Calculation of losses in electricity distribution grids and incorporation into end user tariffs 110.MD

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Table of Contents

Abbreviations 4

Executive Summary 6

1 Introduction 8

1.1 Key Deliverables 8

1.2 Scope of Work 8

1.3 Framework of the Report 8

2 Validation of Loss Estimates 10

2.1 Basic Principles 10

2.2 Technical Loss Rates 1

2.2.1 Power Transformers 1

2.2.2 MV Feeders 3

2.2.3 Distribution Transformers 3

2.2.4 LV circuits 5

2.2.5 Meters 5

2.2.6 LV services 5

2.3 Non-Technical Losses 5

3 EU Loss Estimation Practices 6

3.1 Context 6

3.2 Energy Metering 7

3.2.1 Load Profiling 8

3.2.2 Statistical Sampling 11

3.3 Distribution Network Data 12

4 EU Distribution Tariffs and Losses 14

4.1 EU Practice 14

4.2 Treatment of Losses in Tariffs 15

4.3 Time Period Used to Estimate Losses 16

4.4 Frequency of Loss Estimation 16

4.5 Allocation of Losses by Voltage Class 16

4.5.1 General Case 16

4.5.2 Special Case – Medium Voltage Consumers 17

5 Recommendations for Moldova 19

5.1 Loss Measurement & Estimation 19

5.2 Recovery of the Cost of Losses 19

Table of Figures

Figure 1: Example Energy Balance 1
Figure 2: Illustrative Load Duration Curve and ks Factor 2
Figure 3: Illustrative Load Duration Curve and ks Factor 2
Figure 4: Energy Balance Diagram: Energy and Losses (typical meter reading indicated 7
Figure 5: Loss Profiling Process 10

Table of Tables

Table 1: Example: Power Transformer Technical Losses 3
Table 2: Example: Distribution Transformer Technical Losses 4
Table 3: Total Electricity Losses in EU: 2000 – 2005 (ERGEG, E08-ENM-04-03), Moldova (2014) 6
Table 4: Continuous Metering Practice in the EU (ERGEG, E08-ENM-04-03) 8
Table 5: Commercial Consumer Categories 9
Table 6: Industrial Consumer Categories 10
Table 7: Sample Size with (n_0) and without (n) Finite Population (FP) Correction Factor 12
Table 8: Loss Component in EU Tariffs (various Regulator websites) 15
Table 9: Loss Framework - by Voltage & by Series / Shunt Components 17

Abbreviations

ANRE	National Agency for Energy Regulation
DSO	Distribution System Operator
EU	European Union
HV	High Voltage (> 35kV)
kVA	Kilo-Volt Ampere
kVArh	Kilo-Volt Ampere Reactive hours

kW	Kilo-Watt
kWh	Kilo-Watt hours
LV	Low Voltage (415V)
MV	Medium Voltage (6 (10)kV or 35kV)
Network	The electricity distribution network

Executive Summary

The stated objectives of this technical assistance are as follows:-

- Appraise the ANRE of Moldova in EU mechanisms for establishing reasonable estimates for technical and non-technical distribution losses;
- Identify the dataset required to validate loss levels claimed by distribution companies;
- Establish methods of profiling load on consumption that has no interval metering;
- Review methods of incorporating losses in EU distribution tariffs; and
- Develop recommendations for the revision of the measuring and estimation of losses in Moldova and of options for inclusion of cost of losses recovery in the distribution tariff.

These objectives have been met by way of a discussion of the issues.

The EU mechanisms for establishing losses are presented in this report as a survey of current practices. It is important to recognize that all EU Regulators are concerned first and foremost with the determination of monthly global loss figures, as the difference between physical energy purchases and sales, whether determinations are made ex-ante, ex-post or both. As a general finding on the methods used for loss allocation in the EU, the EU Regulators demand less accuracy from the DSO's than is currently the case in Eastern Europe (including Moldova). This is because the level of losses is low at less than 10%. Only in Spain and Portugal do Regulators give importance to loss allocation. Technical losses are determined by engineering models, whereas non-technical losses are determined as the net difference between physical energy purchases less sales less technical losses. In the liberalized markets the DSO have the responsibility to procure total losses and no attempts are made to determine an accurate split between technical and non-technical losses.

The dataset required to validate the loss levels claimed by the DSO's depends on the approach that ANRE takes to auditing loss computations. ANRE requires the DSO's to compute losses according to an approved technical procedure. It is understood that ANRE has requested the DSOs to provide extensive records of loss computations for the purpose of validation. This has been a contentious matter because it has required considerable effort on the part of the DSOs to prepare the computations in a suitable format. An alternative approach more in keeping with EU practice, recognizes that the loss computations are based on mathematical formulae with fixed parameter settings and variable data terms. The fixed parameters are related to the technical characteristics of the distribution network; once determined the parameters can be considered as fixed for a 5 year period. The variable data includes energy flow data and network topology data which changes from month to month. However, given that the network topology changes slowly, the loss rates at each voltage level can be considered as relatively fixed for a 12 month period. This means that loss rates can be computed for the previous 12 month period on monthly basis and use in conjunction with monthly metered energy data to validate losses at each voltage level. This approach only requires that the DSO provide a monthly dataset of energy import data for each level of the network.

Load profiling is used in the EU countries where interval meters are not available. Methods for profiling load as a means to aggregating loads at given locations within the distribution network are discussed in this report, for residential, commercial and industrial consumers. The development of load profiles involves a field measurement program across the country that can take several years. An alternative is to install interval meters on all medium voltage feeders, and at the LT terminals of a sample of distribution transformers. The sample must be drawn on a sound statistical basis, typically segmented by consumer (consumers per sq km) or line density (consumers per km). The statistical theory is given in this report along with an example calculation. The advantage of the 'meter and sample' approach at the distribution level is that the transformer LT meters can be included in the on-cycle meter reading routes and loss rates can be updated routinely.

The methods of incorporating losses in EU tariffs are discussed in this report. Generally speaking, losses are not the subject of specific loss tariffs. Losses are treated separately as components in 'allowed revenue' equations and in some cases incentives apply; the allowed revenue is subsequently rolled into tariffs according to the consumption of energy for the tariff class and a loss rate applicable to the voltage in question.

The following specific actions are recommended:-

1. Validate loss allocation estimates using loss factors established for each voltage level. Loss factors should be revised on a 12 month basis. Request the DSO to provide records of the physical imported energy to each voltage level. This approach may be applied on a District basis or a segmentation related to the topology of the distribution network.
2. Ensure accuracy of loss allocation by voltage by 1) regulating in support of the installation of interval meters on all medium voltage feeders as a distribution standard, and 2) supporting the use of a 'meter and sample' approach at the low voltage level in preference to load profiling.
3. Maintain the current tariffs in use in Moldova, and rely on the use of targets for loss reduction. At a future time, when market liberalization takes place, it can be expected that the DSO's will need to procure losses. The methods in use in the EU can be considered at that time.

1 Introduction

This Introduction contains a description of the key deliverables and the scope of work for this assignment.

1.1 Key Deliverables

The key deliverables extend to the following:-

- Appraise the ANRE of Moldova in EU mechanisms for establishing reasonable estimates for technical and non-technical distribution losses;
- Identify the dataset required to validate loss levels claimed by distribution companies;
- Establish methods of profiling load on consumption that has no interval metering;
- Review methods of incorporating losses in EU distribution tariffs; and
- Develop recommendations for the revision of the measuring and estimation of losses in Moldova and of options for inclusion of cost of losses recovery in the distribution tariff.

1.2 Scope of Work

The scope of this assignment extends to the following:-

- Prepare a review of the data typically required by regulators to enable the setting/approval of technical and commercial losses in a distribution network. The report should consider the estimation of technical losses due to the physical effect of passing electricity distribution network, and the estimation of non-technical losses arising from inaccurate metering, reactive energy, inaccuracies in the estimation of un-metered supply, theft etc.;
- Review the tariff methodologies in place to encourage the appropriate response to losses in the distribution companies as a component of the tariff methodology, including analysis of apportioning losses to supply at various voltage levels;
- Undertake a consultation and data collection mission to review the existing measurement rules, assumptions and detailed expectations of a revised tariff, with ANRE and representatives of distribution companies;
- To analyse the appropriateness of the parameters used in the methodology from data provided by ANRE, and to comment on reasonable targets by referring to current EU performance;
- To identify potential improvements to the reporting requirements and other procedures to encourage the efficiency of the distribution companies; and
- Present and discuss the outcome of the consultation with the beneficiary.

1.3 Framework of the Report

This report comprises an Executive Summary, Abbreviations, and four sections.

The **Executive Summary** and **Abbreviations** are provided at the beginning of this report.

Section 1 comprises this brief introduction.

Section 2 identifies the dataset required to validate loss levels claimed by distribution companies;

Section 3 details the EU mechanisms in place for establishing reasonable estimates for technical and non-technical distribution losses;

Section 4 reviews the methods used to incorporate losses in EU distribution tariffs

Section 5 includes recommendations for the revision of the measurement and estimation of losses in Moldova, and of options for inclusion of cost of losses recovery in the distribution tariff.

2 Validation of Loss Estimates

In this section the dataset required to validate loss levels claimed by distribution companies is discussed. The dataset requirement is determined by the methodology and approach that ANRE used to validate loss levels. In this regard ANRE requires the DSO's to compute losses according to an approved technical procedure. It is understood that ANRE has requested the DSOs to provide extensive records of loss computations for the purpose of validation. This has been a contentious matter because it has required considerable effort on the part of the DSOs to prepare the computations in a suitable format. An alternative streamlined approach is described that relies on the use of technical loss rates and energy flow data.

2.1 Basic Principles

The data of critical importance to all Regulators is the global monthly energy purchase and energy sales data (in kWh terms). The difference determines the DSO's global physical energy loss. The purchases and sales of physical energy can be validated with accuracy, as the purchased energy is metered (and check-metered) and sales are recorded by the DSO's billing system.

Subsequently the energy flow through the network must equate to the difference between the energy import and energy withdrawal at each voltage level. The flow can be envisaged as an energy balance as shown in Figure 1.

Using an energy balance map of the type shown in Figure 1, it becomes clear that a loss rate can be established for each voltage level or for each distribution network component. The loss rate is the ratio of technical losses divided by the energy import to each voltage (or network component). The loss rate does not change significantly in the short term, unless there is major expansion of the network; loss rates determined on a monthly basis for a previous 12 month period, can be considered as fixed for the next 12 month period.

Technical losses are computed as the sum of losses at each voltage level, referenced to energy purchase volume. Estimates for the allocation of losses by voltage are developing using network technical data and mathematical formulae. The mathematical formulae include technical parameters that are relatively fixed for long periods of time, e.g. distribution network branching characteristics of a network. This means that the technical parameters can be fixed for a period of up to 5 years before being reviewed and updated.

Non-techncial loss validation relies on the validation of technical losses. As a set of equations, the energy balance is explained by the following mathematical relationships:-

- Wtechloss = Wimport – (Wbilled + Wpilferage)
- Wimport can be measured or estimated
- Wbilled is known
- Wpilferage is unknown
- Wtechloss varies with Wpilferage, particularly when pilferage is high

It can be seen that if Wtechloss is computed, Wpilferage is automatically determined as a net quantity. Therefore so long as the technical loss estimates are accurate, it follows that the non-technical loss estimates will be as accurate as they can be.

The use of loss rates means that the dataset required by the Regulator can be limited to:-

1. Global monthly physical energy purchases and energy sales for the entire network; and
2. Monthly physical energy import at key points specified in the network; the key points could be fixed or varied from time to time.