WESTERN POWER DISTRIBUTION

Serving the Midlands, South West and Wales

a nationalgrid company

Losses Strategy

July 2022

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2022 Losses Strategy

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1. Introduction

Distribution network losses are the difference between the electrical energy that enters the distribution network and the electrical energy that reaches the customer. Consequently, a proportion of the energy generated does not reach the end user, meaning more power must be produced to meet demand.

The energy lost in distribution creates a financial cost which is paid for by customers and contributes to carbon emissions. Although the carbon intensity of the UK grid is decreasing, losses remain a contributing factor whilst any electricity generation emits carbon.

Continuing on a pathway to reduce the losses on our network, where reasonably practicable, will result in savings for our customers and reduce Western Power Distribution's (WPD's) carbon footprint. At a time where energy costs are high, attention on operating an efficient network is key. In addition, reducing losses effectively can free up network capacity, which is an essential consideration as energy consumption is likely to increase as we approach 2050. This additional capacity can also result in deferred reinforcement projects that are often costly.

Growth in import and export due to increased distributed generation (DG) and low carbon technology (LCT) connections such as electric vehicle (EV) charging points and heat pumps (HPs) have led to increased peak power flows and total energy demand, resulting in greater network losses. In addition, the operation of a smarter and flexible network means greater the utilisation of existing assets will be necessary, giving rise to additional network losses.

Delivering the best whole-system approach for our customers through operating an efficient, coordinated and economical distribution network is necessary to manage distribution losses as we progress to a smart and flexible electricity network.

This document will provide a fundamental explanation of losses and outline the actions that are being taken by WPD to reduce them.

When losses became a focus for Ofgem, WPD and UKPN commissioned the SOHN Associates 'Management of Electricity Distribution Network Losses report.

This report provided us with a starting position and 26 effective recommendations for reducing distribution losses.

It was decided that the report would reflect the work carried out by WPD in respect of losses and that any third party could observe the progress made.

Management of Electricity Distribution Network Losses - Final Report

Additionally, items from the ENA Technical Losses Working Group have been included, such as the research completed by the engineering consultants WSP.

The document has since extended its focus to take into account future changing demands on the electricity network as a result of the introduction of LCTs and the UK Governments' Clean Growth Strategy, The Energy White Paper and the Future Homes Standard.

1. Introduction

1.1. Understanding losses

As stated, losses are the difference between the electrical energy that enters the distribution network and the electrical energy that reaches the customer. These losses are typically classified as:

Technical losses

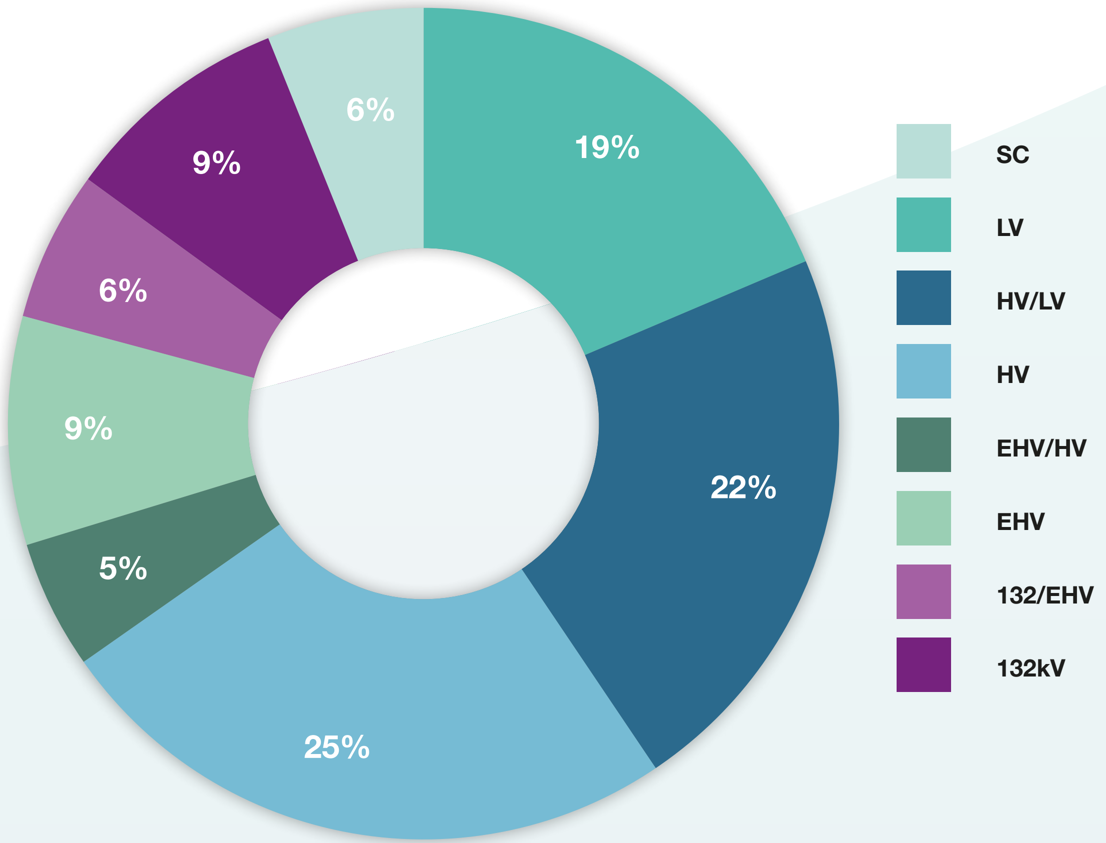
Non-technical losses

In addition to both classifications, other factors including harmonics, phase imbalance and power factor contribute to distribution network losses and will be discussed briefly in this section.

To date, losses are reported through the GB Settlements arrangements. This process is used by suppliers to determine the amount they have to pay for purchases from generators and is defined in the Balancing and Settlement Code (BSC). Distributors obtain information about the electricity entering and leaving the system by reference to the industry-standard data flows to bill suppliers for distribution charges. The reported losses is the difference between the units entering and the units leaving the network. This is a large number and any inaccuracies or errors within this reporting methodology, such as meter reading problems or inaccurate records for unmetered supplies, will have a magnified impact.

From a DNO perspective, maintaining an updated and accurate record of unmetered supplies is therefore important to minimise any inaccuracies in losses reporting.

Figure 1, an extract from the SOHN Associates and ICL report, shows a breakdown of GB distribution network losses, calculated using representative network models. Annual losses are estimated to be between 5.8% and 6.6% of energy delivered and three quarters of losses occur in LV and HV networks.



SC – Service Cable **EHV** – Extra High Voltage[1] **132 (132kV)** – 132,000 Volts

[1] EHV is defined as 22kV or above.

1. Introduction

1.1. Understanding losses

1.1.1. Technical losses

Technical losses arise for physical reasons and depend on the energy flowing through the network, the nature of distribution lines and cables and transformers. The total amount of technical loss is made up of a fixed component (a function of the network itself, independent of the load on the network) and a variable component which is dependent on the level of load on the network. Variable losses may also be impacted by the power factor, network imbalance and the effects of harmonics.

Fixed losses

Some electrical energy is dissipated by network components and equipment such as transformers or conductors as a result of being connected to the network and being energised. Even if no power is delivered to customers, the system has losses when it is electrically energised. These losses take the form of heat and noise and are called 'fixed losses' or 'no-load losses', because they are independent of how much electrical energy the network delivers.

Most fixed losses can be exhibited within transformers from both the iron and copper losses. Besides transformer inefficiency, another source of fixed losses is the electrical insulation in network equipment. Imperfections in electrical insulation lead to the flow of very small currents across them in transformers, overhead lines, underground cables, and other network equipment.

These types of fixed losses are called 'dielectric losses' or 'leakage current losses' and vary with the voltage level, the physical wire diameter, and with weather conditions such as rain and fog.

While fixed losses do not change with current, they depend on the applied voltage. However, as the applied voltage is relatively stable while the network equipment is energised, they are essentially fixed. Therefore, fixed losses are a function of the network itself and depend mainly on the number of energised components.

In general, fixed losses contribute roughly to between a quarter and a third of the total technical losses on distribution networks.

Variable losses

The variable component of losses is created by the heating effect of electricity passing through the cables and windings. All conductors, whether they are coils in transformers, aluminium or copper wires in overhead lines or underground cables and even in switchgear, fuses, or metering equipment, have an internal electrical resistance which causes them to heat up when carrying electric current. As a result, the variable losses change as power flows increase and decrease (proportionally to the square of the current), transmission networks experience a lower level of losses because at higher voltages a lower current is required to transmit the same amount of electric power. Additional factors such as the effect of network imbalance, power factor and power quality can also have an impact on variable losses, as they influence the value of the currents flowing through the conductors.

Additionally, variable losses are dependent on the length and the cross section of the network line as they vary in proportion to the conductor resistance. The resistance of a conductor decreases as its cross sectional area increases. Therefore, the effect of losses is reduced with larger cable sizes. A similar principle also applies to the variable losses in transformers, where the cross sectional area of windings, and the materials used in them, influence the variable losses.

In general, variable losses contribute roughly between two-thirds and three-quarters of the total power system technical losses. They either aim to lower the system power flows or to lower the resistance of the transportation paths. A reduction in the utilisation levels of network assets can contribute to lower both current and resistance. Any capital investments required for loss reduction must show a positive lifetime cost benefit analysis.

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1. Introduction

1.1. Understanding losses

1.1.2. Non-technical losses

Non-technical losses are caused by actions that are external to the power system. They refer to lost energy that is not directly related to the transportation of electricity and occur independently of the physical and technical characteristics of the network (technical losses). Cases of non-technical loss cannot be fixed by upgrading equipment or altering network design. Instead investigations, audits and collaborations with other bodies are required. This kind of loss involves the abstraction of electricity with a loss of revenue to both the network operator and the supplier, and are categorised as follows.

Theft in conveyance

Theft and fraud generally account for a majority of the non-technical losses from the network. These are important challenges for the DNO, and require a concerted effort from a range of stakeholders to mitigate them.

It is difficult to gauge the exact extent of this type of loss as a large proportion of it is likely to go undetected.

When a property does not have a meter installed or a registered supplier, it is referred to as theft in conveyance.

Unmetered supply

Not all supplies in distribution networks are metered. There are many items of electrical equipment where it is neither practical, nor cost-effective, to measure energy consumption using conventional meters. In these circumstances, there are legitimate unmetered supplies whose energy demand is estimated rather than accurately metered. All unmetered connections can be treated as any other type of load, provided that it is registered, properly estimated and accounted for. Moreover, customer-related unmetered connections (e.g. public lighting) or some of the DNO's own consumption (e.g. auxiliary services of substations) can be adequately contracted from an energy supplier and paid for by regular tariffs as any other normal consumption. Therefore, unmetered consumption, whether related to customers or the DNO, can be excluded from non-technical or technical losses, respectively, provided they are adequately contracted. Only the difference between the real and estimated unmetered consumptions is part of non-technical losses.

In the case of equipment such as street lighting, traffic lights and road signs it is not practical to meter every unit. Instead bills are estimated using the power rating of the equipment, the approximated time of use and the number of units. It is not uncommon for these estimates to be inaccurate or an inventory of equipment to be out of date. In order to reduce these losses, DNO's must work alongside customers with unmetered supplies to improve the accuracy of inventories, to produce more accurate bills.

1. Introduction

1.1. Understanding losses

1.1.3. Other factors

Phase imbalance

A network that does not have its load evenly distributed across all three phases will have higher currents in at least one phase meaning it is not optimised for losses. There will also be currents flowing in the neutral conductors if they are present. Due to the quadratic dependence of losses on current, this load imbalance across the three phases will increase losses.

Imbalance is found on all parts of the low-voltage (LV) network due to customers who use one or two phases having different load consumptions. On the high-voltage (HV) network, imbalance is due to the uneven distribution of single-phase transformers or two wire spurs and different loads on each phase for three-phase customers.

The most obvious way to reduce phase imbalance is to carefully balance the aggregated load on each phase, but as customer consumption is not always predictable and varies at different times of day, this can be difficult.

Interventions to alter connections will help balance customers and load across a network based on the maximum demands of those customers. Balancing load profiles over time is very complex, so some imbalance will always occur at certain times of the day. Loads will change in the future so any action taken to balance the network will have to consider what changes are likely to occur in the future.

Harmonics

Harmonic effects are essentially distortions to an AC current profile. They can occur in transformer windings because the AC magnetising current is not perfectly sinusoidal. However, this usually occurs on the triple harmonics (3rd, 6th, 9th etc.) so on a normal three-phase system they are all in phase and do not result in any real harmonic voltages. However, if other equipment connected to the network produces harmonics they will not cancel in the neutral conductor. These can then cause additional I^2R (copper) losses, as in real terms the losses formula becomes $I^2R+\sqrt{H}$ where H = harmonics on the network. This increases the overall load on the network which in turn increases the losses.

Power factor

Two ways to define the power in a system is with real and reactive power. The real power is the capacity of the system to do work and the reactive power is the product of the voltage and the current flowing. The power factor is the ratio of the real power to the reactive power.

Where the power factor is less than unity the current has to increase to deliver the required amount of real power, which results in a loss. This has historically been an issue for installations used by industrial and commercial customers, where most motor loads or power electronic loads were seen. Developments in domestic power electronics and heat pumps mean networks will start to see this issue occurring more on the LV Mains networks.

Since 2010 WPD have been including an excessive reactive power charge for HV and LV half hourly metered, via the Use of System Charges, where customers have a power factor of 0.95 lagging. This is to ensure that the reactive power is kept to a minimum as with any load the DNO has to cater for the reactive power for the sizing of the circuit even though that reactive power is not being used effectively.

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2022 Losses Strategy

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1. Introduction

1.2. Losses Strategy deployment and governance

Since 2016 we have published annual updates to the Losses Strategy to keep stakeholders updated on progress. New items have been included and the strategy has grown to account for decarbonisation and the impact of LCTs.

The WPD Losses Strategy is reviewed on an annual basis and stakeholder events are held annually where losses are discussed. This frequency of review is supported by the stakeholders.

This 2022 version of the Losses Strategy provides updates on any work carried out since the last 2021 Losses Strategy document review and how WPD have progressed on each item.

The WPD Losses Strategy is developed within the Electricity System Development Team and is approved by the CEO.

Within this governance, the Electricity System Development Manager is responsible for the development of topics to address from the SOHN Associates Management of Electricity Distribution Network Losses report. Each year the recommendations from this report are developed into areas for investigation.

During the RIIO-ED1 period WPD will address each of the recommendations and plan to develop at least one technical and one non-technical recommendation per year. Appendix 1 shows plans for each recommendation and a justification for the WPD assessment of each plan.

1.3. Objectives

WPD's objectives regarding losses management by the end of the RIIO-ED1 period in 2023 are as follows:

- Losses across the WPD network will have been reduced to a level that is as low as economically and practically viable;
- all future investment decisions will take losses into account to ensure that the best balance is achieved between network investment costs today and energy supply costs for future customers;
- providing the SMETS 2 smart meter data is available, WPD will have the tools and methods in place to accurately locate the points on the network with particularly high losses;
- all WPD stakeholders will be aware of the importance of losses;
- using the knowledge gained from innovation projects, computer modelling and investment appraisals WPD will, through business-as-usual (BAU), have produced new and effective means to reduce losses.

1. Introduction

1.4. Outputs

During RIIO-ED1, WPD are undertaking the:

- Pro-active replacement of 1,996 distribution transformers for those with increased efficiencies;
- purchase and installation of 90 single-phase, 25kVA 11kV amorphous pole-mounted transformers (PMTs);
- oversizing of 448 ground-mounted transformers and 575 pole-mounted transformers per annum;
- intervention of losses design on new installations of 8,184 distribution transformers and 11,880 kilometres of underground cables;
- discontinuation of cable tapering on all new 11kV and LV mains cable circuits;
- standardisation of new 11kV and LV mains cables to minimum conductor sizes of 185mm² and 300mm², and LV service cables to 25mm² copper (Cu) or 35mm² aluminium (Al);
- identification of units lost to supplier side abstraction, unmetered supplies and theft in conveyance;
- commencement of a stakeholder engagement programme where losses are a designated topic;
- review of WPD policies to ensure losses are a priority consideration for investment decisions;
- reduction of voltages across all four license areas of WPD;
- introduction of three phase service cables and three phase cut-outs, where reasonably practicable, for all new builds and service alterations as BAU.

1.5. RIIO-ED2 proposals

Dependent on Ofgem's determination of our RIIO-ED2 Business Plan, WPD have submitted the following proposals as part of our ongoing ambition to minimise losses where reasonably practicable.

In RIIO-ED2, we will deliver further reductions by:

- Continuing to invest in the most efficient and low loss transformers in line with the EU Eco Design Regulations. Losses from these are 40% lower than with traditional transformers.
- Installing cables with larger cross sectional areas (CSAs),as standard - we will use 300mm² low voltage cable, replacing the use of 185mm² (larger CSAs allow easier power flow, thereby reducing losses).
- Discontinuing the use of smaller transformer sizes on our overhead line networks and removing 25kVA single phase and 50kVA three-phase units from our traditional range. Using larger transformers results in reduced losses as a result of lower energy loss in the transformer core.
- Continuing to work in collaboration with electricity suppliers and other authorities to further reduce electricity theft and illegal abstraction.
- Replacing the 1,095 PMTs installed pre-1958 for new, 'next-size up' (e.g. 50kVA to 100kVA) transformers to increase network capacity and reduce technical losses.

2 Standard conditions of the electricity distribution licence

2.1. Part B: The Distribution Losses Strategy - Clause 49.4

This Losses Strategy has been reviewed and modified to ensure that it provides economically beneficial interventions that will help keep distribution losses as low as reasonably practicable.

The cost-benefit analysis (CBA) methods used in this version of the Losses Strategy are based on the Ofgem CBA process, current WPD cost models and use the current Ofgem valuation of losses.

2.2. Part B: The Distribution Losses Strategy - Clause 49.5

A copy of this Losses Strategy document is available externally on the WPD website:

Western Power Distribution - Losses Strategy

As detailed in section 1.1, during the RIIO-ED1 period WPD have looked to work through the recommendations of the Management of Electricity Distribution Network Losses report. Since the last version of the WPD Losses Strategy in July 2021, WPD has updated the Losses Strategy to include the recommendations considered during the past 12 months as well as any updates on ongoing objectives.

The Losses Strategy document is an update of the previous publication and preserves the existing format to provide a consistent and clear view on progress. Previously, WPD's Losses Strategy undertook considerable restructuring to make the document easier to read and navigate. Updates include project progress such as the three phase housing estates and update on WPD targets.

During 2022 WPD will continue with their Losses Strategy and progress on initiatives to reduce network losses. This includes the ongoing replacement of pre 1958 transformers. Policies prohibiting the tapering of LV and 11kV circuits, the use of 4mm² Cu., 16mm² Cu. and 25mm² Al. LV service cables, 95mm² Al. LV mains and 95mm² Al. 11kV cables remain in place as BAU. Pre-defined solutions e.g. installing a padmount transformer are exempt. Three phase service cables complete with three phase cut-outs are being installed where practicable as BAU for all new build and LV service alterations following the 2020 Consultation. Early indications from a South Wales housing development shows that losses are reduced, as a result of this policy, compared with a single phase alternative.

In addition WPD is taking the government's Clean Growth Strategy to reduce the overall carbon emissions and by using both new build and retrofit projects can gain knowledge on the modelling and effects that photovoltaic (PV), energy storage (ES), HPs and EVCPs will have on the losses on LV and 11kV networks.

Battery electric vehicle (BEV) charging and the installation of HPs are the two major LCT demands that will be seen on the LV network. We must prepare the network for both as the government's Clean Growth Strategy on de-carbonisation of transport and heating incorporates both technologies. Additionally, the introduction of the updated 2021 Part L of the Building Regulations and 2025 issue of new Future Homes Standard could see the installation of HPs and 7.36kW type 2 EV chargers on every new building.

To prepare the network, WPD are working with a number of local councils with a view to creating charging hubs using low loss padmount transformers and working with councils to meet their clean air objectives. Previously, WPD has focused work on older and larger ground mounted transformer units. In 2019, WPD broadened the focus to start addressing losses on single phase pole mounted 11/0.4kV transformers. To date, WPD has purchased and installed the 88 25kVA single phase amorphous PMTs. As single phase transformers are outside of the EU Ecodesign Regulation, the transformers purchased have reduced iron losses to 16W compared to the current CRGO transformer Iron losses of 65W.

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2022 Losses Strategy

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3 Stakeholder input, review and governance

3.1. Stakeholder engagement

Stakeholder engagement is hugely important to every part of WPD's business. In developing the Losses Strategy, WPD carried out a specific losses programme of stakeholder engagement.

To date, we have conducted 4 losses focused stakeholder events since they began in November 2014, where the draft Losses Strategy was presented. The event has since become biennial and is conducted in November.

In January 2015, WPD proposed the topic of losses with stakeholders at six general sessions and soon realised that losses were of real interest to stakeholders, though they were content to leave the more technical debate to specific losses stakeholder events.

Losses event invitations were initially sent to our general stakeholder engagement database, which includes stakeholders with a technical awareness and interest in losses.

We targeted people from manufacturers, other network operators, electricity suppliers, customer groups, academics, consultants and regulatory bodies. This has expanded to include anyone interested in attending.

Our stakeholders have led the way on how we manage both the strategy and events. We are committed to delivering on their agreement that the Losses Strategy should be reviewed and re-issued annually and that dissemination events would be useful every second year, or when a significant development had occurred.

On 9th December 2019, we held the third losses focused stakeholder event and gave an update on our work plan, current learnings and suggested updates to our strategy as a result. At this event, we were excited to discuss our Losses Investigation project and were pleased to welcome SSEN to share our event collaboratively and discuss Low Energy Automated Networks (LEAN) transformer management.

Our next biennial event was planned for 2021 and was to support the formation of our RIIO-ED2 Business Plan stakeholder engagement.

Due to the Covid-19 pandemic, this was not possible and instead we are excited to undertake the next engagement event in autumn 2022.

See Appendix 2 for the topics covered at each event to date.

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3 Stakeholder input, review and governance

3.2. Stakeholder feedback

The majority of the feedback received at the last consultation was positive and stakeholders were pleased that WPD are heading in the right direction and happy for WPD to continue working as they are. As a result of the discussions, suggestions were made for specific actions that should be taken. New subject areas such as the impact of EVs, HPs and future LCT effects on the network have been added into the Losses Strategy.

3.3. Industry-wide engagement

Although less frequently in 2022, all Distribution Network Operators (DNOs), including WPD and ESB meet under the ENA Technical Losses Task Group.

We continue to work closely with National Grid to adapt their standard terms and conditions to allow demand-side response (DSR) customers to operate in both the transmission and distribution flexibility markets. Centrica lauded a 'world first' Local Energy Market (LEM) to all National Grid ESO and WPD to procure flexibility on the same platform.

To widen our engagement to other DNOs and Ofgem, we created the DSR Forum to discuss this platform in more detail.

3.4. International best practice

Now WPD has recently been acquired by National Grid, previous issues raised concerning the differing operation between the British and American systems have reduced, as our previous parent company, PPL, were American based.

While our research into the optimum length of LV feeders did not produce any evidence to change our proposals, the research conducted with SOHN Associates has been presented as a paper in the CIRED conference held in Helsinki in June 2016. A regular topic in the ENA Technical Losses group is a section on best practice where all information that is gleaned from parent companies or data obtained from other sources is discussed and made available.

3.5. Sharing best practice

At WPD we believe engagement with other network operators is essential as it leads to the development of best practice. This desire can be traced back to our IFI project on losses with UKPN. Having concluded prior to the specific work on the WPD Losses Strategies, it helped WPD to shape its own strategy. Project findings have been shared with many other network operators and we are pleased to see the report referenced in other DNO strategies. Scottish and Southern Energy Power Distribution (SSEPD) not only shares WPD's intervention on pre-1960 transformers, but has cited WPD's IFI project as the research source.

Regular updates on our Losses Investigation have been included in the WPD Losses Stakeholder events, at the LCNI in Telford and at WPD's Balancing Act events where all our innovation projects are disseminated. All the documents are available for download on the WPD Innovation website, which can be accessed below.

Western Power Distribution - Innovation Projects

We are always keen to learn from others and utilise their research to develop WPD's plans. The third WPD Losses Strategy included topics highlighted in other DNO strategies and this collaborative approach continues. WPD were also pleased to see that other DNO strategies included elements of the WPD SOHN report. All DNOs face similar issues and this kind of peer review and inclusion is a fantastic development.

As part of sharing best practice, the purchase and installation of the 88 25kVA amorphous cored single phase PMTs resulted from the great work carried out by UKPN and Scottish Power.

4 Innovations and projects

Innovation projects lead the development of new methods to reduce losses, which is why they are a WPD cornerstone of the Losses Strategy. Many of the projects have a focus on network monitoring and automated control, aiming to flatten load profiles.

A range of LCNF and NIA projects are continuing to provide important new insights. New information obtained from these innovation projects can be used to construct new strategies record the progress in the next strategy document.

Innovative losses activities carried out under NIA funding such as the Losses Investigation, are not double claimed, but the information generated is used towards BAU implementation.

Work including the 'next size up' ground mounted transformer (GMT) initiative and the removal of pre-1958 GMTs has been carried out using core RIIO-ED1 funding.

This ranges from the asset upgrade provisions developed after the agreement of the ED1 plan, through to the three phase service cable project, which are being supported by WPD rather than being funded through innovation funding mechanisms.

Much of the work WPD have carried out at an industry level can be seen in our Innovation Strategy. The Innovation Strategy includes projects and initiatives, many of which show a reduction in losses as part of their targets to increase the utilisation of the network. Higher levels of utilisation will always mean an increase in losses, but a smoother demand profile can contribute to the overall reduction of network losses.

The Innovation Strategy can be found here:
Western Power Distribution - Innovation

4 Innovations and projects

4.1. SOHN Associates Losses Report

The SOHN losses report was commissioned by WPD and UKPN to provide an assessment of all the ways in which losses could be reduced. The report was written in partnership by SOHN Associates and Imperial College London to provide an academic viewpoint on the range of the losses problem. The scope of the investigation was very broad, as the intention was to develop multiple potential solutions to reduce losses.

Using a network modelling tool designed by Imperial College London and intelligent forecasting for future demand, potential approaches to reducing losses were identified. The report looked at possibilities such as heat recovery, active network management and asset replacement. These possible approaches led to 26 recommendations for DNOs to consider.

These recommendations have formed the basis of the WPD losses strategies and all will be considered during the course of RIIO-ED1.

4.2. LV Templates

The LV Templates project set up a highly monitored network in South Wales to explore the possibility of characterising substations into a number of 'templates' that could be used to describe the temporal load and voltage behaviour of substations nationwide. The areas chosen for monitoring had dense populations of LCTs. This was to enable scaling up to represent the UK as a whole. It concluded that around 82% of UK substations fitted one of ten district templates identified in this project.

In additions, the project also provided data visibility on LV network voltages indicating that the voltage levels could be reduced and remain within statutory limits. Having completed a programme of voltage reduction in the South Wales area, results have shown that a 0.88% reduction in primary voltage resulted in an average demand drop of 1.16%.

WPD continued to do so in all license areas in 2020. By changing the settings at primary substations, the voltage change can be made automatically without interrupting customers. Although losses increased as a percentage, overall losses were reduced due to the reduction in power.

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4 Innovations and projects

4.3. Losses investigation

This was an NIA funded project and is not claimed as losses work by WPD, but the data gathered has supported network enhancement and reduced losses. Data relating to the power consumed by all individual connections on an LV cable or network was not included in the LV Templates monitoring, which was set up to measure the overall profile of a distribution substation.

Through a field-work programme for HV feeders, one minute resolution logging equipment was installed at the Primary Substation on the source breakers of the sample feeders, and at each load connection point along the feeder. This provides comprehensive information about the power flows for a complete HV feeder, allowing actual losses to be assessed for a specific feeder.

For LV feeders, one minute resolution logging equipment was installed at Distribution Substations, monitoring the entry/exit of power onto LV feeders with one minute data being logged at all connection points along the sample LV feeders. As with HV feeders, this instrumentation provided comprehensive information about power flows for a complete LV feeder, and allows actual LV losses to be assessed for a specific feeder. The LV field work was carried out on the Isle of Man in collaboration with Manx Utility Authority, as WPD are not allowed access to individual customer data in their own regions.

The Losses Investigation report has been completed and final reporting has been carried out, but as the initial work only looked at the East Midlands area this was extended to cover the whole WPD area.

The development of the HV feeder loss estimation process has been completed, feeder-specific annual mean loss estimates have been generated for three of the four regions of WPD. Findings and learning from the HV loss estimation work can be found **here.**

Key items include:

Method - For each HV feeder, the loss estimation method combines network topology data with demand data to run a power-flow analysis from which the individual feeder losses are calculated. These individual feeder results are then collated so that loss characteristics of the overall HV feeder set can be examined and identified. An outline of the method is shown in Figure 2:

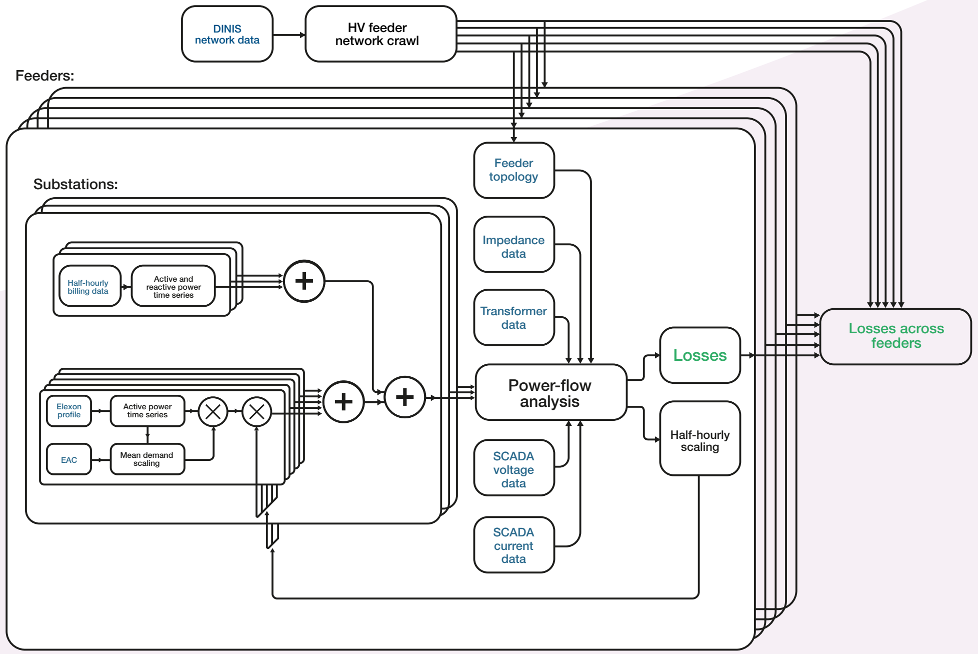


Figure 2 - architecture for loss estimation method used in the Losses Investigation Project

The results of the loss estimation method for the monitored HV feeders established at the start of the project have been found to be in good agreement to the loss assessments of these feeders using the measured data.

4 Innovations and projects

4.3. Losses investigation

Validation - In addition to overall method validation, a number of outlying results have been reviewed. The review of each feeder included feeder topology, together with broad characterising metrics and drivers of the level of loss.

The review also considered potential opportunities to reduce the losses, as a test of the capability of the analysis to support mitigation investigation work. The feeders include in the validation work are highlighted on the plot shown below, with the vertical axis representing the annual cost of individual feeder losses.

In all 15 cases reviewed, the estimated level of loss could be linked to characteristics of the network including length, cross-sectional areas and number of connected transformers and the load such as how the load is distributed across connected substations, and the location of dominate loads on the HV feeder.

Signposting – the HV feeder loss estimation process has demonstrated how HV feeders with high losses can be identified. These high loss feeders can then be reviewed to assess the cost-benefits of loss mitigation. The results also identify a set of higher loss individual feeder branches and possible higher loss distribution transformers.

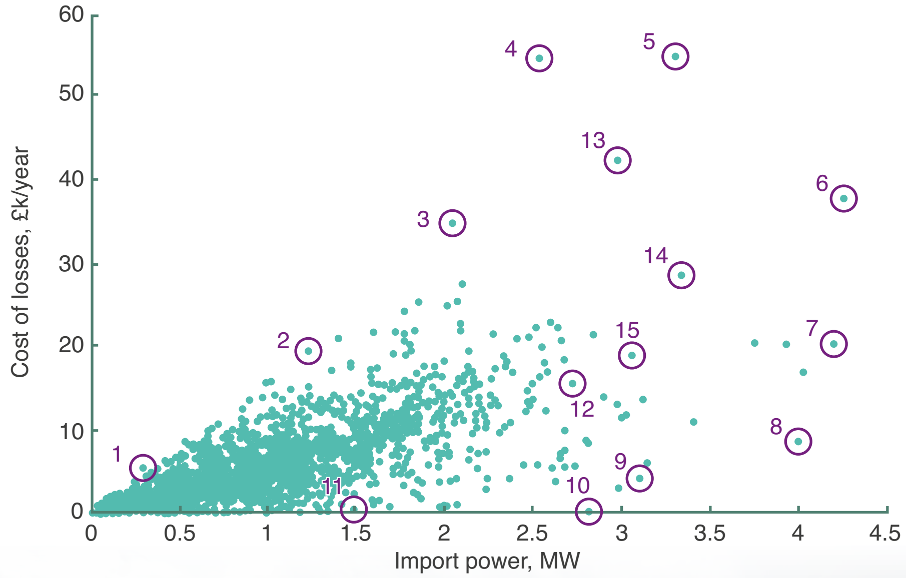


Figure 3 - Feeder annual cost of losses from Losses Investigation project

4 Innovations and projects

4.4. Network Equilibrium

The focus of the Network Equilibrium project was to balance voltages and power flows across the distribution system, using three methods to integrate distributed generation within electricity networks more efficiently. The project considered three methods to improve voltage and power flows: Enhanced Voltage Assessment (EVA); System Voltage Optimisation (SVO) and a Flexible Power Link (FPL).

In some places, parts of the higher voltage networks are run in parallel with the lower voltage networks. This means there is more than one open point between the two levels of the network, allowing loads to be better balanced, in most cases.

The FlexDGrid and Equilibrium projects have developed methods to monitor and automatically reconfigure networks. There are areas of the network where it is not possible to operate with parallel feeding arrangements (meshing) due to technical limitations. These can be due to loads, generation or fault levels.

The EVA method enables the two technology solutions, SVO and FPL, to be suitably modelled and understood. It also demonstrated the value of expanding the existing voltage statutory limits for 11kV and 33kV networks to +/-6% and +/-8% respectively. This would facilitate an increase in utilisation of the existing system, thus removing or deferring the need for additional asset investment.

These models will also enable the network to be optimised in terms of full system losses, aligned with the learning from LV Network Templates and reducing the voltage as strategic points on the network.

The SVO method assesses the operational state of the network in real-time, considering connectivity and connected load and generation, to determine the optimal voltage and then communicate these calculated values to the on-site voltage control relays to implement the voltage change. The SVO system will then calculate the optimised voltage level, lowest value for generation inclusion and highest value for load facilitation, enabling on-site changes to voltage to occur. The system went live in March 2018 and has demonstrated significant network value through actively being able to control the voltage on the system.

The FPL device is an AC-DC DC-AC converter provided by ABB, which has been built, tested and was installed on the live Exebridge substation 33kV system in June 2018. This has enabled WPD to connect the Barnstaple and Taunton BSPs networks in parallel, providing the flexibility to move real and reactive power around the network to optimise the operation of the system and enable increased utilisation of the existing assets.

The FPL aims to enable active power transfer between two network groups whilst independently controlling reactive power between each of the two grid groups to provide additional voltage support. The device works by connecting the two, previously distinct, networks together with two back-to-back AC-DC converters, removing any phase displacement or fault level constraining issues that currently exist. The device itself produces relatively high levels of loss so it will only be used for short periods when the losses benefits outweigh the costs. This has been trialled and the benefits of the FPL have been demonstrated to ensure that there are no network violations on the system whilst enabling more generation to connect to the system.

4 Innovations and projects

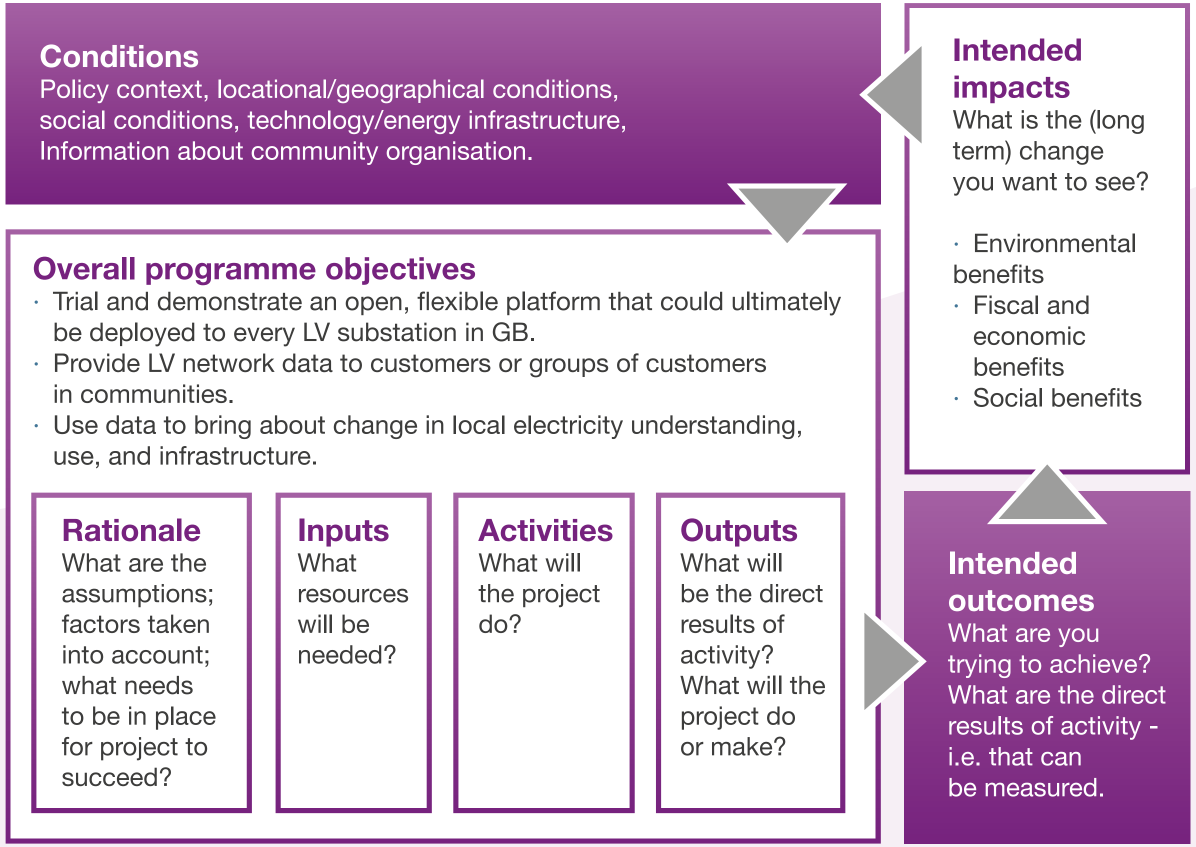
4.5. OpenLV

The OpenLV Project was about trialling and demonstrating an open, flexible platform that could ultimately be deployed to every LV substation in Great Britain. Through three key Methods, the Project demonstrated the platform's ability to provide benefits to the network, customers, commercial entities and research organisations. Once deployed, the OpenLV platform can be used to provide data to customers or groups of customers in communities.

Method 2 trials involved the active engagement of communities to provide organisations and individuals with direct access to LV network data through a secure third party hosted service. This is unique to the OpenLV project so there is learning to be gained from looking at how this will be achieved with the Community Engagement trials, and the ways in which community organisations propose to use LV network data in their communities.

The logic model provides a means of planning community-based project activity to achieve a set of outcomes for use of the OpenLV data, as well as a structure against which to evaluate the trial.

Figure 4 below shows the basic template which was used. Much of the content of the logic models was common to each project, particularly in terms of project activities and intended outcomes.



In RIIO-ED2, we have proposed an £8.88 million investment for OpenLV network monitoring to give communities more visibility of their local network usage, to stimulate and promote net zero actions.

4 Innovations and projects

4.6. Industrial & Commercial Storage Project

Four sites were selected to integrate different configurations in the application of storage. The fundamental operation of the energy storage system will be to store energy at times of low load seen on the network and dissipate energy at times of high load in order to actively manage the load on both the LV and HV networks. More specific applications include peak shaving, load shifting, transmission and distribution support, islanding or emergency back-up. Through this project WPD will be able to develop an alternative connection agreement for behind the meter storage designed for industrial and commercial customers.

At Spilsby, WPD has installed a 50kW/210kWh with 30.75 kW of local PV generation to test peak shaving and PV self-consumption. We will show how storage charges from PV and at peak demand storage can be used to eliminate peaks and reduce losses. Batteries designed to capture surplus electricity generated by a solar PV system can allow consumers to store solar electricity for use later in the day.

At Boston, WPD has installed a 50kW/210kWh with 21 kW of local PV generation. Third party controller integration allows the Powerpack user to change the battery behaviour during the operations. The controller will run multiple services on the customer's behalf. This could be for example a combination of frequency support services and wholesale trading activities.

At Cardiff WPD has installed a 50kW/210kWh with 8 kW of local PV generation. This project has two parts at this site. Part 1 will show the energy storage capability to support the grid via Frequency Support Mode. Part 2 of the project adds 3rd Party Controller (KiwiPower) integration to test the communication interfaces, data monitoring and send remote direct commands to the batteries.

At Taunton WPD has installed a 50kW/210kWh with 50 kW of local PV generation. This will demonstrate Backup & Islanding modes. Despite expectations, some storage systems will not provide power during a power-cut. Some battery storage systems however do have an 'off-grid' functionality, providing a limited amount of power to your premises, or to essential equipment (such as your fridge-freezer, lighting etc.).

But a battery may run out of power before the power cut ends – or have already run out of power if it's been discharging all evening and the power outage starts late at night or early in the morning. If a system is required to operate in 'island' mode, i.e. continuing to provide power to critical loads during times when the distribution network is not available, it is important to understand the load handling and load shedding capabilities of the energy storage system.

As well as being capable of operating in 'island' mode, the battery/hybrid inverter must be rated to supply the power required by the load (including any inrush current). Typically, critical loads will be separated from other loads and connected to the energy storage system via a dedicated distribution board. An automated make and break contactor disconnects mains supply and connects the energy storage system to these loads, so that they receive a continuous electricity supply while ensuring power from the electrical storage system is not fed back to the distribution network.

Additional consideration should be given to the operation of protective devices and the provision of continuous earthing when operating in island mode. RCDs for the critical loads will need to be capable of operating under both supply conditions and not trip as a result of the transition.

Site Name	Status	Application
Spilsby	Commissioned - Online	PV self-consumption
Boston	Commissioned - Online	Active Control by WPD - Nortec
Cardiff	Commissioned - Online	Part 1: Providing Grid Services Autonomously (Primary Frequency Support)
		Part 2: 3rd Party Controller Integration (In collaboration with KiwiPower)
Taunton	Commissioned - Online	Emergency Load Backup

4 Innovations and projects

4.7. New and Retrofit Housing Projects in Wales

To develop new and innovative methods to reduce losses, WPD are working with Pobl Living, Sero Energy and Loughborough University at Parc Eirin in Tonyrefail, South Wales, where 225 new homes are being built, each installed with PV, ES, HP, EVCP and smart white goods. The devices are connected to an Energy Management System (EMS) or Program Logic Controller (PLC) and the homes are supplied via three phase service cables and dark fibre. Fully monitoring each home and the 11kV LV Mains feeders will provide a comparison to the Isle of Man Losses Investigation that looked at single phase LV services. What WPD are envisaging is a reduction of losses in the LV services cables, LV Mains cables and in the 11/0.4kV unit substation supplying the housing estate. It is envisaged that use of three phase service cables will reduce out of balance loads in the LV mains cables and on the 11/0.4kV transformer.

To date, Loughborough University have modelled the estate and provided WPD with analysis of the site. Initial conclusions indicate that a reduction in losses, compared to a single phase equivalent, can be seen. As the utilisation of EVCPs increase, the loss disparity is set to grow, as each EVCP is a three phase device thus does not cause phase imbalances. Understanding on the effective design of three phase housing has been gained, as to ensure that export and import via different phases do not cause imbalances. Further modelling will be conducted to determine the financial benefit analysis through the use of three phase services, but current outputs do not reflect the customer benefits and flexibility capabilities that are added due to increased functionality.

In a second project, WPD are again working with Pobl and Sero in Blaen y maes, Swansea where circa 700 homes are being modified and retrofitted with PV and ES, with each device being connected to a PLC. Each home will be supplied via three phase service cables and some on street EV charging. WPD will be fully monitoring the 11kV LV Mains feeders and each home to replicate the Isle of Man Losses Investigation which was looking at single phase LV services.

We envisage the same results as Parc Eirin and this project will add to the data and analysis gathered.

WPD is looking at part of the Blaen-y-maes Housing Estate project which will be supplying a dedicated three phase 4 core 300mm^2 Wavecon LV mains cable to street furniture and lighting to overcome the issue of charging electric cars, where the house holder does not have a dedicated driveway. To date, our teams have installed a number of new substations, laid new LV mains circuits and de-looped the houses to enable the connection of LCTs for the project.

In both of these projects the data gather will help produce updated ADMD information which will be required for designing future networks to the correct standard, such as the potentially improved diversity of three phase versus single phase EVCPs.

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4 Innovations and projects

4.8. Demand Forecasting Encapsulating Domestic Efficiency Retrofits (DEFENDER)

The aim of this NIA project is to develop an understanding of the electricity demand profile of UK domestic building stock pre-and post-retrofits to building fabric. Produce a methodology for integrating pre- and post-retrofit domestic demand profiles into network forecasting. Assess the potential savings on network reinforcement and flexibility from accounting for energy efficiency in demand forecasting. Perform an economic assessment of the potential benefits to networks from increased penetration of domestic retrofit interventions.

Currently, within the RIIO-ED2 Business Plan it is projected in WPD’s Best View that there will be an approximately increase in peak demand of more than 2GW, resulting in a primary and secondary reinforcement spend in ED2 of £635m, at a cost of approximately £318k per MW. Around 600k heat pumps are expected to be installed within the same period, increasing electrical demand from heating by approximately 1.8GW under current modelling estimates.

A 6% reduction in this demand due to energy efficiency retrofit, as per a 2020 Committee on Climate Change study on residential heat decarbonisation trajectories, could result in an estimated £38m in reinforcement savings in ED2 alone.

Although a reduction in demand through efficiency measures will reduce network losses, greater utilisation of the network for a sustained period could end up creating additional costs from losses. This can be taken into account through a CBA when assessing reinforcement vs energy efficiency retrofit.

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5 Improving understanding

For WPD to reduce losses effectively, there is a need to have a far better understanding of them. WPD needs to quantify the losses that are present on the network, identify where they occur, understand why they occur and have methods for predicting what effect that certain actions taken to reduce losses will have on the losses in real terms.

5.1. Quantifying and monitoring

Raw levels of losses in kWh are of significance for any DNO, but a direct comparison with other DNO losses levels is more difficult. Indeed, DNO losses depend not only on the network structure, but also on network energy flows. Losses rates make a comparison between loss and energy flow levels. Consequently, they provide reference values that may be comparable between networks, even if they are detailed by voltage level for relevant benchmarks.

Raw losses values and losses rates have to be calculated over long periods (at least 3 years) to ensure stability and robustness, as total losses for a given year may not be significant due to variability and uncertainty (due to data collection hazards or climatic conditions). In order to see the effect of reducing losses WPD needs to be able to determine the baseline level of current losses. This was supported by the Losses Investigation project, as described in section 5.3.

As stated in section 1, the measurement at the customer end can be inaccurate, specifically in the case of domestic customers as some meter readings are estimated values. Statutory limits for domestic energy metering is -3.5% to +2.5% accuracy. This rough calculation does not discriminate between technical and non-technical losses, nor does it give any indication of where the losses occur. There are other monitored points along the network, typically substations, which can help identify where the losses occur.

Our standard LV distribution cabinets have always been manufactured with a simple current transformer (CT) fitted, which measures the peak load. When transformers are replaced, they are now installed with more accurate current transformers, which are wired to a terminal block where more advanced monitoring equipment can be attached. On the EHV network, half-hourly loading data is recorded at all substations. However, there are areas of the network, especially at LV where there is limited monitoring across the network. Our proposals for RIIO-ED2 include the installation of 15,500 monitors at the most critical distribution substations on the network, along with the installation of power flow monitors at every primary substation to improve network visibility.

The de-carbonisation of heating and transport will impact the LV network most of all, as this is where the heat pump and battery electric car charging will be connected to the network. WPD have previously trialled the first generation of censored 11kV terminations developed by 3M, which gave the user the ability to measure current and voltage. The second generation is now cheaper, smaller and via the RTU. The number of parameters that can now be measured has increased dramatically, thus allowing the substation to be effectively monitored, especially if that particular substation already has an RTU to enable remote operation. Terminations of this style and functionality are now being considered to form part of WPD's BAU range.

5 Improving understanding

5.2. Smart meters

To date, there are 3 million smart meters connected on our network across our 7.9 million customers. This 38% coverage has already provided us with valuable learning around demand at certain locations, which has supported updates to our System Design policy. In turn, this will provide us with the means to refine our network designs and provide customers with better value for money when connecting to our network.

As the roll out of SMETS 2 smart meters continues, we will have the ability to change the nature of network monitoring as DNOs should have access to data points representing the consumption across their respective networks and LV feeders. Though, the statutory limits for domestic energy metering being [±] 1.5% accuracy must be accounted for. This smart meter data will be readily available in providing information on relevant circuits and updated on far shorter timescales, thereby providing vastly improved data on network loadings. Smart meters are also being installed at other points on the WPD network, so there will be a more complete picture of load flow across the network.

The deployment of smart meters should enable DNOs to implement a number of key strategies to manage losses. Firstly, customers could be incentivised to use less energy at peak times by using time-of-use tariffs, which would flatten the network load profile and consequently reduce losses. Secondly, it would enable areas of high loss to be identified, so that targeted action can be taken to reduce them. Finally, it would allow for real-time network management, meaning generation from both distributed and non-distributed sources and power flow across the network could be controlled to match present demand.

The completion of the smart meter rollout is planned for the 31st December 2024, but it is important to ensure that the necessary data analysis tools are in place to make maximum use of the data generated.

5.3. Computational modelling

Computational modelling is key when forecasting what will happen on our network in future and to determine what is happening on the unmonitored parts of the network. Modelling effectively creates a virtual, fully monitored network which can then examine and test new ideas. By utilising modelling tools, WPD should be able to map where losses occur on the network, allowing for a targeted approach to loss reduction. Modelling can also be used to predict the effect of future changes to the network, so that the effect on losses of all possible future actions can be considered before the changes are actually carried out.

Our LV system modelling tool includes losses calculations for each scenario used, but one of the first measures WPD undertook was to increase the LV Main and LV Service underground cable size and remove cable tapering, resulting in consistency across the company when upgrading the network. The 11kV system modelling tool also includes losses calculations and similarly we increased the 11kV underground cable size and removed cable tapering at 11kV, again resulting in consistent upgrades across the company. At EHV, WPD currently uses two system modelling tools, PSS/E and IPSA, with PSS/E being capable to produce losses calculations.

Whilst all EHV designs are bespoke, WPD has completed work to provide template solutions that incorporate the losses impact for generation connections.

Modelling should become even more useful once used in conjunction with smart meter data. By feeding the data into the model, real-time network models can be produced. Data at specific metering points can then be predicted and compared to the real data to establish the success of the model. The software will need to be redesigned to incorporate this feature. Once this level of insight into the network is established, it will be possible to create more targeted losses strategies, leading to far more effective loss reduction activities.

5.4. Harmonics

Harmonics are generated when non-linear loads are connected to the network. The currents generated by harmonics cause problems on the network and contribute to increased levels of losses. In real terms, losses are defined as $I^2R+\sqrt{H}$, where H is the harmonic content add to the total losses in distribution transformers.

Eddy currents in transformers will increase with the square of the harmonic frequency, so can become significant. Within the electrical world a derating factor, K factor, is defined as a ratio between the additional losses due to harmonics and the eddy current losses at 50Hz. It is used to specify transformers for non-linear loads. In other words K factor is a weighting of the harmonic load currents according to their effects on transformer heating.

WPD network monitoring does not routinely measure harmonics. Assumptions based on calculations of known harmonics can be inaccurate due to the effects of diversity, which apply to harmonics in a similar way to network loadings. The only accurate method of assessing harmonic spectra is to measure the harmonics using PQ monitors on the network. WPD is continuing to record data from the LV Templates monitored network, which gives WPD an indication of harmonic effects by measuring Total Harmonic Distortion (TDH) across an individual distribution substation area.

The standard retrofit LV harmonics monitoring solution is capable of recording THD data where appropriate. Reducing harmonic effects is difficult; the principal approach is to ensure that customers use devices that produce minimal harmonic effects.

The harmonics can also be reduced by fitting harmonic filtering devices, but the economic benefit of reducing harmonics is not great enough to justify the cost of the filters.

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6 Policies and actions

6.1. Assessment

This section contains all the various sections that WPD are currently focusing on with a view to reduce losses going forward. These actions will allow WPD to reorganise the network to make it run more efficiently, whilst identifying actions that can be taken to prevent or reduce energy loss to theft or unmetered supplies. However, there are also discussions regarding network design policies that WPD will be able to implement in the near future, with reference to the innovation projects investigating them.

6.2. Actions completed before 2021

- The discontinuation of cable tapering on all feeder and service cables.
- A comprehensive programme of stakeholder engagement including biennial stakeholder consultation events.
- Reducing cable lengths.
- Rationalisation of transformer sizes and application.
- The on-going reduction in variable losses from underground cables by removing the smaller cross-sectional area cables from normal use.
- The development of a new losses page on the WPD website.
- Creation of a Losses Engineer post within the Policy Section.
- Completed a programme of voltage reduction across all WPD licence areas.
- WPD built IT systems to receive and analyse all accessible smart meter data from the DCC.
- The update of the existing modelling tool for LV mains of the WPD network to output direct losses data and be compatible with smart-meter data.
- Commencement of monitoring housing estates with LCT devices. There are currently 52,000 EV chargers and 10,000 HPs installed on our network.

6.2.1. Cable tapering

Since 2012 WPD as part of the business as usual have installed link disconnecting boxes (LDB's) between LV substations on non-tapered LV mains cables, thereby providing the possibility of mesh connections and back feed potential under fault conditions.

In addition since the start of 2015 WPD has amended the design policy and now all designs of the LV mains underground cable network are designed without cable size tapering. Networks shall be planned using either 185mm^2 or 300mm^2 Wavecon cables.

The size chosen for a particular scheme will be used throughout that scheme and tapering is no longer considered. Again since 2015 WPD has amended the design policy and now all designs of the 11kV underground cable network are designed without cable size tapering.

Networks shall be planned using either 185mm^2 or 300mm^2 11kV cables.

6.2.2. Cable sizes

To reduce the variable losses in underground cables either a lower resistance conductor must be used e.g. using a copper conductor; or the cross-sectional area of the conductor needs to be increased. Once an underground cable is laid and the cable trench is reinstated, it becomes expensive to make alterations to that underground cable circuit. The opportunity to reduce losses exists when an underground cable is installed or replaced. The resistance of a 185mm^2 Al LV cable is around half that of its 95mm^2 equivalent. The additional cost of the cable is less than £10 per metre, a marginal cost when compared to the excavation costs, which can be between £50 and £100 per metre. Whilst this cost is marginal, it is only appropriate to oversize cables in conjunction with other works. This action has formed part of WPD's ED-1 work.

In the case of underground cables on the LV network, it is cost-effective to uprate them, but only in conjunction with other works. For LV service cables it can be demonstrated that a benefit exists in discontinuing the smallest service cable size of 16mm^2. The cost of this will be around £0.33m per year at current prices. At 11kV it can be demonstrated that a benefit exists, in new build work, to discontinuing the smallest cable size of 95mm^2, costing around £1.42m per year at 2014 prices. In 2013 WPD renewed the MV framework contract, with the 33kV cable supply WPD took the opportunity to harmonise our cable sizes with other voltages. WPD discontinued the 240mm^2 size and standardised on the following 185/300/400/630 and 800mm^2 cable sizes.

6 Policies and actions

6.2. Actions completed before 2021

6.2.3. Transformers

Since the introduction of Ecodesign directive and the requirement to replace transformers with more efficient ones is well established and has now become business-as-usual for WPD. At 11kV the distribution transformers used on the WPD network comply with the 2015 Ecodesign directive.

Since 2011 all the WPD transformers purchased at voltages above 11kV, the transformer specifications already exceed the requirements of the Ecodesign 2015 directive.

The variable losses in a transformer are much lower when the unit is partially loaded, and increase quadratically as a unit becomes fully loaded. It is therefore possible to reduce the overall losses by oversizing transformers when they are installed. By using customer meter data to estimate the loading on all of the 500kVA, 800kVA and 1MVA 11kV transformers in the South West, WPD has completed a CBA which identified which transformers on the network are worthwhile oversizing. WPD found that it would be justified to oversize 325 transformers, which would save 854MWh per annum in losses.

Using data from the Centre for Sustainable Energy (CSE) WPD forecasts that the majority of up-take of LCTs will be on approximately 7% of our network; in these cases investment in oversized transformers is clearly justified. WPD as part of the business as usual aim to oversize on average 109 transformers per annum at a cost of around £0.11m per annum. The smallest size of ground-mounted transformer is now a 500kVA unit. There is benefit in oversizing these transformers universally on installation. WPD would aim to oversize on average 448 transformers per annum at a costing approximately £0.38m per annum.

Older designs of ground-mounted transformers have much higher losses than new designs. Whilst it is not efficient to replace all transformers early simply to reduce losses, it is envisaged to replace very old units and large capacity units in advance of their normal asset replacement plan. WPD aims to replace 1,996 pre-1958 ground-mounted distribution transformers (the entire fleet of these units) in the RIIO-ED1 period at a cost of roughly £2m per annum.

6.2.4. Reducing cable lengths

After the SOHN Report was produced, WPD employed SOHN to undertake a redesign trial of recommendation 11 using the WPD new standard of large cross sectional area (csa) cables the trial showed no benefit in additional transformers, in addition to SOHN work WPD have changed the policy documents which set out the design methodologies to be used by changing the design impedances to be used which automatically reduces circuit length. With the government's Clean Growth Strategy, the government's Energy White Paper 2020 which layout the de-carbonisation of heating and transport and the introduction of 7kW EV chargers to all new buildings as part of the Building Performance Regulation change in April 2020. WPD are now designing networks to cater for the increased loads and for decreasing the losses as BAU.

6.2.5. Voltage reduction

The LV Templates project provided data on the voltages seen on the LV network and concluded that there is scope to reduce the network voltage and remain within the statutory voltage parameters. Reducing the voltage will reduce the overall demand and will contribute to loss reduction.

The voltage on the LV network can be reduced in many ways but WPD has chosen to change the settings at the primary substation level. At this point on the network, the voltage change can be made automatically and while the network remains connected. WPD has completed a programme of voltage reduction in the South Wales area, and results have shown that a 0.88% reduction in primary voltage resulted in an average demand drop of 1.16%. As a result of this, losses increased in percentage terms but this is because the current has to be slightly higher to deliver the same power, which increases the variable loss, but the power required is lower, therefore overall losses are reduced. Based on these results, WPD has now completed a programme of voltage reduction across all the WPD licence areas, the targeted completion date of 2020 was meet.

In some places, parts of the higher voltage networks are run in parallel with the lower voltage networks. This means there is more than one open point between the two levels of the network. The advantage of this configuration is that it allows loads to be better balanced, in most cases. The FlexDGrid project previously and now in the Equilibrium project WPD is developing methods to monitor and automatically reconfigure networks. There are areas of the network where it is not possible to operate with parallel feeding arrangements (meshing) due to technical limitations. These can be due to loads, generation or fault levels.

The FlexDGrid project, which investigates the management of fault levels, showed that the installation of a Fault Current Limiter (FCL) has significant losses benefits through enabling the parallel operation of two or more transformers. Using an average network approach and the standard Birmingham 132/11kV transformer, the FlexDGrid work showed that the windings of unmeshed transformers can have an uneven load distribution, typically a 70% to 30% split. Through the installation of an FCL and subsequent network meshing, it allows these uneven windings to be balanced so that each takes 50% of the load. WPD estimates that this could provide savings of around 94 MWh per annum per substation.

6 Policies and actions

6.2. Actions completed before 2021

6.2.6. LV Service cables
During the third quarter of 2020 WPD went out on a consultation to change the standard domestic service cable provision from single phase to three phase. In the consultation WPD pointed out that assets have a fifty year life so that assets being installed now will still be working by 2050, when the UK hope to achieve net zero. WPD explained that the current LV Service cable to the buildings was the smallest cable used on the LV network and this cable was a radial feed.

With the de-carbonisation of transport and the de-carbonisation of heating there would be a strong possibility of the load increasing on the single phase connection to the building. Any increase in load on the Service cable would see the Losses in the service cable increase by a squared factor. One of the ways to reduce the losses would be to provide a three phase supply to the building provided the load in the building was split equally the current carried in each of the cores or phases would be reduced thus reducing the losses.

In addition if three phase devices like a three phase heat pump, EV charger were used as opposed to single phase heat pumps, EV chargers the balance of the network is improved again reducing losses. The outcome of the consultation was that in the fourth quarter of 2020 WPD made it policy that all new build and LV service cable alterations had to be carried out with a three phase service cable as BAU.

6.2.7. Revenue protection - supplier side abstraction
In November 2020 Eon confirmed their intention to internalise their Revenue Protection (RP) activity and not renew the commercial contract with WPD which expired 28/02/2021.

As a result WPD provided notice to all suppliers that our RP services under DUCSA would cease in April 2021 – this only impacted a few suppliers that were taking our services under these default arrangements. Nevertheless we did undertake RP investigations throughout the regulatory up to end of March 21 – during that period we identified 28.7GWh of losses and made 1,335 visits.

The reduction in the number of visits in 2020/21 was mainly due to COVID-19 which resulted in the prolonged suspension of normal RP work.

The number of cannabis factories attended was 448. In November 2019 the RP team reduced in size and also reduced its standby cover in the Midlands so that Network Services have increasingly attended cannabis factories following requests from the police services.

So this number will not reflect all the cannabis attendances in the Midlands – RP has never provided standby cover nor recorded attendances in the South West and South Wales.

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6 Policies and actions

6.3. Actions completed during 2021

- The continued pro-active replacement of 1,996 distribution transformers.
- The design intervention for losses on new installation of 8,184 distribution transformers and 11,880 kilometres of underground cables.
- Completed installation of 88 amorphous cored 25kVA single phase PMTs.
- The on-going development of the losses page on the WPD website.
- Continued membership of the ENA Technical Losses group.
- Ongoing voltage reduction across WPD.
- The Installation of three phase LV service and cut outs for new connections and upgrades became BAU for network planners.
- Twerton 33/11kV transformer change completed in preparation for the conversion to 11kV (from 6.6kV) to free up 30% capacity on the network.
- Electric Vehicle Charging – roughly 52,000 domestic EV chargers connected to our network.
- Large scale connection of heat pumps – roughly 10,000 installed on our network.

From July 2021 all newly manufactured small, medium and large power transformers were required to meet EU Ecodesign Tier 2 Regulation 548/2014, which ensures that transformers meet defined standards of efficiency.

6.3.1. Asset replacement

WPD's work to uprate assets continued through 2021 and will continue through to the end of RIIO-ED1.

6.3.2. Losses pages on WPD website

WPD has developed and published a set of pages related to losses on the WPD website. They explain losses in more detail and lead into actions that are being taken to reduce losses as a result. The WPD Losses page, along with all the DNO's losses pages can now be accessed via requisite links from the ENA Technical Losses page.

ENA Technical Losses

6.3.3. Revenue protection - unmetered supplies

WPD has established good working relationships with unmetered customers, in particular street lighting authorities, whose unmetered connections form approximately 90% of the total unmetered load. This involves regular group and individual meetings, which include discussions about inventory accuracy. Working closely with customers, together with the checks and balances we have in place, have provided us with a reasonable degree of confidence that unmetered system losses are minimised.

The unmetered connection agreements for larger customers, requires them to provide accurate monthly detailed inventories of all their unmetered connections. Checks are made when new inventories are loaded by WPD, to ensure there are valid reasons for records which have been removed. WPD introduced a revised new connections process in 2016. This enables more accurate detail of the unmetered equipment to be captured, resulting in the correct calculation of annual consumptions for smaller non half hourly traded MPANs.

For HH traded customer MPANs, the information enables checks to be made against the larger inventories provided. The process also prevents connection dates being agreed without a valid UMS registered MPAN being recorded, therefore, minimising the risk of load being connected and not accounted for. The current estimated loss from unregistered MPANs is 20,000 kWh, which is mainly made up of MPANs created prior to the revised process being implemented.

In addition WPD will carry out physical street lighting site audits using independent contractors when our own internal inventory checks show further investigation is required. WPD has not found any such cases in recent months. WPD arrangements for LV street furniture connections for electric vehicle charge points only is covered by our Standard Technique ST: SD5G clause 10, which states: - The exit point demand shall be ≤ 7.36kW; and an Elexon approved active measuring device shall be used.

6 Policies and actions

6.3. Actions completed during 2021

6.3.4. Revenue protection - theft in conveyance

WPD retain an obligation to respond to reports from Crimestoppers whom are appointed as the Energy Theft Tip Off Service (ETTOS) and forward details of suspected theft to the appropriate Supplier or Network Operator.

WPD receive and process these notifications from ETTOS; these are referred to the supplier to action, with a small number of cases with no registered supplier requiring a local WPD Network Services team to investigate.

WPD Revenue Protection will be handing over ~70 active investigations to Network Services.

We still have a registered scheme, under Schedule 6 of the Utilities Act 2000, which allows action to take place to recover the monetary value of units abstracted while in conveyance. WPD publishes the unit price in the statement of charges; and in addition have taken cases to court where appropriate – although this did not happen in 2020/21.

Network Services do have processes and reporting procedures to check unregistered MPANS but the back office activity to cross-reference MPAN and UPRN data references was carried out by the RP section, but this activity is not being taken forward since the Eon did not renew the contract.

WPD's Distribution Business has a licence obligation to carry out a 'make safe' service at the request of an appropriate authority. This obligation falls under Condition 27 of the Standard Conditions of the Electricity Distribution License (22nd April 2014) to inform the Authorised Supplier as soon as reasonably practical, when there is reason to believe that there has been either:

(a) Interference with the metering equipment through which such premises are supplied so as to alter its register or prevent it from duly registering the quantity of electricity supplied. Or

(b) Damage to conductors and/or any other equipment associated with the electricity service, resulting from abstraction or attempts to abstract electricity from WPD's network.

Regulation 26, Paragraph (3) of the Electricity Safety, Quality and Continuity Regulations (ESQCR) 2002 states that a supply can be disconnected on the grounds of safety with immediate effect.

Interference with distributer equipment or conductors by unauthorised 3rd parties can be dangerous and lead to disconnection on the grounds of safety.

There is a further obligation to report to the relevant owner (the occupier) if interference or damage, as described in the paragraph above, is discovered affecting privately owned equipment. WPD must inform the Relevant Owner as soon as is reasonably practicable, except if there is reason to believe that the damage or interference was caused by the Relevant Owner.

WPD is also required by the Regulator (Ofgem) to take "cost effective" actions to:

(a) Resolve cases of theft at unregistered sites.

(b) Pursue customers for the value of units stolen where there is theft in conveyance and we have the right to pursue the customer.

Suppliers are responsible for the investigation of theft of electricity used at customer premises. The Suppliers discharge their responsibility either by using their direct staff or by use of an approved Revenue Protection Service provider. Suppliers or Revenue Protection Service providers follow up on reports of meter tampering, including case investigation and the management of warrants to obtain access.

WPD are not a Revenue Protection Service provider and all service disconnections after WPD's equipment should be made by the supplier or their appointed Revenue Protection Service provider.

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2022 Losses Strategy

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6 Policies and actions

6.3. Actions completed during 2021

6.3.5. Distributed generation and DSO

Traditional power stations are large and normally centralised; therefore it was justifiable to connect them directly to the National Grid transmission system.

In contrast to this, renewable energy sources and storage tend to be smaller and more distributed around the country; meaning they are usually connected to local distribution networks. This disrupts the traditional flow of power from generators to transmission networks, to distribution networks, to the customer. If the energy from distributed generation is used locally (and within a suitably short period of time) then this reduces losses.

As WPD moves towards a DSO way of working there will be a need to manage energy flows across the network to increase utilisation and balance demand and generation. This has the potential to increase losses if power flows increase or demand and generation cannot be balanced. Alternatively it could reduce losses if the network was perfectly balanced.

This balance must be achieved against an economic and efficient measure so the cost of losses should be considered.

Work completed for the ENA Technical Losses Working Group by the Engineering Consultants WSP has shown that load could increase by as much as 40% due to the de-carbonisation of heating and transport, thus losses would increase as a result of DSO flexibility, smart solutions allow greater utilisation of network assets and losses increase as a consequence.

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6 Policies and actions

6.4. Plans for 2022 and beyond

WPD plans for 2022 are to build on the work done so far and move the company's focus to new areas of potential increased losses. WPD will continue to increase focus towards LCTs and, in particular, the effects of de-carbonisation of transport with EV charging and the de-carbonisation of heating with the installation of HPs. Continued and future actions are as follows:

- Continuation of the asset replacement scheme started at the beginning of ED1.
- HV phase imbalance and power factor.
- Desktop studies of the LV network and customer connections using data supplied by installers of domestic solar, electric vehicle charging and heat pumps.
- Conversion of legacy networks i.e. Bath 6.6kV to 11kV at Twerton due to start following completed substation upgrades. This will free up 30% of capacity, thus reducing losses.
- Assessment of other legacy 6.6kV networks that may be converted to 11kV.
- Continued monitoring and analysis of the three phase housing estate in Parc Eirin, South Wales.
- Continue building the enhanced network for partners Pobl and Sero Homes in retrofitting the Blaen-y-Maes Housing Estate. Our teams are installing new substations, laying new LV mains circuits and de-looping the houses to enable the connection of LCTs.
- Installation of pad mounted low loss transformers to support car park EV charging installations.
- Continuation of installation of three service cables and cut-outs as BAU.
- Continuous improvement of processing and systems for smart meter data to enable effective analysis and real-time network monitoring.

6.4.1. Parc Eirin LCT connected estate

Work on site has recovered following the pandemic and more residents continue to occupy the estate. It should be noted that all the devices on the estate are single phase with the exception of the EV charger.

The housing estate is being fully monitored on the 11kV and LV side with a view to ascertaining the losses and load balancing on a "hybrid" three phase connected housing estate, when compared to the single phase connected houses in the Losses Investigation Project on the Isle of Man. Initial findings, by Loughborough University show that losses are reduced by using three phase service cables on new build properties.

At this time, we are looking for another project where all devices are three phase.

6.4.2. Retrofitting housing with LCTs

According to the Centre for Ageing Better, 21% of all homes in the UK were built before 1919, 38% were built before 1946, and only 7% after 2000, making the UK housing stock the oldest in the EU[2]. Large sections of WPDs existing 11kV and LV mains networks were designed for 1950s, 1960s and 1970s where the electricity usage assumptions and building fabric standards at the time of installation were lower than the building standards first introduced during the 1990s. As stated, WPD are involved in the design exercise of the Optimised Retrofit Project (ORP) with the Welsh Government, Pobl and Sero Homes at Blaen-y-Maes. Roughly 700 homes will be retrofitted with LCTs and the structure of the buildings brought up to an EPC A rating.

Our teams are installing new substations, laying new LV mains circuits and de-looping the houses to enable the connection of LCTs. The Innovation team in WPD are now looking at undertaking an innovation project which would use information from the ORP to incorporate building fabric into electrical system design.

[2] Clarke, S. More than 1m over 55s living in hazardous homes Home Care Insight study finds. 09/05/2019. https://www.homecareinsight.co.uk/more-than-1-million-over-55s-living-in-hazardous-homes-study-finds/

6 Policies and actions

6.4. Plans for 2022 and beyond

6.4.3. Small size pole mounted transformers

The iron losses for an amorphous cored 25kVA single phase transformer compared to an identical CRGO cored 25kVA single phase transformer can be calculated using the following formula:

no-load losses = no-load loss in watts * relevant hours

The total iron losses for 1 year are:

Amorphous 25kVA transformer= 140W
CRGO 25kVA transformer = 569W

This gives an iron loss saving of 429W per year per transformer when using the single phase 25kVA 11kV amorphous cored transformer. Using the Ofgem price of **48.42 £/MWh** for losses, this equates to a cost saving of £20.78 (iron losses only) per transformer per year.

For the 88 that we have installed, this results in a total saving of **£1,828.64** per year. Across a lifetime of 40 years, that equates to **£73,145.60.**

6.4.4. Car park EV charging

To support the facilitation of EV charging infrastructure, we are working with Schneider Electric in Leeds to specify and offer a 1.6MVA Metalclad Distribution Substation to chargepoint operators (CPOs) as a single customer. This will allow the CPO to connect more or larger chargers at LV than a typical 1MVA supply and enables an LV connection rather than HV. In addition, this solution will offer a reduced footprint with a single point of contact for.

6.4.5. Actions proposed for ED2 (2023-2028)

During RIIO-ED 2, on the LV mains UGC network, WPD will install 300mm² Wavecon LV Mains cable using the next size up for all LV Mains cable designs in the RIIO-ED2 period. This will cost WPD around £2.89m per year at current costs. This means WPD will discontinue the installation of 185mm² LV mains cables except for service cables and fault repairs.

During RIIO-ED1, WPD discontinued the use of 15kVA single phase and 25kVA three phase transformers, using larger sized assets as the minimum size available. This provided both a losses and capacity benefit. In RIIO-ED2, WPD will extend this approach and discontinue using 25kVA single phase and 50kVA three phase units. This will mean the smallest units used are 50kVA single phase and 100kVA three phase (which will be of a lower loss amorphous core design). Taking the combined steps of uprating the minimum sizes and using amorphous cores for the smallest remaining sizes in our range will lead to around 160 units per annum being installed with a higher rating and lower losses.

To improve our network visibility, we will be looking to install 15,500 monitors at the highest priority, low voltage substations. At high voltage, WPD will ensure that it has 100% visibility of the power flows on its network at all 1,800 of its primary substations. We will also enhance and refine our network planning models through the utilisation of smart meter data.

Our Distribution Network Options Assessment provides a systematic methodology to recommend a single investment option when looking at flexibility vs reinforcement. The various options are compared using the common Evaluation Methodology, produced by the ENA, which considers multiple factors including losses. In ED2, we will look to incorporate losses into these decisions. The Losses Estimation Tool will also be used to estimate the additional losses due to flexibility.

We have also signed up to a Science Based Target (SBT) for our environmental actions. Network losses must be accounted for in this, as they contribute to carbon emissions. Therefore, any reduction in losses will support with our SBTs. Throughout RIIO-ED2, we will continue to work in collaboration with electricity suppliers and other authorities to further reduce electricity theft and illegal abstraction. Additionally, efficiency will remain a key consideration in our procurement activities for transformers.

Glossary of terms, abbreviations and acronyms

Abbreviation	Term
A	Ampere
ac	alternating current
Al	Aluminium
BAU	Business As Usual
CBA	Cost-Benefit Analysis
CSE	Centre for Sustainable Energy
CT	Current Transformer
Cu	Copper
DC	Direct Current
DINIS	Distribution Network Information System
DSR	Demand Side Response
DNO	Distribution Network Operator
DSO	Distribution System Operator
ENA	Electricity Networks Association
ES	Energy storage (battery)
EU	European Union
EV	Electric Vehicle
EVA	Enhanced Voltage Assessment
EHV	33kV and up to and including 132kV (WPD standard)
FCL	Fault Current Limiter
FPL	Flexible Power Link

Abbreviation	Term
GWh	Giga Watt hour
HH	Half hourly
HV	11kV (WPD standard)
IIS	Interruptions Incentive Scheme
IPSA	Independent Power System Analysis
IPC	Insulation piercing connector
kVA	Kilo Volt Ampere
kW	Kilo Watt
kWh	Kilo Watt hour
LCNF	Low Carbon Network Fund
LCTs	Low Carbon Technologies
LDBs	Link Disconnecting Boxes
LEAN	Low Energy Automated Networks
LV	240/400V Low Voltage
m	million
MPAN	Meter point administration number
MV	Medium Voltage
MVA	Mega Volt Ampere
MWh	Mega Watt hour
NIA	Network Innovation Allowance
NOPs	Normal Open Points

Abbreviation	Term
PSSE	Power System Simulation and Engineering
PV	Photo Voltaic (Solar)
PMT	Pole Mounted Transformer
RIIO-ED1	Revenue = Incentives + Innovation + Outputs – Electricity Distribution 1
RIIO-ED2	Revenue = Incentives + Innovation + Outputs – Electricity Distribution 2
SCADA	System control and data acquisition
SMETS 1	Smart Metering Equipment Technical Specification first version
SMETS 2	Smart Metering Equipment Technical Specification second version
SVO	System Voltage Optimisation
TASS	Transformer Auto Stop Start
TDH	Total Harmonic Distortion
UGC	Underground cable
UK	United Kingdom
UKPN	United Kingdom Power Networks
UKRPA	UK Revenue Protection Agency
UMS	Unmetered supply
UPRN	Unique property reference
WPD	Western Power Distribution
WSP	Engineering Consultants

Appendix 1

This appendix includes the 26 SOHN report recommendations, with actions taken against each of them.

Recommendation 1:

The network modelling and analysis tools used in the study are based on calibrated representative network models data. Given the increasing importance of losses, it would be appropriate that DNOs establish the capability of modelling and evaluating loss performance of their present and future networks, under different future development scenarios.

Action

This has now been adopted and become BAU for LV and 11kV. At LV, the LV/Connect platform includes losses calculations for each scenario used.

Benefit for customers

WPD's LV and 11kV system modelling tools include losses calculations for each scenario used. However, as one of the first measures WPD undertook in this area was to increase the underground cable size and remove cable tapering, this means upgrades are uniform across the company.

WPD's Network Planners are therefore able to comply with the majority of losses designs by using the uprated selection of cables and transformers made available in 2016. At EHV WPD currently uses PSS/E that can produce losses calculations.

Whilst all EHV designs are bespoke, WPD has completed work to provide template solutions for generation connections and these templates incorporated the losses impacts.

Recommendation 2:

DNOs to consider carrying out more systematic data gathering associated with power factor to assess the materiality of the issue and to enhance the understanding of the costs and benefits of power factor correction at consumers' premises. The business case for power factor correction may then be developed.

Action

Since 2010 WPD has been including an excessive reactive power charge for HV and LV half hourly metered, via the use of System Charge, with a power factor of 0.95 lagging.

Benefit for customers

This is to ensure that the reactive power is kept to the minimum. When sizing a circuit the total load has to be catered for, this means both the active load and reactive load need to be catered for, cumulatively, even though the customer would only effectively use the active load.

By keeping the power factor at or about 1 means the customer is paying and using all the power. If for example they had a very bad power factor they could end up paying for one unit of power but in real terms only do half a unit effective work so they pay for the power that was wasted due to poor power factor.

Recommendation 3:

Further work is required to assess the extent of the imbalance problem and to test various solutions, which will not only reduce losses but deliver many other benefits of a well-balanced network. It may be appropriate to develop policies and working practices for avoiding excessive imbalance in future.

Action

WPD has completed the LV Templates project where imbalance was addressed. In addition WPD has completed the Losses Investigation project in IOM where feeder and services (typically single phase) on the LV and 11kV systems are fully monitored, with data having being assessed by Loughborough University and subsequently published to share the learnings with others.

Benefit for customers

Using substations that are part of LV Templates project, WPD has identified that the phase imbalance in the LV network can lead to neutral currents at around 35% of the phase current. More recent work from the Losses Investigation Project suggests that ratios of neutral current to phase current are higher still. Majority of feeders have neutral current/mean phase current ratio above 0.35. Neutral current ratios tend to be higher for feeders with lower mean current. Going forward WPD is involved in a new build of circa 225 houses where the services will be three phase and all service and feeders on the LV and 11kV will be monitored in a similar manner to the IOM Losses Investigation project so a direct comparison can be made between the respective losses from single phase versus a three phase estate. The new build houses also include EV chargers and heat pumps so that the out of balance can checked with the enhancement that is expected.

Appendix 1

Recommendation 4

The inaccuracy of loss calculation using half-hourly data at the edges of the LV network should be recognised when conducting network studies.

Action

WPD's LV system modelling tool includes losses calculations for each scenario used, but as one of the first measures WPD undertook was to increase the underground cable size and removed cable tapering this means upgrades are uniform across the company.

Recommendation 5

As the benefits of peak demand reduction may be material, an assessment of the opportunities enabled by alternative SmartGrid techniques to achieve this should be carried out.

Action

WPD use demand side response to reduce the peaks of load and associated losses on our network. As a result of our FALCON project, WPD found that customers are often not able to help with DSR due to contracts in place with National Grid. WPD is working with National Grid to change their standard terms and conditions to allow customers to operate in both markets.

Benefit for customers

Centrica's new Local Energy Market enables National Grid ESO and WPD to simultaneously procure flexibility from the same platform. WPD have set up the DSR Forum, where DNOs, Ofgem and National Grid are represented, to discuss this in more detail.

Recommendation 6:

As the benefits of active voltage control in LV distribution network may be significant, comprehensive assessment of the opportunities to further reduce network losses should be carried out.

Action

WPD is reviewing the roll out of ENWs project Smart Street project which is using 11/0.4kV transformers complete with OLTC to address the issue of clusters of Low Carbon Technology where there are voltage fluctuations happening on an almost daily basis.

Benefit for customers

In addition the WPD Innovation team are undertaking a project with Efacec which will be looking to address the issues around dealing with wide variations of voltage on the LV network.

Recommendation 7:

When considering active network management solutions and technologies to facilitate low-carbon connections, the impact on losses should be given full consideration Future Consideration

Action

WPD, via the ENA Technical Losses group, commissioned WSP to undertake the Impact of Low Carbon Transition – Technical Losses Report.

Benefit for customers

In summary the report states losses are expected to be impacted by the predicted increase in electrical demands as Great Britain (GB) adopts Low Carbon Technologies (LCTs) for heat and transport such as heat pumps (HPs), electric vehicles (EVs) and photo voltaic solar generation (PVs). Increases in demand are associated with increased losses, however, absolute losses could be reduced if larger conductors or additional circuits are added and network utilisation is reduced. Distributed generation connected in close proximity to demand reduces losses when the generation offsets power flowing through the wider network to supply the demands, however, distributed generation can increase losses when the generation is sufficiently in excess of the demand.

Recommendation 8:

There is a clear case for fundamentally reviewing cable and overhead line ratings to ensure that future loss costing has been included in the economic rating calculation. This could be based on Ofgem's loss investment guidelines or on loss-inclusive network design standards.

Appendix 1

Recommendation 9:

In future, losses may drive early asset replacement when economically efficient. If early replacement programmes are economically justified and capable of being funded, appropriate resources would need to be made available to facilitate delivery of such programmes.

Action

the following actions have now been rolled out as business-as-usual:

- Discontinued small size cables for large conductor size cables on new works
- Discontinued small size transformers for new works
- Adoption of a 'next size up' design policy
- Targeted early retirement of older than 1958 ground mounted transformer designs.

Benefit for customers

Asset replacement is the ongoing and most direct way in which WPD can reduce technical losses. From a losses point of view old transformers and underground cables encompass the majority of assets which provide the best value to a DNO and customer to reduce the losses seen on a network.

With this in mind it then becomes part of the business as usual that WPD will be changing pre 1958 ground mounted transformers for newer models which will reduce overall losses as new transformers have lower losses than old ones.

In addition the variable losses in cables can be reduced by using cables with larger cross sectional areas, which also increases their capacity. Where overhead line conductors are replaced WPD aims, where possible, to replace smaller diameter conductors with larger diameter conductors as BAU.

Recommendation 10

The transformer loss calculations indicate that the benefits of investing in low-loss transformers may be significant and this should be considered further to establish or otherwise the low-loss transformer business case in line with UK energy and carbon policy.

Action

WPD has always purchased low loss transformers since pre-privatisation and all primary and ground mount transformers meet or exceeded the Euro Eco design. In 2018 WPD purchased circa 100 amorphous pole mounted single phase transformers to install and monitor as single phase does not form part Euro transformer Eco design this are now being rolled out onto the network. In addition WPD is pushing the ENA Losses group to produce an industry standard for amorphous cored transformers.

Benefit for customers

All customers pay for the losses therefore by reducing the no load losses of the transformers reduces the wasted energy that would be necessary to drive those losses, it also then by default frees up extra generation.

Recommendation 11:

Network designers may consider the option of installing additional distribution transformers to minimise LV network reinforcement cost and reduce losses.

Action

After the SOHN Report was produced WPD employed SOHN to undertake a redesign trial of recommendation 11 using the WPD new standard of large cross sectional area cables.

The trial showed no benefit in additional transformers. Electrical demand is set to double by 2050, therefore preparing our network for this is key.

Benefit for customers

WPD is now designing networks to cater for the increased loads and for decreasing the losses as BAU.

Recommendation 12:

In the light of future developments, particularly in relation to the integration of low carbon demand and generation technologies, it may be appropriate to reconsider long-term distribution network design. This may take a strategic view of future voltage levels and include consideration of losses in the decision-making.

Action

WPD is involved in a new build of 225 houses in Parc Erin, south Wales, where the services are three phase with a full suite of LCT.

Benefit for customers

All service and feeders on the LV and 11kV will be monitored in a similar manner to the IOM Losses Investigation project so a direct comparison can be made the losses on a single phase and three phase estate can be compared and analysed for out of balance on the LV main and unit transformer.

The new build houses will also include PV, ES, EV chargers and heat pumps so that the out of balance can checked with the enchantment that is expected.

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Appendix 1

Recommendation 13:
In order to reduce losses and provide future flexibility within LV networks, LV tapering policy may be re-examined. Adopted

Action
Since 2012 WPD as part of the business as usual have installed link disconnecting boxes between LV substations on non-tapered LV mains cables, thereby providing the possibility of mesh connections and back feed potential under fault conditions. In addition since the start of 2015 WPD has amended the design policy and now all designs of the LV mains underground cable network are designed without cable size tapering. Networks shall be planned using either 185mm² or 300mm² Wavecon cables. The size chosen for a particular scheme will be used throughout that scheme and tapering is no longer considered. In RIIO-ED2, we will look to use 300mm² as standard.

Benefit for customers
All customers pay for the losses therefore by reducing the losses of the LV Mains circuits reduces the wasted energy that would be necessary to drive those losses, it also then by default frees up extra generation.

Recommendation 14:
A review of DNOs' network modelling and analysis tools and capabilities may be required to support design engineers in applying new policies and processes relating to loss-inclusive network design.

Action
In order to forecast, what will happen on the WPD network in the future and to determine what is happening on the unmonitored parts of the network, the most powerful tool is computational modelling. WPD's LV system modelling tool includes losses calculations for each scenario used, but as one of the first measures WPD undertook was to increase the underground cable size and removed cable tapering this means upgrades are uniform across the company.

The WPD 11kV system modelling tool also includes losses calculations, but as one of the first measures WPD undertook was to increase the underground cable size and removed cable tapering at 11kV this means upgrades are uniform across the company. At LV and 11kV, planners are able to comply with the majority of losses designs by using the uprated selection of cables and transformers made available in 2016.

At EHV WPD currently uses PSS/E, which can create losses calculations. Whilst all EHV designs are bespoke, WPD has completed work to provide templated solutions for generation connections, these templates incorporated the losses impacts.

Benefit for customers
Modelling effectively creates a virtual, fully monitored network which can then examine and test new ideas. Using the modelling tools WPD should be able to map where losses occur on the network, allowing for a targeted approach to loss reduction. Modelling can also be used to predict the effect of future changes to the network, so that the effect on losses of all possible future actions can be considered before the changes are actually carried out.

Modelling should become even more useful once used in conjunction with smart meter data. By feeding the data into the model, this will be able to produce models of the network in real-time. Data at specific metering points can then be predicted and compared to the real data, to establish the success of the model. The software will need to be redesigned to incorporate this feature.

Once this level of insight into the network is established, it will be possible to create more targeted losses strategies, leading to far more effective loss reduction activities.

Recommendation 15:
There is an opportunity for considerable further learning in Europe and also from National Grid. It would be beneficial to share experiences of waste heat recovery installations among DNOs.

Action
WPD have carried out a provisional analysis with a heat pump manufacturer of using a heat pump in the oil line between the primary transformer and the cooling fins bank to heat the substation buildings. Discussions are being had with the Innovation team around the feasibility of such a project.

Benefit for customers
Such a system would make use of wasted heat, which will therefore be a carbon-free form of heating.

Appendix 1

Recommendation 16:
An Innovation Project, based upon learning from this initial Study, may be initiated in order to gather further insight into the technical and practical solutions which can be tested at more sites. The Project could be scoped to also tackle the regulatory and commercial market structural issues which will also need to be overcome to bring heat recovery and use into mainstream application.

Action
WPD worked with a primary transformer manufacturer to come up with a bespoke design. Discussions with the Innovation team are underway to understand the feasibility of such a system.

Recommendation 17:
DNOs may maintain an awareness of the potential for heat recovery when planning the installation of EHV transformers and seek to install more systems where the recovered heat may be of commercial use.

Action
WPD has discounted commercial use based on a report by Centre for Sustainable Energy (CSE). In addition, WPD has checked all its grid transformer sites with a view to creating a mini district heating system but because of the distance involved between buildings and transformers it becomes un-viable.

Recommendation 18:
Further work on heat storage may be integrated with future trials work on recovery of heat from the distribution network, as it may improve the economics of more basic heat recovery systems.

Action
WPD has discounted commercial use based on a report by CSE. In addition WPD have checked all of their grid transformer sites with a view to creating a mini district heating system, the distance involved between buildings and transformers deems it un-viable.

Recommendation 19:
DNOs should develop loss-inclusive network design strategies, based on their specific data, in order to ensure that the overall economic network operation and design criteria are met. This should include network modelling capability for answering "what-if" questions in order to predict the impact of proposed network polices, projects and network demand forecasts on the overall reported network losses.

Action
WPD has created the Network Strategy team with responsibility for producing and assessing the impact of a range of Distribution Future Energy Scenarios (DFES), aligned with those developed by National Grid. The newly published Network Development Plan makes use of this forecasting.

Benefit for customers
DFES have been produced for all four WPD licence areas to predict the impact of proposed network polices, projects and network demand forecasts on the overall reported network losses.

Recommendation 20:
DNOs, with support from DECC and Ofgem, may determine the common basis in relation to loss mitigation and loss-inclusive network design and investment.

Recommendation 21:
There is a need to establish the basis for assumptions on future electricity costs and carbon prices that would be used in loss-inclusive network investment that is consistent with the overall UK low carbon policy.

Action
WPD carry out the Ofgem Cost Based Analysis (CBA) with any Losses project to prove the case for the particular project. WPD use the Ofgem supplied value of £48.42/MWh in the CBA calculations.

In addition, when converting carbon WPD use the DEFRA carbon conversion factors for both UK electricity (kWh) and Transmission & Distribution (kWh).

The 2019 values for example are 0.2556 kgCO2e for Electricity and 0.02170 KgCO2e for Transmission & Distribution. We must also report losses as part of our SBT.

Benefit for customers
By adopting this method of assessment this ensures that the customer gets a consistent and auditable approach in CBAs.

Appendix 1

Recommendation 22:
Early in the RIIO-ED1 period, DNOs may develop more accurate means of measuring and reporting of distribution network losses.

Action
WPD undertook the Losses Investigation project in conjunction with the Isle of Man, Manx Utility Authority and Loughborough University. One of the key issues identified is that measuring losses is difficult because the level of losses that are being looked for are small circa 7% and the losses on the Smart meter for example are -3.5% to +2.5%. This is also shown by the ENA Losses Measurement Report.

Benefit for customers
The ENA Technical Losses group employed WSP to recommend a new Losses mechanism which can be used by Ofgem during ED2, the proposal is to use a CBA method as adopted by other utilities around the world. By adopting this method of assessment this ensures that the customer gets a consistent and auditable approach in CBAs.

Recommendation 23:
The DECC and Ofgem comparison of reported losses shows a discrepancy that may cause a distorted view of GB DNO losses within industry, government and internationally.

Action
Currently DNOs and IDNOs are treated differently. DNOs are required to reduce losses but IDNOs are not. Where the IDNO network connects to the host DNO network at the Point of Common Coupling, no metering is allowed therefore all the losses incurred on the IDNO network are all added to that particular host DNO network. This then shows a discrepancy on that particular host DNO feeder. It is part of the ENA Losses group to ensure that this becomes a level playing field.

Benefit for customers
This would ensure that all new networks were designed to similar criteria and the ability to connect new LCT equipment can be met.

Recommendation 24:
DNOs may grasp opportunities to influence loss reporting in other countries and as it is presented in international studies. This is in order to ensure that GB DNOs' loss management performance is presented accurately.

Action
As part of the ENA Technical Losses group, all DNOs report back into the group on what their respective owners carry out on losses and what each DNO has learnt from other sources. All these items are then discussed and considered by the group and decide whether to take them forward or not.

Benefit for customers
If losses can be reduced by adopting methods that have been trailed oversea then this will ultimately see a reduction of losses on our network, which reduces the wasted energy that would be necessary to drive those losses. By default it also frees up capacity.

Recommendation 25:
Industry, government and regulators should consider developing appropriate regulatory and commercial frameworks that would facilitate development of loss-generated heat schemes where economically justified.

Action
WPD have not seen a commercial heat solution yet, but discussion with the Innovation team will continue.

Recommendation 26:
DNOs loss strategies may be "stress tested" to demonstrate that they can deliver an objective of achieving an economic level of losses based upon avoided loss valuation, engineering costs and future network demands.

Action
The ENA LCT Group issued a contract to WSP Consulting to produce the LCT Planner Tool Design and Methodology.

Benefit for customers
This carried out essential stress testing of the methodology in practice to ensure the results achieved were correct.

Appendix 2

January 2014

General Stakeholder engagement where losses were included as a topic

- The concept of losses.
- Ways losses can be reduced.
- Early versions of the WPD Losses strategy.
- High level objectives and results.

November 2014

Specific Losses stakeholder event

- SOHN losses report.
- Losses strategy items including process of selection.
- Cost benefit analysis.
- Early transformer replacement for pre-1958 units.
- Discontinuation of small sizes of transformers and cables for new works.
- Design changes for networks to remove tapering.
- Network phase balancing.
- Revenue protection.

November 2015

Specific Losses stakeholder event

- SOHN Losses Report.
- Losses Strategy update.
- Innovation projects and losses.
- Low voltage cable length modelling.
- Heat recovery from large transformers.

November 2017

Specific Losses stakeholder event

- SOHN Losses Report.
- Losses Strategy update.
- Innovation Projects and losses.
- Losses Investigation Project.
- Measuring losses.
- Collaborative Working.
- Housing estates of the future.
- Retro-fit service cables and loss reduction.

November 2019

Specific Losses stakeholder event – in conjunction with SSE.

- SOHN Losses Report.
- Losses Strategy update.
- Losses Investigation Project.
- Collaborative Working.
- Housing estates of the future.
- Retro-fit service cables and loss reduction.
- Amorphous padmount transformer.
- Primary transformer heat pump to heat substation.
- SSE presentation on TASS/ Lean project.

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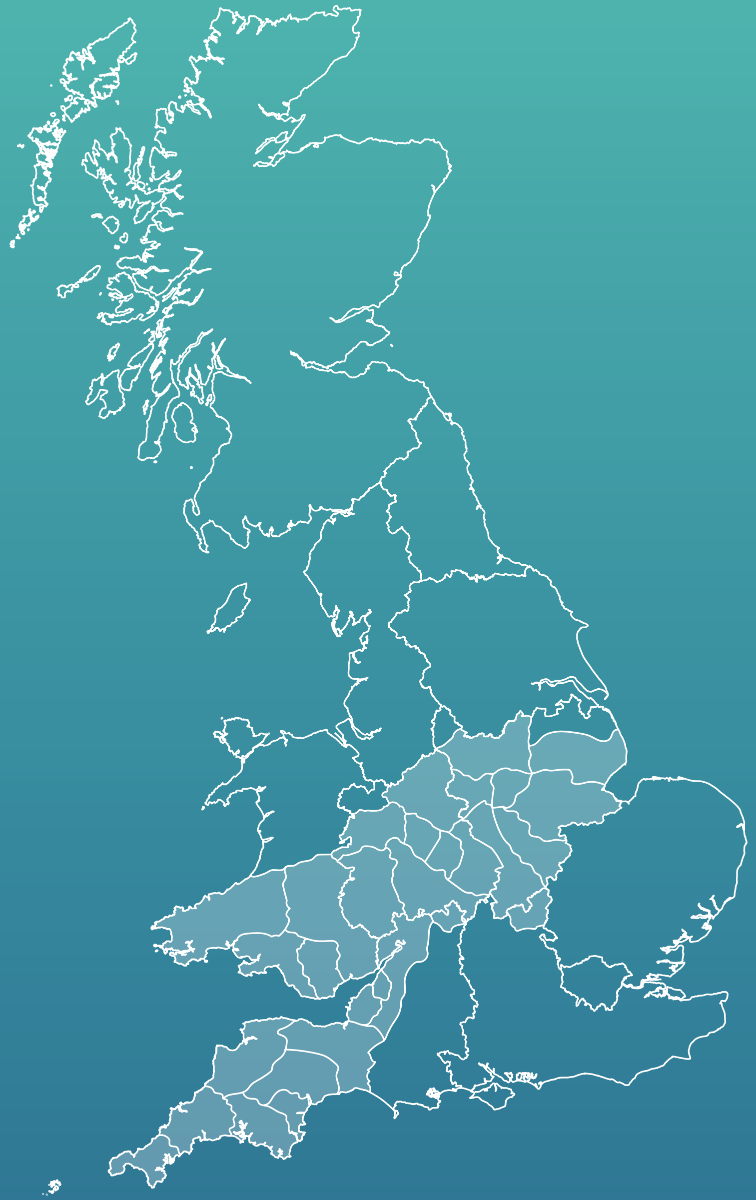

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