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Edition 1

QUANTIFYING AND REPORTING OF ENERGY LOSSES IN ELECTRICITY DISTRIBUTION NETWORKS

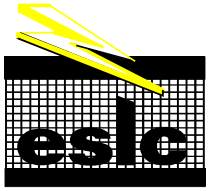

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Table of changes

Change No.	Date	Text affected

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Foreword

This specification was prepared on behalf of the Electricity Suppliers Liaison Committee (ESLC).

The Working Group comprised the following members:

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R Buckas	National Energy Regulator
H Essop	City of Cape Town
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Introduction

Distribution energy losses have been increasing over the years due to a number of reasons ranging from purely technical e.g. load growth, to non-technical e.g. energy theft. Although efforts have been made to manage these losses, these lacked proper co-ordination and, consequently, progress has not been significant. This specification is intended to provide a consistent methodology for estimating and reporting on non-technical losses with a view to a more concerted approach in future.

All electricity distributors internationally experience non-technical losses. However, there is very little information in the available literature on energy losses and on non-technical losses in particular, and even that which is available is inconsistent and unreliable. Hence it is very difficult to compare utilities or countries with regard to non-technical energy losses because even in cases where the data is available, it is packaged differently by the various utilities.

The technical loss factors provided in table 1 are based on an incomplete national sample. It is anticipated that a comprehensive investigation and statistical analysis will be undertaken to provide more representative and applicable technical loss factors in future editions of this specification.

The management of these losses is essential due to the amount of revenue lost by the industry. To manage these losses, procedures, mechanisms and especially benchmarks need to be developed to enable utilities to effectively manage the process. A national project was launched to establish these procedures with the National Energy Regulator (NER) playing a central role. Non-technical loss will be one of the key performance indicators required by the NER from licensees.

A standard format is required for this information so that benchmarking can be done. In this way, lessons can be drawn from best performing utilities.

This standard complements NRS 055 (Standard for Revenue Protection).

Keywords

non-technical losses, technical management losses, energy losses, measurements, benchmarking.

Contents

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QUANTIFYING AND REPORTING OF ENERGY LOSSES IN ELECTRICITY DISTRIBUTION NETWORKS

1 Scope

This specification sets out a standard methodology for quantifying and reporting energy loss statistics in the South African Electricity Distribution Industry by:

a) specifying the process for quantifying energy losses;

b) standardizing the estimation of technical losses;

c) reporting these losses internally and to the NER in a consistent format.

2 Normative references

Not applicable.

3 Terms, definitions and abbreviations

For the purposes of this specification, the following definitions apply:

3.1 Terms and definitions

energy delivered [energy purchased by the utility]
energy measured at substation feeder level from which customers are connected;

NOTE The difference between energy delivered and energy sales will give total losses.

non-technical losses
generally due to theft, faulty meters, billing errors, etc and calculated by subtracting technical losses from total losses

rural networks
electrical networks found in areas that are sparsely populated e.g. farming communities; [networks that are not defined as urban (see urban networks)]

technical losses
energy losses in electricity supply networks due to the resistivity of the conductors and energization of transformers

NOTE This is generally referred to as copper and iron losses. Technical losses can be calculated using well proven methods that yield acceptable accuracy levels.

total distribution losses
difference between total distribution purchases and total distribution sales

technical loss factor
factor which links energy sales, energy delivered and technical losses

NOTE technical loss factor multiplied by energy sales equals energy delivered.

total sales
total measured or estimated energy consumption of a group of customers

urban networks
networks that meet any one of the following conditions:

a) serving a proclaimed township or within a proclaimed township as determined by the Townships Board;

b) the number of connections within a 1 km radius of the particular point of supply exceeds 314. All connections within the particular development will then be classified as urban; and

c) the number of current and newly applied connections per km of MV line exceeds 44 and there must be at least 40 connections in one development.

3.2 Abbreviations

NER National Energy Regulator

4 Requirements

4.1 Background to standard energy losses measurement methodology

Energy balancing is the process of measuring energy sales at customer premises and comparing that with energy delivered (injected) in the network at which those customers are linked, for a defined time period. The difference between sales and energy delivered is the total energy losses.

As illustrated in figure 1, energy balancing can occur at different levels, either at the substation (where energy measured by meter S_x is compared to sales linked to both feeder 1 and feeder 2) or at feeder level (where for example, energy measured by meter F_1 is compared to sales linked to feeder 1). Balancing at substation level requires fewer meters as compared to balancing at feeder level. However, feeder balancing has an advantage of being able to localize losses to a manageable area.

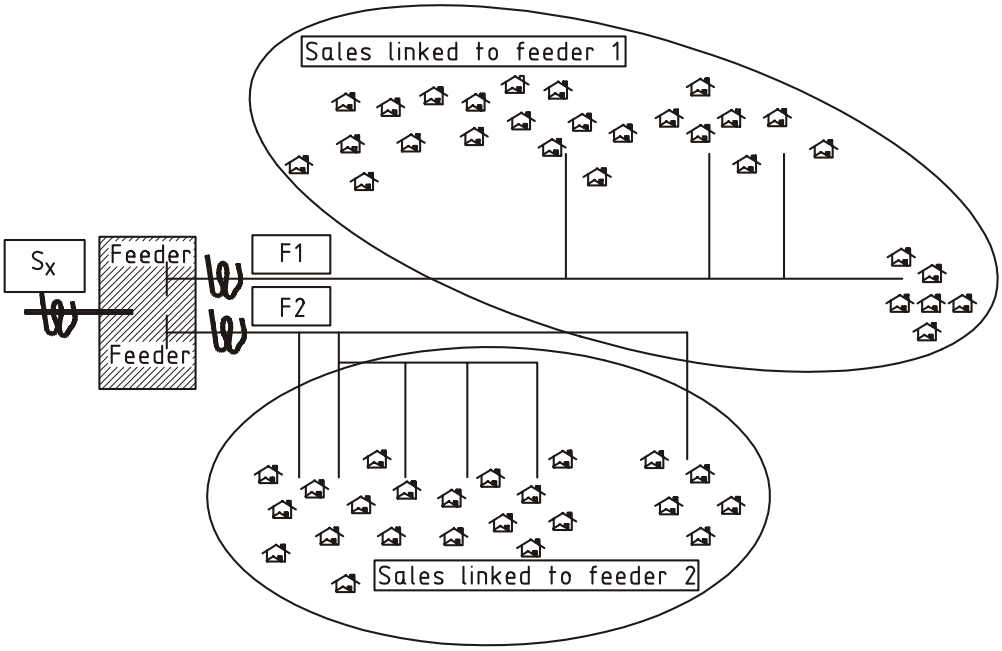

Figure 1 — Illustration of energy balancing at substation and feeder level

To ensure that the energy balancing process is accurate and meaningful, all sales should be associated with the correct network. Therefore, meter reading schedules should ideally be planned in such a way that meters in a specific network are read on the same day. However, this is invariably not possible. Also, where customers have been provided with prepayment meters, energy sales will be in advance of energy delivered. To ensure the time and energy mismatches, and for comparison of results, a three-month moving average shall be used for all energy loss reports.

NOTE Reports to the NER will in general, be expected to be reports for a 12 month period (see 4.5).

4.2 Technical and non-technical energy losses split

It is important for the utility to be able to distinguish between technical and non technical losses if proper and workable strategies are to be developed and implemented to reduce or manage the losses, because these losses have different dynamics.

The technical loss factor is calculated from the formula in equation 1:

$$1 + (tl / ed) = tlf$$

where

tl are technical losses

ed is energy delivered

tlf is technical loss factor

The energy delivered is equal to the sum of the total sales plus the total energy losses.

The total energy loss is equal to the sum of the non-technical losses plus the technical losses.

NOTE The management of non-technical losses in NRS 055.

4.3 Technical energy losses calculation/estimation methodology

To quantify the non-technical losses in its networks, the utility needs to estimate, fairly accurately the technical losses associated with those networks. Ideally, a proper metering infrastructure should be in place to measure these losses. However, accurate measurement of technical losses is usually not practicable, so models have been developed to estimate technical losses using proven methods that yield acceptable accuracy levels.

Using equation 1, the technical losses shall be estimated using the loss factors in tables 1(a) and 1(b), unless the utility is able to justify the use of alternative loss factors.

NOTE Alternative loss factors may be determined by carrying out load flow studies on sample networks. There are a number of load flow study tools in the market. Each utility can use the tool accessible to them.

4.4 Classification of network types

It would be ideal to model each network and have technical losses calculated. However, utilities have huge numbers of these networks and it will be time consuming to model each and keep records separately, so it is necessary to group these networks into a manageable number of network classes/groups and have a model per class/group. For the purposes of this specification, the classifications in tables 1(a) and 1(b) shall be used.

Table 1(a): Loss factors for urban networks

1	2
Classification	**Loss factor**
<500V	1.0912
≥500V – <66kV	
Industrial	1.045
Small Holding	1.057
Residential	1.086
≥66 – ≤132 kV	1.0174

Table 1(b): Loss factors for rural networks

1	2
Classification	**Loss factor**
<500V	1.1189
≥500V – <66kV	1.0900

NOTE The industrial, small holding and residential networks above are mostly 11kV and 22kV.

4.5 Standard energy losses report

A standard structure/format for energy loss reports should be used for internal reporting, as shown in the example in table 2. This will allow for comparison between different areas, regions, and utilities. The frequency of the report for internal use will depend on the utility management's requirements. The information in these reports provides the data to be summarized in a report for the NER.

Once a year, or as required by the NER, each utility shall submit a summary report to the NER, in the format shown in table 3.

Annex A
(informative)

Reporting formats

A.1 Energy and revenue loss report format for internal use

1	2	3	4	5	6	7	8	9	10	11	12
	Voltage [kV]	**Network type [rural/urban]**	**Number of customers (see note 1)**	**Energy delivered [kWh]**	**Total sales [kWh]**	**Total losses [kWh]**	**Technical losses [kWh]**	**Non-technical losses [kWh]**	**Non-technical losses [% of energy delivered]**	**Revenue loss associated with technical losses [R]**	**Revenue loss associated with non-technical losses [R]**
Network name	A	B	C	D	E	F = (D-E)	G (see note 2)	H = (D-E-G)	I = (H/D) × 100	J	K
TOTAL UTILITY											

NOTE 1 The number of customers is not used in the calculations but is provided for possible comparison purposes. The number of customers which are connected to the network being reported on at the beginning of the reporting period should be used.

NOTE 2 The technical loss factors shall be calculated using the applicable loss factors in table 1.

A.2 Calculation of technical losses

The technical loss factors shall be calculated using the applicable loss factors in table 1.

Technical losses, G = D (loss factor −1) [see equation 1]

A.3 Calculation of revenue losses

In the case of revenue losses associated with technical losses, the revenue losses (J) shall be calculated using the bulk purchasing rate applicable to the utility. In the case of non-technical losses (K), the revenue losses shall be calculated using the average tariff applicable to all customers.

A.4 Energy and revenue loss — sample report form for reporting to the NER

Name of utility: .....

Reporting period: from ..... to .....

1	2	3	4	5	6	7	8	9	10
Network classification	**Number of customers**	**Energy delivered [kWh]**	**Total sales [kWh]**	**Total losses [kWh]**	**Technical losses [kWh]**	**Non-technical losses [kWh]**	**Non-technical losses [% of energy delivered]**	**Revenue loss associated with technical losses [R]**	**Revenue loss associated with non-technical losses [R]**
< 500 V urban									
≥ 500 V – < 600 V urban									
Industrial									
Small holding									
Residential									
≥ 66 kV – ≤ 132 kV urban									
< 500 V rural									
≥ 500 V – < 66 kV rural									
TOTAL UTILITY									