The Modern Power Grid, Eskom’s 765KV Super Grid & Planning Strategies

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Eskom South Africa
Overview

- Transmission Tower Design Evolution
- Testing & line routing technology
- Conductor opt. & design software
- Construction & Live Line mtce.
- DCB, dead tank bkrs, Bkr & a half
- Lightning and fire tracking
- Smart substation information architecture
- 765KV Super Grid
Transmission Tower Design Evolution

Some specifics of the environment

- High altitude (± 1600 m)
- Long distances
- High isocraunic level – lightning
- Cane / veld fires
- Bird protection
- Pollution (industrial and marine)
Transmission Lines - Overview

SERVITUDE AND CONDUCTOR CLEARANCE
400kV TRANSMISSION LINE

Guyed suspension type

Servitude
33.0m  (average)

Min. Conductor clearance
8.5m

Cross-Rope

Servitude
21.0m

Min. Conductor clearance
8.5m

Self-Supporting type

Servitude
30.0m  (average)

Min. Conductor clearance
7.8m
Evolution of EHV Structures in Eskom

Pre-1985
- Self-Supporting Suspension
- 100% Cost

1985
- Guyed Vee Suspension
- 65% Cost
Evolution of EHV Structures in Eskom

- **1995**: Cross-rope Suspension, 50% Cost
- **1998**: Compact Cross-rope Suspension
2002 Athene – Pegasus 400KV Line

Angle guyed strain towers
Palmiet - Stikland 400KV line

“Invisible Tower”
In place for 10 yrs
Design – Historical Perspective

Development cost

Line

Year

Towers

$\times 1000/km

Testing facilities - motives

- Testing at high altitudes & industrial & marine pollution test sites
- Full scale testing to prove design before going into application - to minimise risk
- Improved confidence level – no failure to date from poor design
Dielectric Testing Facilities

SABS NETFA
full scale dielectric tests
Dielectric Testing Facilities

Corona Cage at MWP

Impulse Generator at UKZN
Insulation Pollution Testing Facilities

Koeberg Site
Marine Pollution

Sasol 1 Site
Vanderbijlpark
Ind Pollution
Mechanical Tower Testing

Rosherville Tower Test Station
Vibration Testing Facilities

Kroonstad Test Line

Indoor Vibration Test Lab at UKZN
Line Routing

- Airborne Laser Survey (ALS)
- 3D digital image
Conductor Optimisation
Line Design Software
Line Design Software – 3D

Electric Field contours prediction
Construction

- Construction technologies
  - Conventional
  - Using helicopter
Lifting of guyed-vee 765kV structure
Live Line Maintenance
Live Line Maintenance
Operation and Maintenance

Example - Increased power flow capability; Real time monitoring system - RETMOS
Operation and Maintenance

Performance:
New design vs old design – 2 to 3 times reduced number of faults!

Self Supp.  Guyed-vee  x-rope  Compact x-rope

[Bar charts showing performance data for different designs and lines, with average values indicated.]

MINIMUM PORTION OF LINE Faults DUE TO PIGGYBACK FAILURE
Disconnecting Circuit Breaker - DCB

- Replaces the conventional combination of circuit breaker and separate disconnectors

- Conventional AIS equipment:
  - circuit breaker
  - disconnector
  - busbar

- Disconnecting CB Combined
  - disconn circuit breaker

- Optimized substation design
- Improved availability
- Safe, simple, fast and reliable installation
Only one set of moving contacts/pole - DCB

- The disconnection function for a Combined DCB is obtained by the circuit breaker contact set.
- No additional contacts or other components for the disconnecting function in the breaking chamber.

Highest reliability; the same as for a standard circuit breaker.

LTB Combined 145
AIS 765KV Bkr at BETA
Dead Tank Bkr at 550/138KV Yukon S/S APS
Breaker and a Half
SYSTEM HEALTHY
MODIFIED 1½ CIRCUIT BREAKER SCHEME
ADVANTAGES OF MODIFIED 1½ CIRCUIT BREAKER

- Busbar fault does not cause circuit interruption
- Power flow is automatically redirected
- Can carry out maintenance on all circuit breakers without removing circuit from service (not only feeders as in double bus selection with bypass)
- Initially many single lines, cannot afford to lose circuits due to busbar faults (as will be the case with double bus selection)
- Transmitting large blocks of power
- High level of flexibility
ADVANTAGES OF MODIFIED 1½ CIRCUIT BREAKER (con’t)

- Proposed AIS more vulnerable to elements, need a change in philosophy
- Need high level of flexibility
- Require to re-instate feeders when line reactors become faulty, hence selectability of busbar reactor to any of the lines
- Layout is very clear and most switchgear in the longitudinal bay
- Longitudinal bay comprises 3x bus couplers in series
- Not far to walk for Isolating faulty subsection
- In most cases can lose both busbars and still maintain supply
DISADVANTAGES OF MODIFIED 1½ CIRCUIT BREAKER

- New layout concept
- System Operators need training on Switching procedures
- Field staff need training on switching procedures
- Labelling of primary Plant, especially circuit breakers and Isolators require precise identification
Remote sensing of fires
(Active Fire Information System - AFIS)
AFIS
Sensor Web Fire Mapper

CSIR SAC

Internet Service Provider (ISP)

ArcIMS Web Server

Internet

Eskom

MODIS

Email/SMS Fire Alert

Weekly/monthly reports
Notification of info available on website
Lightning and Storm Tracking

- Southern African Lightning Detection Network (SALDN)
  - Commissioned by SA Weather Service
  - Installation started October 2005
  - First useable data November 2005

- Vaisala thunderstorm system
  - National coverage - 19 sensor configuration
Lightning Strokes 21\textsuperscript{st} and 22\textsuperscript{nd} Nov 2007

Strokes recorded – 579,665 in 24 hrs
Power Line Exposure – Ground Stroke Density
Power Line Incidents – Match Date & Time
Power Line Incidents – Match Date & Time
Information/monitoring data

- Data/Info’ at S/S level increasing eg:
- Disturbance recorders
- QOS metering
- Tariff metering
- Fault location (TWS & P531)
- Trfr oil monitoring (DGA)
- Security alarms etc.
- Data in silos & individual access only
- Need integration & open access for informed decision making
Proposed Architecture
Super Grid & Planning Strategies for the future
Overview

- What is a Super Grid?
- Why a Super Grid?
- What will the Super Grid look like?
- What is the progress?
- Where to from here?
What is a Super Grid?

Super Grid is proposed to be

- A high capacity, EHV electricity transmission system
- Incorporating new technologies, such as HVDC, and designed for high reliability and flexibility
Why a Super Grid?

Business Environment

Environmental pressures will continue to increase, including difficulties obtaining rights-of-way (servitudes).

Need to **reduce CO2 emissions** and improve energy efficiency.

Concerted effort to increase and sustain **economic growth** through ASGISA.

Increased power flows between Eskom power system & neighboring utilities.
Why a Super Grid?

**Increased Power Transfer**

**Substantial increase in new Power Generation**
- 20GW nuclear generation programme
- Increase renewable energy sources
- New clean coal generation technologies

**Substantial increase load forecast**
Position Forecast Load Demand of around 80GW by 2026
What will the Super Grid look like?

*Generation Location Uncertainty*

Inland & Coastal Generation scenarios.

The Inland Generation scenarios
Possible Base Loads (coal) power stations

The Coastal Generation scenarios
Nuclear generation power stations.

Combination scenario
Combination of Inland & Coastal scenarios
What will the Super Grid look like?

**Current Tx Network Grids**

- **CENTRAL**
  - **NORTH WEST**
  - **CAPE CORRIDOR**
  - **WESTERN**
  - **EASTERN**
  - **NORTHERN**

- **SOUTHERN**
  - **NORTH EAST**
  - **EASTERN**
  - **SOUTHERN**
  - **CAPE CORRIDOR**
  - **WESTERN**
  - **NORTH WEST**

- **765kV**
- **400kV**
What will the Super Grid look like?

**Current Tx Network Main Generation**

- **Matimba**
- **Central**
- **North-East Power Pool**
- **P/Storage**
- **Koeberg (Nuclear)**
What will the Super Grid look like?

Relative Network Forecasted Loading

Current Load

Future Load
What will the Super Grid look like?

Current Tx Network Power Flows
What will the Super Grid look like?

Inland Scenario Power Flows

New Generation Pools

- Coal Generation
- Pump Storage Generation
- Nuclear Generation

Map showing power flows and generation pools in South Africa.
What will the Super Grid look like?

*Coastal Scenario Power Flows*

**New Generation Pools**
- Coal Generation
- Pump Storage Generation
- Nuclear Generation

- **765kV**
- **400kV**
Why is a Super Grid?

**Combination Scenario Power Flows**

**New Generation Pools**
- Coal Generation
- Pump Storage Generation
- Nuclear Generation

![Map of South Africa with power flow arrows and generation pools marked](image-url)
What will the Super Grid look like?

Super Grid Backbone Corridors

- MATIMBA
- VENDA
- WITBANK
- KZN EAST
- COAST
- PORT ELIZABETH
- GENERATION POOL
- TX SUPPLY NODE
What will the Super Grid look like?

**Major Regional Corridors - North**

- **GENERATION POOL**
  - MATIMBA
- **TX SUPPLY NODE**
  - POLOKWANE
  - LOWVELD
  - PRETORIA
  - RUSTENBURG
  - JHB NORTH
  - KLERKSDORP
  - JHB CENTRAL
What will the Super Grid look like?

**Major Regional Corridors - South**

- **CAPE PENINSULA**
- **PORT ELIZABETH**
- **EMPANGENI**
- **PINETOWN**
- **WITBANK**
- **CENTRAL**
  - Central RED
- **GAMMA**
- **FERRUM**
- **BETA/PERSEUS**
- **WELKOM**
  - North Western RED
  - Eastern RED

**Generation Pool**

**TX Supply Node**
What is the progress?

Forecasted Generation till 2018

Confirmed site
Potential site

Mmamabula
Matimba
Medupi
Steelpoort
North-East Power Pool
Central
Bravo
Ingula
P/Storage

Ankerlig
Koeberg (Nuclear)
Gourikwa
CCGT1 / Nuclear 1

765kV
400kV
What is the progress?

765kV Super Grid
Where to from here?

**Super Grid Requirement**

**Design least regret network**
- Not an optimized network
- Flexibility to adapt to changing gen & load

**Maximize capacity through exiting servitudes**
- HVAC to HVDC conversions
- Expanded bundle (increase SIL)
- Restring new conductor technology

**HVDC application**
- Expand application of HVDC
- Flexible HVAC line used for upgrading
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THANK YOU!

QUESTIONS?