National Blackout Awareness

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Introduction

- **Objectives:**
  - To provide insight into the concept of a power system blackout
  - To address Eskom’s core mandate of preventing a blackout, readiness to respond, and restoration of the national power system.
  - To provide stakeholders a view of the national response from a load perspective

This is in the context of power system contingency planning for extreme events as required by the South African Grid Code and Disaster Management Act
Early warning: Notice of a national blackout will be limited (most likely, none at all).
The onset will be infinitely more rapid than disasters such as the pandemic.

Load shedding: Does not increase the risk of a national blackout; it is implemented to prevent a national blackout.
### Terminology - general

<table>
<thead>
<tr>
<th><strong>Terminology</strong></th>
<th><strong>Description</strong></th>
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<tbody>
<tr>
<td>Interruption of supply</td>
<td>Separation of a customer or group of customers from the Interconnected Power System (“grid”). Usually localized.</td>
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<tr>
<td>Load shedding</td>
<td>Controlled rotational interruption of supply in order to prevent a complete blackout of the power system</td>
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<tr>
<td>Regional / area blackout</td>
<td>Uncontrolled separation and de-energisation of a significant portion of the transmission system. e.g. Western Cape blackout. All customers connected to that portion of the network lose supply.</td>
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<tr>
<td>Network island / separation</td>
<td>Portion of the grid separates from the main grid but remains energized and stable with generators in the island supplying customers in the island.</td>
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<tr>
<td>National blackout</td>
<td>The complete, uncontrolled, de-energisation of the power system. Generators may “island to house load”. All customers lose supply.</td>
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The fragility of a power system

- The South African power system can be thought of as **one big machine** all the way from Matimba in the north to Koeberg in the west.
- This “machine” is made of many pieces of equipment, failure of which could result in it affecting stability of the network.
- Technical causes of blackouts from this “machine” could include frequency imbalance, voltage stability issues etc.
- Load shedding is a tool used by the System Operator to ensure supply-demand balance.
Notable International Regional and National Blackouts (2020-2023)

USA Texas (2021 Feb): 4m, 4d, Gx 30% gas 15% wind, cold weather.
Pakistan (2021 Jan): 200m, 1d, Gx cascading.
(2023 Jan): 220m, 1d, Tx failure
Puerto Rico (2022 Apr) 1.5m 5d Fire
Trinidad & Tobago (2022 Feb) 1m, 1d, Network fault
Bangladesh (2022 Oct) 150m 7h, Tx overload.
UK (2022 Feb) 1.4m, 4 days, Storm Eunice
Jordan (2021 May) 10m, 5h, Tieline
Mumbai [India] (Oct 2020) 20m, 1d, substation trip
Kenya (2022 Nov) 3 blackouts
Argentina (2023 Mar) 20m, 1d, Fire
Southern USA [Multiple states] (Apr 2020) 4.3m, 5d Tornado outbreak
USA Texas (2021 Feb): 4m, 4d, Gx 30% gas 15% wind, cold weather.
## Notable International Regional and National Blackouts (2020-2023)

<table>
<thead>
<tr>
<th>Area</th>
<th>Date</th>
<th>Duration (days)</th>
<th>Affected (millions)</th>
<th>Cause</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southern USA</td>
<td>April 2020</td>
<td>5</td>
<td>4.3</td>
<td>Tornadoes</td>
</tr>
<tr>
<td>Mumbai, India</td>
<td>October 2020</td>
<td>1</td>
<td>20</td>
<td>Substation trip</td>
</tr>
<tr>
<td>Pakistan</td>
<td>January 2021</td>
<td>1</td>
<td>200</td>
<td>Gx cascading</td>
</tr>
<tr>
<td>Texas, USA</td>
<td>February 2021</td>
<td>4</td>
<td>4</td>
<td>Snowstorm</td>
</tr>
<tr>
<td>Jordan</td>
<td>May 2021</td>
<td>1</td>
<td>10</td>
<td>Tie-line trip</td>
</tr>
<tr>
<td>Southern UK</td>
<td>February 2022</td>
<td>4</td>
<td>1.4</td>
<td>Storm Eunice</td>
</tr>
<tr>
<td>Trinidad &amp; Tobago</td>
<td>February 2022</td>
<td>1</td>
<td>1</td>
<td>Network fault</td>
</tr>
<tr>
<td>Puerto Rico</td>
<td>April 2022</td>
<td>5</td>
<td>1.5</td>
<td>Fire</td>
</tr>
<tr>
<td>Quebec, Canada</td>
<td>May 2022</td>
<td>7</td>
<td>1.1</td>
<td>Derecho (windstorm)</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>October 2022</td>
<td>1</td>
<td>150</td>
<td>Tx overload</td>
</tr>
<tr>
<td>Pakistan</td>
<td>January 2023</td>
<td>1</td>
<td>220</td>
<td>Tx failure</td>
</tr>
<tr>
<td>Argentina</td>
<td>March 2023</td>
<td>1</td>
<td>20</td>
<td>Fire</td>
</tr>
</tbody>
</table>

- These are the blackouts that occurred this decade.
- 2023 has so far seen major blackouts in Ghana and Pakistan.
- Note the variety of causes
## A few key impacts of a national blackout

<table>
<thead>
<tr>
<th>Component</th>
<th>Impact Details</th>
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</thead>
</table>
| **Telecommunications** | - Mobile sites will be sustained 2-4hrs (*what about traffic & priority access*)  
- Backbone failure within 8hrs  
- Recharging batteries  
- Other South African Telco’s will not be available after a while                                                                 |
| **Water**           | - Local reserve 48hr guideline for munics (not universally in place)  
- Water treatment essential (cannot distribute raw water)  
- Water required for data centres  
- Power stations may have min 3 days (for 6 units) // downstream flooding                                                                 |
| **Liquid fuel**     | - Storage available “3-5 days” subject to requirements (no backup gens)  
- Ports and refineries need electricity (No contingency plans)  
- Industry will be required to ration and prioritise supply                                                                 |
| **Security**        | - Sectors cannot rely on national security structures (limited resources)  
- Correctional services – generators only 24hrs not adequate capacity  
- International experience have shown widespread looting during a blackout                                                                 |
Most likely cause
- An unforeseen sequence of events that results in a cascading collapse of the transmission/generation system, leading to a complete loss of supply across the country

Warning period
- Little-to-no warning. At best, the System Operator may be able to alert the country should the system be at increased risk

Duration
- Restoration of the first loads would occur after several hours and restoration of the whole system could take multiple days (possibly weeks). This is dependent on the root cause and prevailing conditions

Unique South African challenges
- A large centralized power generation pool
- A large geographically distributed customer base separated by very long transmission lines
- The smaller size of the power systems in neighbouring countries in comparison to South Africa and weak interconnections that South Africa shares with these smaller neighbouring countries
- The strong likelihood that a South African blackout may cause corresponding blackouts in neighbouring countries
A low likelihood incident: multiple layers of protection are in place to prevent a blackout.

Failure = the simultaneous failure of several barriers

Coordinated national sector & provincial disaster plans

Prevention
- System Design
- System Operations
- Manual Response
- Automatic Protection

Response & Recovery
- Islanding Scheme
- Black start Facilities
- Restoration Plan

Adequate capacity/reserves/demand response
Prudent operations (reserves)
Auto start
Curtailment (10-20% 2hr)
Shedding 15-30min
Contingency schedules
Real time response

7 stages (50%)
3x3.3% 4x10%
<1sec

Failed black start
From the System Operator perspective, the following high-level responsibilities form part of the overall strategy in response to a blackout.

Throughout all phases, System Operator will be responsible for disseminating timeous and accurate information pertaining to the restoration process to the rest of the business.
Load Restoration Objectives

OBJECTIVES

- Restore Safely
- Minimise restoration time
- Minimise impact to public
- Restore Smoothly and deliberately
- Maintain flexibility to respond

REQUIRED INITIATIVES

- Maintain safety of people and assets
- Determine network risk and prepare for PS restoration
- Keep management and public informed
- Balance real load and generation
- Provide support to NMC
- Avoid thermal overloading
- Implement SOPs for preservation of diesel and DC
- Restore critical loads
- Balance reactive loads (MVAr management)
- Plan for changing conditions
- Management of over-voltages (Ferranti and reactive devices)
- Restoration plan current, in place and exercised
- Restore essential loads
- Avoid repeated interruptions/trips
- Normalise the interconnected power system
1. **Resistive load:** Municipalities, Metropolitan Municipalities and Eskom Loads

2. **Enabling requirements:** DMS (SCADA), DCS, Back-up DMS and DCS, ERCC, PJCCs, PEoC, EoCs, IGCC, EP Centers, MWP, Telecommunication infrastructure, Data Centre, Schools and Community halls, Police, SANDF etc.

3. **Other considerations:** DWAF, Pumping stations, P/S unit supplies, P/S auxiliary and essential services, Oil refineries, Hospitals and Sewerage supplies etc.

**PRIORITY 2**

1. **Bulk supply customers:** Municipalities, Metropolitan Municipalities and Eskom Loads

2. **Key Stakeholders:** CNCs; Resource management; Contact Centers; Regional head offices; Power station office blocks; National, Provincial, Metro and District DMCs, Equipment stores, etc.

3. **Other considerations:** Agricultural and Commercial loads (Airports, Top Customer house load and auxiliaries, SABC, Banking sector, Retail sector, SENTEC towers, etc.)

**PRIORITY 3**

1. **Industry load:** Mining (Coal, Platinum, Gold etc.), Steel, Manufacturing, etc.

2. **Key stakeholders:** Walk in centers, Local offices, Conference centers etc.; Distributed energy resources, Co-gen, etc.

3. **SAPP/SADC:** Lesotho, Mozambique, Namibia, Botswana, Zambia, Zimbabwe etc.
Key roles in a blackout – A load perspective

1. **Blackout prevention, response and recovery**
   - Power system operations & protection systems
   - Black start facilities & islanding
   - Execution of black start system restoration plan
     (System Operator, Generation, Wires Business)

2. **Organisational response & business continuity**
   - Integrated emergency response & comm’s
   - Continuity of critical business operations
   - Safety of staff & the environment

3. **Collaborative planning and response:**
   - National, provincial, municipal disaster structures
   - National sector departments and organs of state
   - National/provincial crisis communications
   - Stakeholders

4. **Collaborative planning and response:**
   - South African Power Pool joint planning
   - Support to the NDMC in engaging SADC countries
     (South African Power Pool, NDMC)
Possible improvements to current process - Customer role in a blackout

- It is assumed that all customers have, and will follow their **internal emergency preparedness plans** while taking **instruction from Eskom** regarding the restoration process.

- In order to assist with the restoration process, the System Operator would require **customer technical information ahead of time** to verify if a customer can be used to **safely load generators** without risking the restoration process:
  - Location of customer (geographically and electrically)
  - Load size, load type and industrial process
  - Load characteristics upon start-up, during run-up to full load and during normal operation (e.g., load values at key stages, minimum/maximum ramp rates, transients, etc.)
  - Any specialised protection schemes installed that are not visible to Eskom (e.g., frequency, voltage, etc.)
  - Constraints (human and plant risks, operational limits, etc.)
  - Maximum and/or minimum time off or on

- Those customers that are located on a critical restoration path and have suitable load characteristics and values can be incorporated in the restoration plan as a **potential** source of load in the initial restoration process.

- Identified customers will be engaged individually to firm up on prospective plans and requirements.

- All other customers will be prioritised as per the Load Restoration Guideline i.e., they will receive power after there is an established ring network(s) with multiple generators synchronised.
Customer communication preparation

- As stated earlier, each customer has the **responsibility** to ensure that they have their own internal Disaster Management and/or Emergency Preparedness plans.

- As a minimum, **irrespective of the load restoration prioritisation**, the teams need to work together to answer the following important questions:
  - Who is your contact person/point for situational awareness? (Municipality, Distribution, etc.)
  - Is this contact aware of your interdependence on them for **two-way communication** regarding the restoration process?
  - What will be your primary and secondary **means of communication** during the national emergency? (Fixed line, mobile network, satellite phone, etc.)
  - Are your means of communication aligned with your contact person/point above?
1. **Eskom Disaster Plan**: In place, updated annually (*incl. 11 national disasters*)
2. **Blackout**: This remains a low-likelihood, high-impact incident
3. **Early warning**: Most likely none, though some conditions increase risk
4. **Load shedding**: Stages 1-8 in place as risk reduction measures (Review underway)
5. **Blackout restoration plan**: In place, exercised, risks monitored (Eskom Board level)
6. **Restoration**: Deliberate, not focused on critical loads (focus is avoiding a 2\textsuperscript{nd} failure)
7. **Eskom contingency planning**: In place, continually being improved.
8. **Country plan**: **Not in place**.