Scottish & Southern Electricity Networks

SHE Transmission

Transmission Losses Strategy

Rev 3.0 October 2016

Transmission Losses Strategy

Summary

This paper presents SHE Transmission's views and approach on the impact of transmission losses on the transmission system. While every measure is taken to minimise transmission losses, there are a number of factors which must be taken into account when making investment decisions and not all of these result in a reduction of transmission losses.

All investment planning studies carried out by SHE Transmission take account of transmission system losses to ensure compliance of the transmission system with the National Electricity Transmission System Security and Quality of Supply Standard (NETS SQSS) as required under Standard Licence Condition D3 and section 9(2) of the Electricity Act. In addition, selection and purchase of new transmission plant requires an evaluation of the asset lifetime costs, an important part of which includes the assessment of the capitalised cost of losses.

As a Transmission Owner (TO) we do not measure actual losses on the system throughout the year, however our investment planning process does take into account the impact of electrical losses in our network development plans. Our focus is therefore on modelled losses which are assessed against a predefined generation and demand background in accordance with the NETS SQSS. SHE Transmission also considers the impact of losses when undertaking cost-benefit analysis on network expansion and reinforcement options.

Losses occur in the transmission system due to the heating of conductors in transmission lines and the heating of transformer windings. Transmission losses also occur due to the magnetisation of overhead line conductors and iron core in transformers. Losses can be reduced through existing overhead line reconductoring, voltage conversion, flexible AC transmission system, HVDC and use of low-loss transformers. Loss reduction strategies are rarely cost-effective when based on the loss reduction alone, however, strategies like reconductoring or voltage upgrade to increase transfer capacity can include loss reduction (savings) as part of a cost-benefit analysis to justify the investment.

During the RIIO-T1 price control period, SHE Transmission proposes a number of key transmission developments to accommodate the rapid growth in renewable generation in the north of Scotland. These developments include various conventional reinforcement works such as new overhead lines and substations, re-insulation and re-profiling of existing overhead lines as well as new technology such as HVDC links and Static Var Compensators. While all these have a beneficial impact on transmission losses, the rapidly increasing power exports through the network means that overall losses could remain flat or increase slightly over time.

Introduction

As part of its statutory and Transmission Licence obligations, SHE Transmission has a number of duties including the obligation to publish annual Transmission Losses report for the previous relevant year on or before 31 October, unless the Authority directs otherwise, in accordance with the requirements of the Special Condition 2K of our licence conditions.

Losses occur in a transmission system when power is transported from the power generating stations to the grid supply points. There are two main components of losses in a transmission system: fixed losses and variable losses, also classified as no-load losses and load losses respectively. Fixed losses occur in a transmission system by virtue of it being energised and are independent of loading conditions. The fixed losses are made up of corona losses in overhead lines and iron losses in transformers.

Variable losses occur due to the loading of the transmission system and are proportional to the load squared. The variable losses are heating losses due to the resistance of the conductor in overhead lines and the resistance of copper in the HV and LV windings of the transformers.

Losses can be reduced through existing overhead line reconductoring, bundling of phase conductors, raising nominal voltage, voltage conversion (HVDC), flexible AC transmission system, and use of low-loss transformers, among others.

This paper presents our approach to minimise the level of transmission losses on the SHE Transmission system in respect of section 9(2) of the Electricity Act to develop and maintain an efficient, co-ordinated and economical system of electricity transmission.

Methodologies

As a Transmission Owner (TO) we do not measure actual losses on the system; that is a function of how the system is operated and, hence, is monitored by National Grid as System Operator (SO). Our focus is on modelled losses which are assessed against a predefined generation and demand background.

SHE Transmission's investment planning studies are carried out against GB generation and demand backgrounds provided to SHE Transmission by National Grid, the National Electricity Transmission System Operator. Generation backgrounds are based on a future energy scenario approach that has been developed by NGET. Demand and small embedded generation figures are based on the Grid Code 'week 24' submissions from the local Distribution Network Owner (Scottish Hydro Electric Power Distribution) and any directly connected transmission users. The subsequent system power flow studies used for transmission investment planning and for the assessment of new connections include the assessment for transmission losses.

Transmission losses are estimated from power load flows under different generation and demand background scenarios using PSS/E power load flow software and Multiple Load Levels losses methodology.

Load Related Reinforcement Projects

Power flow studies are used to determine the impact of the proposed load related reinforcement projects on transmission losses against generation background at system peak demand in the completion year of the project.

Non-load Related Asset Replacement Projects

Power flow studies are used to determine the impact of the proposed non-load related asset replacement projects on transmission losses against generation background at system peak demand in the completion year of the project.

Material and Equipment Specifications

The procurement of materials and equipment (for example, transformers, static VAr compensators and High Voltage Direct Current links) takes account of the whole lifetime costs including transmission losses. Suppliers are provided with a capitalized loss value in £/kW to enable the optimum design to be established.

Transformers / HVDC

Within our tenders for transmission, we consider whether capitalised system losses are a valid criterion to include within our commercial evaluation (these are typically included for tenders for transformers, SVC and HVDC links). Consideration is also given to the inclusion of post completion performance tests to demonstrate losses are no different to loss values given in the tender.

Conductors

When replacing overhead conductors, an assessment of suitable replacements consistent with the capability of the existing tower structures is undertaken. Where appropriate, this can include a review of the conductor size versus cost, and replacing conventional ACSR conductors with AAAC conductors or new technology conductors which have a lower resistivity.

Cables

When selecting underground cables for asset replacement or reinforcement projects, consideration is taken on the type of conductor, dielectric material and sheath of the cable in order to select cables that provide optimum solution in terms of installation costs and losses.

Annual Reporting

To provide a consistent and coordinated approach to the measurement of Transmission Losses for each TO, a joint methodology was agreed between the respective TOs and SO to utilise the existing metering on the National Electricity Transmission System and the apportionment of losses for each respective TO licencee`s system. This methodology sets out principles and assumptions for this calculation to allow each TO to report on their metered Transmission Losses as per the TOs Special Condition 2K.4 (a). (see Appendix 1)

Multiple Load Levels losses methodology is used by SHE Transmission to estimate annual transmission energy losses. This methodology provides sense-checks on the losses figures reported by the SO. In the event of discrepancies between the losses figures, we engage with the SO to address them. For the avoidance of doubt, the sense-checks are estimates by SHE Transmission. The actual losses figures remain the responsibility of the SO.

Approach to new and alternative technologies

SHE Transmission's approach to new and alternative technologies is to apply solutions that offer the greatest potential benefit for transmission customers and our wider stakeholder groups. Our stakeholder-led priorities within this approach are to maintain security of supply and to keep costs down. In order to keep costs down and reduce the environmental impact of our activities, we are pursuing opportunities to reduce losses through new technologies. These include the following key examples:

ACCC overhead conductor (Project: IFIT 2010_01)

We have completed the assessment and trial installation of an Aluminium Conductor Composite Core (ACCC) conductor on a 132kV wood pole transmission line. The design of the ACCC maximises the area of conductive material in the conductor, providing the same power-carrying capacity at a lower operating temperature than in conventional conductor designs. The lower comparative operating temperature leads to reduced losses, as well as a high current-carrying capacity that can defer or avoid the requirement for more costly conventional network reinforcement. We are currently undertaking analysis of the trial results prior to potential transfer to business-as-usual in RIIO-T1. We will also continue to explore conductor opportunities other than the ACCC conductor which offer further opportunities to reduce losses as well as increasing capacity.

Multi-terminal test environment for HVDC systems (Project: SSEEN01)

A key aspect of SHE Transmission's longer-term strategy to reduce losses is the deployment and optimisation of high voltage direct current (HVDC) systems. HVDC systems are applicable to transmission over longer distances (i.e. greater than 60-70km), where the lower losses exhibited by HVDC systems make them a more economically viable solution than conventional alternating current (AC) systems. SHE Transmission is proposing to establish a collaborative facility which will enable the planning and optimisation of future HVDC systems in GB. This proposal was submitted to Ofgem in August 2013 for consideration as part of the Electricity Network Innovation Competition (NIC). This facility is known as the Multi-Terminal Test Environment (MTTE). It would allow detailed study of the interaction between new HVDC and existing AC networks as well as modelling of operational approaches to optimise DC and AC system performance, potentially leading to reduced losses. The outputs of the MTTE could potentially contribute to reducing losses in the latter years of RIIO-T1.

Further information about these priorities and how we apply them in our innovation programme is provided in SHE Transmission's Innovation Strategy submission for RIIO-T1 (p.1, Keeping the lights on and supporting growth: Our strategy for a smarter network, January 2012) at, https://www.ssepd.co.uk/WorkArea/DownloadAsset.aspx?id=1473

In addition to these technologies, we continue to assess new technologies related to reactive power compensation on the transmission network. One of the new technologies whose assessment has been completed is the 132kV insulated crossarms (NIA_SHET_0007). The purpose of the crossarms is to hold the conductors clear of the tower structure. Retrofitting the innovative crossarms to existing towers can enable the upgrading of existing lines to a higher voltage to enable higher power flows as well as reduce losses. This avoids the higher cost and greater environmental impact of rebuilding the affected lines to provide additional capacity.

We believe the set of new technologies described in this section address the need to reduce losses on our network as well as delivering our priority to deploy solutions which deliver the greatest net benefit for transmission customers and our wider stakeholder groups.

Impact of future developments on losses

During the RIIO-T1 price control period, SHE Transmission is implementing a number of key transmission developments to accommodate the rapid growth in renewable generation in the north of Scotland. These developments include various conventional asset replacement and reinforcement works such as transformer replacements, new overhead lines and substations, re-insulation and re-profiling of existing overhead lines as well as new technology such as HVDC links and Static Var Compensators. While all these have a beneficial impact on transmission losses, the rapidly increasing power exports through the network means that overall losses could remain flat or increase slightly over time. Figure 1 below gives a forecast of the losses in the SHE Transmission network at the time of system peak demand over the next eight years. The figure reflects the relative improvement works against a background of increasing power exports from north to south.

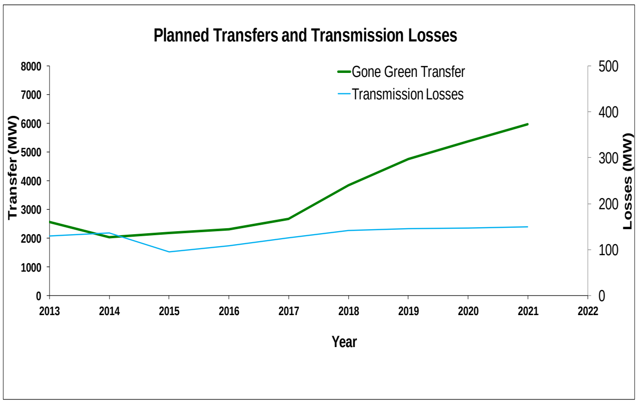

Figure 1: SHE Transmission Planned Transfers vs Transmission Losses

Losses Calculation

Multiple Load Levels losses methodology is used by SHE Transmission to estimate annual transmission energy losses. This methodology provides sense-checks on the losses figures reported by the SO. In the event of discrepancies between the losses figures, we engage with the SO to address them. For the avoidance of doubt, the sense-checks are estimates by SHE Transmission. The actual losses figures remain the responsibility of the SO.

SHE Transmission considers seasonal variations to determine the number of load levels, as well as the daily load variations. 3 sample days in each of the four UK seasons (Spring, Summer, Autumn and Winter) are used to represent peak, median and minimum load days in the season. Four samples per day are used to represent peak, shoulder, plateau and minimum load level. The 48 load levels are then simulated in PSS/E to determine the load losses in MW at each load level. The load losses at each load level are plotted against the load level. A load-loss relationship is established using regression analysis in a form of a quadratic loss equation. The quadratic loss equation is the average loss equation which is used to determine transmission energy losses over a particular period of time. The loss factor equation is given below: -

$$Loss\ factor = C_1 + C_2 L + C_3 L^2$$

Where L is the load level in per unit of annual peak demand and C_1, C_2 and C_3 are regression coefficients

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