Power system resilience – enablers supporting an effective Blackout response

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Introduction

- A major electricity-related incident (**such as National Blackout Incident**) has a significant impact on the country.
- **Grid Code** require that a utility plan for a range of contingency scenarios, including those that have a **high impact but a low probability of occurring**.
- This paper focuses on the **resilience and technical planning** required for a blackout incident.
- It also discusses the **blackout recovery phases and technical considerations** for responding to a blackout incident.
- The paper concludes with a **discussion on the blackout facilities** and highlights the SA Grid Code (SAGC) and System Operator requirements for black-start capabilities, such as: (i) *Islanding schemes*, (ii) *Nuclear safety*, (iii) *Black-start facilities* and (iv) *Independent Power Producers*.

Utility Obligation

- The protection of critical infrastructure, such as that for electricity provision, is **crucial to government, regulatory bodies and society in general**.
- **Therefore**, it is incumbent on the utility to be prepared for an eventuality such as the entire disconnection of the IPS.
- Eskom's obligation as a **regulated entity** is directed by a number of legislative and regulatory instruments, such as the Electricity Act, SAGC, Disaster Management Act / Framework.
- System Operator **plan and prepare** for a range of disaster scenarios by compiling response and recovery plans as well as developing the capabilities to respond to extreme incidences including that of a national blackout.

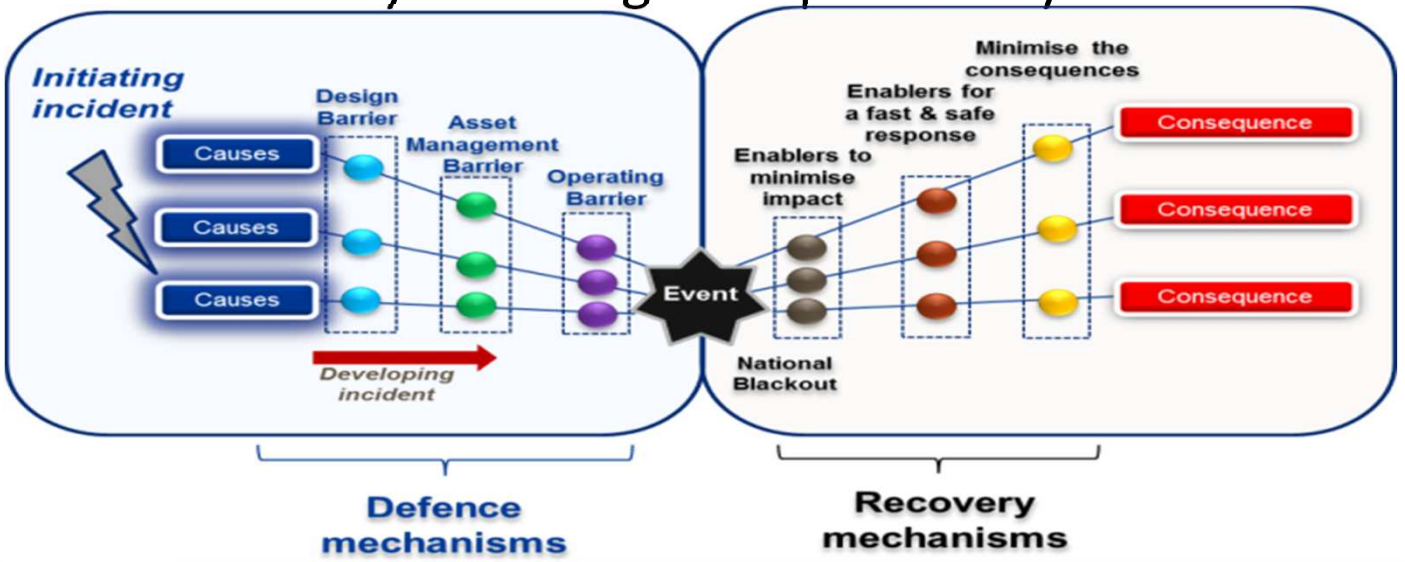
South African Grid Code

The System Operator obligations are defined as follows:

- Scheduling of generation and ancillary services *(incl. demand response, reserve margins, black-start, unit islanding capability, and testing of these facilities);*
- System reliability and safety *(incl. connection conditions, load curtailment, generation merit order, loadshedding protocols, emergency and contingency planning);*
- System security *(incl. frequency, voltage and power quality, and specialised protection systems);*
- Agreements for off-site supplies to nuclear power stations (*incl. ensuring operable grid connection);*
- Operational measures *(incl. protection schemes, procedures, outage coordination and fault management).*

PLANNING TO RESPOND TO A BLACKOUT

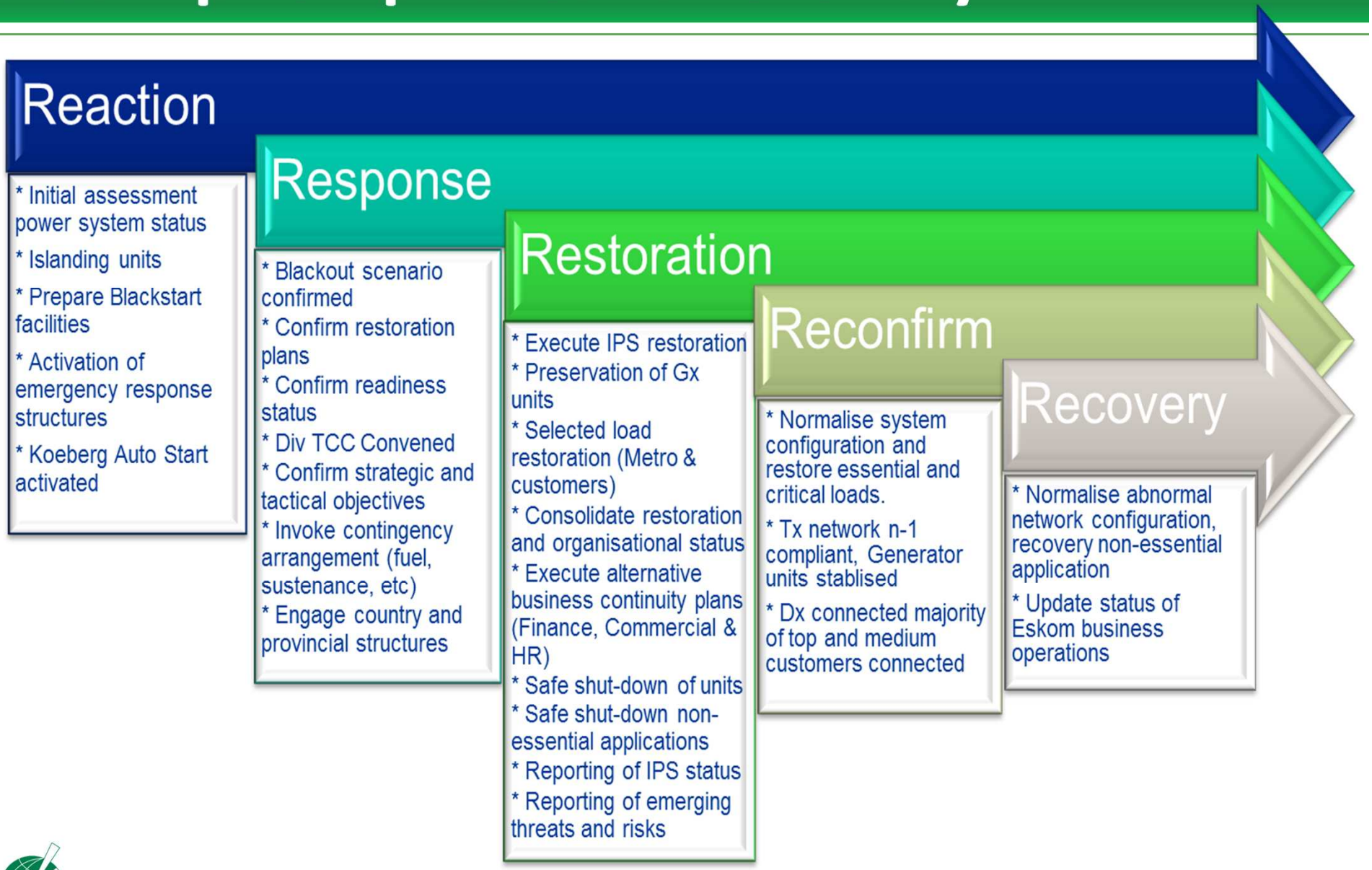
- The ability of a utility to respond and recover in a coordinated manner to a national blackout incident depends on the **resilience strategies adopted** prior to it occurring.
- Appropriate *design, asset management and operational* philosophies be adopted to contain the severity and quicker recover.
- This establishes the capabilities (e.g. *black-start, unit islanding, standby generators*, etc.) and abilities (e.g. *technical response plan*, etc.) necessitated by the obligation previously discussed.



Blackout recovery mechanisms

- While the IPS has **multiple defense barriers**, these cannot guarantee that a blackout will be avoided.
- The restoration of loads and normalisation of the IPS focuses on efforts that support the blackout restoration process to achieve the following: (i) *create islands*; (ii) *stablise islands* and (iii) *synchronise islands*.
- The blackout recovery objectives will focus on *minimising the severity; maximising the safety* and *restore by not comprising* the integrity of the restoration.
- Recovery phases should evaluate the IPS status and *organisational condition to contain, maintain and monitor the emerging risks* and threats to the response and contingency plans.
- The goals during the initial **reaction, response, restoration, reconfirmation and recovery** of the IPS are:
  - **Enablers to minimise impact;**
  - **Enablers for a fast and safe response; and**
  - **Efforts to minimise the consequence.**

Description phases to recovery



Blackout response objectives

- In terms of the **Incident Command System (ICS)** the blackout response objectives to a blackout are defined for the emergency response structures at the strategic, tactical and operational levels.
- These objectives establish the foundation for coordinated emergency planning between the **different blackout planning roles** namely:
  - The Power System Black-Start Plan
  - The Utility Blackout Plans
  - The Country Blackout Plans
  - The Regional Blackout Plans
- Given the emergency planning roles, the utility emergency response structures require defined emergency objectives to steer, coordinate and direct the response and recovery of operations.

#	Eskom Blackout Response Objectives	Description
1	Contain the incident and enable system restoration	• *Successful operation of automatic systems (unit islanding) and/or black-start facilities* • *Rapid incident assessment and blackout declaration* • *Activation and mobilisation of response systems (golden hour)*
2	Securely restore the national power system	• *Restoration of the power system in a deliberate, secure manner (to avoid a subsequent blackout during restoration)*
3	Ensure the safety of personnel, plant, systems and the environment	• *Preservation of generation units and nuclear safety* • *The safety of Eskom responders and general staff* • *Operating plant within thermal limitation* • *Safe shutdown of non-essential systems Manage environmental violation*
4	Support the country and region's blackout response	• *Coordination with national and provincial emergency response structures* • *Liaising with Government Invoking contingency arrangement with key role players*
5	Ensure the continuity of identified critical operations and staged recovery of all operations	• *Continuity of mission critical processes and operations* • *Safe recovery of non-essential applications* • *Recovery business operations to deliver product and service*
6	Recover Eskom's reputation and stakeholder confidence	• *Demonstrate an effective technical and crisis communications response to all identified stakeholders* • *Support country communication and stakeholder management.*

Blackout response principles

- **Blackout principles** provide a basis for planning across operations to ensure the harmonization of technical switching plans between generator, transmission, distribution (Customers).
- The principles forms the foundations for the detailed procedure on how to restart the IPS.
- This is crucial for the identification of the following: (i) potential threats and vulnerabilities, (ii) the sequence of the restoration, and (iii) the mobilisation of resources to prioritised areas.
- This would include the following **restoration principles during the normalisation** of the interconnected power system:
  - Auxiliary load, N-1 (network rings), initial load pickup (power system security), customer base (residential), speed of restoration (slow with deliberate action), multiple island restoration, Nuclear safety.

Blackout (non)- technical considerations

- **Non Technical considerations**
  - National Control will perform the blackstart
  - Training: Control Centre staff must be skilled on execution of the black-start and islanding plans.
- **Technical considerations**
  - Frequency Control
    - Frequency Control (load pick up and synchronizing of Generation), Generator Loading, Automatic Generation Control (AGC), Generator reactive limits, Synchronising of generators, Pumped Storage Generators, Bulk water and coal distribution.
  - Voltage Control
    - Power Angle between Islands, Reactive devices, Surge Impedance Loading, Line length, Non power station ends first,
  - Operating:
    - Cold Load Pickup, Load Type, Stability, Substation switching, Power lines auto re-closure settings, Returning a line to service, Independent Power Producers

Black-Start Facilities and Islanding

- **Islanding scheme:**
  - First option for restoration
  - Various islands will be formed

- **Black-Start Facilities:**
  - Two blackstart facilities
  - Test the blackstart facilities

- **Nuclear safety:**

Black-Start Facilities

- Existing System Restoration Plan is a **detailed procedure** on how to restart the power system following a blackout. This plan **continues to evolve** to incorporate new understanding based on simulation and testing.

- We are continuously pushing the barriers in black start testing by being **more realistic** in the test conditions and incorporating opportunities to learn from each test. These tests offer an opportunity to include a wider staff compliment in the technical and logistical aspects of black start.

Conclusion

- The planning to respond to a major electricity-related incident requires the **establishment of a number of capabilities to prevent and respond** to a national blackout incident.
- These **regulatory instruments require utilities to plan for a range of contingency scenarios**, including those that have a high impact but a low probability of occurring.
- This paper focuses describing the **blackout recovery phases and planning required for responding** to a national blackout incident.
- It provides a numbers of aspects a system engineer should consider when compiling it technical blackout restoration plan, such as: *recovery mechanisms, response objectives, principles and technical consideration*.
- The paper concludes with a discussion on the *black-start facilities, nuclear safety, IPP and OCGTs* consideration in the evaluation of the technical restoration plan.

THANK YOU – ANY QUESTIONS