

ELECTRICITY NETWORK LOSSES

Malcolm BEBBINGTON
SP Energy Networks - UK

Malcolm.Bebbington2@spenergynetworks.co.uk

Wendy MANTLE
SP Energy Networks - UK

wendy.mantle@spenergynetworks.co.uk

Russell BRYANS
TNEI Services Ltd – UK
Russ.Bryans@tnei.co.uk

ABSTRACT

This paper is focused on Electricity Network Losses and the regulatory approach set by UK Electricity Regulator, Ofgem, during the regulatory period RIIO ED1 period (2015 to 2023). This approach ensures that network losses are kept as low as reasonably possible and will provide details on the additional actions proposed as part of the Losses Discretionary Reward mechanism aimed at extending the boundaries of what a DNO can do to further understand and manage the losses on its network.

1. INTRODUCTION

Electricity losses are an inevitable consequence of transferring energy across electricity networks and contribute a significant financial and environmental impact upon consumers. Effective losses management can therefore reduce the environmental impact and protect consumers from unnecessary increases to the distribution costs they pay.

Historically, network losses were calculated by UK Distribution Network Operators (DNOs) using meter settlement data and reported annually to the electricity regulator, Ofgem. This practice ceased in 2010 due to inherent inaccuracies in calculating losses and the challenges of making meaningful comparisons between different DNO licence areas.

Instead, DNOs are now obligated (under license) to design, build, and operate their Distribution Systems in a manner that can reasonably be expected to ensure that losses are as low as reasonably practicable. The test for “reasonably practical” is an economic cost/benefit analysis and both technical and non-technical losses are covered.

The Licence condition requires DNOs to publish a strategy showing how they will ensure that Distribution Losses from their systems are as low as reasonably practical and to maintain and act in accordance with their Distribution Losses Strategy.

In addition, during the current regulatory period (from 2015 to 2023), Ofgem introduced a Losses Discretionary Reward (LDR) which aims to encourage and incentivise DNOs to undertake additional actions to better understand and manage electricity losses.

The reward is worth up to £32m across all DNOs and will be made available in three tranches over the eight year RIIO-ED1 price control, with the first submissions made

in January 2016. The assessment focus of Tranche 1 was predominantly forward looking with submissions assessed against the stated criteria of: understanding of losses; effective engagement and sharing of best practice with stakeholders on processes to manage losses; and innovative approaches to losses management and actions taken to incorporate these into business as usual activities.

2. ISSUE

Losses on electricity distribution networks are currently complex and difficult to quantify. Energy loss inevitably arises from the action of transferring energy across distribution networks, as prescribed by the laws of physics. SP Energy Networks’ existing distribution networks are extensive, would cost more than £17bn to replace like-for-like, and take several decades to replace with lower loss alternatives. The amount of energy that customers use and the timing of this also have a direct impact on network losses.

SP Energy Networks (SPEN) is committed to better understanding and managing its network losses despite these significant challenges. It has identified specific actions aimed at developing administrative, commercial and technical infrastructure to enable and encourage customers to participate in loss reduction and capacity enhancement initiatives.

A key activity for SPEN is to undertake ongoing studies and to develop tools, data processing systems and trials to consider the value of loss reduction schemes. The future availability of Smart Meter Data has a key role in improving understanding of the level and location of losses.

3. APPROACH

The actions set out in SPEN’s Losses Strategy and Losses Discretionary Reward submission have been developed to improve its understanding and management of network losses. They are designed to ensure effective engagement and sharing of best practice with stakeholders, and will demonstrate the actions it is taking to incorporate innovative approaches into business as usual activities.

Losses Strategy

SPEN published its Losses Strategy in September 2015 to support its strategic vision of “*considering all reasonable measures which can be applied to reduce losses and adopt those measures which provide benefit for*

customers”.

The Strategy sets out SPEN’s overall intention for loss reduction given what is reasonably practicable, and is based on its current knowledge and ability to manage network losses. Its processes will continue to evolve to ensure it establishes a culture of considering network losses in every major investment decision it undertakes.

In line with EU regulations it will install lower loss transformers where it is replacing end of life assets. Further, specifically as a result of its Losses Strategy, SPEN will accelerate replacement of more than 1,000 higher loss transformers. These would have been replaced between 2023 and 2039 however these will now be replaced before 2023.

It is anticipated that the actions included within its Losses Strategy will lead to carbon savings of circa 24,000 tCO_{2e} and 45,000 tCO_{2e} in SP Distribution and SP Manweb respectively, and reduce the cost of network losses to energy suppliers, and ultimately customers, by around £8m during the RIIO-ED1 period.

Losses Discretionary Reward Mechanism

Ofgem challenged the UK DNOs to consider whether they are able to go beyond the licence requirement, essentially inviting the DNOs to consider whether:

- there are additional actions which they could take and are outside the reasonableness test set down as a licence requirement;
- any actions which they have already defined within their Losses Strategy document fall beyond the reasonableness test.

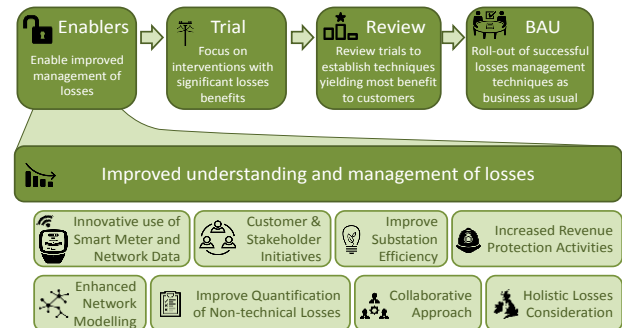
The LDR is managed in three tranches during ED1, Tranche 1 is concerned with “processes and methods which DNOs are exploring and implementing to understand and ultimately better manage losses on their networks”.

The objective of SPEN’s Tranche 1 submission was to present a number of initiatives which it considered would add long term value for customers, the energy industry and the widest possible group of stakeholders and thus seek funding for these initiatives under the LDR mechanism. (Such initiatives which did not meet the cost benefit analysis test were in general not eligible for funding under the normal RIIO-ED1 mechanism and therefore couldn’t proceed without alternative funding).

Portfolio of Initiatives

Building on the work undertaken to develop its Losses Strategy, a dedicated working group considered the challenges faced, taking account of national and international learnings and industry developments. From this analysis a portfolio of initiatives, additional to the licence requirement and focusing on the LDR criteria, were identified and assessed as suitable candidates for

long term losses benefit. These initiatives address eight key themes and fit into the long term context of loss reduction as follows:



In compiling its portfolio of LDR initiatives SPEN considered Ofgem's guidance, DNO's published Losses Strategies, information from industry experts, best practice from its parent company, Iberdrola, along with the needs of its network and processes.

Initiative 1 - Smart Meter Data Analysis Systems to reduce non-technical losses

The granularity of data presently available to SPEN limits its ability to quantify the level, location and variance of non-technical losses across its networks. This initiative will improve understanding of non-technical losses by: comparison of LV network data and Smart Meter Data; and developing demand pattern analysis to aid localisation of differences. Specific activities include automating the comparison of LV network monitoring data with Smart Metering Data, quantifying the difference in energy supplied versus energy billed. Network asset and topology data will be used to disaggregate technical and non-technical losses and apply fraud detection algorithms being successfully employed by Iberdrola in Spain to develop prototype analysis tools. Part of this initiative will be to develop multi-factorial pattern-detection algorithms to identify suspicious usage profiles.

Target Outcomes: Aims to clarify the benefits of co-joining information from network monitoring and metering data in identifying customers with exceptional trends/detecting fraud; facilitates more targeted investigation; and identifies whether there is non-technical loss reduction value in widespread network monitoring.

Initiative 2 – Smart Meter Data analysis systems to reduce technical losses

With the data presently available to SPEN, it is limited in its ability to identify specific areas of LV network incurring high-losses. This initiative will use Smart Meter Data to identify areas of the LV network with thermal constraints and potential for interventions to reduce technical losses. Specific activities will be to develop a model which identifies high losses in HV/LV

substations and LV feeders including validation of the accuracy of modelled losses; determine how Smart Meter Data may be integrated into business as usual model runs when data becomes available; and identify (with other DNOs, suppliers and meter operators) how to complete data sets and/or generate accurate synthetic data.

Target Outcomes: Use Smart Meter Data to improve losses understanding and decision making for the LV networks by: providing a tool for identifying areas of rapid demand growth, e.g. LCT clusters, without requiring additional network monitors to be installed.; enabling consideration of how losses and capacity would be affected by network reinforcements or stakeholder co-operation to shift or reduce loads; and as electric vehicle technology is rolled out, enabling consideration of how network usage may be incentivised for maximum capacity and minimum losses

Initiative 3 – Voltage Optimisation to Improve Network Losses and Load

Historically SPEN's voltage control strategies have been designed with standardised settings, principally focusing on capacity. The losses/capacity impact, through all voltage levels, of applying different voltage control strategies requires further study in order to optimise control strategies. This initiative seeks to optimise voltage to improve losses; and improve understanding of load/voltage sensitivity for planning and operational purposes. Once it has determined the selection criteria and select network sections for trials and building on LCNF projects already undertaken, SPEN will determine impact on losses and capacity of a range of target voltage strategies ensuring adequate network and system user monitoring and control are in place.

Target outcome: Improved understanding of the losses impacts of optimising network voltage in a range of its networks.

Initiative 4 – Improved Modelling of Complex Networks (HV) to reduce losses

Existing losses assessment tools are limited in their ability to accurately assess the technical losses in more interactive/complicated areas of SPEN's networks. This work will develop improved tools for considering losses in the planning timeframe. This will enhance the ability to make losses related investment decisions. Specific activities include: determining the real-time data / meter-data links and data gap assumptions regarding demand, embedded generation, load pattern and economic aspects to be used for life-cycle modelling; developing wide views on model principles and architecture; assessing / providing guidance on conditions where all half-hour periods should be assessed independently versus a method of banding hours at flow-levels; coding, documenting and validating the model; and considering the applicability of approaches to real-time active network management.

Target Outcomes: Improve knowledge regarding losses / capacity impacts for load related and asset replacement decision making, enabling SPEN to hold a more accurate view on the long term losses impacts of HV network development strategies; and losses minimised settings for innovative network components e.g. Phase Shifting Transformers and STATCOMs. Also enable holistic assessments with TSOs regarding whole-system losses optimisation.

Initiative 5 – Improved Modelling of HV Rural Networks to reduce losses

At present the imbalance arising due to single-phase HV spur lines is rarely assessed. This work will develop and validate improved modelling tools for identification of areas of rural HV networks with high phase-imbalance. Specific activities include formulating a parametric model based on readily available network data, establishing appropriate weightings for each criteria to indicate the likelihood of phase imbalance. Any applicable pre-existing data collected during LCNF Tier 2 Flexible Networks will be used to refine/improve the parametric model and carry out small scale measurement trials to determine which parameters and network characteristics are indicative of worst cases. Trials involve measurement at various line locations and comparison with predicted flows. The results of these trials will be used to inform locations for more detailed modelling / study.

Target outcomes: Improve understanding of the losses (and capacity) impacts of phase-imbalance on HV rural networks using a validated process. Clarify the economic and technical basis for approval of intervention actions.

Initiative 6 – Assessment of Power Factor to Improve GB Losses

A long term, whole-system view should be taken to understand and optimise the efficiency of the overall GB electricity systems. This work will develop/test a system of holistic working with stakeholders by considering power factor to improve losses, in context of the total system. (NGET have indicated a move towards maintaining a lagging power factor at each interface.) This will consider the challenges and appropriate whole system solutions. Specific activities include: Undertake an investigation of how power factor at each transmission interface changes naturally both hourly/seasonally and agree with NGET and all key stakeholders of how the total system impacts of proposals would be assessed. SPEN will agree a range of alternative options to achieve equivalent stability measures and how these options would be valued, and consider the impact on its own system and on Transmission/Distribution and inter-DNO boundary flows / losses to facilitate assessment of whole-system. Quantify the increased cost (losses and capacity) associated with maintaining a range of agreed lagging power factor values at each NGET and DNO interface.

Target outcomes: Supports a process for consideration of total system impacts of planning and operational initiatives however and wherever arising. Tests the process by linking it to a real system issue and establishes a mechanism for deriving and critiquing costs (including losses and opportunistic capacity values) to be used for cross-utility option assessments.

Initiative 7 – Improved detection of theft through Revenue Protection

Electricity theft continues to be an issue faced by the industry; this work seeks to improve detection through:

- **Police Initiatives** by allocating a full time member of staff to Merseyside Police Cannabis Dismantling Team and working with Police Scotland to set up Information Sharing Agreement and Memorandum of Understanding to allow both parties to work closely together for mutual benefit.
- **Awareness Sessions** whereby reaching out and informing managed housing associations SPEN can take advantage of the volume of statutory visits made to tenants by those associations. It has already set up working protocols with Liverpool Housing Trust and the Glasgow Housing Temporary Accommodation Unit and has a view to rolling out to other appropriate partners for this work.

Target outcomes: Reduce present instances of significant theft and assist the police to discourage future theft.

Initiative 8 – Improving Network Loading by Active Stakeholder Engagement

The losses incurred in SPEN's networks are dominated by the way its customers use energy. This work will develop administrative, commercial and technical infrastructure for customers to participate in loss reduction and capacity enhancement initiatives. It will encourage user and influencer participation in the development of processes and in overall value determination and DUoS banding.

Target outcomes: Investigate and report on the main factors to be considered to encourage users to participate in active network management; develop key enablers of active network management, including undertaking a national and international assessment; provide a platform for a number of network zones suitable for active network management trials and enthuse key users to participate in trials; and develop mutually beneficial arrangements with customers willing to participate in demand reduction schemes.

Initiative 9 – Substation Efficiency – Investigate alternative uses for waste heat

Reducing wasted energy reduces carbon pollution and slows climate change. This work will evaluate the viability of using transformer waste heat as an energy source, prioritising cases based upon economic

cost/benefit and technical applicability and applying a range of values for unit of heat to determine cases worth pursuing. SPEN will assess existing projects to understand which cases met/ failed an economic test and assess the range of technical challenge and feasibility of retro-fitting heat exchangers to existing equipment. To build on key findings from Flexible Networks Tier 2 LCNF project, look to quantify to what degree active heat recovery from a transformer can be used to enhance the thermal rating and release transformer capacity.

Target outcomes: Quantify the benefits and obstacles to distribution level substation heat recovery projects and identify specific projects worth developing.

Initiative 10 – Substation Efficiency – Monitoring & consider self-sufficient substations

SPEN currently has no facility to accurately record the energy required to operate its substations. The energy is not large for individual substations but collectively it is substantial. This work seeks to improve substation efficiency by: determining the level and pattern of substation in-house load; reducing load by efficiency measures; and considering whether substations can be engineered to be self-sufficient and propose trials. SPEN will look to identify a sample of typical substations (in both its network areas), install meters which perform to standard but are recovered as part of other programmes and analyse data to estimate load and load patterns at all substations.

Target outcomes: gain a better understanding of load consumed by substation equipment.

Criteria Assessment

Whilst each initiative contributes more or less to each criteria, taken together the portfolio achieves a good balance against the four areas.

Initiatives 1 to 5 relate to better understanding and providing a strong platform for improving network losses, including incorporating the use of Smart Meter Data. Initiative 6 develops processes aimed at holistic working and SPEN has already entered discussions about the requirements for work in this area with other DNOs. Initiative 7 provides for revenue protection services to further address non-technical loss reduction and includes extending a trial already underway thus giving a lengthy reporting period.

The nature of customers' demand and generation is the single largest variable factor affecting network losses. Initiative 8 looks to develop administrative, commercial and technical infrastructure for customers to participate in active network management. This type of initiative could not be funded within the Losses Strategy because the cost benefit analysis, as presently performed, values the DNO cost but not the total social benefits of motivating such improvement. Typical activities needed are:

- assessing whether international best practices could be deployed by users as well as DNOs;
- incentivise better power flow profiles by involving stakeholders in the design of incentives;
- assess total value of encouragement of customers to improve their overall efficiency of energy use, which also reduces network losses and improves capacity.

This initiative also considers how the DUoS tariff and other motivators can influence stakeholders (customers, councils and devolved government) to create reduced and smoothed demand patterns to avoid the network peak. Lowering demand and smoothing the use pattern of energy significantly reduces losses. On average, energy consumed at peak loading time in winter creates 3 to 6 times the variable losses compared with energy consumed at the minimum time in winter.

Initiatives 9 and 10 are aimed at reducing substation losses by seeking to convert transformer heat to useful energy and by monitoring substation house load with a view to reducing waste and moving toward self-sufficient substations. Initiative 9 improves accountable losses by removal of certain transformer losses from the count (because they would be producing useful energy). Initiative 10 uses innovation to create a good housekeeping example for system users. SPEN will be including a public expert event open to (and seeking contributions from) EU energy managers, customers, academics, other DNOs, the regulator and BEIS. Parent company Iberdrola will contribute their wider experience of loss reduction activity and it expects to extend knowledge on all aspects of loss reduction - from approaches to regulation through to more technical aspects such as development of Smart Meter Data analysis systems, transformer waste heat applications and low energy use substations.

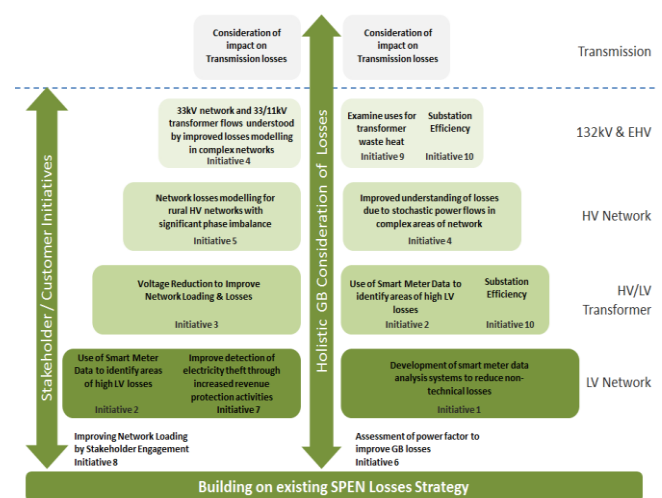
4. CONCLUSION

The portfolio of initiatives is balanced to match SPEN's overall needs and networks, recognising that a stakeholder and holistic approach is required when analysing and managing losses to achieve the maximum benefit. They have been identified to:

- improve losses knowledge over its entire network, geographically and with regard to voltage;
- build upon work carried out within the UK and capture international experience from its parent company and others;
- develop tools to use Smart Meter Data and network information ahead of the widespread roll out of the Smart Meter equipment, dealing with partial data availability;

- ensure the interests of stakeholders are recognised in designing the way forward;
- share the learning widely and encourage collaborative working;
- develop enablers for the DSO role of Active Network Management, as a way of reducing losses and facilitating capacity; and
- develop holistic working within the industry and its stakeholders.

This approach, considering all voltage levels, network interfaces and stakeholder and customer engagement is summarised as follows:



5. NEXT STEPS

A reward of up to £1.3m was available to each DNO group and the results were published by Ofgem in July 2016.

SPEN's submission was ranked third and received a reward of £770k. It was specifically praised for providing a strong set of initiatives which included consideration of both technical and non-technical initiatives.

Now that the level of reward is known, SPEN are progressing work on the initiatives and investigating working with other DNOs to achieve the maximum efficiency and breadth of coverage of the initiatives. In some cases industry-wide management of initiatives might be appropriate.

REFERENCES

- [1] Losses Strategy, Issue No 2, September 2015, SP Energy Networks, UK
- [2] Losses Discretionary Reward – Tranche 1 Submission, January 2016, SP Energy Networks, UK