electricity north west

Bringing energy to your door

Functional Specification on the use of SCADA and ADMS to detect and fragment islands formed on the distribution network.

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VERSION HISTORY

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GLOSSARY

Abbreviation	Term
CI	Customer Interruptions
CML	Customer Minutes Lost
DG	Distributed Generation
DNO	Distribution Network Operator
DSR	Demand Side Response
ESQCR	Electricity Safety, Quality and Continuity Regulations
EU	European Union
GB	Great Britain
LOM	Loss of Mains
NMS	Network Management System
RoCoF	Rate of Change of Frequency
TA	Topology Analyser

1 BACKGROUND

Due to incentives offered by the government to meet the CO_2 targets the amount of generation connected to distribution networks at all voltage levels has steadily increased in recent years. This has led to parts of the network where generation matches or exceeds demand at certain points on the load curve.

The emergence of commercial measures such as Demand Side Response (DSR) contracts used to balance system frequency, trading positions and network constraints have also increased in recent years. A particular concern arises when increased Distributed Generation (DG) output combines with DSR activation within a single group. This can result in the groups demand being met by the DG and risks the formation of an island should a network fault occur.

Islanded operation is avoided is due to safety concerns and issues surrounding protection coordination. The current practice is to avoid islanded networks from being formed and sustained using Loss of Mains (LOM) protection on each distributed generator so that if the DG detects a loss of the network, it will disconnect and prevent the network it is connected to from being continuously energised.

The new requirements for grid connection of generators detailed in the European Network Code allows the dynamic behaviour of generators and their protection and control facilities to change under certain fault conditions in order to preserve or to re-establish system security. This additional control capability allows “fault ride through” and is applicable to generators above 1MW. In addition to the EU Network Code changes there have been changes to the GB Distribution Code to alter the Rate of Change of Frequency (RoCoF) settings for generators.

Future Distribution Network Operator (DNO) networks will have more DG connected and DSR contracts will proliferate as low carbon generation and demand technologies are adopted by network customers. The combination of altering settings or control on generators to allow them to remain connected for smaller system disturbances and the increase in demand and associated DSR will potentially lead to an increase in the risk of a generator supporting an islanded network.

The problem facing DNOs is how to reliably detect when an island has formed and what steps to take once an island has been detected.

2 ISSUES WITH AN ISLAND

Once formed islands can give rise to several operational issues relating to safety and the quality of supply.

2.1 Statutory voltage

The voltage to be supplied to a customer is prescribed in ESQCR Regulation 27 and is currently a mandatory requirement. DG does not tend to have voltage regulation equipment fitted and would be unable to guarantee to keep the network within the statutory limits.

2.2 Statutory frequency

The frequency to be supplied to a customer is prescribed in ESQCR Regulation 27 and is a mandatory requirement. DG does not tend to have frequency controls fitted and when they do not have the Grid connection to rely on will drift from the nominal frequency.

2.3 Earth connection

ESQCR Regulation 8 states “A generator or distributor shall ensure that, so far as is reasonably practicable, his network does not become disconnected from earth in the event of any foreseeable current due to a fault”. The use of the term “so far as is reasonably practicable” recognises the fact that it is not possible to ensure that an earth is always connected but the absence of an earth has safety implications as equipment may remain live in the event of a fault.

Electricity networks are earthed at strategic points on the network eg the 11kV network tends to be earthed at each primary transformer. Therefore depending on the location of the separation between the network and the island it is possible that there is no earth within the island to provide a return path for fault current.

2.4 Adequate fault levels

A minimum level of fault current, specific to each DNO network and operating voltage, is required in order to ensure that in the event of a fault protection will operate and disconnect the affected area.

2.5 Correct operation of protection

When an island has formed it can result in different power flows compared to the standard network operation. In the event of a fault this could result in the protection disconnecting more of the network than required which leads to an increase in Customer Interruptions (CI) and Customer Minutes Lost (CML).

3 LIKELIHOOD OF AN ISLAND

A common technique employed for LOM protection devices on DG is to measure the ROCOF and trip the DG if the ROCOF exceeds a predetermined threshold. Recently the GB Distribution Code has altered ROCOF settings to desensitise the protection to reduce nuisance tripping. The new desensitised settings will allow greater proportion of DGs to remain connected to the network and therefore increase the probability of islands forming.

To investigate the likelihood of an island forming WSP, our project partner, conducted some modelling work using both the old (G59) and revised (G99) LOM settings. This work determined the load range under which an island can form for different levels and types of generation. A summary of the results are shown in Table 1.

Table 1: Load range at which an island can form

Standard	Scenario	Load Range for Island Formation (%)
G59	High Export	55 – 75
	Low Renewables	55 – 70
G99	High Export	65 – 115
	Low Renewables	45 - 90

The results show that there is a significantly wider load range over which an island can be sustained when using G99 settings thereby significantly increasing the risk.

4 BENEFITS OF AN ISLAND

There are potential benefits to allowing the operation of islands. It can increase the reliability of the network and reduce supply interruptions. Critical loads can benefit from uninterrupted supply in the event of outages in the upstream utility supply. It can also assist with black start after the network has undergone a local, regional or national black out. Careful planning and design is required to allow islanded networks to be operated.

An island formed at 11kV or 33kV will generally give rise to an unearthed system and hence should normally be shutdown but if an alternative earth can be provided and the DG can maintain voltage and frequency we could consider keeping the island running to maintain supplies. In an island situation, embedded generation could feasibly control frequency and voltage magnitude, potentially with support from static compensation as required

5 FUNCTIONALITY

5.1 Detecting the Island

All events which lead to the formation of an island involve the operation of switchgear on the DNO network which will be reported by the Network Management System (NMS) in real time together with power flows on circuits.

As part of the NMS the Topology Analyser (TA) uses network connectivity, switch status and placement of any temporary elements, to provide the network topology for the control engineers and any other applications. The TA analyses the network following any switch state change or model change and is responsible for the following functions:

- Providing the current network topology to other NMS applications
- Presenting the user with various display “perspectives” that depict the state of the network
- Providing a report for the current state of the network, containing network data such as:
    - Number of customers
    - Number of substations
    - Loading
    - Feeder ratings
    - Energisation Source - The TA uses the switch states and attributes within the network model to determine the energisation source. Only generators which have the “Island operation” attribute in the Network Model set to ‘true’ are deemed to be to supply islands.” This attribute is manually set on commissioning.

Modifications Required

The NMS will only recognise islands if the network is supplied from a generator with the “Island operation” attribute set to true. This is not conclusive proof that the generator is still supplying the network. Real time analogues would provide the additional evidence that the generator is supplying an island network.

Using the analogues and network topology the NMS can successfully detect the island and currently this would be recorded in the TA report. This report is currently in tabular form and requires a control engineer to open, review and act on if necessary. To enable an efficient response to the formation of an island the NMS configuration requires modification.

As alarms are not currently generated modification to the coding is required to recognise if a network is “Energised by DG” and then to generate an alarm alerting the control engineer to the formation of an island. This alarm should ask the control engineer if they wish to “maintain” or “shut down” the island.

Allowing the NMS to decide automatically whether to keep the island running or not could prove difficult to achieve considering the dynamic nature of some of the islands or sub-islands that could be created. Automatic response will not be possible without some customisation; currently there is not enough experience in this area to successfully develop this functionality.

5.2 Maintaining the Island

Following investigation and/or repair work the island can be reconnected to the DNO network in one of two ways.

i. If synchronising equipment is installed checks can be made to ensure that there are no voltage and frequency deviations and the networks can be reconnected automatically. The current Electricity North West topology has few locations for synchronisation and if multiple generators are maintaining an island, it could be difficult to coordinate resynchronisation of the island. If the networks are connected together without ensuring synchronisation damage can be caused to customers and DNO equipment.

ii. If there is no synchronising equipment is available the NMS and associated automation can be used to shut the island down and then re-energise from the DNO network. Pre-defined sequences can be programmed so this can be carried out within three minutes thereby avoiding the associated CIs / CMLs. Currently this would be considered the safer option.

5.3 Shutting Down the Island

Shutting down the island can be done using a set of pre-defined procedures built in to the NMS which would simultaneously open all circuit breakers within the island or open a remotely controlled device at the generator. Given the complexities which may be involved in pre-defining procedures the current preferred option would be for the island to be shut down manually by the control engineer.