Technical Performance Reporting of the Eskom Transmission Systems for 2004

1. SUMMARY

The Eskom Licence requires its Transmission Division to provide the NER with an annual report on its system performance. This is part of the annual power quality reporting requirement as per the NER Power Quality Directive.

Analysis of the current reporting period statistics provided by Eskom Transmission reveals the following:

- Eskom Transmission technical system performance has shown a steady improvement over the six-year period since reporting commenced.
- There has been a drastic improvement in harmonics performance in the last year.
- There has been an increase in number of major incidents experienced each year resulting in an increase in system minutes.
- The overall performance displays a stable trend (no real improvement or decline).

2. DISCUSSION

2.1 Background

Quality of supply (QOS) is defined by NRS048 as “the technical parameter to describe the electricity supplied to customers”. QOS information is used to determine the extent to which the needs of customers are met in the utilisation of electricity.

The NER follows the NRS standard and therefore requires correct and complete QOS information in order to make these assessments as to whether customer’s needs in this regard are being met.

The quality delivered by the Transmission Grid provides a foundation for the quality delivered by regional distributors. The Transmission Operator provides annual reports on performance of the national grid to the NER with regard to:

- voltage waveform quality (voltage magnitude, harmonics, and unbalance),
- voltage dips, and
- interruption performance.
The Power Quality directive developed by the NER with the assistance of the Power Quality Advisory Committee requires that the NER publish an annual report detailing the following:

- National annual power quality statistics (including comparative and historical trends on power quality performance),
- Complaints statistics (non-conformance reports as well as disputes that have reached the level of the NER in the context of the Power Quality Management System implemented by licensees), and
- Progress of the licensees in implementing their Power Quality Management Systems.

This specification defines the manner in which licensees report their performance statistics, the monitoring requirements for such reporting, and the publication of the results by the NER.

The scope of such reporting is:

- Voltage quality (voltage magnitude, harmonics, unbalance, flicker),
- Voltage disturbances (dips),
- Interruption performance,
- Power quality complaints statistics,
- Instrument statistics and instrument availability data, and
- Progress in terms of the Power Quality management System Implementation plans submitted to the NER.

2.2 Technical performance reporting of Eskom Transmission.

Reliability indices

Eskom transmission declared and provided measurements of 114 monitored sites out of a total of 116 supply points, which were used to calculate SAIDI and SAIFI for the period 1999 to 2004. When looking from a regulatory point of view, a target for all sites is that not more than 5% of monitored sites should exceed the limits. All the sites that exceeded the limits are reported annually.

SAIFI is the system average interruptions frequency index of sustained interruptions. This index is designed to give information about the average frequency of sustained interruptions per customer over a predefined area.

SAIDI is the system average interruptions duration index. This index is normally refereed to as customer minutes of interruptions or customer hours. It is designed to provide information about average length of time the customers are interrupted in a year.
The SAIFI and SAIDI for Eskom Transmission from 1999 to 2004 are shown in Figure 1 below.

From the graph, it is clear that reliability has been inconsistent from year-to-year. This is not an acceptable situation and Eskom will need to be tasked to put measures in place to instil confidence that the system will be sustainable and reliable in the future and that this fluctuation in performance stabilises.

Note: **SAIFI-SI on Secondary Axis

**Bulk Electricity Events**

Major System interruptions are categorised according to bulk electricity system (BES) events (e.g. cascading faults affecting a large area) and localised events (e.g. failure of a local transformer).

Detailed information regarding the major events that were reported on by Eskom Transmission for the period 2001 to 2004 is supplied in Attachment A of this document. During 1999 and 2000 Eskom did not experience any major incidents. However, from 2001 to 2004, a number of major incidents occurred, which resulted in an increase in total system interruptions minutes over this period.

The graphs in Figure 2 clearly indicate the substantial impact that major incidents have on the total (all incidents) system minutes. The graph of the system minutes for minor incidents reported is stable from year to year, however, when the major incidents are included and the graph plotted for all incidents, the picture changes dramatically.
The total system minutes graph shows a disturbing fluctuation from year to year, with an overall upward trend. These have an impact on the SAIFI and SAIDI shown in Figure 1 as they are used in their calculation. The degree of severity of the incidents is not indicated but can be extrapolated from the capacity affected and time taken before restoration.

In summary, six major systems interruptions were reported between 1999 and 2004, three of those occurred in the Eastern grid and one in each of the Western, North Eastern and Northern grids. A detailed breakdown of each incident is given in Attachment A.

![System Minutes Graph](image)

**Figure 2: System minutes (SM)**

System Minutes are defined as:

\[
\text{System Minutes} = \frac{\text{Total Estimated Unsupplied Energy (MWh)} \times 60}{\text{System annual peak demand for the period}}
\]

**Harmonics**

Figure 3 below shows the percentage of monitored sites that exceeded the limits for harmonics during the 6-year period. Eskom Transmission is required to provide harmonics reports on the sites that exceed the harmonics limit, excluding the first 5% of the monitored sites. The significant improvement of the
voltage harmonics is caused by the revision of NRS-048:2 on the assessment period. The revision expanded the daily assessment period to at least a week. For that reason the percentage sites exceeding limit dropped drastically, and we will monitor the situation onwards.

![Harmonics Graph](image)

**Figure 3: Transmission Harmonics performance**

**Voltage Dips**

The dip performance at all the monitored Transmission supply points is given below in Figure 4 for the period 1999 to 2004. Only dips caused by events on the Transmission network are reported on.

A **Voltage Dip** is defined as a sudden reduction in voltage for a period between 20 milliseconds and 3 seconds on any or all of the phases. The duration of a dip is the time measured from the moment a voltage drops below 0.9 per unit of declared voltage to when the voltage rises above 0.9 unit of declared voltage.

Voltage dip performance is strongly influenced by annual weather patterns. For this reason a year on year comparison of dip performance is not a good indication of actual performance trends (particularly in the case of one site).

The average represents the average number of dips experienced for all the monitored per annum over the 6 year period. The dips are separated into the various categories of dip as detailed in the table below.
The average number of voltage dips seen by each of the supply points appears stable over the analysis period, but does display an increasing trend in the latter years.

![Transmission Dip performance graph]

Figure 4: Transmission Dip performances

<table>
<thead>
<tr>
<th>Dip category</th>
<th>Values of duration and depth</th>
<th>Basis for definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Y</strong></td>
<td>Duration &gt; 20 ms to 3s</td>
<td>Dip definition (20 ms to 3s)</td>
</tr>
<tr>
<td></td>
<td>Depth 30 %, 20 %, 15%</td>
<td>Minimum plant compatibility requirement (this covers a significant number of short duration dips)</td>
</tr>
<tr>
<td><strong>X1</strong></td>
<td>Duration &gt; 20 ms to 150 ms</td>
<td>Typical Zone 1 clearance (no pilot wire)</td>
</tr>
<tr>
<td></td>
<td>Depth 30 % to 40 %</td>
<td>Desired plant immunity – as this spans many dips caused by remote faults on the licensee network</td>
</tr>
<tr>
<td><strong>X2</strong></td>
<td>Duration &gt; 20 ms to 150 ms</td>
<td>Typical Zone 1 clearance (no pilot wire)</td>
</tr>
<tr>
<td></td>
<td>Depth 40 % to 60 %</td>
<td>Dips potentially causing drives to trip, caused by remote faults on the licensee network</td>
</tr>
<tr>
<td><strong>S</strong></td>
<td>Duration &gt; 150 ms to 600 ms</td>
<td>Typical Zone 2 and accelerated clearance Also some distribution faults</td>
</tr>
<tr>
<td></td>
<td>Depth 20 % to 60 %</td>
<td>Plant compatibility (drives trip &gt; 20 %) caused by remote faults on the licensee network</td>
</tr>
<tr>
<td><strong>T</strong></td>
<td>Duration &gt; 20 ms to 600 ms</td>
<td>Zone 1 and zone 2 clearance times</td>
</tr>
<tr>
<td></td>
<td>Depth 60 % to 100 %</td>
<td>Plant compatibility (contactors trip &gt; 60 %) Caused by close-up faults on the licensee network</td>
</tr>
<tr>
<td><strong>Z1</strong></td>
<td>Duration &gt; 600 ms to 3 s</td>
<td>Back-up and thermal protection clearance or long recovery times (transient voltage stability) or both</td>
</tr>
<tr>
<td></td>
<td>Depth 15 % to 30 %</td>
<td>Remote faults Post-dip motor recovery without stalling</td>
</tr>
<tr>
<td><strong>Z2</strong></td>
<td>Duration &gt; 600 ms to 3 s</td>
<td>Back-up and thermal protection clearance</td>
</tr>
<tr>
<td></td>
<td>Depth 30 % to 100 %</td>
<td>Closer faults Potential motor stalling</td>
</tr>
</tbody>
</table>
**Voltage Magnitude**

Voltage waveform quality is managed by setting limits on the deviation of the voltage from the ideal 50Hz sinusoidal waveform. For Transmission delivery points, these limits are based on planning levels in NRS-048-2 or by agreement with customer.

Waveform quality is affected by both the operation of the Transmission grid and by the combined effect of customers connected to the grid. It is therefore difficult to guarantee that a specific site will not exceed the limits in any given year. From a regulatory point of view, the target for all sites is that no more than 5% of the sites should exceed the agreed levels and limits.

Note: a specific site does not remain continuously outside of the limits (i.e. action is taken by the system operator to address problems as they occur).

The sites that exceeded the agreed levels are reported on annually. Figure 5 below shows the percentage of sites that exceeded voltage magnitude limits for years 1999 to 2004.

The performance for the current year (2004) is within regulatory limits, this is a huge improvement from the previous year/s.

![Eskom Transmission: Voltage Magnitude Performance](image)

**Figure 5:** Transmission Voltage magnitude performance at 98% of sites.

**Voltage Unbalance**

Figure 6 below indicates the percentage of sites that exceeded the unbalance limits for the 6 year period. This aspect of the performance has been satisfactory since reporting began in 1999 and for 2004 there was no voltage unbalance reported.
2.3 Quality Management System Implementation

NER requires that each licensee have a Power Quality Management System Implementation Plan (PQMS) in place that meets the requirements laid down by the Power Quality Advisory Committee (PQAC) in the Power Quality Directive.

Conformance to the requirements is verified by the NER through consultation with PQAC. Eskom Transmission submitted its plan/s in June 2004. These were approved by the NER and Eskom has confirmed that these plans have been implemented. An audit will be performed to confirm that this is indeed the case.
RECOMMENDATIONS:

- **System reliability** (SAIDI & SAIFI) has been inconsistent from year-to-year. This is not an acceptable situation and Eskom will be tasked to put measures in place to instil confidence that the system will be sustainable and reliable in the future and that this fluctuation in performance stabilises.

- There has been an increase in the number of **major incidents** experienced each year resulting in a significant variation in system minutes from year to year with an increasing trend.

- There has been a drastic improvement in **harmonics performance** in the last year.

- The average number of **voltage dips** seen by each of the supply points appears stable over the analysis period, but does display an increasing trend in the latter years.

- The **Voltage Magnitude** performance for the current year (2004) is within regulatory limits, this is a huge improvement from the previous year/s.

- Eskom Transmission’s overall technical system performance has shown a steady improvement over the six-year period since reporting commenced.

- No voltage unbalance was reported for the current year (2004)

- Workshops will be held with the licensee and stakeholders to collectively address continued and sustainable improvement.
## Major System Interruptions

<table>
<thead>
<tr>
<th>Date</th>
<th>Major System Interruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sep-01</td>
<td>Eastern Grid  &lt;br&gt;Starting at 03:10 on 14 September 2001, extreme snow conditions in the Eastern grid caused multiple trips, which resulted in two separate interruptions to several parts of KwaZulu-Natal (SM = 5,514 &amp; 1,296).</td>
</tr>
<tr>
<td>Oct-01</td>
<td>Western Grid  &lt;br&gt;The supply to the Western Cape was interrupted at 10:45 on 12 October 2001, due to instability of the Transmission network south of Hydra Substation. This condition was detected by the out-of-step (OST) tripping relays at Droëriver and Aries Substations. The purpose of these relays is to split the transmission system into islands to prevent damage to the generating units, transmission plant and customers' equipment (SM = 5,711).</td>
</tr>
<tr>
<td>Apr-02</td>
<td>North Eastern Grid  &lt;br&gt;At Vulcan substation, in the North Eastern Grid, at 01:17 on 30th April 2002, an attempted conductor theft on the decommissioned Vulcan – Minerva line resulted in a conductor falling onto the 132kV Vulcan – Kromdraai and the 132kV Vulcan – Ekangala lines. There was an interruption to Transmission customers of 40MW for 134 minutes, 50MW for 164 minutes, 30MW for 186 minutes and 68MW for 127 minutes (SM = 1,397).</td>
</tr>
<tr>
<td>Dec-02</td>
<td>Eastern Grid  &lt;br&gt;At Invubu substation, in the Eastern Grid, at 09:46 on 3rd December 2002, 275kV Impala No1 Bus No1 Isolator SF6 compartment flashed over during a routine bus changeover. This resulted in a buszone operation. There was an interruption of supply to Transmission customers of 270MW for 150 minutes (SM = 1,324).</td>
</tr>
<tr>
<td>Mar-03</td>
<td>Eastern Grid  &lt;br&gt;At Invubu substation in the Eastern Grid, at 06:53 on 30th March 2003, 400/275/22kV Transformer No3A tripped. Investigation revealed a blown red phase VT fuse. There was an interruption of supply to Transmission customers of 280MW for 132 minutes (SM = 1,169).</td>
</tr>
<tr>
<td>Mar-04</td>
<td>Northern Grid  &lt;br&gt;At Bighorn substation, in the Northern Grid, at 04:23 on 22 March 2004, 275/88kV Transformer No2 tripped when it faulted internally. The remaining Transformer No1 was then over loaded by 21%. Load shedding was done and the Bighorn - Spitskop No1/400kV line re-routed via the Spitskop - Beestekraal 88kV line as per the emergency plan. There was an interruption of supply to Transmission customers equivalent to 857.584MW for 809 minutes (SM = 23.100).</td>
</tr>
</tbody>
</table>