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Substation Black Start Resilience

www.energynetworks.org

Operations Directorate
Energy Networks Association
6th Floor, Dean Bradley House
52 Horseferry Rd
London
SW1P 2AF

Amendments since publication

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1 Background

A shutdown of the entire electricity network is identified as a risk on the national Risk Register. The process of recovering from this situation is known as a Black Start and involves the following stages:

- Initial switching by DNO's and TSO's to prepare the de-energised network for restoration in sections.
- DNO's and selected local power stations working together to energise small sections of network in accordance with pre-defined Local Joint Restoration Plans (LJRP's).
- TSO's reconnecting sections of network to form Power Islands by interconnecting LJRP's.
- TSO's managing the reconnection of demand and generation, balancing the system and reconnecting the Power Islands to restore the interconnected network.

Following a series of major blackouts around the world, the UK government and the electricity industry set up Exercise Phoenix in 2006 to review the resilience of GB to Black Start events. As part of the exercise, the recovery time of electricity supplies was studied and this concluded that it may take up to 72 hours before electricity supplies are restored. Therefore the industry, with the support of UK government (DECC) and the regulator (Ofgem), recommends that the loss of supply resilience of grid and primary substations for the GB electricity networks be extended to a 72 hour period. The validity of the 72 hour period is to be kept under review by the Energy Emergencies Executive Committee (E3C).

It is essential that provision be made to safely re-energise the electricity network following a Black Start event. In particular the protection and tripping systems at substations, which disconnect supplies in the event of a local network fault, need to be functional upon re-energisation.

Over the last decade companies have replaced large numbers of electro-mechanical protection relays (which had a low power consumption), either as part of new connections work, asset replacement and reinforcement programmes or in connection with more sophisticated schemes to improve network performance. However replacement relays are typically electronic micro-processor based with increased power consumption and therefore a higher continuous demand on the DC battery supply. Therefore once external supplies are lost to a substation, the relays will drain the tripping/protection batteries more quickly than earlier designs.

If substation batteries fail before a substation is re-energised, modern protection systems become non-operational and faults on the network may not be identified and consequently not disconnected. This could endanger people and properties that are affected by the faults and/or cause catastrophic failure of network assets e.g. substation plant. Remote protection may disconnect faults, albeit in some cases with limited discrimination.

In a Black Start scenario failure of substation batteries to a point where they cannot support circuit-breaker or protection functions would:

a) delay the restoration of circuits until such time that the substation batteries could be sufficiently charged to re-energise the supplying networks with statutory protection in place (which may require visits to multiple substations - possibly under extremely difficult conditions)

or

b) require a risk assessment before re-energising the network, knowing that statutory protection maybe jeopardised, and accepting an increased risk to life and property.

As a consequence of a prolonged Black Start event a large population of substation batteries may suffer damage through excessive discharging or continuous drain which may (i) affect their ability to be recharged and (ii) necessitate their premature replacement.

In a similar manner, SCADA system RTU's and ancillary equipment have a continuous demand for power.

If the SCADA battery, or the telecommunications batteries supporting SCADA services in a substation fails under a Black Start scenario, then the ability to control the substation remotely will also fail, requiring visits to multiple substations to confirm the operational state of the network and to undertake manual switching. This would further delay the restoration of the electricity network.

Prior to the issue of this document, no industry standard existed for the resilience of substation batteries for protection/control systems or SCADA systems. For any individual localised incident the situation is likely to be manageable and the risk to society in general is low. In a Black Start scenario, the societal impact is high and widespread, and consequently an industry standard is deemed appropriate.

2 Requirements

GB TSO and DNO companies are required to ensure that suitable measures are put into place at core electricity transmission and distribution substations, such that in the event of a partial or total shutdown of the mainland electricity network, adequate protection and control systems are available to permit safe re-energisation of these substations while meeting statutory requirements e.g. those set out in The Electricity Safety, Quality and Continuity Regulations 2002, Regulation 6.

In accordance with the 'Black Start Recovery – Substation and SCADA Resilience' report by the Electricity Task Group (ETG) of the Energy Emergencies Executive Committee (E3C) – July 2010, it is recommended that such measures should, as a minimum, be suitable to cater for a partial or total shutdown of the electricity network lasting up to 72 hours.

The baseline requirement is for core electricity transmission and distribution substations to be designed so that they are resilient for a minimum period of 72 hours. This shall be taken to mean that the substation protection, control and SCADA functions shall be available such that the site can be safely energised within 72 hours of the inception of a Black Start event. Where resilience is substantially provided via a battery alone, the battery capacity shall be determined taking into account the likely deterioration in battery capacity over its life and as a minimum considering the standing load on the battery (on the basis that the additional battery capacity required to cater for any switching operations within the 72 hour period following the inception of a Black Start event is negligible), although the DNO/TSO may provide additional battery capacity if it considers this to be appropriate.

3 Scope

This Engineering Recommendation specifies for GB the substation battery resilience required to support substation protection and control systems and SCADA systems at TSO substations, joint TSO/DNO substations and DNO substations with a secondary voltage of 11kV[1] and above other than those supplying a single end customer. The scope includes all batteries installed at substation sites for protection, control and SCADA purposes irrespective of whether there are dedicated battery systems provided for different functions.

The resilience of key communications circuits which form an integral part of protection schemes between substations are also within scope where the circuits are essential to facilitate the safe re-energisation of the electricity network following a Black Start event i.e. where the back-up protection is considered to be inadequate for emergency recovery.

The ability to recover successfully from a Black Start event also requires resilient SCADA networks and voice communications. Recommendations for achieving the necessary level of resilience from (SCADA and voice) communications networks to successfully re-energise the electricity network under Black Start conditions are outside of the scope of this document, although they shall need to be considered as part of individual companies' strategies to delivering overall Black Start resilience.

Plans will also need to take into account the presence of any switchgear dependent upon an AC supply for correct operation – possibly by use of portable/mobile generation plant.

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[1] In some DNOs this may include lower voltage systems (e.g. 6.6kV) performing a similar function.