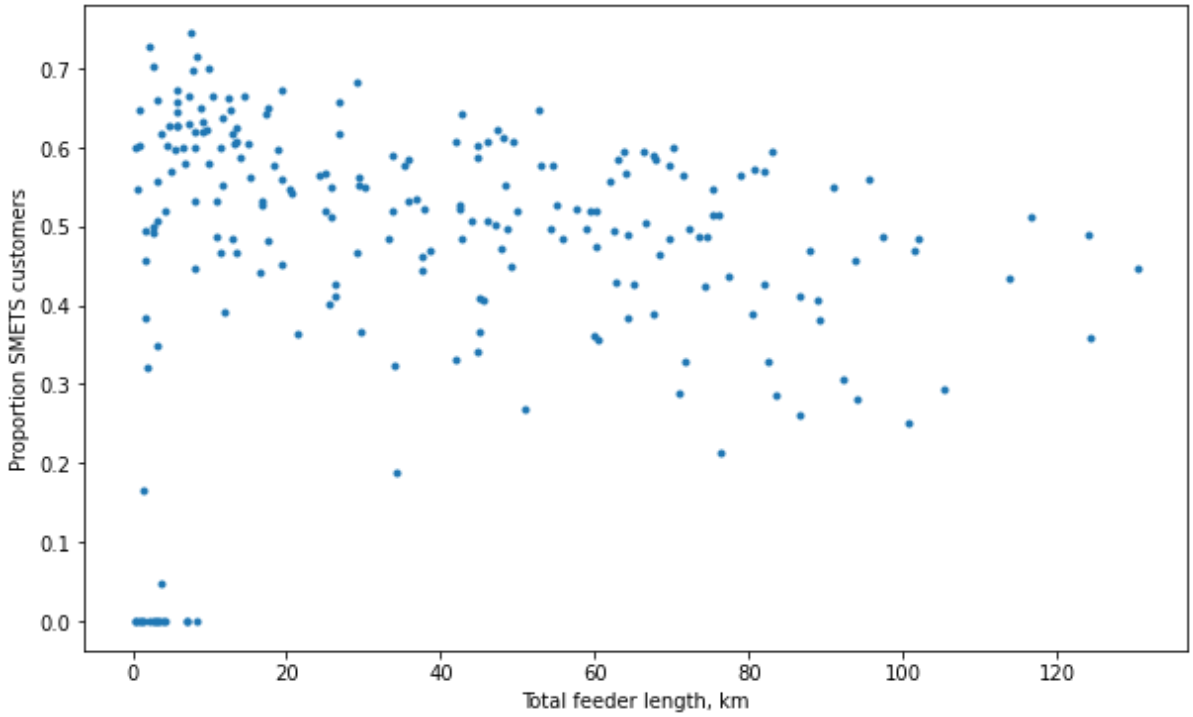


Figure 5: Proportions of LV customers with smart meters on priority HV feeders

5. CROWN data

5.1 Data files

Further data has been provided describing all NGED distribution substations (file name Distribution Substations Transformers V2.xls). This has been used to collate data for the substations on each HV feeder, rather than just those feeders identified by planners as being potential risks for phase unbalance. This data is useful as it allows for feeder selection from a more representative range of feeders, rather than just those that are unusually long.

For each substation the data file provides:

- Substation asset number and name
- HV feeder connection
- Ground-mounted or pole-mounted
- Number of phases
- Phase connection (e.g. Red/Blue for a single-phase transformer)
- Transformer rated power

Additional data (file name smets_by_substationDec24.xlsx) provides details of the number of customers at each substation, including:

- Substation asset number and name
- HV feeder connection
- Primary substation
- Number of customers without smart meter
- Number of customers with smart meters
- Numbers of SMETS1 and SMETS2 meters

For the purposes of the HV Pilot project it is assumed that the functionality of SMETS1 and SMETS2 meters is similar and that there is no need to draw any distinction between them.

5.2 Distance of distribution substations from primary substation

As noted above, the data relating to priority HV feeders identified the total circuit length for each HV feeder but does not necessarily imply this is the longest length from the primary to the furthest distribution substation as the total length generally includes a number of side branches.

An analysis of the longest distance to a distribution substation would ideally be calculated by identifying the topological route from the primary substation and then summing the lengths of each feeder cable along this route. However, an approximation of the distance to each distribution substation connected to the feeder can be derived more simply by finding the straight-line distance between the location of the primary and the location of the distribution substation. The longest distance is then given by the maximum of these distances. While this clearly does not allow for any additional length due to the cables not following a straight-line route, it does at least indicate the minimum possible length of the HV feeder.

The longest distance to a distribution substation on each HV feeder has been calculated by combining the list of substation connections with data available from the NGED data portal for the eastings and northings coordinates of primary and distribution substations.

The longest distances to a distribution substation on each HV feeder are summarised in Figure 6. When compared with Figure 1, this shows that the longest distances are typically very much shorter than the total circuit distance, with most feeders being below 10 km in maximum length.

A second plot in Figure 7 shows the longest distances to only the single-phase substations. As expected, the mean distance is greater than when all substations are included.

If it is considered desirable to include a range if HV feeder lengths in the sample selection, this suggests that the selected feeders might ideally include, for example, feeder lengths from around 2 km up to 12 km.

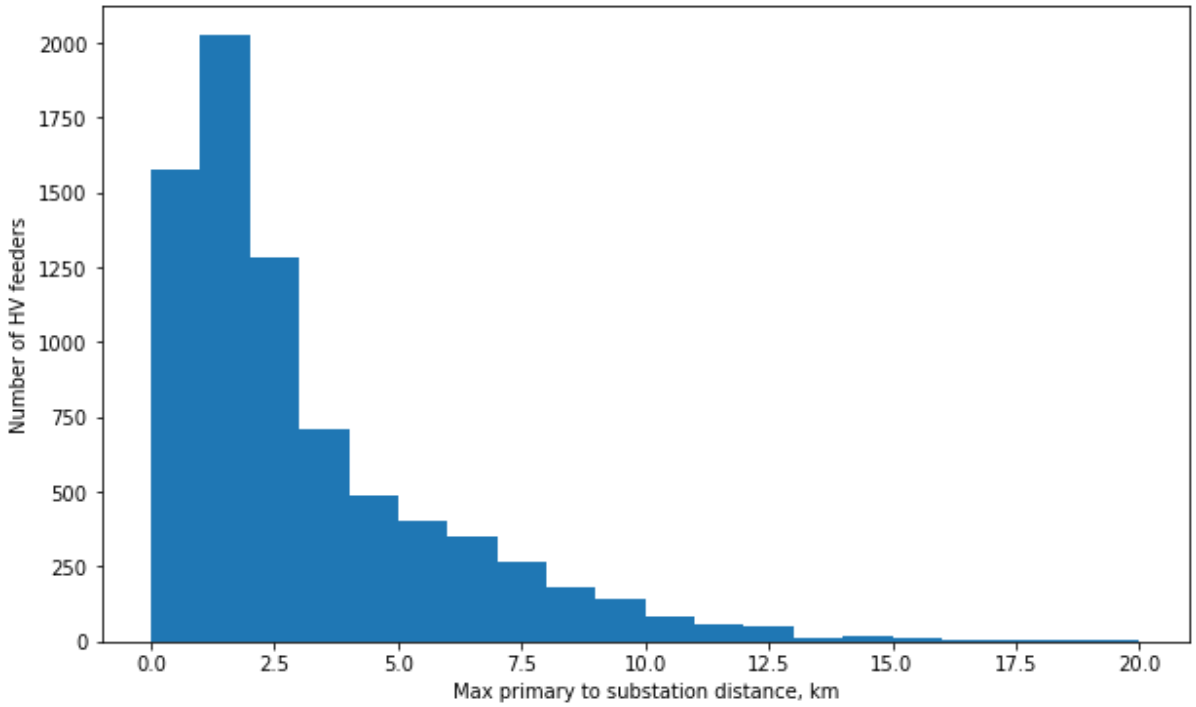


Figure 6: Longest distance to distribution substations on HV feeders

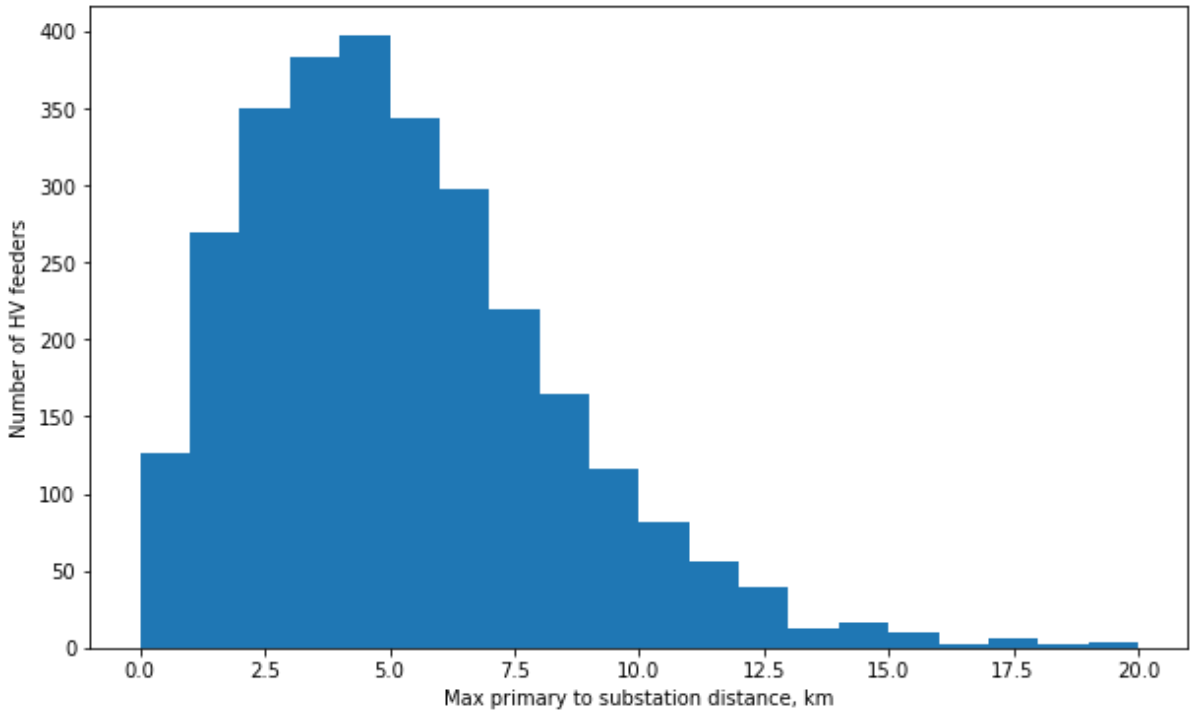


Figure 7: Longest distance to single-phase distribution substations on HV feeders

These longest distances are significantly less than the total circuit length plotted previously in Figure 1. The relationship between these two metrics is shown in Figure 8. There are a few outliers where the longest distance to a distribution substation is very high, and these appear to be explained by erroneous substation records. Feeders with longer distances to the furthest substation typically also have a greater total length, but the furthest substation distances are much less than the total circuit length.

Figure 8 includes a linear regression to indicate the expected maximum distance to a substation d for a given total circuit length l, approximated as

$$d = 2638 + 0.151l$$

where both d and l are in metres. If this relationship is considered useful for planning purposes, a better estimate could be derived in future where the set of points includes all HV feeders rather than just those identified as a priority, typically those with longer lengths, and where the maximum distances to a substation takes the cable path length into account rather than just the straight-line distance between the substations.

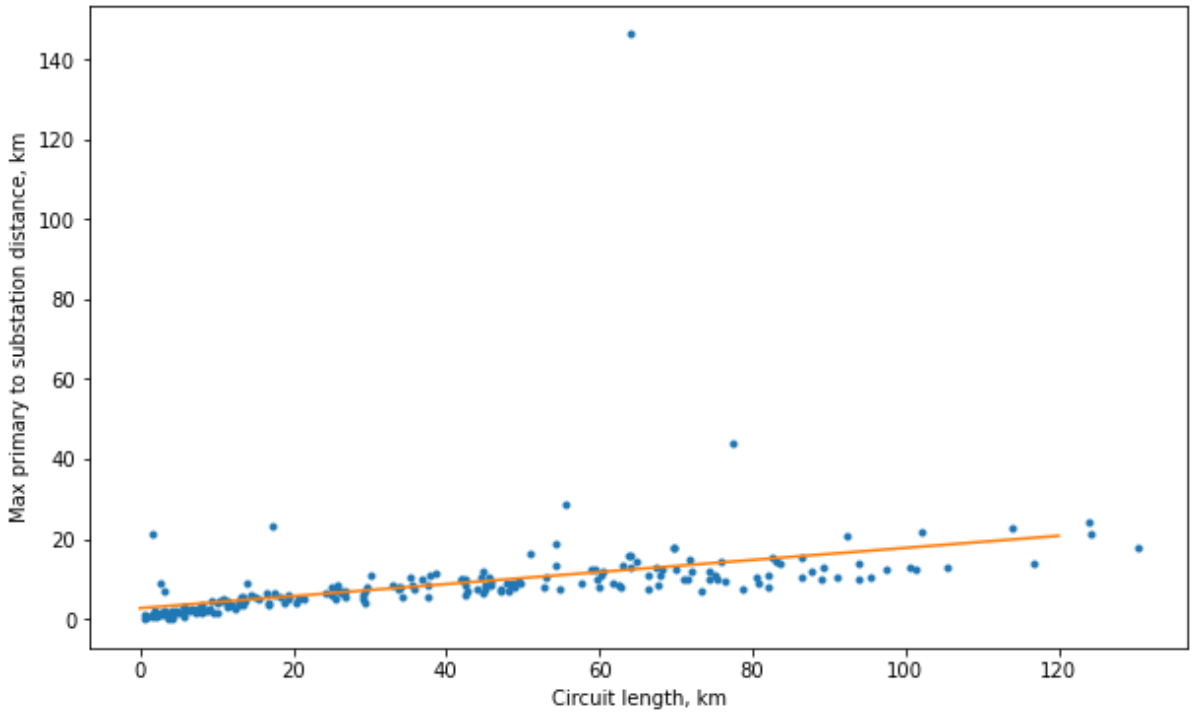


Figure 8: Longest distance and total circuit length of priority HV feeders

Figure 9 shows the numbers of distribution substations on HV feeders, with a few outliers having up to around 200 substations. As with the very long feeders, these feeders are not representative of the overall picture and most feeders have less than 100 substations. HV feeders that are entirely three-phase have a different distribution, as in Figure 10. Over half of HV feeders that have no single-phase transformers connected have no more than 10 substations.

The proposed phase identification method using smart meters ideally requires at least one three-phase substation that can be used as a reference. If this is not available, it may be possible to use three-phase substations on other HV feeders, although the load-related voltage variations will differ between feeders, reducing the success of the correlation method.

Figure 11 shows the proportion of single-phase substations on HV feeders, relative to the total number of substations. This shows that on feeders with a greater number of substations, a higher proportion of those will be single-phase. There are only 20 HV feeders where there are no three-phase substations, so in all other cases a three-phase reference will likely be available.

(In Figure 11 the points on the lower left fall into distinct '$1/x$'-shaped curves as the proportions of substations are ratios of integer values, with the denominator also providing the horizontal axis. For any given integer number of single-phase substations there are a range of possible integer denominators. Across the full set of HV feeders, there will be some with a number of non-three-phase substations k, and this will occur on feeders having n, $n+1$, $n+2$ etc substations in total. The set of possible ratios therefore plots out a series of reciprocal curves scaled by discrete integer values of k.)

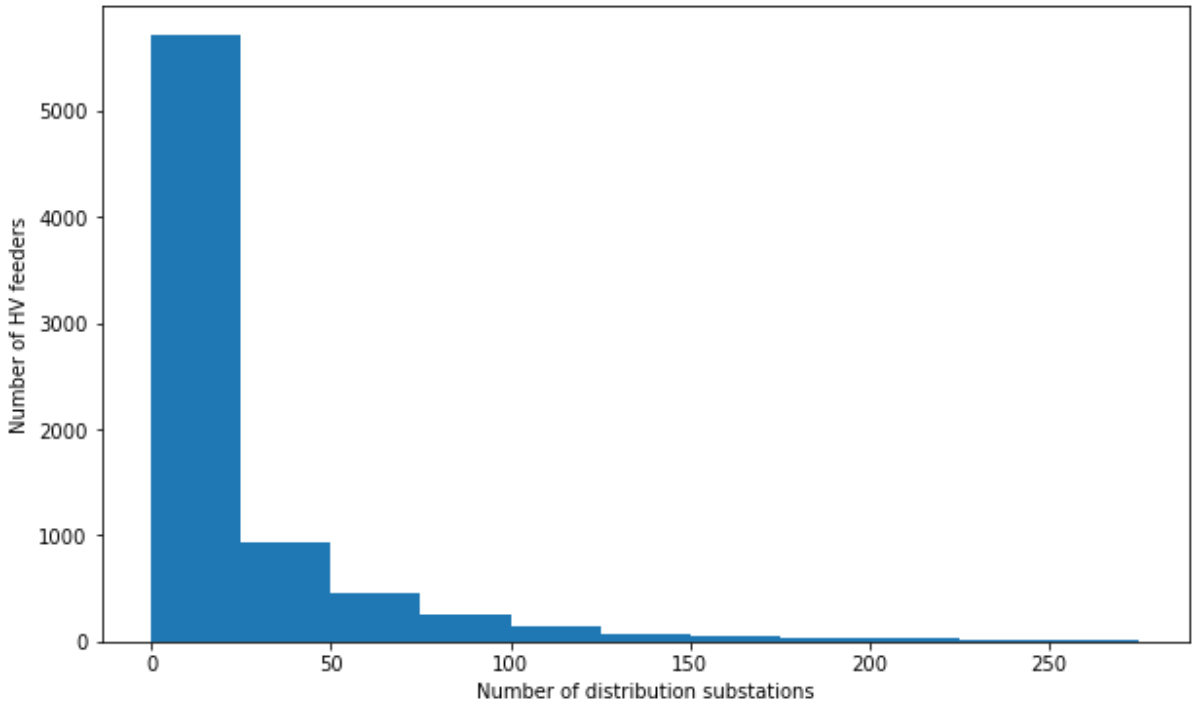


Figure 9: Numbers of distribution substations on HV feeders

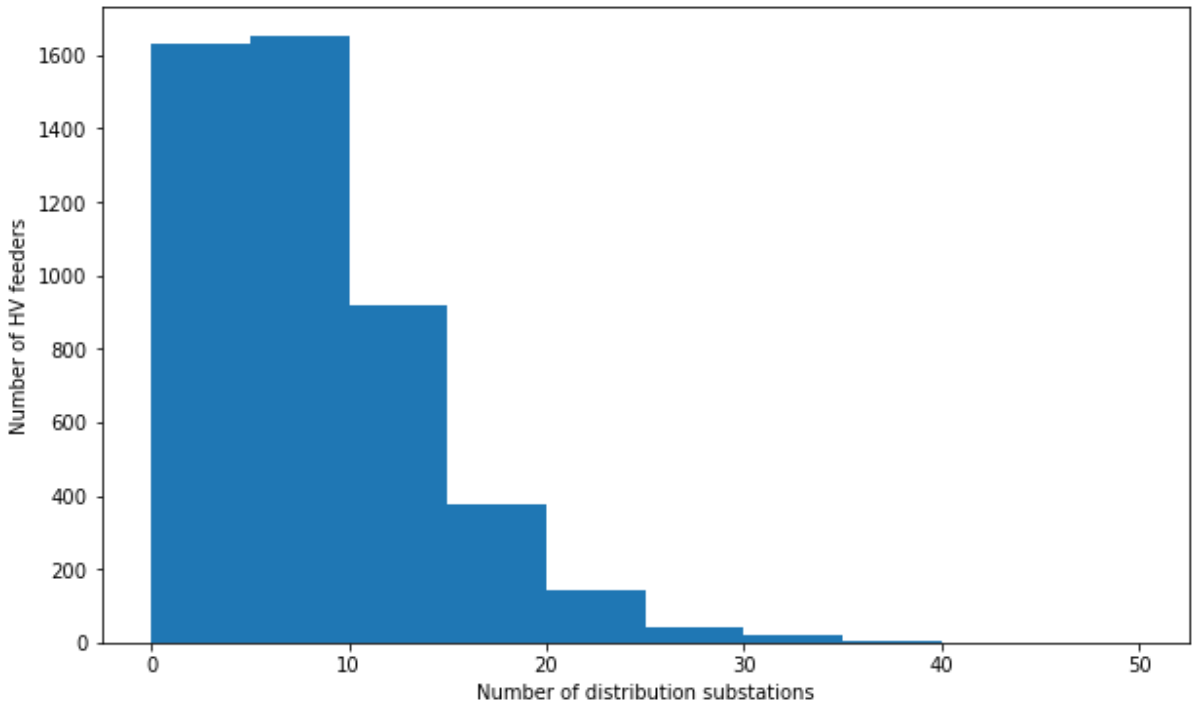


Figure 10: Numbers of distribution substations on HV feeders where all substations on the feeder are three-phase

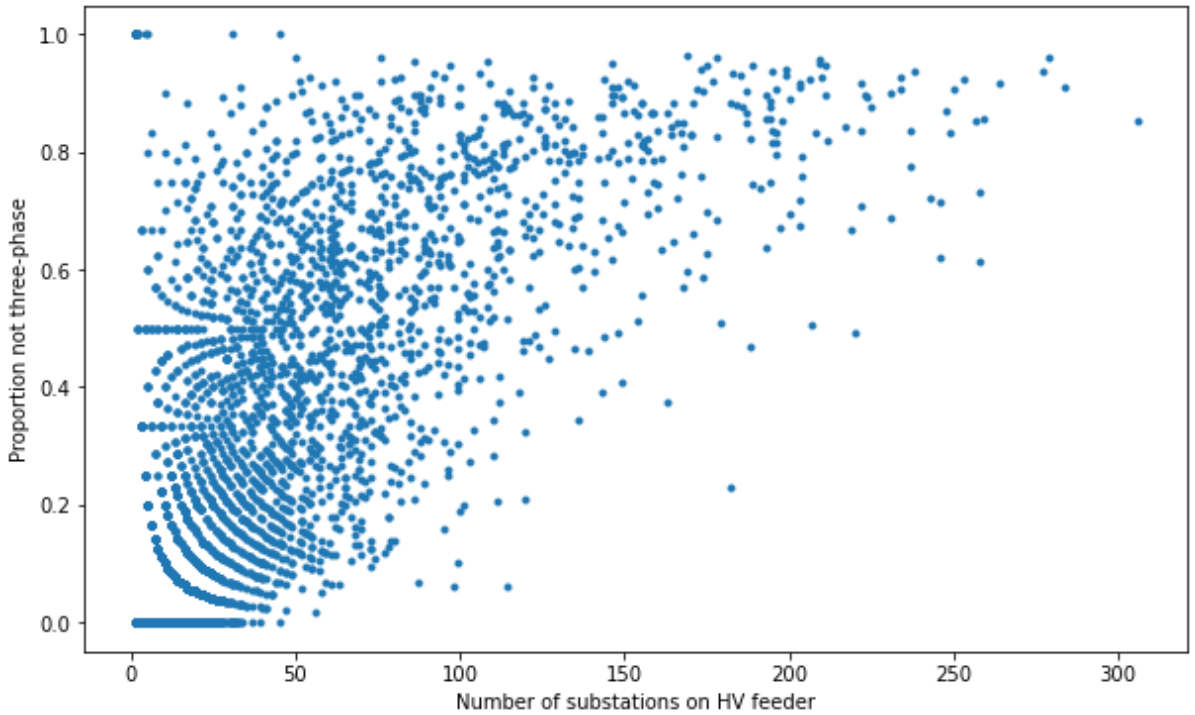


Figure 11: Proportion of single-phase substations

Three of the priority set of HV feeders have total circuit lengths over 120 km. These are:

HV feeder	Primary name	Region	Total circuit length, km	Longest substation distance, km
610077/0080	Brecon	South Wales	134.0	18.0
610092/0020	Builth Wells	South Wales	123.9	22.4
670121/0005	Knighton	West Midlands	124.3	21.4

The topologies of these feeders are shown in the figures below.

Feeder 610077/0080 from Brecon has two main branches joining together near to the primary. In effect, this could be considered to be two separate feeders with a short section of shared cable near to the primary. Voltage variations on one branch would be expected to differ significantly from those on the other branch due to differences in the short-term load variations. It may be appropriate for the phase identification method to treat this as if it were two separate feeders.

The same applies to some extent on feeder 610092/0020 although the branching occurs further from the primary. This may be more challenging as the load-related voltage variations will partly be shared. The total line length is also clearly greater than the straight-line distance to the furthest substation.

On HV feeder 670121/0005 there are at least two rings in the topology, such that the total route along the cables could be very much less than the furthest straight-line distance to a substation.

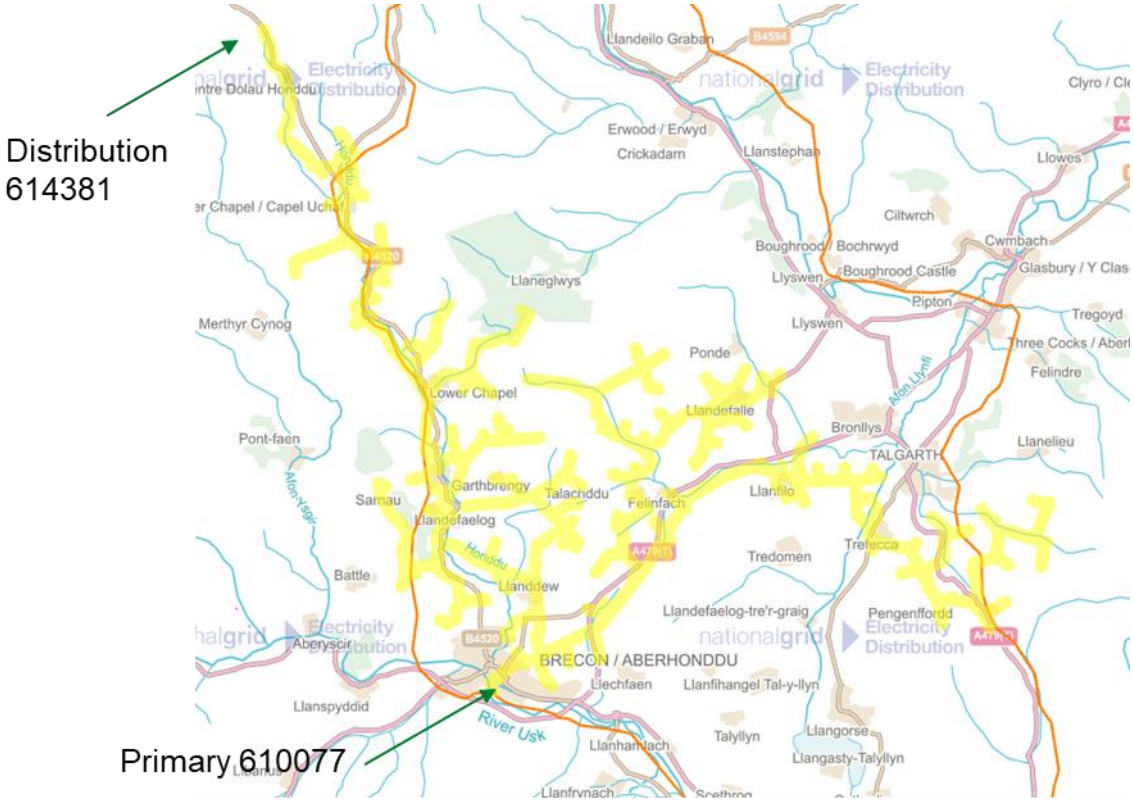


Figure 12: HV feeder 610077/0080

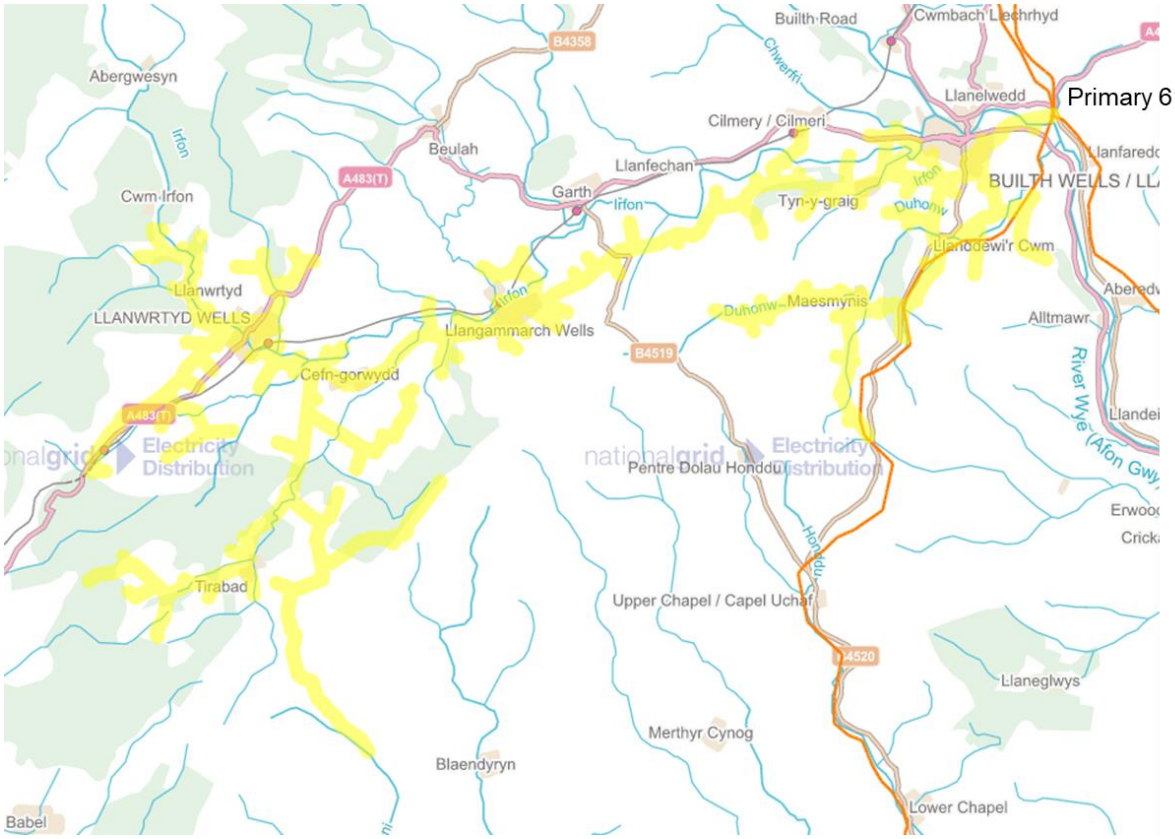


Figure 13: HV feeder 610092/0020

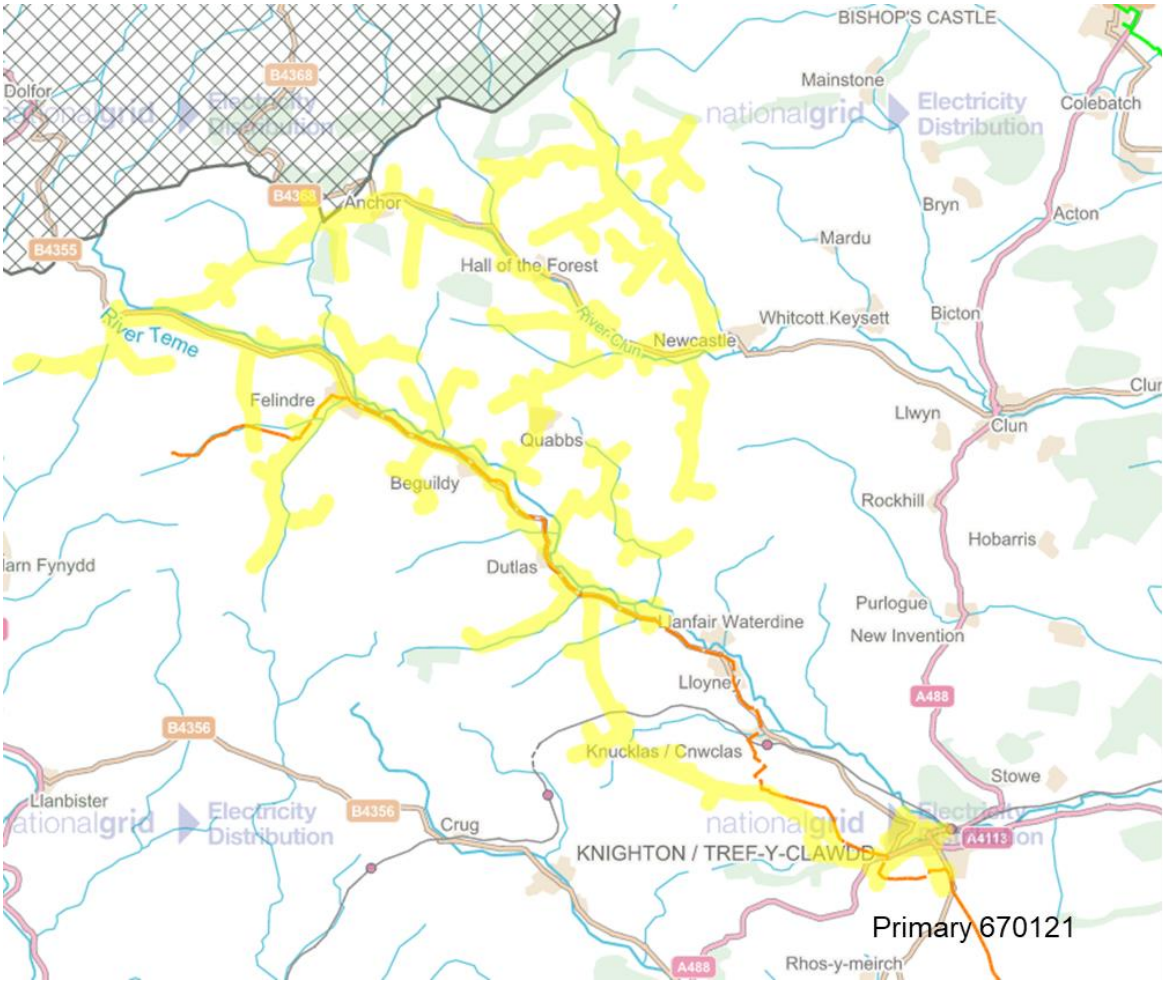


Figure 14: HV feeder 670121/0005

5.3 Smart meter uptake

Two data sources from NGED provide information on the numbers of smart meters at each substation.

Inventory data from the NGED smart meter team lists the substations for which demand data is routinely captured and stored. Data is stored after aggregation over individual LV feeders, or over all the customers at each distribution substation. Substations are included in this data capture process when the uptake of smart meters reaches a defined percentage threshold, with this threshold currently being 65%. Aggregated data for LV feeders is only captured when there are 3 or more customers, and similarly for substations. In some cases aggregated data is therefore available for the substation but not for the LV feeder.

Where substations do not meet these criteria, no data is captured. However, it has been confirmed that it will be possible to capture voltage data for substations that would not normally be included in the demand data capture since voltage data is treated as operational rather than personal data.

Information on numbers of smart meters is also included in the CROWN data extract. This is useful here as all substations are included in the data, rather than just those where data capture has been enabled. It is likely that many of the single-phase substations where phase identification is needed will be pole-mounted transformers serving only a few customers.

6. Initial selection criteria

It was initially planned for the project to test the phase identification methods on a set of around five primary substations, each having several HV feeders. However, it has been difficult to find primaries where multiple feeders have high quality visual survey data and so the selection criteria for the sample selection have been updated to consider a set of HV feeders, without the constraint that this needs to include several feeders from the same primary. Details of the final selected feeders will be confirmed in the WP1 D3 Area Selection Report deliverable which will integrate the learning from this report and from the WP1 D2 Visual Data Assessment Report.

The visual data assessment work has found that aerial images from the Cycle 6 or Cycle 7 are likely to be suitable for the phase identification work, but not the images from earlier cycles. However, even when Cycle 6 or Cycle 7 images are available, a manual checking process is still needed for each feeder to ensure that the images can be used.

The process to review the helicopter survey data is time-consuming and so an initial 'long-list' of HV feeders has been created, with the aim of selected those from within this list for which there is high quality helicopter survey data.

HV feeders have been included on this long-list if they meet the following criteria:

- Cycle 6 or Cycle 7 aerial survey data is available
- There are at least 2 three-phase distribution substations with 12 or more customers having a smart meter

  These substations are likely to be ground-mounted and have a larger number of customers, and would act as the phase identification reference
- There are at least 6 single-phase distribution substations with at least 3 customers having a smart meter

  These substations are likely to be pole-mounted and are the substations 'under test' for phase identification
- There is at least one substation on the HV feeder with either monitoring (of any type) installed, or monitoring at the primary

  Those with monitoring at the primary are the substations included in the Pre-fix project.

  Although monitoring should not be required for the operation of the phase identification method, the availability of monitoring data will assist in validation of the test results.

This initial selection produces a list of 99 feeders as follows in Table 1. Since this is a long list for manual checking, feeders have been sorted in four groups, as follows:

1. The four selected feeders that are already in the Pre-fix project
2. Another 8 feeders that are identified as priority interest
3. Feeders with Cycle 7 aerial survey data
4. All others with Cycle 6 survey data

Table 1: Initial selection of long-list primaries

HV feeder id	Pre-fix project	Priority feeders	Cycle	Primary	Longest distribution substation distance, km	Number of single-phase substations with SMETS	Numbe three-phase substat with SMETS
310011/0016	Yes	Yes	6	310011	9.70	6	6
310015/0018	Yes	No	6	310015	10.46	18	11
310015/0023	Yes	No	6	310015	3.53	7	10
310016/0019	Yes	No	6	310016	7.06	17	11
260260/0096	No	Yes	7	260260	10.62	18	18
350015/4066	No	Yes	6	350015	8.90	20	4
350015/4067	No	Yes	6	350015	15.84	28	6
530177/0070	No	Yes	6	530177	9.88	22	4
530252/0928	No	Yes	6	530252	8.60	23	6
600017/0031	No	Yes	6	600017	10.58	15	5
600017/0034	No	Yes	6	600017	10.11	18	7
600200/0051	No	Yes	6	600200	6.85	12	18
210020/0864	No	No	7	210020	5.26	9	13
210020/0866	No	No	7	210020	4.36	9	21
250310/0288	No	No	7	250310	7.57	16	10
417780/0043	No	No	7	417780	6.79	6	6
437210/0043	No	No	7	437210	3.83	6	14
437440/0043	No	No	7	437440	3.90	7	10
437670/0047	No	No	7	437670	4.91	7	14
530196/0347	No	No	7	530196	6.28	6	17
600085/0006	No	No	7	600085	7.82	13	19
600085/0009	No	No	7	600085	11.27	16	2
670042/0001	No	No	7	670042	3.69	17	14
670042/0004	No	No	7	670042	10.03	12	20
670042/0013	No	No	7	670042	4.89	9	13
670072/0061	No	No	7	670072	9.41	17	84
670081/0003	No	No	7	670081	5.86	8	7
670081/0012	No	No	7	670081	8.31	14	34
670090/0002	No	No	7	670090	11.13	27	30
670090/0005	No	No	7	670090	10.01	12	22
670124/0007	No	No	7	670124	8.44	7	8
840013/0008	No	No	7	840013	7.62	9	14
850014/0003	No	No	7	850014	6.91	8	21
930072/0004	No	No	7	930072	9.78	6	11
161532/0008	No	No	6	161532	4.05	7	12
180006/0010	No	No	6	180006	7.28	6	10
181230/0002	No	No	6	181230	3.40	9	9
260220/0024	No	No	6	260220	4.81	11	17
340016/0026	No	No	6	340016	9.40	33	9
340019/0018	No	No	6	340019	8.61	15	20
350011/0023	No	No	6	350011	8.37	12	11
350017/4008	No	No	6	350017	10.87	37	28
417010/0041	No	No	6	417010	4.15	17	17
417020/0042	No	No	6	417020	3.13	9	4
417030/0043	No	No	6	417030	5.49	23	9
417070/0041	No	No	6	417070	4.21	10	12
417110/0042	No	No	6	417110	2.43	7	11
417140/0042	No	No	6	417140	4.42	14	8
417140/0044	No	No	6	417140	9.52	8	27
417140/0046	No	No	6	417140	14.25	13	8
417150/0041	No	No	6	417150	6.75	16	26
417150/0046	No	No	6	417150	7.71	16	14
417170/0042	No	No	6	417170	9.39	14	8
417560/0041	No	No	6	417560	9.13	13	13
417560/0042	No	No	6	417560	7.94	12	6
437190/0044	No	No	6	437190	4.12	9	11
437360/0044	No	No	6	437360	6.09	13	23

HV feeder id	Pre-fix project	Priority feeders	Cycle	Primary	Longest distribution substation distance, km	Number of single-phase substations with SMETS	Numbe three-phase substat with SMETS
437370/0045	No	No	6	437370	4.63	9	12
437380/0046	No	No	6	437380	6.14	14	8
437450/0043	No	No	6	437450	7.12	15	9
457240/0041	No	No	6	457240	7.08	8	7
457240/0044	No	No	6	457240	8.65	11	17
457280/0042	No	No	6	457280	4.82	22	5
457290/0041	No	No	6	457290	9.56	45	13
457290/0044	No	No	6	457290	6.10	21	14
457470/0042	No	No	6	457470	5.43	17	2
520137/0778	No	No	6	520137	5.17	8	12
530907/0007	No	No	6	530907	5.39	13	7
550208/0294	No	No	6	550208	4.65	8	14
560912/0006	No	No	6	560912	6.40	8	16
580072/0012	No	No	6	580072	3.35	7	9
580072/0495	No	No	6	580072	3.52	10	5
580078/0258	No	No	6	580078	12.60	16	8
590021/0042	No	No	6	590021	9.67	17	6
590021/0043	No	No	6	590021	51.06	6	13
590021/0233	No	No	6	590021	4.31	6	7
590052/0003	No	No	6	590052	9.63	6	8
590180/0074	No	No	6	590180	7.23	9	5
600188/0090	No	No	6	600188	5.61	19	9
670019/0003	No	No	6	670019	6.21	20	22
670019/0008	No	No	6	670019	6.91	17	12
670085/0003	No	No	6	670085	9.17	9	14
670101/0012	No	No	6	670101	7.32	16	23
670104/0006	No	No	6	670104	6.04	22	19
670116/0005	No	No	6	670116	11.42	44	6
680061/0002	No	No	6	680061	12.25	16	25
770002/0004	No	No	6	770002	7.16	20	7
770002/0005	No	No	6	770002	7.10	8	4
770003/0001	No	No	6	770003	6.16	9	9
770003/0009	No	No	6	770003	10.82	26	21
770005/0004	No	No	6	770005	7.71	8	25
790002/0004	No	No	6	790002	6.57	12	10
790008/0477	No	No	6	790008	3.57	6	4
840017/0001	No	No	6	840017	8.10	12	21
840021/0008	No	No	6	840021	8.87	10	11
840025/0012	No	No	6	840025	10.36	6	19
850007/0005	No	No	6	850007	7.78	12	10
850024/0001	No	No	6	850024	6.30	9	13
910026/0008	No	No	6	910026	6.21	8	15

7. Conclusions

This report summarises the data sources considered for the HV Pilot project, including network data, monitoring data, and substation asset data.

A number of additional data files have been provided by the NGED HV planning team to assist with the project sample area selection. This sample area is expected to include around 5 primary substations, and would include substations any suitable HV feeders from these primaries.

An investigation of available monitoring data has identified that around a third of distribution substations have LV instrumentation installed, but has not revealed any significant additional volume of data available from HV monitoring. However, there is some limited data available from monitoring installed for innovation trials, such as HV Pre-fix. Data from other instrumentation, in many cases intended for fault detection and location, typically records high resolution event data when triggered by a peak voltage or current, but does not record the regular time-series data as needed for HV Pilot.

There may be scope for monitoring to be temporarily installed on the selected feeders, using equipment that would normally be deployed where there is a concern that voltage ranges could be exceeded.

Analysis of the transformer and substation asset data shows that HV feeders typically serve distribution substations that are up to 20 km distance from the primary substation. In some cases the cable route may be much longer than this, but mostly significantly less than the total circuit length including side branches.

A key requirement for the phase identification is that HV feeders should include at least one three-phase substation and this is the case for all but 20 HV feeders. Phase identification based on smart meter voltage data requires that the substations have a sufficient number of smart meters, and arbitrary thresholds . These require that the three-phase reference substations have at least 12 smart meters, intended to ensure that there are several on each of the three phases, and the single-phase substations should have at least three smart meters. Ideally, only one smart meter is needed at the single-phase substations to correlate with the three-phase reference, since all customers have the same phase, but having several smart meters available improves the likelihood that a customer will be located closer to the substation, avoiding the impact of LV voltage drops, and allows for occasional interruptions in the voltage data.

HV feeders are considered suitable for the phase identification if they have two more three-phase substations where 50% of customers have smart meters, and if they have at least 8 single-phase substations where 50% of customers have smart meters. To support validation of the results, HV feeders are prioritised if at least one substation (or primary) has three-phase voltage monitoring.

To support the second phase identification method within HV Pilot, good quality helicopter survey data is needed for the selected sample area feeders. Initial review of this survey data suggests this requirement will constrain the selection of primary substations. The process to review this data is not fully automated so a ‘long-list’ of substations has been identified for which the smart meter data is likely to be appropriate. This list can then be reviewed from the perspective of the helicopter data.

The final deliverable WP1 D3 from this work package will bring results of these two assessments together to select the sample set of primary substations.