Ekurhuleni PQMS
Presented by Stephen Delport: Chief Engineer
The EMM distribution networks are supplied with electricity from 50 Eskom intake points, at voltage levels ranging between 132/88/66/44/33/22/11/6.6kV.

- Approximately 400,000 mixed customer base
- Winter months - demand exceeded 2300 MVA
- Installed HV transformer capacity (at intake points) > 4000 MVA:
- EMM current distribution area 2642 Sq km plus future Eskom distribution area within EMM 1923 Sq km.
- 2012/13 Revenue requirements: - >R10 billion or US$1.25 billion
### Number of Transformers >8000

<table>
<thead>
<tr>
<th>CCC</th>
<th>Primary Transf kVA</th>
<th>COUNT</th>
<th>MV Transformers (Incl. Mini-Subs)</th>
<th>COUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alberton</td>
<td>470 000</td>
<td>28</td>
<td>307 725</td>
<td>1072</td>
</tr>
<tr>
<td>Benoni</td>
<td>560 000</td>
<td>28</td>
<td>335 565</td>
<td>832</td>
</tr>
<tr>
<td>Boksburg</td>
<td>602 500</td>
<td>23</td>
<td>399 140</td>
<td>990</td>
</tr>
<tr>
<td>Brakpan &amp; Kwa-Thema</td>
<td>315 000</td>
<td>18</td>
<td>272 025</td>
<td>859</td>
</tr>
<tr>
<td>Edenvale &amp; Bedfordview</td>
<td>180 000</td>
<td>13</td>
<td>314 315</td>
<td>740</td>
</tr>
<tr>
<td>Germiston</td>
<td>622 500</td>
<td>56</td>
<td>465 085</td>
<td>1012</td>
</tr>
<tr>
<td>Kempton Park</td>
<td>606 000</td>
<td>40</td>
<td>376 790</td>
<td>966</td>
</tr>
<tr>
<td>Springs-Nigel</td>
<td>500 000</td>
<td>16</td>
<td>356 905</td>
<td>818</td>
</tr>
<tr>
<td>Tembisa + Clayville's</td>
<td>260 000</td>
<td>13</td>
<td>137 845</td>
<td>405</td>
</tr>
</tbody>
</table>
History of NRS 048-2 first edition

- From a regulatory perspective, South Africa has been a leader in developing and implementing quality of supply standards through its implementation of NRS 048-2.
- The history of NRS 048-2 dates back to 1986.
- Purpose is intended to set minimum standards for QoS and to provide the NERSA with a means of evaluating and regulating the QoS provide by Utilities.
The working group, which was appointed by the ESLC, comprised the following members:

R G Coney (Chairman)  Eskom
A Booyzen  Roodepoort Electricity Department
H O Boshoff  Bellville Electricity Department
R W Curtis  JCI
A J Dold  Durban Electricity
P D Hennessy  Germiston Electricity Department
P A Johnson (Project Leader)  NRS Project
R Koch  Eskom
G R Marloth  Metropolitan Electricity, Greater Johannesburg TMC
T O Mould  Kimberley Electricity Department
M Outram  Port Elizabeth Electricity Department
A T Smith  Benoni Electricity Department
J S van Heerden  SABS
D Vrey  Pretoria Electricity Department
M Wilson  Boksburg Electricity Department
Power Quality Parameters

- Frequency
- Voltage Magnitude
- Flicker (LV and MV networks)
- Events (dips, swells and interruptions)
- Transients
- Supply voltage unbalance
- Voltage and current harmonics
- Mains signaling on the supply voltage
V \times I = \text{Watts}\quad \text{pf}=1

Positive Watts = 230W
Negative Watts = 0W
Total Watts = 230W
Unbalance: Positive, Negative and Zero sequence
Voltage Dip effect
Harmonics
Background

• In order to implement and operate a PQMS, Ekurhuleni required essential Power Quality Monitoring information regarding its own network.

• This was necessary to develop and learn from measurement results as well as to accommodate future regulatory requirements.
In a visionary step, the Ekurhuleni H.O.D : Energy, Mark Wilson, recommended to the Mayoral Committee of the City of Ekurhuleni to commit to a power quality monitoring program, this as far back as September 2003.
Objective of the PQMS

• The power quality monitoring programme for EMM shall contribute to EMM’s objectives to meet the needs of its valued customers.

• To achieve a leading position with regard to the key competencies (including Power-Quality Management...
The Bigger Picture

What is Power Quality (New Topologies and Technologies)?

- Hospital with cogeneration (1.5 MW)
- Utility-owned wind turbine site (1 MW)
- Small wind turbine (10 kW)
- Factory with natural gas fuel cell (100 kW to 5 MW)
- Residential photovoltaic system (6 kW)
- Residential Fuel cell (7 kW)
- Utility-owned Photovoltaic site (500 kW)

Substation

Leading the Electricity Distribution Industry
Sounds Simple, What’s the Catch?

“Lakes” Network Model

G = Generator
C  = Customer
Sounds Simple, What’s the Catch?

- Electricity cannot be stored, so supply (generation) must be produced exactly when needed to meet customer demand and to avoid system failure.

- Level in electricity “lake” must be kept constant at all times.

- Laws of physics dictate that power flows along path of least resistance; we cannot direct it along specific route.

Individual “Lake” Model
3. Operational Responsibilities of Distributors

(1) The Distributor shall operate the Distribution System to achieve the highest degree of reliability and shall promptly take appropriate remedial action to relieve any condition that may jeopardise reliability.

(2) The Distributor shall co-ordinate voltage control, demand control, operating on the Distribution System and security monitoring in order to ensure safe, reliable, and economic operation of the Distribution System.
**PQ reports available on “Logon”**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily reports pinpointing power quality exceedences and reporting on network incidents.</td>
<td></td>
</tr>
<tr>
<td>Power quality assessments according to NRS048-2:2007. Also available is a viewer for the raw 10-minute trended data, as well as data availability and electrical consumption reports.</td>
<td></td>
</tr>
<tr>
<td>Yearly power quality reports, including tables 9 to 12 as documented in the NERSA reporting standard.</td>
<td></td>
</tr>
<tr>
<td>Incidents are formed by grouping classified events (dips, surges etc) that occurred within a specific time window from each other. <em>Probabilistically they share the same cause.</em> Incidents can be viewed and information about the cause can be annotated. Drill-down to individual events is possible.</td>
<td></td>
</tr>
<tr>
<td>Reports on events for individual sites. Both short events (dips and swells) as well as interruptions are reported on.</td>
<td></td>
</tr>
<tr>
<td>Reports to show performance of a collection of sites and ranking of individual sites.</td>
<td></td>
</tr>
</tbody>
</table>
List of Sustained and Momentary Interruptions: www.pq-portal.com

Sustained Interruption List For Ekurhuleni Alberton For Period: 2012-08-01 To 2012-09-30
List of Dips
During the assessment period, 14 events were recorded at this site, 12 of which were also recorded by other instruments in the network.

<table>
<thead>
<tr>
<th>Dip Type Y</th>
<th>Dip Type X1</th>
<th>Dip Type X2</th>
<th>Dip Type S</th>
<th>Dip Type T</th>
<th>Dip Type Z1</th>
<th>Dip Type Z2</th>
<th>Swell</th>
<th>Interruption</th>
<th>Over Voltage</th>
<th>Under Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Event Chronology

NRS048 Scatterplot

Events per Hour of day

Events per Day of week
Drill down capabilities!

Event Vrms Profile

10min Trends For The Day - 2012-07-25
PQ Stats

- Power quality information is of a statistical nature. It requires time to establish a suitable measurement capability and to accumulate the representative profile information needed for quality management processes.

Data Availability

Paragraph 4.2.1.6 of NRS048-2:2007 considers an assessment to be valid for statistical purposes when the data available for the period is at least 90% and valid for investigational purposes when the data available is at least 98%.

- This assessment is valid for statistical purposes.
- This assessment is valid for investigational purposes.
On-Line Communication System
Typical Field Installations: EMM have more than 400 instruments installed.
Commissioning PQ Instrument

[Image of a PQ instrument interface showing voltage phases and measurement data]
To achieve QOS it is important to start making recorded PQ data visible all managers.
70 Year or older Sub Refurbish
Benoni Ind new Transformers Installed with Tap Changers Old vs New Voltage Regulation

QoS before and after!
## Daily Problem Sites For Nodegroup - All Ekurhuleni Nodes
**Date:** 2012-10-01

### Section A - Sites That Does Not Comply With NRS048 Criteria For Voltage Regulation And Voltage Unbalance

<table>
<thead>
<tr>
<th>Sitename</th>
<th>Data Availability</th>
<th>Voltage Magnitude</th>
<th>Voltage Unbalance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Max</td>
<td>95% Max</td>
</tr>
<tr>
<td>Criteria</td>
<td>&lt; 95%</td>
<td>&gt; 110%</td>
<td>&gt; 105%</td>
</tr>
<tr>
<td>EMM Alberton Air Liquide 33kV</td>
<td>99.90</td>
<td>96.06</td>
<td>95.61</td>
</tr>
<tr>
<td>EMM Alberton Albertsdal T2 6.6kV</td>
<td>100.00</td>
<td>108.11</td>
<td></td>
</tr>
<tr>
<td>EMM Alberton Albertsdal T3 6.6kV</td>
<td>99.90</td>
<td>108.06</td>
<td></td>
</tr>
<tr>
<td>EMM Alberton ApexHi 6.6kV</td>
<td>100.00</td>
<td>107.35</td>
<td></td>
</tr>
<tr>
<td>EMM Alberton Arnold 6.6kV</td>
<td>98.51</td>
<td>107.45</td>
<td></td>
</tr>
<tr>
<td>EMM Alberton Eiger T3 6.6kV</td>
<td>100.00</td>
<td>108.49</td>
<td></td>
</tr>
<tr>
<td>EMM Alberton Hayes Lemmerz 6.6kV</td>
<td>98.81</td>
<td>107.16</td>
<td></td>
</tr>
<tr>
<td>EMM Alberton Petronet 6.6kV</td>
<td>100.00</td>
<td>108.37</td>
<td></td>
</tr>
</tbody>
</table>
Assessment Trends

Voltage Magnitude (Daily 7-day sliding assessments)

- Limit Compliance Level
- Compatibility Compliance Level

% of Declared Voltage

Date:
- 09/14/2012
- 09/18/2012
- 09/22/2012
- 09/26/2012
- 09/30/2012
- 10/04/2012
- 10/08/2012

% Missing Data (Logarithmic)

115
110
105
100
95
90
85

10
1

10min RMS Voltage Readings

% of Declared Voltage

Day of month:
- 14
- 15
- 16
- 17
- 18
- 19
- 20
- 21
- 22
- 23
- 24
- 25
- 26
- 27
- 28
- 29
- 30
- 31
- 01
- 02
- 03
- 04

 Histogram - Vrms

% of Time

% of Declared Voltage

0
10
20
30
40
50
60
70
80
90
100

# List Of Sites Not Producing Any Data For Period

<table>
<thead>
<tr>
<th></th>
<th>Site Name</th>
<th>Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EMM_Alberton_Trident_Steel_6.6kV</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>EMM_Boksburg_Grinaker_11kV</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>EMM_Brakpan_Sudfracht_Operating_6.6kV</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>EMM_Edenvale_Ann_T1_6.6kV</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>EMM_Edenvale_East Gate_6.6kV</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>EMM_Edenvale_TownSub_T3_6.6kV</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>EMM_Benoni_Rynfield_BusA_132kV</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>EMM_Brakpan_Dalpark_T1_11kV</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>EMM_Brakpan_VanEckpark_T2_11kV</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>EMM_Edenvale_Ann_T2_6.6kV</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>EMM_Edenvale_Phomolong_T1_11kV</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>EMM_Germiston_Andrew_Mentis_11kV</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>EMM_Benoni_ScawMet_11kV</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>EMM_Brakpan_North_T2_11kV</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>EMM_Brakpan_Vulcania_Suid_11kV</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>EMM_Edenvale_Bosco_6.6kV</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>EMM_Edenvale_TownSub_T1_6.6kV</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>EMM_Germiston_AtomRoad_33kV</td>
<td></td>
</tr>
</tbody>
</table>
Conclusion

- Ekurhuleni has implemented a web-based Power Quality Management System (PQMS).
- Instrumentation has been placed at points in the network that ensure comprehensive visibility on voltage parameters.
- The widespread integration of QoS instrumentation in the Ekurhuleni network and on-line access to information, enabled voltage waveform incidents (for example dips) to be analysed in the context of the root cause and source of the incident.
- Data analysis is mostly automated and operational personnel can focus on using the information in a day-to-day business.
Way Forward

• Analyse and benchmark data to determine embedded opportunities and threats.
• Determine and separate internal and external (Eskom/IPP’s) root causes of incidents. (drive them both down – there is always room for improvement.)
• Profile the network to identify rough lines.
The future presents both challenges and opportunities for the AMEU, certainly the AMEU have a role to play in leading the distribution industry in QoS.

I thank you!

“Everything should be made as simple as possible, but not simpler.”

Albert Einstein