

Review of Transmission Loss Adjustment Factors

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1. INTRODUCTION

This paper has been prepared by ESB National Grid (ESBNG) to provide information on the current methodology used for the calculation of Transmission Loss Factors. It also provides a formal opportunity to interested parties to raise any comments on the methodology and to suggest potential improvements to it.

This process is separate from the Commission for Energy Regulation (CER) Market Review of Trading Arrangements and only comments relating to the current loss factor methodology will be considered in this process. Interested parties are invited to comment on any aspect of this methodology, to ensure that adequate consideration is given to all comments please ensure they reach ESBNG by 6th May 2003. Comments should be sent, preferably electronically to:

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2. BACKGROUND

In 2000, the CER set forth the following principles with respect to losses after consultations in respect of a number of relevant papers¹.

2.1 Principles – Losses

The key principles associated with the treatment of losses are:

- The costs of transmission and distribution losses are borne by the individual market participants who cause them, and not spread equally across generators and customers as a whole.
- All settlement is assumed to take place at the interface between the transmission and distribution grids. This ensures that all quantities are calculated on a consistent basis.
 - Supplier contract nominations and metered consumption for each distribution-connected customer are scaled by a Distribution Loss Factor.
 - Generator contract nominations and metered generation for each generator are scaled by the generator's Transmission Loss Factor.

2.2 Principles – Transmission Losses

Losses are incurred on the transmission system as electricity is transported from generators to the transmission / distribution interface. In settlement of imbalance trades, the transmission losses are allocated to generators (including generators embedded in the Distribution System) using what are termed Transmission Loss Adjustment Factors, (TLAFs). Some generators are responsible for proportionally more transmission losses than others depending on their point of connection to the grid. For this reason, TLAFs are site specific. TLAFs therefore support efficient real-time dispatch of the system and also help to promote the efficient location of generating plant.

The following parties are subject to transmission losses:

- Generators connected to the transmission network.
- Distribution connected (embedded) generators, connected after 19-02-2000.

The following principles apply to the treatment of TLAFs:

- Loss factors are calculated by ESBNG (current [TLAF Table](#) can be found on the EirGrid website) and approved by the CER on an annual basis.

¹ Relevant papers include the Commission's Final Proposals for a Transitional Electricity Trading and Settlement System, published 27/1/00 (page 10 –11), ESBNG's Transmission and Distribution Losses Treatment papers, published 7/2/00, Transmission and Distribution Use of System Charges, published 18/12/00, and the Trading and Settlement Code (published 18/2/00).

- In deriving TLAFs, ESBNG first calculate Marginal Loss Factors (MLFs) for each affected generator.
- MLFs must be scaled to arrive at the TLAFs. This scaling ensures that throughout the year, annual forecast losses are exactly recovered.
- The TLAFs of certain generators will be greater than 1 because their output could have the effect of reducing, rather than increasing, transmission losses. However, most generators will have TLAFs of less than one.
- The Settlement System Administrator (SSA) uses the TLAFs assigned by ESBNG for each generating unit for the purposes of settlement of trade imbalances. The SSA uses the loss factors to adjust all generator dispatch instructions, metered outputs, and ex-post unconstrained schedule quantities to the trading point.
- Generators take into account losses when trading by using the applicable loss factor(s) to determine tradable quantities available.
- For purposes of energy market settlement, all transfers across the Interconnector during day hours and night hours will be adjusted by the TLAF for the applicable season and transfer flow direction.

3. ESB NATIONAL GRID METHODOLOGY

ESBNG prepares the TLAFs for each year in accordance with the CER's principles described in section 2. ESBNG's approach derives a location-based MLF for each generation bus and for the interconnector point. This section describes ESBNG's methodology, assumptions, and procedures involved in deriving the Transmission Loss Adjustment Factors.

3.1 Description

Transmission Loss Adjustment Factors, which are calculated using MLFs, are derived for each generator, taking account of forecast assumptions of average system demand and average generation dispatch for designated seasons and periods of the day (daytime and night-time). For a particular load and generation dispatch scenario, the MLF of a generator can be defined as the ratio of the change in system losses to the change in generation of the generator.

ESBNG's approach to TLAF derivation involves the use of power flow modelling software for marginal loss studies for each generator in the Republic of Ireland accessing the market. ESBNG develops a number of study cases that represent real system conditions and dispatch.

The losses allocated by MLFs are higher than base-case (or average) losses. This results in a requirement for scaling of marginal loss factors to ensure that only the base-case losses, as determined by separate studies in our power flow modelling software, are allocated to users.

The MLFs derived for each generator are scaled uniformly using a shift, or subtractive, approach so that the apportionment (generator output multiplied by the loss factor) meets the base-case losses. This is performed for each applicable case (i.e. day and night for each season). The overall loss allocation for each representative case (losses multiplied by case hours) is summed to determine whether the total allocated losses meet the forecast of overall system losses for the year. These factors are then scaled, again using the shift method, to ensure the final apportionment (forecast generator output multiplied by the TLAFs) exactly recover the annual forecast of transmission system losses.

3.2 Assumptions

3.2.1 Effective Time Periods

Transmission Loss Adjustment Factors are calculated for 5 seasons² of the year. These are similar to those selected by the CER for Top-Up tariff pricing. For each season, TLAFs are calculated for day and night hours. A day and night hour differentiation was selected as it represents reasonable differentiation in system demands within a season and was felt to be commercially manageable by generators. Further differentiation would involve degrees of study precision that would be complex from an ex-ante perspective and would be more complex for individual generators to implement.

² These designated seasons are detailed in Appendix A part 3.

3.2.2 Load Allocation

Demand estimation and distribution throughout the system is based on historical Special Load Reading (SLR)³ data which is scaled uniformly, except for stations with major industrial loads, as required to meet the demand requirement of the study. Industrial demand is forecast separately and is added to studies based on the expected industrial load demand at that site for the appropriate seasons and times of day.

3.2.3 Generation Dispatch

Weekly energy figures, which take account of unit maintenance outages, are forecast. From these, average generation unit dispatches are derived for each period to meet the system demand.

3.2.4 Network Configuration

The network configuration is based on the predicted transmission system for the relevant year and where changes or modifications are scheduled to occur within the year, such changes are added to the network in the season following their expected in-service date.

3.2.5 Reactive Power Dispatch and Voltage Control

The generation dispatches are modified where necessary to facilitate AC power flow study and to avoid unrealistic scenarios that would distort the results of the loss studies. Reactive power dispatch and voltage control have a significant effect on system losses and can not be modelled by DC analysis. To ignore AC analysis would therefore introduce significant distortion in the results.

Transmission system capacitors are in service, where necessary, to keep voltages within normal operational limits.

3.2.6 Distribution connected (embedded) generation

Embedded generation affects power flow on the transmission system in the same manner as directly connected generation. Consequently, in the derivation of the TLAfs the same approach used to determine transmission loss factors for directly connected generators is used for embedded generation, based on the transmission bus at which the embedded generator is connected. This ensures that loss factors do not provide perverse incentives that may bias the decision to connect to the distribution or transmission system.

3.2.7 Interconnector transfers – Imports and Exports

Loss factor derivation for import transfers on the interconnector is treated in the same manner as generation located within the Republic of Ireland. Exports from ROI should attract a loss factor which is dependent on the location of the interconnector to ensure that customers in Ireland are not impacted by international flows.

³ Load readings of each transmission station are taken at different times of the year.

3.3. Power Flow Studies

3.3.1 Initial base case studies

Using power-flow modelling software PSS\e from Power Technologies Inc., ESBNG perform power flow studies on day and night cases for each seasonal period base case to obtain a figure for total system losses in each case. Checks are performed to ensure the cases solve properly.

3.3.2 Season-period case batch run

Using features in the PSS\e software to allow multiple operations to be performed in succession the following study is performed on each generator bus:

1. The outputs of all generators to be studied are set at their specified dispatch levels.
2. The busbar to which the generator is connected is set as the swing bus⁴. This means that the generator being studied is the only one capable of compensating for changes in load and losses on the system.
3. The initial exported power (i.e power generated – house load) of the generator is recorded.
4. The system demand is increased by 5 MW using PSS\e's internal scaling function, which performs a pro-rata increase across all demand buses. The exported power of the generator bus is recorded and the difference between this and the initial value is the amount of extra power the generator must produce to meet the extra 5MW demand. The MLF is calculated for the increased demand.

$$\text{MLF} = (\Delta \text{ System Demand}) / (\Delta \text{ Exported Power of unit})$$

5. The system demand is then decreased by 5 MW. The exported power of the generator bus is again recorded. As before, the difference between the initial and final value is calculated. The MLF is calculated for the decreased demand.
6. The MLF for the generator at the dispatch level in question is obtained by calculating the average of the MLFs for the system demand increase and decrease.

Repeat for next generator using PSS\e's batch feature until complete.

Repeat for each Season-period case until complete.

3.4 Case Evaluation and Scaling Process

The results of the various studies are reviewed for completeness and for any anomalies. An example of the form of results is noted in Appendix A. The MLFs are multiplied against the full dispatch of the generation and the resulting over-allocation and scaling requirement are noted. Scaling of the MLF to meet the base case losses is performed

⁴ The swing bus is sometimes referred to as the slack bus. In a power flow study it is usual that the sum of the predicted injections at each bus will not exactly meet the total demand including losses. For this reason the injection at one bus must be adjusted, the bus selected for this adjustment is the swing bus.

using the shift method (subtractive or additive). This same procedure is repeated for each Season-period case.

3.5 Adjustment to Recover Annual Forecast Losses

Once the various case evaluations and scaling processes are complete, the base-case losses results of each Season-period case are multiplied by the number of hours each represents and are then summed to find annual losses. This value, the losses amount to be allocated by the Scaled MLFs, is compared to the forecast losses for the year to determine what adjustment, if any, needs to be made. As the various season-period cases all represent an average demand, average generation pattern and a fully intact network, the total losses calculated by this method are usually below the forecast of total transmission losses for the year. (For example transmission outages generally cause higher flows on other lines and increase overall system losses.) The Annual Losses Recovery (k) Factor is then calculated in the same manner as described in Appendix A part 3 to meet forecast annual transmission losses.

Therefore, to arrive at the final Transmission Loss Adjustment Factor, the k factor is subtracted from (or added to) the Scaled MLFs so that their allocation would increase (or decrease) slightly in each of the season-period cases in order to exactly recover the forecast transmission system losses over the course of the year.

4. SUMMARY

This paper provides an explanation of the workings of Transmission Loss Adjustment Factor derivation complete with a worked example. It also provides a formal opportunity to interested parties to raise any comments on the methodology and to suggest potential improvements to it. Please ensure that your comments reach ESBNG by 6th May 2003.

APPENDIX A: EXAMPLE CALCULATION AND METHOD

The following example provides a detailed description of the derivation of the Transmission Loss Factor Adjustments. The calculation provided in this simple example uses fictitious values and is purely for illustrative purposes.

Season 1 Day Case

Looking at the derivation of loss factors for 10 generators:

1. Marginal Allocation

Unit	Dispatch MW	System Demand Change (Δ SD) MW	Average Generator Dispatch Change (Δ DG _i) MW	Marginal Loss Factor (MLF = Δ SD/ Δ DG _i)	Marginal Allocation (=Dispatch \times MLF) MW
G1	100	5	4.75	1.053	105.3
G2	100	5	4.9	1.020	102.0
G3	100	5	5.125	0.976	97.6
G4	100	5	5.175	0.966	96.6
G5	100	5	5.2	0.962	96.2
G6	100	5	5.225	0.957	95.7
G7	100	5	5.25	0.952	95.2
G8	100	5	5.25	0.952	95.2
G9	100	5	5.325	0.939	93.9
G10	90	5	5.5	0.909	81.8
	990				959.5

2. Determination of the Scaling Factor required to obtain SMLFs

For this particular season case, base case losses for these 10 generators were calculated to total 19.9 MW. We see that marginal losses are greater than the base case/average losses. The scaling factor required to shift these losses down so their allocation will equal the base case losses is calculated.

	Generation (MW)	Demand (MW)	Losses (MW)
Marginal	990	959.5	30.5
Base Case	990	970.1	19.9

$$\text{Scaling Factor} = (\text{Marginal Losses} - \text{Base Case Losses}) / \text{Total Generation}$$

$$= (30.5 - 19.9) / 990$$

→ **Scaling Factor, SF = 0.0107**

A scaling factor is calculated for each season day/night case.

3. Annual Losses Recovery (k) Factor

The forecast of annual losses (2.4%) is based on 25,020 GWh transported across the transmission system in that period. The scaled marginal allocation is calculated and then compared to the annual forecast losses. We calculate these as a percentage of total generation and find the differences to yield the k factor.

We find the Scaled Marginal Allocation by multiplying the losses for each case by its designated hours.

Case	Hours in each period
Winter day (JanFeb)	885
Winter night (JanFeb)	531
Spring day	1380
Spring night	828
Summer day	1380
Summer night	828
Autumn day	915
Autumn night	549
Winter day (NovDec)	915
Winter night (NovDec)	549

We sum the MWh losses for each case to get the total average losses. For this example, the average losses for the year sum to 467,870 MWh and the forecast losses sum to 600,480 MWh.

$$\begin{aligned}
 \text{k factor} &= (\text{Forecast Losses} - \text{Average Losses}) / \text{Total Exported Generation} \\
 &= (2.4\% - 1.87\%) / 100 \\
 &\rightarrow \mathbf{k = 0.0053}
 \end{aligned}$$

The Annual Losses Recovery (k) factor is static for the year.

4. Final

Unit	Dispatch MW	System Demand Change (Δ SD) MW	Average Generator Dispatch Change (Δ DG _i) MW	Marginal Loss Factor (Δ SD/ Δ DG _i)	Marginal Allocation (= Δ Dispatch \times MLF) MW	SMLF (MLF + SF)	Scaled Allocation MW	TLAF (SMLF -k)	Final Allocation MW
G1	100	5	4.75	1.053	105.3	1.063	106.3	1.058	105.8
G2	100	5	4.9	1.020	102.0	1.031	103.1	1.026	102.6
G3	100	5	5.125	0.976	97.6	0.986	98.6	0.981	98.1
G4	100	5	5.175	0.966	96.6	0.977	97.7	0.972	97.2
G5	100	5	5.2	0.962	96.2	0.972	97.2	0.967	96.7
G6	100	5	5.225	0.957	95.7	0.968	96.8	0.962	96.2
G7	100	5	5.25	0.952	95.2	0.963	96.3	0.958	95.8
G8	100	5	5.25	0.952	95.2	0.963	96.3	0.958	95.8
G9	100	5	5.325	0.939	93.9	0.950	95	0.944	94.4
G10	90	5	5.5	0.909	81.8	0.920	82.8	0.915	91.5
MW	990				959.5		970.1		964.9

GLOSSARY OF TERMS

Annual Loss Recovery (k) factor: The factor required to shift total base-case losses for the year up to the level of forecast losses.

Base Case Losses: The average system losses as determined by a power system software model for each season/day-night dispatch case. These are calculated for ideal system conditions.

Forecast Losses: The forecast losses for a given year are based on expected annual losses but take into account transmission maintenance outages.

Generation Bus: The point of connection of a generator to the transmission or distribution system.

Marginal Loss Factors, MLFs: For a particular load and generation dispatch scenario, the MLF of a generator can be defined as the ratio of the change in system losses to the change in generation of the generator.

Scaled Marginal Loss Factor, SMLFs: The resultant loss factors when MLFs are scaled to meet base-case system losses. These are required because MLFs will over recover losses.