DSO Losses Strategy 2021

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1 Glossary

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
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

Abbreviation	Term
LCT's	Low Carbon Technologies
LDB's	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
NOP's	Normal Open Points
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 Number
WPD	Western Power Distribution
WSP	Engineering Consultants

2 Aims, Objectives and Outputs

2.1 Aims of this Document

The intention of this document is to provide an outline of the actions that are being taken by Western Power Distribution in order to reduce losses. The Introduction and Theory section provides a basic explanation of losses on distribution networks. A comprehensive list of the actions that have or are being taken to reduce losses can be found in the Polices and Actions section and summarised in the Table of Outputs. When losses became a focus for Ofgem WPD decided on a starting position, this starting position centred on the SOHN Associates in their 'Management of Electricity Distribution Network Losses' report which is attached in Appendix 1. It was decided that the report would reflect the work carried out by WPD in respect of losses that any third party could inspect to see the progress made on a losses front by WPD. WPD has included items from the ENA Technical Losses Working Group, including research completed by the Engineering Consultants WSP. The document, in addition has extended its focus to take into account future changing demands on the electricity network as a result of the introduction of Low Carbon Technologies (LCT's) and the UK Governments Clean Growth Strategy, The Energy White Paper and the Future Homes Standard.

2.2 Objectives

WPD's objectives regarding losses management are that by the end of the RIIO-ED1 period:

- The 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 of the WPD stakeholders will be aware of the importance of losses; and
- Using the knowledge gained from various innovation projects, computer modelling and investment appraisal WPD will through BAU have produced new and effective means to reduce losses;

2.3 Outputs

During RIIO-ED1 WPD are undertaking:

- The pro-active replacement of 1,996 distribution transformers;
- Purchase and installation of circa 90 single phase 25kVA 11kV amorphous PMTs;
- The oversizing of 448 ground-mounted transformers and 575 pole-mounted transformers per annum;
- The design intervention for losses on new installation of 8,184 distribution transformers and 11,880 kilometres of underground cables;
- The discontinuation of cable tapering on all new 11kV and LV Mains cable circuits;
- The standardisation of new 11kV and LV mains cables to 185mm^2 and 300mm^2, with LV service cables the minimum conductor size is now 25mm^2 Al. & Cu. or 35mm^2 Al
- The identification of units lost to supplier side abstraction, unmetered supplies and theft in conveyance;
- A programme of stakeholder engagement where losses are a designated topic;
- A comprehensive review of the WPD policies to ensure losses are a priority consideration for all the investment decisions;
- Voltage reduction across the four license areas of WPD;
- The introduction of three phase service cables and three phase cut-outs for all new builds and service alterations as BAU.

3 Standard Conditions of the Electricity Dist. Licence

3.1 Part B: The Distribution Losses Strategy - Clause 49.4

WPD's 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 CBA's 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.

3.2 Part B: The Distribution Losses Strategy - Clause 49.5

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

https://www.westernpower.co.uk/smarter-networks/losses/electrical-losses

As detailed in clause 2.1, during the RIIO-ED1 period WPD plan to work through the recommendations of the 'Management of Electricity Distribution Network Losses' report (listed in Appendix 1 on page 30). Since the last version of the WPD Losses Strategy in February 2020, WPD has updated the Losses Strategy to include the recommendations considered during the past 12 months.

WPD's Losses Strategy document has undergone considerable restructuring, to make the document easier to read and navigate. A number of sections have been added, to provide more detail on certain areas. All of the WPD policies on losses and the actions WPD is taking have been compiled into a single section, titled 'Policies and Actions.'

During 2021 WPD will continue with their Losses Strategy, and the replacement of the pre 1958 transformers. The tapering of LV and 11kV circuits is no longer permitted. The use of 4mm² Cu., 16mm² Cu. LV service cables, 95mm² Al. LV mains and 95mm² Al. 11kV cables is no longer permitted, other than pre-defined solutions e.g. installing a padmount transformer, this redefined cable sizing is incorporated in WPD Policy documents and is rolled out as business as usual.

During 2020 WPD held Consultations with all interested parties and as a consequence WPD has redefined the LV service cable to all new build and LV service alterations as three phase service cables complete with three phase cut-outs, this is now incorporated in WPD Policy documents and is rolled out as business as usual.

With the UK governments release of the Clean Growth Strategy, The Energy White Paper and the Future Homes Standard this has prompted many Local Councils and Housing Associations to upgrade their building stock to meet Net Zero and reduce carbon emissions, as a consequence WPD are using the new build and retrofit projects to gain knowledge on the modeling and all the effects PV, ES, HP and electric vehicle charging will have on the losses on LV and 11kV networks.

Battery Electric Vehicle (BEV) charging and the installation of heat pumps are two of the major low carbon technologies demands which will be seen on the low voltage network. Both of which have to be accommodated as a result of the Governments de-carbonisation of transport and heating as per the Clean Growth Strategy plus with the introduction of the updated 2021 Part L of the Building Regulations and 2025 issue of new Future Homes Standard which could see the installation of heat pumps and 7.36kW type 2 EV charger on every new building. Projections carried out by WSP for the ENA Technical Losses Group show LV loads could increase by as much as 40%, this will have an effect on the losses.

To meet the de-carbonisation of transport requirement WPD are currently working with a number of Local Councils with a view to creating charging hubs using low loss padmount transformers, so that councils can meet their clean air objectives. WPD's losses strategy plans will be incorporated alongside the de-carbonisation work as normal business as usual.

WPD has previously focussed work on transformers of the older larger ground mounted units. In 2019 WPD broadened the focus to start addressing losses on single phase pole mounted 11/0.4kV transformers. WPD has purchased 88 25kVA single phase amorphous PMTs. Single phase transformers are outside of the Eco design transformer legislation, the transformers purchased have reduced Iron losses to 16W compared to the current CRGO transformer Iron losses of 65W. These 88 25kVA are currently in the process of being installed on the single phase 11kV overhead line network within WPD.

4 Stakeholder Input, Review and Governance

4.1 Stakeholder Engagement

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

In November 2014 WPD presented our draft third Losses Strategy to invited stakeholders with a specific interest in losses. The invitation list – carefully selected from our general stakeholder engagement database – included 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.

The events

On 6th November 2014 WPD held a stakeholder event at the IET in Birmingham. WPD welcomed over 30 representatives who had the opportunity to learn more about the work that formed the losses strategy. WPD provided a draft strategy and launched a consultation period, which closed in December 2014 when the strategy was finalised.

On 12th November 2015 WPD held second stakeholder event where WPD gave an update on the losses work and all the changes that had been incorporated into the losses strategy. WPD welcomed stakeholders who had not previously attended and took the opportunity to summarise once more the whole content of the losses strategy. The feedback WPD received on the day really supported the high level objectives and actions of the losses strategy.

At the 2015 event WPD also discussed the future timing and format of stakeholder integration through the RIIO-ED1 period. The stakeholders agreed with the idea of reviewing and re-issuing the Losses Strategy each year. They suggested that specific dissemination events would be useful every second year or whenever a significant development had occurred.

On 14th November 2017 WPD held a third losses stakeholder event where WPD gave an update on our work plan, current learnings and suggested updates to our strategy as a result. Our proposals for Superfast Electricity were discussed in detail at this event. This was our first biennial event based on stakeholder feedback.

On 9th December 2019 WPD held a third losses stakeholder event where WPD gave an update on our work plan, current learnings and suggested updates to our strategy as a result. At this event we discussed our Losses Investigation project and were also pleased to welcome SSEN to share our event collaboratively to discuss LEAN transformer management.

Our next biennial event is planned for 2021, and will form part of our RIIO-ED2 Business Plan stakeholder engagement. We will undertake this engagement in the autumn of 2021.

The strategy

In January 2016 WPD published the 2016 version of the Losses Strategy, pulling together everything WPD had learnt in 2015. This revision included updates on all the work carried out since the last review and showed how WPD were progressing on items on the SOHN list of recommendations.

Since that time WPD has published annual updates to the Strategy. New items have been included as they have developed and the strategy has grown to take account of decarbonisation and the impact of Low Carbon Technologies.

This 2021 version of the Losses Strategy, provides updates on all the work carried out since the last 2020 Losses Strategy document review and shows how WPD have progressed on all the items.

4.1.1 Topics Covered at Stakeholder Engagement

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

4.2 Industry-wide Engagement

WPD along with all the other DNOs and ESB hold regular meetings of the ENA Technical Losses Task Group, much of the work WPD have carried out at an industry level can be seen in the WPD Innovation Strategy. The Innovation Strategy includes plenty of 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.

WPD use demand side response to reduce the peaks of load and associated losses on our network. As a result of our FALCON project, we found that customers are often not able to help us with DSR due to contracts in place with National Grid. WPD are working with National Grid to change their standard terms and conditions to allow customers to operate in both markets. Centrica is lauding a 'world first' as its Local Energy Market (LEM) enables National Grid ESO and Western Power Distribution (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.

4.3 International Best Practice

WPD have engaged with their current parent company PPL, as to what methods they use to minimise losses but because of the fundamental way the British and American systems operate there is no common ground. PPL state that the level of losses on their LV and MV system is at 3% and as a consequence they have no active losses measurements.

While WPD's research into the optimum length of LV feeders did not produce any evidence to change our proposals, the research WPD conducted with SOHN Associates has been presented as a paper in the Cired conference held in Helsinki in June 2016.

One of the regular topics 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.

4.4 Sharing Best Practice

It's important to WPD to engage with other network operators as this leads to the development of best practice – a desire that can be traced back to WPD's IFI project on Losses that was completed with UKPN. This took place before the specific work on the WPD Losses Strategies and really helped WPD to shape its own strategy. WPD have shared the project's findings with many other network operators and are pleased that elements of it and references to it appear 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.

With WPD's Losses Investigation project there have been regular updates on this project in the WPD's Losses Stakeholder events, at the LCNI in Telford/Glasgow 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.

WPD are also always keen to learn from others and use their research to develop WPD's plans. The third WPD Losses Strategy included topics highlighted in other DNO strategies and this collaborative approach continues. One of the items for further research in WPD's current strategy is the de-energisation of plant when not required. WPD have been investigating SSEPD's Low Energy Automated Networks LCNF project with a view to explore the viability in adopting the process, at this moment in time finding a suitable substation location with the good fibre optic communications is proving troublesome.

WPD were pleased to see that other DNO losses strategies now include some of the elements of the WPD SOHN plan. All DNOs face similar issues so this kind of peer review and inclusion is a fantastic development. As part of the sharing of best practice WPD have recently purchased circa 88 25kVA amorphous cored single phase pole mounted transformers on the back of work carried out by UKPN and Scottish Power on amorphous transformers. The single phase amorphous PMTs are currently being installed on the WPD 11kV network as part of BAU.

WPD picked up a criticism in Ofgems LDR 3 report on sharing best practice. As a way of addressing this short coming, during the latter stages of 2020 WPD agreed to Partner Loughborough University on an "Understanding the approaches to LV networks in other territories" project, if this project were to go ahead it would be very useful in helping us make the best use of our network and potentially change designs to provide better customer service. Loughborough University are through to the second round of an EPSRC funding competition for a 3-year UK-US centre-to-centre research project. Work-package 2 (of 3) focuses on: "Designing the evolution of last-mile power networks to support the wholesale installation of electric vehicle chargers, heat pumps, photovoltaics and energy storage". It is envisaged that learning from the project can be used to improve the LV network which will benefit the Customer, what with the De-carbonisation of heating and transport being major priorities extending out to 2050, these changes will impact the losses on the wider LV network.

4.5 Losses in relation to wider Stakeholder Engagement

WPD's specific stakeholder engagement for losses is detailed in 4.1 above, but the story doesn't end there. Losses have also formed part of the more general stakeholder engagement work. In January 2015, WPD proposed the topic of losses with the stakeholders at six general sessions to find out if there was an appetite. WPD soon realised that losses were of real interest to the stakeholders although many were content to leave the more technical debate to a specific stakeholder event. Smaller subsets of stakeholders were keen to engage in more depth and attended our various November events in 2015, 2017 and 2019.

4.6 Stakeholder Feedback

The majority of the feedback received at the last consultation was positive and stakeholders were pleased that WPD were heading in the right direction, so they were 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 that will have on the network have been added into the losses strategy.

4.7 Losses Strategy Review

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. WPD has a range of LCNF and NIA projects that are ongoing which are continuing to provide important new insights. Each year WPD will develop and act on the strategies targeted in the SOHN document, obtain new information from the innovation projects, construct new strategies (which may be based on the results of the innovation projects) and then record the progress in the next strategy document. The intention is both to review what has been done in the previous year and plan what is intended to do in the coming year and update the strategy accordingly.

4.8 Losses Strategy Governance

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 "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.

4.9 Innovation funding

WPD can confirm that innovative losses activities which are carried out under NIA funding like the Losses Investigation, are NOT double claimed, but the information generated is used towards BAU work. Work like the Next size up ground mounted transformer (GMT) work 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 RIIO-ED1 plan, through to the three phase service cable project which are being supported by WPD rather than being funded through innovation funding mechanisms.

5 Innovations and Projects

Innovation projects are the main way in which new methods can be developed 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.

5.1 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 come up with as many potential solutions to reducing losses as possible. Using a network modelling tool designed by Imperial College 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.

5.2 LV Templates

The LV Templates project set up a highly monitored network in South Wales, to see if it was possible to characterise substations into a number of 'templates' which could be used to describe the temporal load and voltage behaviour of substations nationwide. The areas chosen for monitoring had dense populations of LCT's. This was to enable scaling up to represent the UK as a whole. The project found that around 82% of UK substations fitted one of ten district templates identified in this project.

The project also provided data on the voltages seen on the LV network. It 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 makes a contribution 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 without interrupting customers. 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 started a programme of voltage reduction across all the WPD licence areas, this work has now been completed during 2020.

5.3 Losses Investigation

This was an NIA funded project, and is not being claimed as Losses work by WPD, but the data gathered does get used to enhance the network and reduce the 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.

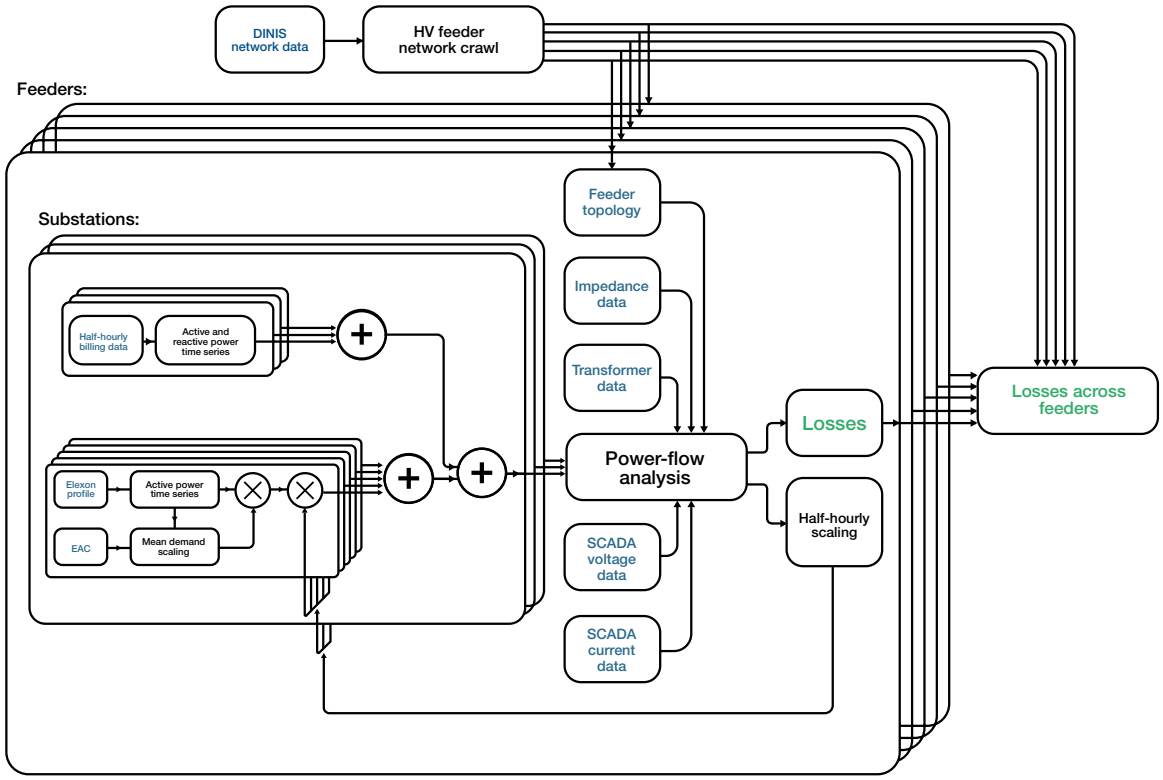
Through a field-work programme, for HV feeders, one minute resolution logging equipment was installed at the Primary Substation on the source breakers of the sample feeders, and at each load connection point along the feeder. This provides comprehensive information about actual power flows for a complete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

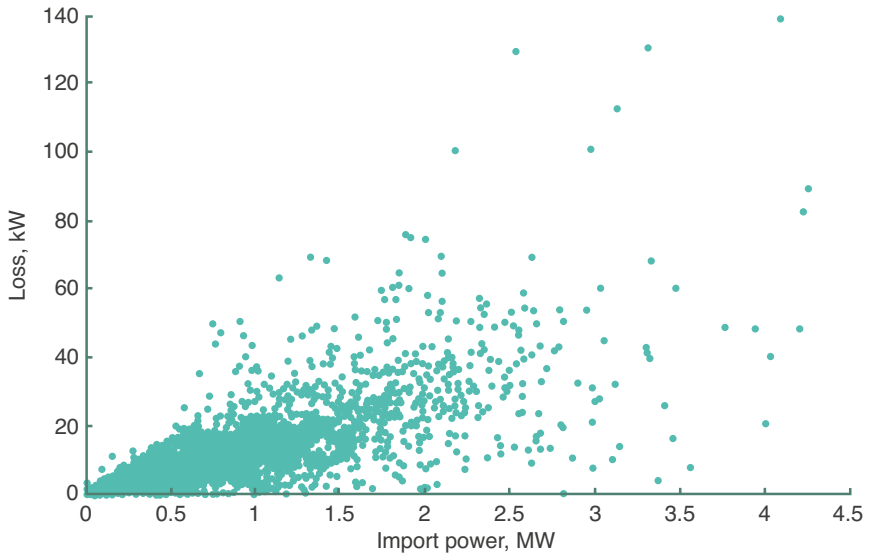
The development of the HV feeder loss estimation process has been completed, feeder-specific annual mean loss estimates have been generated for three of the four regions of WPD. Details of findings and learning for the HV loss estimation work are available, with key items including:

Method - for each HV feeder, the loss estimation method combines network topology data with demand data in order 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 the diagram below:

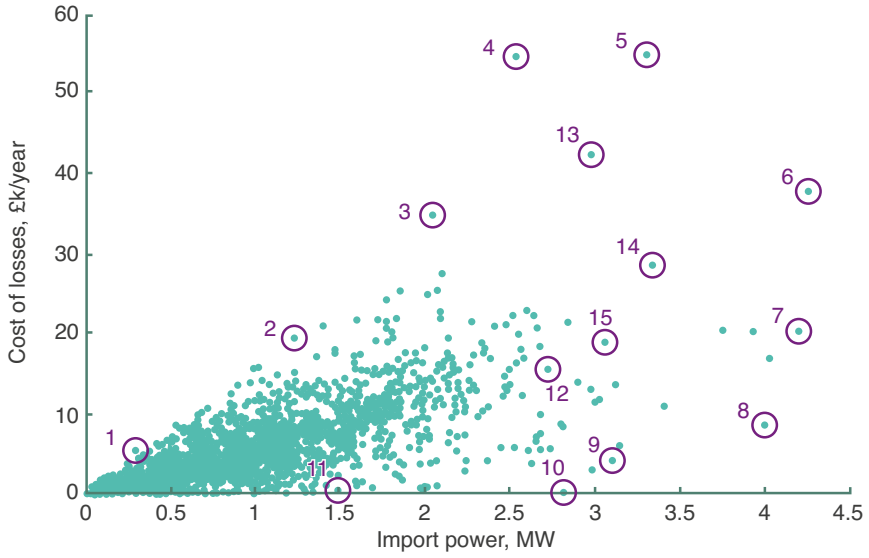


The results of the loss estimation method for the monitored HV feeders established at the start of the project have been found to be in good agreement to the loss assessments of these feeders using the measured data.

Results - one of the fundamental outputs from the HV feeder loss estimation result set is a scatter plot of mean total loss power versus feeder mean power, see below. Many other forms of analysis are provided, and these are detailed in the final report.



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 included in the validation work are highlighted on the plot shown below, with the vertical axis now 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 (e.g. length, cross-sectional areas number of connected transformers), and the load (e.g. 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.

Learning – Detailed points of specific learning are described in the final report.

5.4 New and retro fit homes in Wales

WPD is looking to new and innovative areas to reduce losses, to this end WPD are working with Pobl and Sero Homes where currently in Parc Eirin, Tonyrefail, South Wales circa 250 new build homes are being built, each house is fitted with PV, ES, HP, EV charging, smart white goods each device is connected to an Energy Management System (EMS) or Program Logic Controller (PLC) these homes are supplied via three phase service cables and dark fibre to each house, 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. 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.

In a second project WPD are again working with Pobl and Sero Homes in Blaenu y maes, Swansea where currently circa 700 retro fit homes are being modified, each house is fitted with PV, and ES each device is connected to a PLC these homes will be supplied via three phase service cables to each house, 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. 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. In both of these projects the data gather will also produce updated ADMD information which will be required for designing future networks to the correct standard.

5.5 EQUILIBRIUM

The focus of the Network Equilibrium project is to balance voltages and power flows across the distribution system, using three methods to integrate distributed generation within electricity networks more efficiently. The project considers 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. The advantage of this configuration is that it allows loads to be better balanced, in most cases.

With the FlexDGrid and Equilibrium projects WPD has 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. The EVA also demonstrated the value of expanding the current voltage statutory limits for 11kV and 33kV networks to +/-6% and +/-8% respectively. This would facilitate an increase in utilisation of the existing system 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.

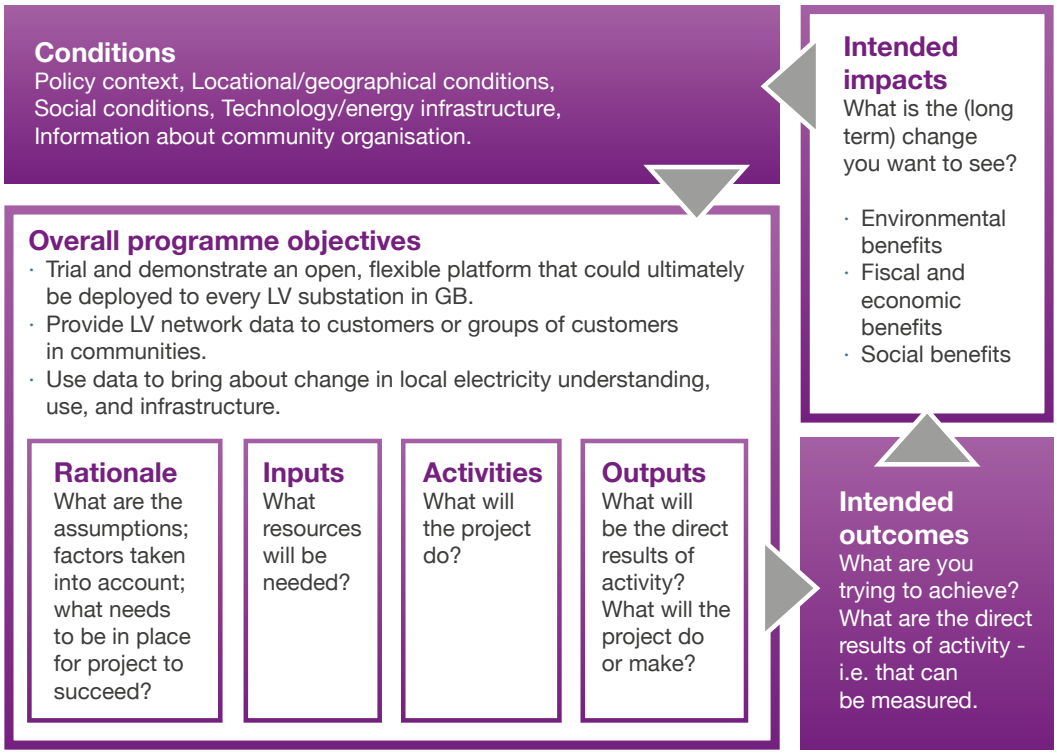
The FPL aims to enable active power transfer between two network groups whilst independently controlling reactive power between each of the two grid groups to provide additional voltage support. The device works by connecting the two, previously distinct, networks together with two back-to-back AC-DC 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.

5.6 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.

The Method 2 trials involve 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 trials. Figure below shows the basic template which was used. Much of the content of the logic models was common to all the projects, particularly in terms of project activities and intended outcomes.



5.7 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, and 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 & 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.

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

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.

6 Improving Understanding

In order 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.

6.1 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. The Losses Investigation project aims to establish such a baseline for several highly monitored LV and HV feeders picked to be representative of the main UK network topologies. This will allow WPD to better understand the locations of the losses on the network as well as the main causes. The project will also establish the level of information required to accurately assess the losses across the rest of the network and enable a more targeted approach to reducing losses. There is more detail on this project in Section 5.3.

To measure overall losses on the network, the power entering the network from the transmission network and the power which leaves the network are compared. The measurement at the customer end can be very inaccurate in the case of domestic customers as some meter readings can be 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.

WPD's 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 the substations. However, currently there are areas of the network, especially at LV where there is limited monitoring across the network.

With the de-carbonisation of heating and transport this 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 sensored termination developed by 3M these were 11kV terminations which gave the user the ability to measure current and voltage. The second generation have moved things along by being 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 during 2021.

6.2 Smart-meters

The roll out of SMETS 2 smart meters has the ability to change the nature of network monitoring. It still needs to be considered that the statutory limits for domestic energy metering is [±]1.5% accuracy. DNO's should have the access to data points representing the consumption across their respective networks and LV feeders. This smart meter data will be readily available in providing data for the 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. Provided the SMETS 2 smart meter roll out is completed by the deadline of end June 2021, it is important to ensure that the necessary data analysis tools are in place to make maximum use of the data generated.

The deployment of smart meters should enable DNO's 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 to 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.

6.3 Computational Modelling

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. 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.

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 LV Main and LV Service underground cable size and removed cable tapering this means upgrades are uniform across the company. The current WPD 11kV system modelling tool also includes losses calculations, but as one of the first measures WPD undertook was to increase the 11kV underground cable size and removed cable tapering at 11kV this means upgrades are uniform across the company. At EHV WPD currently uses two system modelling tools, PSS/E and IPSA. PSS/E 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.

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.

6.4 Harmonics

Harmonics are generated whenever 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 the 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 retro-fit LV harmonics monitoring solution is capable of recording Total Harmonic Distortion (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.

6.5 Asset Replacement

Asset replacement is the ongoing and is the 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 technical 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 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 cross sectional area cables with larger cross sectional area cables.

7 Policies and Actions

7.1 Assessment

This section contains all the various sections that WPD are currently focusing on with a view to reduce losses going forward. These actions can be split into three areas: actions completed before 2020, actions completed during 2020 and plans for 2021 and beyond. These actions will allow WPD to reorganise the network to make it run more efficiently, identifying actions that can be taken to prevent or reduce energy loss to theft or unmetered supplies. However, there are also some discussions, particularly in the network design section, of policies where WPD will be able to implement in the near future, with reference to the innovation projects which are investigating them.

Actions Completed Before 2020

- 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;
- Start of voltage reduction across WPD;
- The on-going reduction the variable losses in 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;

7.1.1 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.

7.1.2 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 RIIO-ED1 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.

7.1.3 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.

7.1.4 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 governments Energy White Paper 2020 which lays out the de-carbonisation of heating and transport, and with the Future Homes Standard due to be published in 2025 where heat pumps and most likely EV chargers are to be incorporated into new build properties, WPD are now designing networks to cater for the increased loads and for decreasing the losses as BAU.

7.1.5 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 met.

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.

7.2 Actions Completed During 2020

- 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;
- The continuing installation of 88 amorphous cored 25kVA single phase PMTs;
- 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;
- 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;
- Completed a programme of voltage reduction across all the WPD licence areas;
- WPD completed a Consultation on three phase cables and from 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 and three phase cut-out as BAU.

7.2.1 Asset Replacement

WPD's work to uprate assets continued through 2020 and will continue through to the end of RIIO-ED1.

7.2.2 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.

7.2.3 Stakeholder Engagement

The WPD stakeholder engagement plans continue and full details are detailed in Section 5. In 2017 WPD hosted a Stakeholder Engagement session. At that event WPD shifted the focus of the losses work to include the effects of de-carbonisation of heating and transport and as such introduced plans to target electric vehicle and other Low Carbon Technologies demand as the next significant area of increased losses on WPD network. During early December 2019 the latest bespoke WPD Losses stakeholder event took place at the IET in Birmingham, SSEN joined WPD to give feedback on their Losses project TASS/LEAN.

7.2.4 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.

7.2.5 Revenue Protection - Supplier Side Abstraction

In November 20 Eon confirmed their intension 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 19 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.

7.2.6 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.

7.2.7 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.
(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.

WPD'S role in revenue protection - 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, all service disconnections after WPD's equipment should be made by the supplier or their appointed Revenue Protection Service provider.

7.2.8 ENA Losses Group

Since 2016 WPD along with all the other DNO's and ESB have been holding regular meetings of the ENA Technical Losses Task Group.

7.2.9 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.

7.3 Plans for 2021 and beyond

WPD plans for 2021 are to build on the work done so far and move the company's focus to new areas of potential increased losses. WPD will focus more towards low carbon technologies and, in particular, the effects of de-carbonisation of transport with EV charging and the de-carbonisation of heating with the installation of heat pumps.

- Continuation of the asset replacement scheme started at the beginning of RIIO-ED1;
- Electric Vehicle Charging;
- Large scale connection of heat pumps;
- Network Optimisation at 11kV;
- 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 in Q4 2021;
- WPD are currently involved with Pobl and Sero Homes in producing the Housing Estate for the Future in Parc Erin Tonyrefail;
- WPD are currently involved in the redesign of the existing 1950s network to come up with an enhanced network for partners Pobl and Sero Homes in the retro fitting the Blaen-y-maes Housing Estate where each house is expected to be fitted with a three phase LV service cable, solar panels and battery storage all devices will be programme logic controlled;
- Pad Mounted low loss transformers to support car park EV charging installations;
- Continuation of installation of three service cables and cut-outs as BAU;
- In 2020 WPD built IT systems to receive and analyse all accessible smart meter data from the DCC, however when processing consumption data these systems are currently requiring further enhancements; In relation to this Smart meter data, although WPD have an approved Privacy Plan this is currently going through a review to ensure the processes planned for consumption data fully conforms to the detail of the document.

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

As WPD have large amounts of long single phase overhead lines feeding small single phase transformers, these will become an issue with the de-carbonisation of heating and transport. Whilst these units are outside the Eco design transformer legislation, WPD will explore what losses could be reduced by using alternative transformer designs and to meet the de-carbonisation targets.

WPD is looking at part of the Blaen-y-maes Housing Estate project which will be supplying a dedicated three phase 4 core 300mm² Wavecon LV mains cable to street furniture / lights to overcome the issue of charging electric cars where the house holder does not have a dedicated driveway to enable EV charging i.e. terrace housing or housing association housing. In conjunction with an LV accessory supplier a new small insulation piercing connector / joint for LV mains / service cables has been designed. The use of an SNE cable would overcome earthing issues associated with CNE cable circuits.

7.3.1 11kV Network Optimisation

From the Losses Investigation Project Loughborough University has done modelling which shows by relocating 11kV NOP's to the optimum position for losses can reduce the 11kV element of losses by 8-12%, with the greatest potential saving occurring on overhead networks. WPD plans to develop this further taking into account the relative benefits of loss reduction, the capacity for new LCT connections and the Interruptions Incentive Scheme, but it should be noted that there is a balance between losses reduction in kWh's and potential Customer Interruptions with more customers on a feeder. We will progress a practical trial in the South West area during 2021.

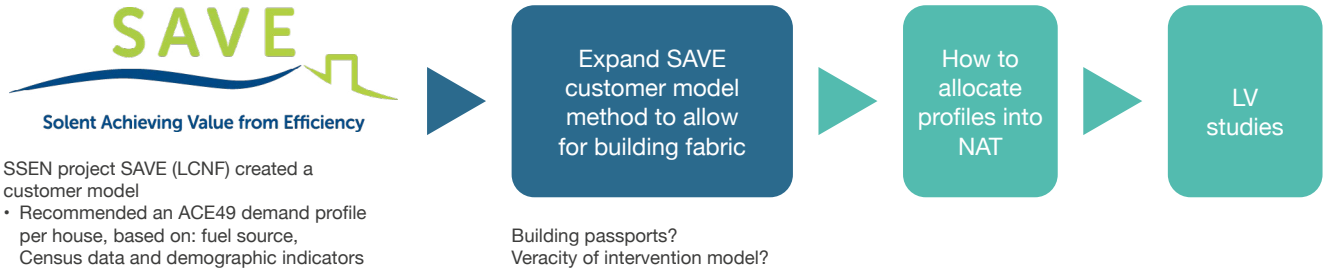
7.3.2 Parc Eirin LCT Connected Estate

The site work has continued, on reduced scale during the Covid period, with the losses project involving Pobl, Sero, Morganstone Homes and WPD, there are now the first customers living on the estate, which when finished will contain 238 homes at Parc Eirin in Tonyrefail – The Housing Estate for the Future, where each house will be fitted with a three phase LV service cable, solar panels, battery storage, heat pump, electric vehicle charging, smart washing machine and dishwasher all device will be programme logic controlled.

It should be noted that all the devices on the estate are single phase with the exception of the EV charger. The housing estate will be 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 Losses Investigation Project on the Isle of Man, the object being to produce an audit trail showing losses are reduced by using three phase service cables on new build properties. At this time WPD are looking for another project where all the above conditions are meet but the houses use three phase devices this would complete the audit trail which has been mentioned previously.

7.3.3 What needs to be done first before 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[1], as such a large section of WPD's existing 11kV and LV mains networks were designed for 1950s, 1960s and 1970s where the electricity usage assumptions building fabric standards at the time of installation were lower than the building standards first introduced during the 1990s. WPD have been involved in the design exercise of a second losses project with the Welsh government, Pobl and Sero Homes, Optimised Retrofit Project, where some 700 homes will be retro fitted with LCTs and the structure of the buildings brought up to an EPC A rating, these homes are in the Blaen-y-maes Housing Estate, where each house is fitted with a three phase LV service cable, solar panels, battery storage and possible heat pump all devices will be programme logic controlled. The Innovation Team in WPD are now looking at undertaking an Innovation project which would use information from the ORP scheme to build in the very important building fabric side of any retrofit project otherwise the lossy-ness of the building will not align to LCT introduction.



Discussions are on-going with the Welsh government on whether heat pumps should be fitted or not. As there are no driveways in Blaen-y-maes WPD will be looking to provide the cabling for on street charging to be installed by the council / third parties. The housing estate will be fully monitored on the 11kV and LV side with a view to ascertaining the losses and load balancing on a three phase connected housing estate compared to the single phase connected houses in Losses Investigation Project on the Isle of Man, the object being to produce an audit trail showing losses are reduced by using three phase service cables on upgraded retrofitted properties.

7.3.4 Small size pole mounted transformers

Consequently WPD have purchased 88 single phase 25kVA amorphous transformers, these transformers have Iron losses of 16W compared to the standard CRGO transformer Iron losses of 65W. Using these figures one year's cost of Iron losses for an amorphous cored 25kVA single phase transformer compared to an identical CRGO cored 25kVA single phase transformer using the following formulae show below:

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

1 Years amorphous 25kVA transformer iron losses = 140W.
1 Years CRGO 25kVA transformer iron losses = 569W.
This gives an iron loss saving of 429W per year per transformer by using the single phase 25kVA 11kV amorphous cored transformer. Using the Ofgem price of £48.42 £/MWh, this equates to a cost saving of just the iron losses per transformer per year of £20.78

[1] Page 1 More than 1m over 55s living in hazardous homes Home Care Insight study finds. Access/Intelligence/Studies by Sarah Clarke 09/05/2019 https://www.homecareinsight.co.uk/more-than-1-million-over-55s-living-in-hazardous-homes-study-finds/

7.3.5 Substation Footprint

WPD have raised the issue of the current substation foot print where the existing ground mounted transformer is a 1MVA and with the need to meet the governments Clean Growth Strategy of de-carbonising heating and transport could see a circa 40% increase in load on the LV network. This possible increase will create issues in existing suburbs or housing estates and where new substations need installing to meet the growing load requirements and taking into account current legislation. Various proposals have been made to the ENA Losses group and to the ENA LCT group to creating a unified DNO response, this work is currently on-going and it is proposed that BEIS/OZEV/Ofgem and the ENA form a working group to look into this.

7.3.6 Car Park Charging & Padmount transformers

WPD are currently working with Wilson Power Transformers of Leeds to design and manufacture a 1MVA amorphous cored transformer specifically for multiple electric vehicle car charging in car parks etc. WPD are still looking for a site where this concept can be proven, there has been interest from some County Councils but this has waned recently. We expect the hubs to provide an 11kV connected charging solution to cater for up to six 150kW rapid chargers and this would be used in areas where there is no off street parking in housing estates or in depots where fleet charging is required.

7.3.7 Network Design

WPD's current LV system modelling tool WinDebut is being replace by ConnectLV which is a new Planning tool which is more suited to the LCT devices which are becoming more prevalent on our network, the Planning tool is capable of Losses calculations, 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. During 2021 the 11kV tool will be replaced with the Sincal tool for all areas, which also supports losses modelling functionality.

With the adoption of PSSE throughout the company, the West Midlands models are all converted and switch-levelled, the Primary System Design engineers are being trained, and we are rolling the models out into the various tasks over the coming weeks and months. With the East Midlands, the conversion PSSE is on-going and is earlier in the process when compared to the West Midlands, perhaps some six months behind. Whilst all EHV designs are bespoke, WPD has completed work to provide templated solutions for generation connections, these templates incorporated the losses impacts.

7.3.8 Actions Proposed for RIIO-ED2 (2023-2028)

During RIIO-ED2, on the LV mains UGC network, WPD will install 300mm^2 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 185mm^2 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.

Appendix 1

In this section we list all of the original 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 with the WinDebut platform includes losses calculations for each scenario used.
Benefit for customers – WPD's LV and 11kV system modelling tools includes 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 two system modelling tools, PSS/E and IPSA. PSS/E can create a losses calculation, it is envisaged that PSS/E will become the standard system within WPD by Q4 of 2019. Whilst all EHV designs are bespoke, WPD has completed work to provide template solutions for generation connections, 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 because of a 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 just 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 now 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 230 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 will also include EV chargers and Heat Pumps so that the out of balance can checked with the enhancement that is expected.

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 (LEM) enables National Grid ESO and Western Power Distribution (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.

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 SHON 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. With the Governments Carbon Plan 2011, the governments Road to Zero Strategy 2018 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.

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 circa 230 houses in Parc Erin Tonyrefail where the services will be three phase.

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.

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

Action – 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 185mm² or 300mm² Wavecon cables. The size chosen for a particular scheme will be used throughout that scheme and tapering is no longer considered.

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 two system modelling tools, PSS/E and IPSA. PSS/E can create losses calculations, it is envisaged that PSS/E will become the standard system within WPD by Q4 of 2019. This date has been delayed due to a compatibility issue between the latest release of PSS/E and the WPD corporate IT hardware/operating system, which will be refreshed during 2019. 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

Benefit for customers – This proved viable and WPD is now working with a primary transformer manufacturer to come up with a bespoke design, this is ongoing and will be rolled out as soon as complete, where the installation can be monitored with a view to make it BAU.

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 is now working with a primary transformer manufacturer to come up with a bespoke design. This is ongoing and will be rolled out as soon as complete, where the installation can be monitored with a view to make it BAU.

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 building 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 their grid transformer sites with a view to creating a mini district heating system but because of the distance involved between building and transformers it becomes 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

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 $KgCO_2e$ for Transmission & Distribution.

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

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

Action – WPD has recently concluded 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 RIIO-ED2, the proposal is to use a CBA method as adopted by other utilities around the world this would. By adopting this method of assessment this ensures that the customer gets a consistent and auditable approach in CBAs.

Recommendation 23: The DECC/Ofgem comparison of reported losses shows a discrepancy which 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 lumped together on that particular host DNO network, this then will show 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 meet.

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 respect 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 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 the network which reduces the wasted energy that would be necessary to drive those losses, it also then by default frees up extra generation.

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.

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.

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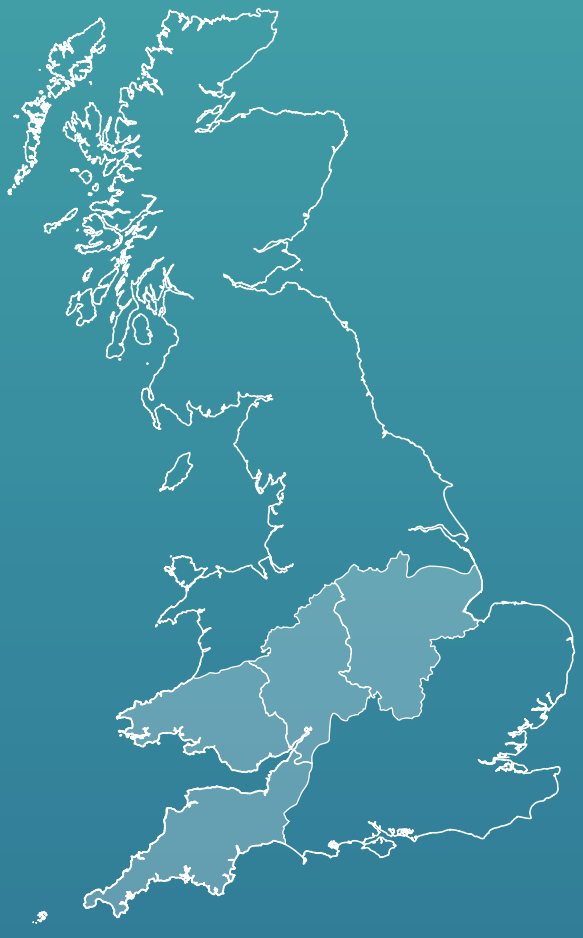

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