



## **Line Loss Factor Calculation Methodology**

**SP Distribution and SP Manweb**

**Version 1**

**Effective from 1 May 2009**

# Statement of Line Loss Factor Calculation Methodology for SP Energy Networks' Electricity Distribution Networks

## 1. General Information

- 1.1. This appendix describes the methodologies applied by SP Energy Networks in the calculation of its Line Loss Factors (LLFS) for authorised users of its distribution network.
- 1.2. SP Energy Networks is providing this statement as an appendix to the Use of System Charging Methodology. It details the methodology that is used for the calculation of its published Line Loss Factors and is made available in order to provide clarity and transparency for users of its distribution network. The statement is in addition to the Use of System Charging Methodology statement and is not subject to approval by the Authority.
- 1.3. SP Energy Networks is obliged under Standard Condition 14 of the Distribution Licence to publish a statement of charges for the use of the distribution system that is in a form approved by the Authority. The statement is required to contain "a schedule of adjustment factors to be made for distribution losses" in the company's Condition 14 statement. SP Energy Networks Line Loss Factors are made available to Elexon (and therefore all market participants) through the provision of the dataflow, D0265 for SVA Line Loss Factors and an Elexon prescribed data format for CVA Line Loss Factors. All Line Loss Factors are calculated to an accuracy of 3 decimal places<sup>1</sup> and in accordance with the following Seasonal Time of Day (SToD) time periods<sup>2</sup>.

Period 1	Night	23.30-07.30	All Year
Period 2	Other	Any time other than Periods 1, 3, 4	
Period 3	Winter Weekday	07.30-16.00	Mon-Fri 1 Nov - 28 Feb
		19.00-20.00	Mon-Fri 1 Nov - 28 Feb
Period 4	Winter Weekday Peak	16.00-19.00	Mon-Fri 1 Nov - 28 Feb

- 1.4. Line Loss Factors are determined through the application of two methodologies. The Generic Line Loss Factors are calculated using a methodology similar to that developed by EA Technology, in conjunction with the majority of distribution businesses. This process produces averaged Line Loss Factors for use with all customers connected at LV and HV voltage levels and temporarily for new customer sites connected at Extra High Voltage (EHV) or above until a **Site Specific** LLF is calculated.
- 1.5. Site Specific Line Loss Factors are calculated for those sites connected at EHV<sup>3</sup> or above or where the DNO agrees to apply Site Specific calculation<sup>4</sup> following a Customer's particular request, using load flow models. The treatment of both demand and generation sites within these models follows the substitution method.

<sup>1</sup> BSCP128 Principle 2

<sup>2</sup> BSCP128 Principle 8

<sup>3</sup> Sites connected at EHV are all allocated unique SVA LLFCs or CVA MSIDs. A list is maintained, updated when new LLFCs or MSIDs are assigned and cross-checked with MDD.

<sup>4</sup> BSCP128 Principle 1

## 2. Generic Line Loss Factors

- 2.1. Generic Line Loss Factors are calculated for all SVA (non EHV) registered authorised users for the predetermined SToD time periods of the year. The allocation methodology and software model (program newLAF), similar to that developed by EA Technology, is utilised to calculate the Generic Line Loss Factors. The Generic Line Loss Factors are recalculated and published at least every 2 years<sup>5</sup>
- 2.2. The LLFC Groups for which Generic LLFs are calculated in SP Manweb and SP Distribution are listed below and are consistent with Principle 7 of BSCP128<sup>6</sup>:

SP Manweb	SP Distribution
132kV Extra high voltage Import (Generic )	
132kV Extra high voltage Export (Generic )	
33kV Extra high voltage Import (Generic)	33kV Extra high voltage Import(Generic)
33kV Extra high voltage Export (Generic)	33kV Extra high voltage Export(Generic)
High voltage substation connected	
High voltage network connected	High Voltage
Low voltage substation connected.	Low voltage half-hourly metered
Low voltage network connected.	Low voltage non-half hourly metered

- 2.3. At non-EHV voltage levels these LLFC Groups do not differentiate between import and export. LLFs for non-EHV sites where import and export are at the same voltage level will have the same values<sup>7</sup>.
- 2.4. At EHV, where a site temporarily has to be assigned one or more Generic LLFs for any reason this will be the relevant Import LLF where the site is predominantly import and the relevant Export LLF where the site is predominantly export. Where there is more than one site MSID at the same EHV voltage level, this dominant LLF will be assigned to all (typically both) MSIDs to ensure compliance with BSCP128 Principle 6.
- 2.5. In overall principle the model takes into account the units entering the system from known purchases at GSPs and from embedded generation and the units leaving the system, based upon known unit sales. The total system losses therefore take into account both technical and non technical losses<sup>8</sup> and are given by the following expression.

$$\text{Total System Losses} = \text{Units Entering System} - \text{Units Leaving System}$$

- 2.6. The voltage levels of 132kV(Manweb only), 33kV, HV and LV and the transformation levels of 132/33kV (Manweb only), 33/HV and HV/LV are represented within a network model. The model is populated with the set of standing data. For example, the fixed loss constant (in megawatts) and the variable loss constant (per megawatt squared) for each voltage and transformation level are contained within the standing data.

<sup>5</sup> BSCP128 Principle 12

<sup>6</sup> BSCP128 Principle 7

<sup>7</sup> BSCP128 Principle 6

<sup>8</sup> BSCP128 Principle 4

- 2.7. The model is also populated with the metered volumes of energy per annum at the various network voltages, including the energy metered profiles at the connection points with the transmission network and the contribution from distributed generation within the SP Energy Networks distribution network. The GSP and generation profile data enables accurate LLFs to be calculated for the predetermined SToD time periods of the year.
- 2.8. In the calculation of Generic LLF's, the losses apportioned are the difference between purchases and sales for the whole GSPG. The Losses associated with site-specific customers are also fully considered in this calculation. Aggregated data from all Site Specific SVA and CVA sites at each voltage level is entered into the model. The groupings for aggregation are listed in Paragraph 2.2 Non-EHV site specifics are treated as in Paragraph 2.11. The model then calculates the specific Generic losses associated with these groups of Site Specific sites along with the losses for the other Generic LLFC groups<sup>9</sup>. This is described more fully below.
- 2.9. In order to satisfy BSCP128 Principle 5 fully, the methodology considers the losses due to site-specific customers in the following ways.
- 2.10. At EHV, based on the aggregated EHV data input to the model, newLAF derives the total (sum of technical and non-technical) losses for each EHV group and calculates Generic EHV LLFs. These Generic LLFs are equivalent to an average of the site-specific EHV losses for that LLFC grouping, with allowance for the fact that different datasets may have been used for the site-specific (technical) and Generic calculations, and that the EHV Generics must include allowance for non-technical losses<sup>10</sup>.
- 2.11. At any other voltage level than EHV, the site-specific STOD LLFs and profile will be entered explicitly into newLAF for that site.
- 2.12. This ensures that losses due to site-specific customers will not be double counted by being reapportioned to any other LLFC groups during the Generic calculation.
- 2.13. A 'Top-Down' approach is used for estimating network losses starting from the GSP. The energy delivered from the higher voltage level is used to deduce the losses on the assets and thus the energy passed through to the lower voltage level.
- 2.14. The model calculates for each half-hour in the year the energy passed through the network into the next voltage level below using the following empirical equation:

$$P_{out} = P_{in} - v.P_{in}^2 - f - L + G$$

where  $P_{in}$  = Power into voltage level from higher voltage level,  $P_{out}$  = Power out of voltage level into lower voltage level,  $f$  = Fixed loss constant for voltage level,  $v$  = Variable loss constant for voltage level,  $L$  = Metered sales at voltage level,  $G$  = Metered generation at voltage level.

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<sup>9</sup> BSCP128 Principle 5

<sup>10</sup> BSCP128 Principle 4

2.15. This is illustrated by the following example which is carried out for each half-hour:

LLF at input at 132kV	1.0000
Power input at 132kV	2,000MW
Calculated fixed losses on the 132kV network	0.5MW
Calculated variable losses on the 132kV network for 2,000MW	9.5MW
$LLF_{132kV} = 1.0000 * 2,000 / (2,000 - 0.5 - 9.5) =$	1.0050
Sales from 132kV network with Site Specific LLF of 1.002	300MW
Generation into 132kV network with Site Specific LLF of 1.001	100MW
Power out into 132/33kV transformers = $2000 - 0.5 - 9.5 - 300 + 100 =$	1,790MW
Losses carried forward attributable to downstream customers	
$= 0.5 + 9.5 - 300 * (1.002 - 1) + 100 * (1.001 - 1) =$	9.5MW
LLF at input to 132/33kV transformers = $(1790 + 9.5) / 1790 =$	1.0059
Calculated fixed losses at the 132/33kV transformation	10MW
Calculated variable losses at 132/33kV transformation for 1790MW	20MW
$LLF_{132/33kV} = 1.0059 * 1790 / (1790 - 10 - 20) =$	1.0230

2.16. This is repeated through the voltage and transformation levels until the LV network is reached. The half-hourly metered load for that half-hour is then subtracted to leave the estimated demand for that half-hour attributed to the quarterly metered customers. This is not known for each individual half-hour. Therefore the total estimated quarterly metered demand for the year is compared with that used in producing the estimate of the Units Leaving System. There will always be at least a very small discrepancy in these two figures due to assumptions in the model and variations in LV metered data accuracy, e.g. time registration unmetered supplies, theft etc. This discrepancy represents unapportioned electrical losses and is thus reapportioned iteratively across all voltage levels by the model itself to match the two values. The model achieves this by adjusting the variable losses via the variable loss constants. Since estimates of fixed losses and of variable loss constants at EHV are more robust than the estimates of the variable loss constants at lower voltages the adjustments are weighted towards the variable loss constants at the lower voltages.

2.17. At this stage the model also apportions losses in the system at each voltage level to each electrical unit of energy flowing through that level.

2.18. The newLAF program calculates a LLF for each LLFC group for each half-hour at each voltage level.

2.19. The output LLF for a predefined time period, for each LLFC Group, is calculated as the average weighted value for that time period.

2.20. A customer's import or export supply is thus allocated LLFs dependant upon their point of connection with the network in relation to the exit points identified.

### 3. Site Specific Line Loss Factors

- 3.1. Site Specific LLFs are calculated on an individual basis where Principle 1 of BSCP128 applies. Each customer's supply is modelled individually using a model representation of the distribution network that contains details of the customers load profile, the system load profile and the specific DNO assets used to supply them. They are recalculated when there has been a relevant change (as defined in BSCP128) to the site or network, and at least every 5 years<sup>11</sup>.
- 3.2. The Site Specific LLFs are calculated for the same STOD time periods as the Generic losses.
- 3.3. As the Site Specific LLFs are derived from technical network models they account only for losses caused by the intrinsic electrical characteristics of the distribution network which consist mainly of power dissipation in components such as lines, power transformers and measurement systems<sup>12</sup>.
- 3.4. Significant changes year to year are much more likely to occur when losses are calculated on a site-specific basis. Changes in demand or consumption on one site can cause significant changes to the losses incurred due to that particular customer's connection. Such changes are not swamped by the overall inertia of the entire network and consequently site-specific losses are more volatile. However such significant changes are the exception rather than the rule as customers' overall demands and consumptions tend to remain fairly consistent (allowing for seasonal variations) given no major site or economic changes.
- 3.5. Site Specific Line Loss Factors are calculated for both load and generation customers using the substitution method.

### 4. Substitution method

- 4.1. Load flow and energy loss calculations are carried out with the customer connected and then disconnected from the network in the 4 time periods as specified. The change in losses is attributed to the customer.
- 4.2. A load flow approach is used for calculating network losses on all assets employed to service each customer, from the 132kV bar (or other lower voltage where applicable) at the GSP to the users point of metering with the network.
- 4.3. As a general principle load flow studies calculate a single set of results based upon a single set of network parameters and conditions. Therefore load flow studies are carried out, one for each of the time periods of interest using the customer's RMS demand attained in each period.
- 4.4. Half hour metered profile data is available for these customers from which the customers MD, RMSD and LLF can be readily calculated for each of the predetermined SToD time periods from actual or assumed half hourly metered data or assumed profiles.
- 4.5. The network model used to calculate Site Specific losses is based on Energy Networks' Long Term Development Statement and uses the best available asset data throughout.

<sup>11</sup> BSCP128 Principle 13

<sup>12</sup> BSCP128 Principle 3

- 4.6. Where more than one Site Specific customer exists locally on the network then each customer will be evaluated in turn using the substitution method described above.
- 4.7. LLFs for generation whose output causes an overall reduction in system losses will be  $>= 1$  (generators are assigned a benefit). Generation whose output causes an overall increase in system losses will have Line Loss Factors.  $<=1$ . Demand customers which offset generation losses and provide an overall reduction in losses also would receive a LLF  $<=1$ .
- 4.8. The LLF is given by the losses attributable to the customer in each time period averaged over the number of units generated. This process is carried out for each of the four predetermined time periods.

## 5. Revision of Published LLFs, Quality Assurance and Publication of LLFs

- 5.1. SP Energy Networks makes all reasonable efforts to maintain the consistency and accuracy of LLFs output by the calculation process<sup>13</sup>. Examples of the steps taken are:
  - Use of the highest quality data available to calculate Site Specific and Generic LLFs.
  - To calculate Generic LLFs, settlements data at reconciliation R2 or better for a twelve month period specified by Elexon will be used<sup>14</sup>.
  - Validation of input data by comparison with previous year(s) to identify potential errors, inconsistencies or trends with corrective action taken where appropriate.
  - Use of proven models and automated processes wherever practicable to increase consistency and reduce the introduction of errors
  - Thorough documentation of calculations and associated quality assurance processes.
  - Validation of calculated LLFs by comparison with previous year(s) to identify potential errors, inconsistencies or trends with corrective action taken where necessary.
  - Identification of the main contributory changes in electrical network parameters where LLFs change significantly.
  - Adjustments to LLFs, to take into account historic market wide issues noted in the BSC Auditor's latest Report, can only be made if agreed to be appropriate by the Panel<sup>15</sup>.
- 5.2. No changes will be made to approved Generic LLFs mid year<sup>16</sup>. LLFs calculated using this methodology are made available as an annual update and take effect from the 1st April each year. Where default LLFs have been applied due to an audit failure, these may be updated to the approved LLFs on a prospective basis as determined when the LLFs resubmitted by the LDSO have been approved by the Panel.
- 5.3. Changes to Site Specific LLFs will only be made mid year if there has been a material change (as defined in BSCP128) affecting the site and when agreed by the Panel<sup>17</sup>. Annual updates will have an effective from date of 1 April. Where default LLFs have been applied due to an audit failure, these may be updated to the approved LLFs on a prospective basis as determined when the LLFs resubmitted by the LDSO have been approved by the Panel.
- 5.4. Retrospective changes shall not be made to approved Site Specific or Generic LLFs other than to correct material manifest errors<sup>18</sup>.

<sup>13</sup> BSCP128 Principle 11

<sup>14</sup> BSCP128 Principle 9

<sup>15</sup> BSCP128 Principle 10

<sup>16</sup> BSCP128 Principle 14

<sup>17</sup> BSCP128 Principle 16

<sup>18</sup> BSCP128 Principle 15

- 5.5. For both Generic and Site Specific LLFs, the calculations will be saved with a timestamp indicating the date of calculation. In the process leading to each annual submission, inspection of the elapsed time since the last calculation will determine whether recalculation is required.
- 5.6. Where events trigger a recalculation under Principles 10, 15 or 16 of BSCP128 the recalculation will be carried out to the required BSCP128 timescales regardless of the date of the previous calculation.

## 6. Contact Details

- 6.1. This statement has been prepared to provide clarity and transparency for users of SP Energy Networks' distribution network. If you have any questions about the contents of this statement, please contact the relevant person at the address shown below.

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