DISTRIBUTION LOSS ADJUSTMENT FACTORS

ESB SUBMISSION

TO

THE COMMISSION FOR ELECTRICITY REGULATION

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Introduction:

The Commission for Electricity Regulation (CER) have published ESB's proposals for a transitional trading system in Ireland. ESB's proposals envisage that transmission losses will be self provided by generators and that the consumer demand for each supplier will be grossed up to the Transmission – Distribution interface by distribution loss adjustment factors.

ESB have provided CER with a paper *Transmission Losses Treatment – ESB Submission to the Commission for Electricity Regulation* which sets out ESB's proposals on how transmission loss adjustment factors will be determined.

This paper sets out ESB's proposal in relation to distribution loss adjustment factors for consumption. These will be used to apportion distribution losses to kWh consumption metered at end user sites. A schedule of indicative loss adjustment factors is provided.

Embedded generators affect distribution losses. The kWh attributed to the embedded generator for settlement purposes should be the kWh exported to the distribution system, adjusted to take account of the effect on distribution losses. This paper includes proposals on distribution loss adjustment factors for embedded generators and how they will be determined.

1. Distribution Loss Adjustment Factors for Consumption.

For consumption, ESB are proposing time differentiated loss adjustment factors for each voltage level in the system. The loss adjustment factors would be applied to the consumption metered at the customers premises to gross it up to the Transmission - Distribution interface.

Time differentiation between day-time and night-time only is proposed as per the existing ESB end user tariffs.

Distribution loss factors are calculated using the following procedure:

- The losses on the distribution system during the latest year for which data is available are determined by subtracting the total kWh distributed from the kWh entering the distribution system[1].

- The total losses are allocated to the various levels of the distribution system.
  This allocation is based on computer based load flow studies of the distribution system.

- This allocation of losses is reconciled with the metered consumption at the various levels to produce a system loss summary. This describes the inputs, losses and outputs for each level of the system.

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[1] At present the metering at the transmission - distribution interface is not capable of measuring the kWh entering the distribution system with sufficient accuracy for this purpose. The energy input into the distribution system is determined by taking aggregate generation and subtracting the consumption of transmission connected customers and an estimate of the losses incurred on the transmission system. This estimate of transmission losses is determined using load flow studies.

- From this system loss summary, the ratio between input energy and output energy is determined for each level of the system. The loss adjustment factor at a given level is the product of the input/output ratio of that level and all the upstream levels.

- The loss adjustment factor at each level is then time differentiated by reference to the system load profile.

Indicative Distribution loss adjustment factors for ESB's system are shown in table 2.1:

Level	**Time Period**	
	Day	**Night**
38kV	1.018	1.015
MV	1.050	1.041
LV	1.107	1.087

Table 2.1 - Indicative Distribution Loss Adjustment Factors for Consumption

Day-time is from 8.00am to 11.00pm, summer and winter in accordance with the present retail tariffs for 38kV and medium voltage customers.

The loss adjustment factors will be set for a calendar year and will be published in advance.

ESB's proposal strikes a balance between the desirability of reflecting the physical conditions on the network on one hand and of having stable factors determined in a transparent way. ESB does not favour the application of site specific loss adjustment factors for consumption. Site specific factors for consumption would be complex to calculate and would be subject to change over time as the configuration and loading of the local network evolves. It is anticipated that in general suppliers and their customers will prefer loss factors which are stable and predictable over time.

ESB' proposal to adopt standard time differentiated loss adjustment factors for consumption is in line with the treatment in the U.K. for LV and 11kV customers.

2. Distribution Loss Adjustment factors for Embedded Generators.

In general terms, embedded generators have two counteracting effects on distribution system losses:

- Normally, embedded generators reduce losses on the parts of the distribution system shared with end users.

- Losses are incurred on the connecting network increasing Distribution system losses.

The overall effect of any given embedded generator on distribution system losses depends on the point of connection to the main distribution network, (the voltage level is particularly significant), the loading on the part of the network to which the generator is connected and on the electrical characteristics of the connecting network.

ESB propose that site specific loss adjustment factors be used for generators which will reflect the most critical determinants of the losses effect of the generator in a reasonably simple and transparent way. The most critical determinants are:

- The voltage level of the point of common coupling of the generator with end users.
- The electrical characteristics of the connecting network between the generation site and the point of common coupling with end users

The site specific loss adjustment factor will be determined using the following formula

$$\mathbf{GEN\_LAF(t) = LAF_v(t) - CLF} \qquad \text{(Equation 3.1)}$$

where

LAF_v(t) are time differentiated loss adjustment factors which reflects the effect of the energy exported by the generator on losses on the part of the distribution system shared with end users.

CLF is the loss factor for the connecting network[2].

Normally, **LAFv(t)** will be taken to be the loss adjustment factor for consumption for the voltage level at the point of common coupling between the generator or end users. As these factors are greater than unity, their effect will be to increase the kWh attributed to the generator reflecting the more common situation where embedded generators reduce losses on the part of the distribution system shared with end users.

Where it is clear that the effect of the generator is to increase losses on the networks shared with end users[3] rather than reduce them, it is proposed that site specific **LAF_v(t)** factors will be determined.

CLF is the ratio of the losses incurred on the connection as a percentage of the energy exported by the generator. It is a relatively simple quantity to calculate for a given site. Appendix B describes how ESB propose to calculate CLF.

Given that the length and other characteristics of embedded generator connections vary considerably, it is appropriate that **CLF** be calculated on a site specific basis. A site specific approach strengthens location signals.

The site specific loss factor, **GEN_LAF(t),** would be applied to the energy metered at the embedded generator site to gross it up to the transmission distribution interface.

[2] Any network on the generators side of the metering is not part of the connecting circuit.
[3] ESB propose to adopt the criteria that if the generator production (kWh) is greater than twice the load supplied by the substation feeding the network to which the generator is connected,) site specific LAF_v(t) s will be determined. These will be less than unity reflecting the physical reality in these cases where the generator is increasing the losses on the network rather than reducing them

Two examples of how the site specific loss adjustment factors work out in practice are given below

Example 1: A 1 MW Hydro generator connected to the medium voltage (MV) network by a 2kM overhead line.

The point of common coupling with end user customers is at MV. Referring to table 2.1, the loss adjustment factors (LAF_v (t)) for consumption at MV are:

Day time : 1.050

Night-time: 1.041

The connection loss factor (CLF) for a 2 km circuit of 50s SCA conductor, operating at 10kV (assuming metering at 10kV) is 0.011

Based on equation 3.1 above, the site specific distribution loss adjustment factors are:

Day time: 1.050 - 0.011 = 1.039

Night time: 1.041 - 0.011 = 1.030

This would mean that daytime generation would be uprated by 3.9% and night-time generation by 3.0% for settlement purposes. A transmission loss factor would also be applied to take account of the losses effect on the transmission system.

Example 2 A 10 MVA Wind farm connected to the 38kV network via a 10km line.

The connection is to the 38kV network. . Referring to table 2.1, the loss adjustment factors (LAF_v (t)) for consumption at 38kVare:

Day time : 1.018

Night-time: 1.015

The connection loss factor (CLF) for a 10km circuit of 100s SCA conductor operating at 38kV (assuming metering at 38kV) is 0.020.

Based on equation 3.1 above, the site specific distribution loss adjustment factors are:

Day time: 1.018 - 0.020 = 0.998

Night time: 1.015 - 0.020 = 0.995

A factor of 0.998 would be applied to kWh export metered at the generator’s site during day-time hours to determine a quantity of kWh delivered to the transmission system. A transmission loss factor would then be applied to this gross quantity to determine the kWh produced for settlement purposes. Similarly a factor of 0.995 would be applied to kWh exported during night hours and a transmission loss factor applied.

The above examples illustrate how the proposed method yields site specific loss factors which reflect the physical reality reasonably well and while retaining the advantages of transparency and stability of the resultant loss factors over time.

APPENDIX A

GLOSSARY OF TERMS

Main distribution system	The lines cables and transformers deployed to distribute electricity to end users. It does not include assets deployed for the sole purpose of connecting an embedded generator or generators to the system.
Connecting network	The ESB owned lines cables and transformers which are deployed for the sole purpose of connecting an embedded generator or generators to the main distribution system. It does not include networks used to distribute electricity to end users.
Point of common coupling with end users	The point on the distribution system were the connecting network joins the main distribution network

APPENDIX B

DETERMINATION OF CONNECTION LOSS FACTOR (CLF)

Figure A2.1 below illustrates the general case. The connecting network is shown dotted.

In most cases only one generator will be involved. However for completeness, the procedure is described for the more complex case where part of the connecting network is shared by more than one generator. In the illustration below, sections 2,3 and 4 are shared by the two generators.

In most cases, the connecting network will not include a transformer. However the procedure is described for the more complex case where the connecting network includes a transformer as per the illustration below.

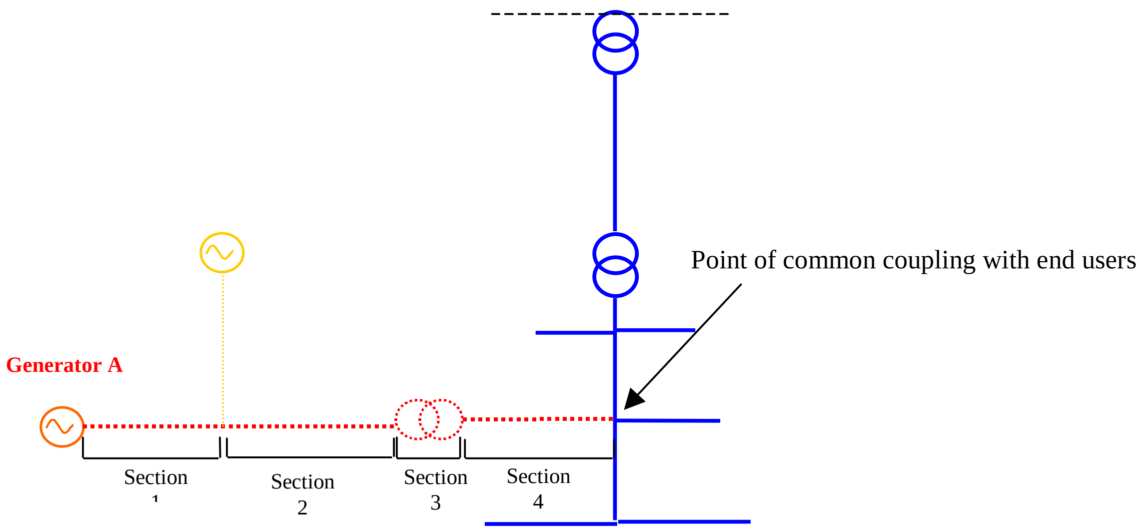

Figure A2.1

To calculate the connection loss factor **(CLF)** for a generator, the connecting network is split into sections such that shared sections are distinct from sections utilised by a multiple generators and transformers are a distinct section.

The connection loss factor **(CLF)** for any generator is the sum of the loss rates for the network sections and the transformers between the metering at the generator site and the point of common coupling with end users.

In Figure A2.1 above, the Connection loss factor **(CLF)** for Generator A would be the

$$\mathbf{CLF = LF_1 + LF_2 + LF_3 + LF_4}$$

where LF_1, LF_2 etc are individual loss rates for the network section 1, network section 2 respectively. The formulae for the loss rates for line/cable sections and transformers are given below.

(a) Loss rate for an overhead line or underground cable section

The loss rate for an overhead line or underground cable section is calculated using the following formula:

$$LF_i = \frac{MAX\_GEN_i \times R_i \times LLF}{P.F.^2 \times V_l^2 \times 1000 \times LF}$$

where

MAX_GEN_i is the maximum generation in kW exported through the network section i

Where the network section is utilised by a single generator, **MAX_GEN_i** is taken as the agreed maximum export capacity of the generator.

Where the network section is shared by more than one generator (e.g. sections 2,3, and 4 in Figure A2.1), then **MAX_GEN_i** is the sum of the individual generator export capacities.

V_l is the line voltage of network section in kV

P.F. is the operating power factor**.** Where ESB specify a range it will be taken to be the mid point on the range.

R_i is the phase resistance of the network section I

LLF/LF the ratio between the loss load factor and the load factor for the technology involved i.e. wind, hydro, landfill.

This ratio would be derived from typical generation profiles for each technology.

(b) Loss rate for a transformer section

The loss rate for a transformer is calculated using the following formula:

$$LF_i = \frac{MAX\_GEN}{P.F.^2} \times \frac{Cu\_Loss}{TRAFO\_KVA^2} \times \frac{LLF}{LF} + \frac{Ir\_Loss}{MAX\_GEN \times LF}$$

where

MAX_GEN_i is the maximum generation in kW exported through the transformer.

TRAFO_KVA is the rating of the transformer in kVA

P.F. is the operating power factor**.** Where ESB specify a range it will be taken to be the mid point on the range.

Cu_loss is the transformer variable loss at rated current in kW

Ir_loss is the transformer fixed loss in kW

LF/LLF the ratio between the loss load factor and the load factor for the technology involved i.e. wind, hydro, landfill.

This ratio would be derived from typical generation profiles for each technology.

LF the load factor for the technology involved derived from typical