Review of Eskom's procedures and tools for technical loss calculation in power networks (HV, MV and LV level)

Workshop 1 – Part 2
Monday 14.09.2020 – Friday 18.09.2020

- Session 4
  - 11 kV Power Factory study case – dynamic iterative loss calculation method
- Session 5
  - 132 kV Power Factory study case – how the loss pattern is affected by changes in power flow direction as the traditional top-down system is challenged
- Session 6
  - Review on loss calculation procedures and tools
    - Review note D1.1 with gap analysis

Pre-recorded sessions released on Monday 14.09.2020

QA session: Monday 21.09.2020

QUANTIFYING AND REPORTING OF ENERGY LOSSES IN ELECTRICITY DISTRIBUTION NETWORKS - NRS 080:2004

- 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.

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I couldn't agree more!
Difficult to compare/benchmark due to these reasons

The management of losses is essential – lost revenue

QUANTIFYING AND REPORTING OF ENERGY LOSSES IN ELECTRICITY DISTRIBUTION NETWORKS - NRS 080:2004

- 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.
- 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.
- 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.

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The split between technical and non-technical losses is important to do, since the mitigation strategies differ drastically

QUANTIFYING AND REPORTING OF ENERGY LOSSES IN ELECTRICITY DISTRIBUTION NETWORKS - NRS 080:2004

- 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.
- 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.
- 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

QUANTIFYING AND REPORTING OF ENERGY LOSSES IN ELECTRICITY DISTRIBUTION NETWORKS - NRS 080:2004

- A standard structure/format for energy loss reports should be used for internal reporting. 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.

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									

QUANTIFYING AND REPORTING OF ENERGY LOSSES IN ELECTRICITY DISTRIBUTION NETWORKS - NRS 080:2004

The NRS-method, in short, provides average percentages for technical losses in different network types (urban and rural) and for different voltage levels (LV, MV, HV), but says that the factors are based on an incomplete national sample, opening up for utilities to justify the use of alternative loss factors, determined by carrying out load flow studies on sample networks.

The average percentages for technical losses in different network types constitute a very simple method, but probably not very accurate. A grateful help for those utilities that haven't managed to develop any customized loss factors or any more detailed method.

How widely are the average percentages for technical losses in different network types used today at Eskom OUs?

Collection losses are not mentioned as part of the method. The energy loss reports should include a column for this as it is usually of management's interest – also contributing to lost revenue.

Reporting of losses on European level

entsoe

What are Network Codes?

Network codes are a set of rules drafted by ENTSO-E, with guidance from the Agency for the Cooperation of Energy Regulators (ACER), to facilitate the harmonisation, integration and efficiency of the European electricity market. Each network code is an integral part of the drive towards completion of the internal energy market, and achieving the European Union's energy objectives of:

- at least 40% cut in greenhouse gas emissions compared to 1990 levels.
- at least a 32% share of renewable energy consumption.
- at least 32.5% energy savings compared with the business-as-usual scenario.

Reporting of losses on European level

entsoe

The code families

Connection

- Demand Connection Code
- Requirements for Generators
- High Voltage Direct Current Connections

Operations

- Emergency and Restoration
- Operations

Market

- Forward Capacity Allocation
- Capacity Allocation & Congestion Management
- Electricity Balancing

Reporting of losses on European level

CEER Report on Power Losses

Reporting of losses on European level

Generally about Loss Calculation Methods

- There are a number of different methods to determine technical losses.
- Even with the most advanced tools and procedures the exact technical losses are hard hard to capture. Assumptions and simplifications are part of any method.
- Three main backbones in every technical loss determination:
  - **Network model** (topology, line and transformer parameters)
    – things that don't change
  - **State/estimates/scenarios** (switching status, tap changer position, FACTS-status, load and production situation)
    – a single moment of things that change
  - **Load and production profiles over time** (daily, weekly, yearly profiles)

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Generally about Loss Calculation Methods

- A technical loss estimation method includes having an “approach” for each of the backbones.
- A method can be Empirical (based on formulas derived from earlier studies) or more Intuitive (your engineering thinking) or Absolute (exact calculations – if possible…)
- Different levels of the network might require different methods.
  - For HV level you usually have the correct network model and hourly switching states and measurements – absolute method with hourly calculations?
  - For MV you might have a reasonable network model and measurements per feeder in the substation – empirical formula (load factor – loss factor) or intuitive method with typical states scaled to an average
  - For LV – use your best estimation…

Eskom methods

- HV – Sub-transmission/Distribution
  - Interim Technical Loss Calculation Method
    - Inclusion of Embedded Generation Energy Purchases within a Sub-Transmission network Technical Loss Calculation has been added.
    - The method requires measurement data in either hourly or half-hourly sample periods which are available from the Transmission MDMS for both MTS and RPP.
    - Sub-Transmission Losses Template in Excel.
    - Uses load factor / loss factor empirical formula to determine losses by comparing to peak power losses calculated in PF.
    - An additional Excel Template is provided as a tool to assist in creating the Total Energy Purchases with Embedded Generation included.

Eskom methods

- HV – Sub-transmission/Distribution
  - Iterative Technical Loss Calculation Method
    - Uses iterative loss scrips in PF
    - This method requires that measurement data is available for the MV and HV loads and embedded generation within the Sub-Transmission network instead of being measured as a summation at the MTS.
    - Individual loads at distribution substations in the PF model need to contain the MV90 or equivalent load profile data along with the RPPs.
      - Data quality > 80 %?
    - Can we call this an absolute method with hourly calculations?
      - The result is only more accurate if the network model and load / production scenarios have high data quality.

Eskom methods

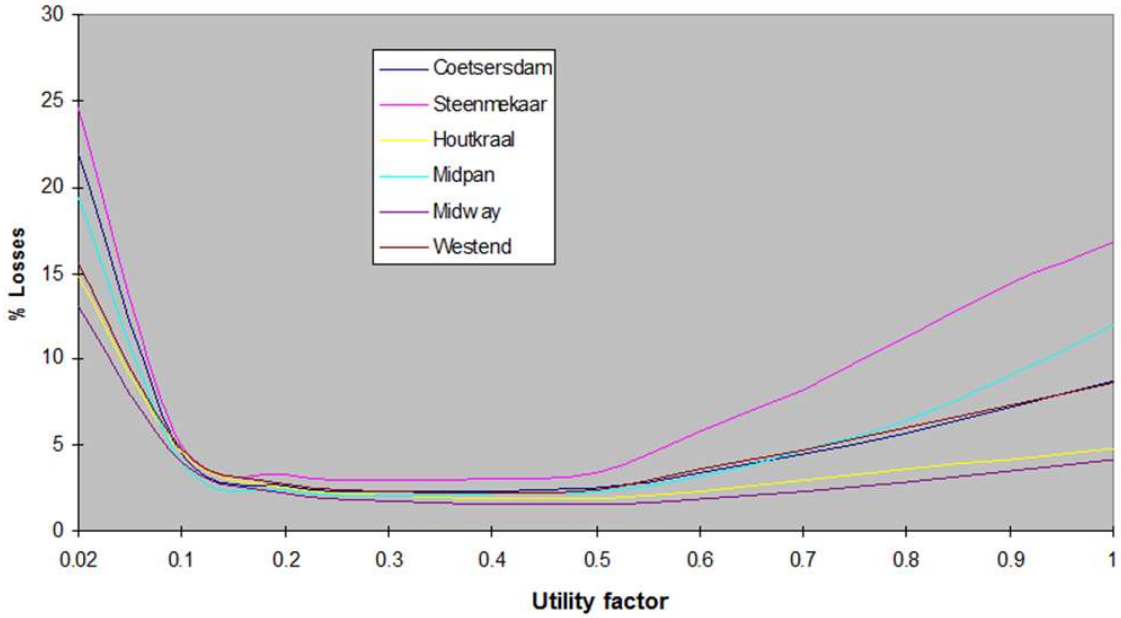
- Separate appendix
- *Review on loss calculation procedures and tools / Workshop 1, Session 6_appendix*

Eskom methods

- MV – Distribution/Reticulation
  - “Graph method” – Eskom standard?
  - The method uses average to determine losses.
  - “Based on the MV and LV line design principals. Taking typical lines; long lines, short lines, highly loaded lines and lines with low load”.
  - Calculating and plotting the losses creating the load factor – loss factor relation.
  - Using the graph to read the percent losses and working back to energy losses by multiplying with the sold/purchased energy.
  - Downsides?

Eskom methods

- MV – Distribution/Reticulation
  - “The load factor of the MV lines vary between 0.1 and 0.7 and one can say that the average loss is 2.9%”.
  - Calculated in PF?
  - How do you capture the difference between months – by different load factors?

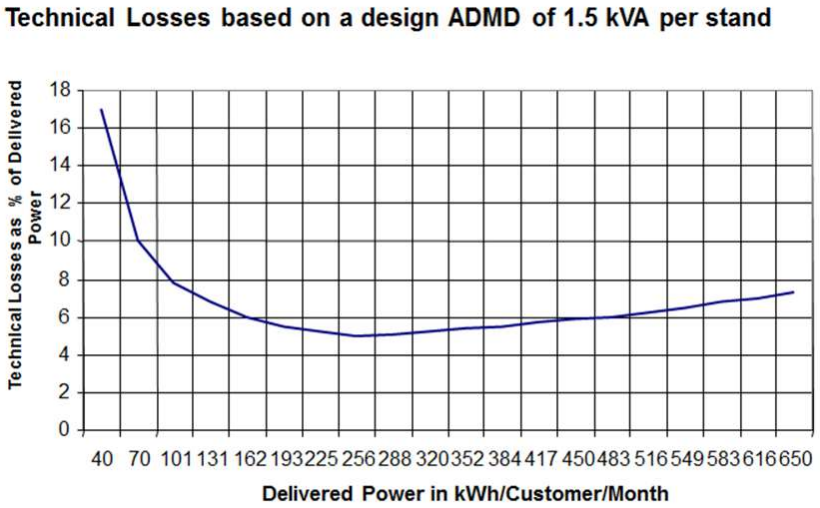


Eskom methods

- MV – Distribution/Reticulation
  - The KZNOU follows a Feeder Temporal Analysis, a quasi dynamic/iterative method similar to the HV technical loss method in the DPL script but using average profiles for the feeder loading.
  - The year hourly load profile is used to develop averaged profile for weekday/weekend, season.
    - “because of our loads being cyclic the loads periods have been recycled into eight profiles”

Eskom methods

- LV
  - Average values based on assumptions.
  - “A manual calculation using specifications and average load profiles – very much the same as with MV losses”.
  - “Actual energy measurements on LV are extremely scares – only measure at customer’s house. So this need to be ‘guessed’ in the near future or up until a new method is discovered”.



Eskom methods – overall feedback

- Comments and feedback better/consistently summarized in the *Review note D1.1*

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