International Benchmarking

Source: KEMA Grid Price and Performance Benchmarking Report, 2010
Continual improvement in SAIDI

SAIDI - System Average Interruption Duration Index

SAIDI = Σ UiNi / Total No. of Customer served

SINGAPORE'S POWER NETWORK PERFORMANCE

Condition Monitoring implemented

*99.99%

*99.999%

*99.9999%

8 years

SAIDI
International Benchmarking

Distribution Reliability Index - SAIDI

Source: KEMA Price and Performance Benchmarking Report 2010
Network Asset Management System

- High Quality
- Reduce Failures
- Optimise Costs

- Low Price
- Condition-Based Maintenance Programme

- Customers

- Condition Monitoring Programme

Network Asset Management

Condition Monitoring
SINGAPORE CONDITION MONITORING ROAD MAP

Prevention
- Condition Monitoring Programme
- Condition Based Maintenance Programme
- Quality Management System
- Systemized Contingency Operation Plan
- Asset Replacement Programme
- Asset Security and Protection

Mitigation of Potential Failures for Reliability & Quality Power
- Network Protection System
- Remote Control and Monitoring Capability
- Systemized Contingency Operation Plan
- Operational Readiness and Fast Response
- Business Continuity Management
- Generators Mobilisation

Containment
EVOLUTION OF MAINTENANCE PRACTICES

CURRENT

- Post-Fault Repairs
- Preventive
- Predictive
- Condition-Based

NEW APPROACH

- Up to 44% of all faults can be detected by PD techniques
- 85% of all disruptive failures are PD related
CONDITION MONITORING (CM) BENEFITS

- Ensure **reliability and quality** of supply
- **Less faults** to repair
- Rectification cost **cheaper** than repair cost after failure
- **Evidence of root cause of PD** not destroyed and preventative maintenance can be done before a failure occurs
- Time based maintenance is **not always effective**, so do effective maintenance only when the condition of equipment requires maintenance
- Typical business challenges;
  - Business culture change **“First Time Right”**
  - **Resources required** to test and to do audits and investigations
CONDITION MONITORING
EXPECTED RESULTS

- HV and MV system faults averted = cost saving of faults averted (R500k– R30mil/fault depending what damage is caused by the fault)
- Reduction of OPEX and CAPEX costs required to repair failures
- Improved network performance and reduced outage times (NRS 047, 048, SAIDI, CAIFI etc.)
- Less risk of explosions which could injure or kill staff and public!
PARTIAL DISCHARGE (PD)

- The magnitude of PD is usually small; however, they cause progressive deterioration of insulation that will lead to eventual failure.
TYPES OF PARTIAL DISCHARGES

a) Corona discharges
b) Surface discharges
c) Discharge in laminated material
d) Cavity discharges
e) Treeing
PARTIAL DISCHARGE (PD)

- The most practical techniques for non-intrusive testing are the detection of the radio frequency part of the **electromagnetic and ultrasonic emissions**

If you can smell or hear PD without instrumentation, beware as failure could occur at anytime!
Online **non-intrusive** CM testing techniques are:

- Ultrasonic
- Transient Earth Voltages (TEV)
- Radio Frequency (RF)
- Inductive coupling frequency response via High Frequency Current Transformers (HFCT)
- Capacitive coupling frequency response
- Dissolved gas analysis (DGA)
- Infrared
BASIC SWITCHGEAR
PD TESTS

Thermal Scan
TEV test
Ultrasonic test
EA TECHNOLOGIES NEW UltraTEV Plus²
EA Technology’s *proprietary ultrasonic classification* algorithm differentiates between noise and actual PD.
Radio Frequency Switchgear Assessment

- Internal
- Tracking
- Partial Arcing
- Corona

Insulation
Surface
Contact
In Air
PD LOCATED WITH ULTRASONIC TESTING
CONDITION MONITORING TECHNIQUES

- Ultrasonic, TEV detectors and Infrared camera for SS and OHL purchased
- 9 gas DGA online monitors for power transformers (17 transformers)
- Off line PD diagnostic for MV cable systems test equipment purchased
- Off line PD and Tan Delta for MV cable systems with VLF source test equipment to be purchased. Limit DC testing. SANS 10198-13 revision
- Off line PD and Tan Delta HV and EHV cable systems (AC, RAC, OWTS, VLF) not possible with DC
- Online PD detection for HV GIS switchgear
CABLE PD TESTING TRAINING (OWTS M28)

Non-destructive Partial Discharge Diagnosis
CABLE TESTS AGED PILC CABLE (NO CONCENTRATED PD)
CABLE PARTIAL DISCHARGE DIAGNOSIS XLPE CABLE

Joint 7 (PD at blue phase)  Joint 8 (PD at red phase)
PD Cleared!!

End to end Cable length
CBI OFFLINE HV & EHV CABLE & GIS PD & OVERVOLTAGE TESTING
Currently we are remotely monitoring seven large power transformers
CONDITION MONITORING
ONLINE DGA SYSTEM

Hydrogen ($H_2$)

Methane ($CH_4$)

Ethane ($C_2H_6$)

Ethylene ($C_2H_4$)

Acetylene ($C_2H_2$)

Gas Generation (Not to Scale)
Approximate Oil Decomposition
Temperature above 150°C
Capillary temperature pocket broke off – too long
Caused circulating currents and overheating of TX
MR OFFLINE HV & EHV TRANSFORMER PD & ELECTRICAL TESTING
• Asset condition data is essential for CM to be successful
• Online continuous data acquisition is essential to protect important assets
• Trended data show changes in asset condition
• A online system is required to monitor all asset conditions and operating performance
PD LOCATED AND RECTIFIED AND A FAILURE AVERTED

DETECTED WITH ULTRASONIC TEST EQUIPMENT
PD LOCATED AND RECTIFIED AND A FAILURE AVERTED

DETECTED WITH ULTRASONIC TEST EQUIPMENT
88kV TERMINATION FAILURE CASE STUDY
88kV TERMINATION FAILURE
CASE STUDY
88kV TERMINATION FAILURE CASE STUDY
City Power have roughly 350 88kV terminations of the same design. A simple **offline ductor test** is extremely reliable and repeatable, outages are not always possible. City Power worked with MARTEC who have **specialized online** testing techniques to test and establish the unique PD pattern for the failure mode has been identified. The **PD failure pattern** was previously eliminated as corona (Noise) when in fact it was **partial arcing** at the main earth contact.
• Condition monitoring control room with integrated risk based asset management real time software
• SAP PM Master data verification project to verify all data in GIS, SAP PM, SCADA and FRS systems
• Check energy meters and disturbance recorders. These will assist with network performance and incident investigations
• Role out 9 gas DGA online monitors for large power transformers
• Fluid-filled HV cables pressure monitoring system
• Online PD detection system for HV GIS
• MV joints and termination database to capture positions and jointer details and skills accreditation. Contractors utilized currently
• Failure investigations and proactive prevention measures
IT ALWAYS SEEMS IMPOSSIBLE UNTIL IT’S DONE.