The Utilisation of Bus-Section Reactors to Increase Distribution Network Hosting Capacity: Challenges and Recommendations

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SC C2 – PS2 – CIGRE UK NGN Young Members Showcase

2024 CIGRE Session - Paris – 25/30 August 2024

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SP Energy Networks

Agenda

Hosting Capacity and Fault Level

Distribution Network Use Case

System Analysis Challenges

Future Recommendations

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Hosting Capacity and Fault Level

The rapid growth of embedded generation can significantly erode network hosting capacity

Fault Level

- Maximum prospective fault current must be constrained within equipment ratings
- Embedded generation has ability to **inject additional current** during a fault event
- **Health and safety** – implications of fault level on the safety of employees, members of public and equipment

In order for DNOs to operate a safe and secure network, design limits are imposed

System Voltage	Three Phase Symmetrical Short Circuit Current		Single Phase Short Circuit Current	
	MVA	kA	MVA	kA
33kV	1000	17.5	240	4.2
11kV	250	13.1	250	13.1

When a site has been identified and validated as having potential constraints, fault level mitigation is key

In order to meet ambitious Net Zero targets, it is vital that DNOs find solutions to create further hosting capacity

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Current-Limiting Reactors

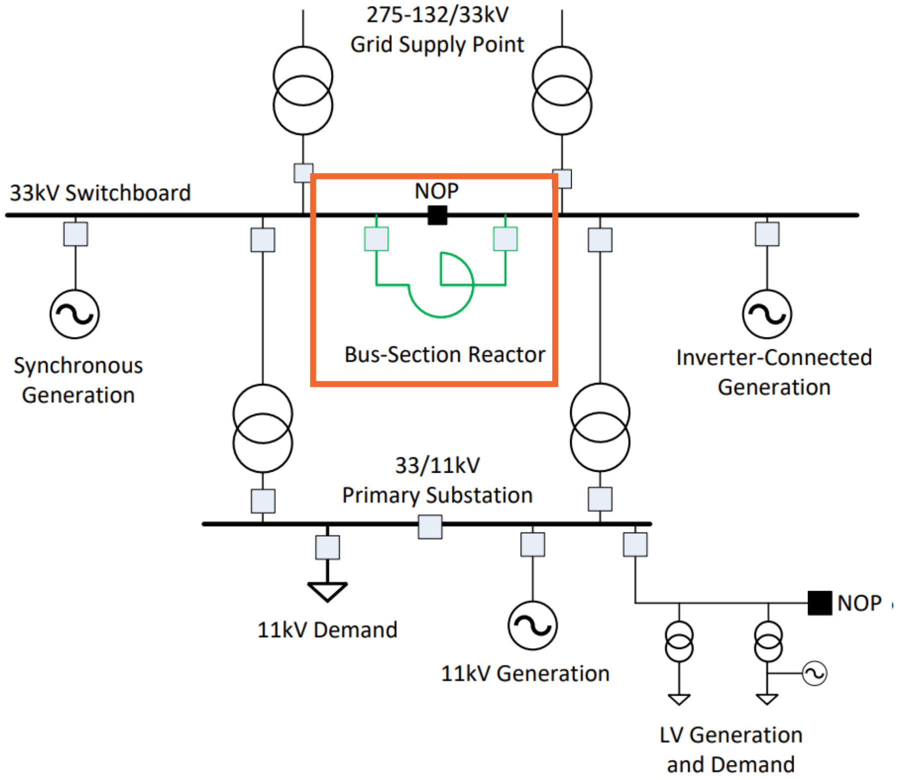
Well-established devices used to reduce short-circuit current

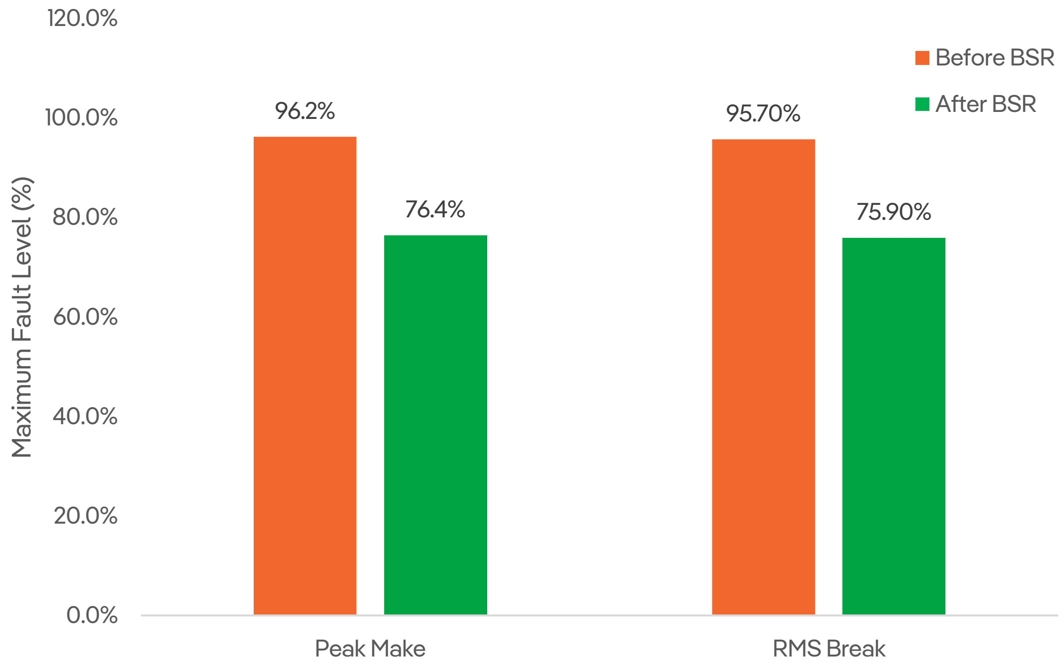
- Devices consisting of inductive coil with large inductive reactance compared to resistance
- Either connected in series with lines, or parallel across feeders/switchboards
- Typically either oil or air-cored, with advantages and disadvantages for both
- Proven technology, with academic insights being established over 100 years ago, present relatively low risk in utilisation

A number connected to the distribution network in central and southern Scotland, with many more planned in the future, now built into network models

Distribution Network Use Case

Grid substation switchboard can be split through usage of the bus-section circuit breaker



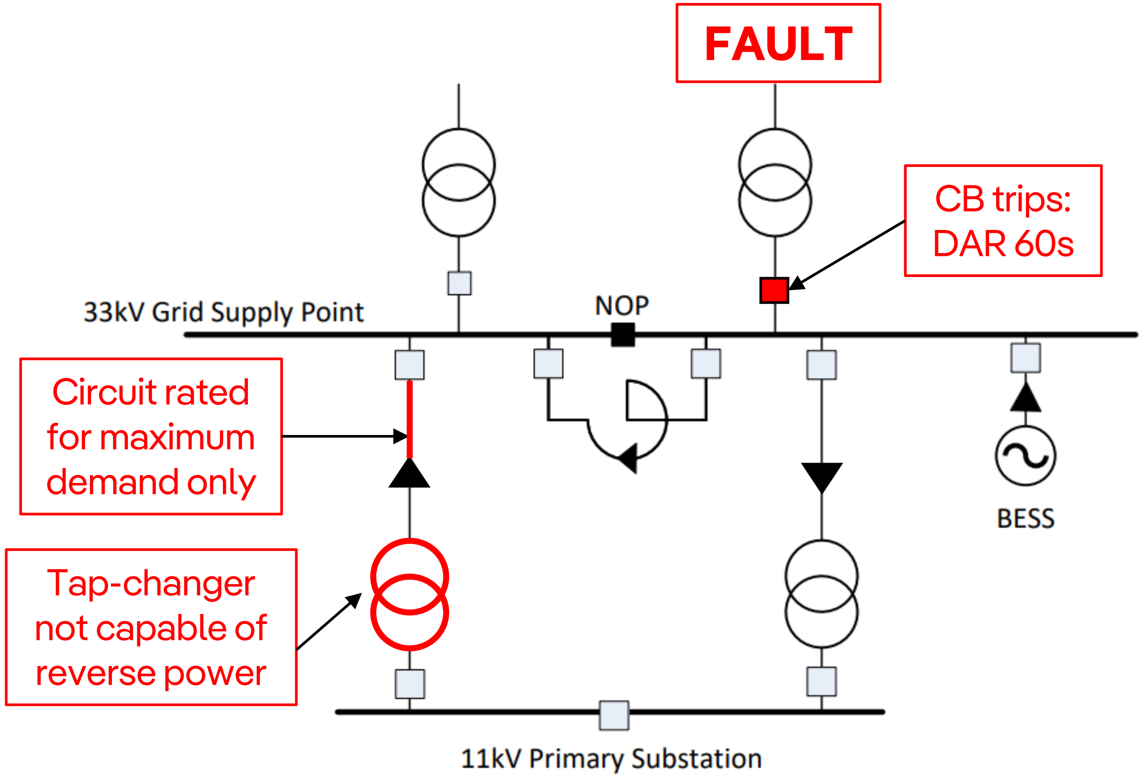


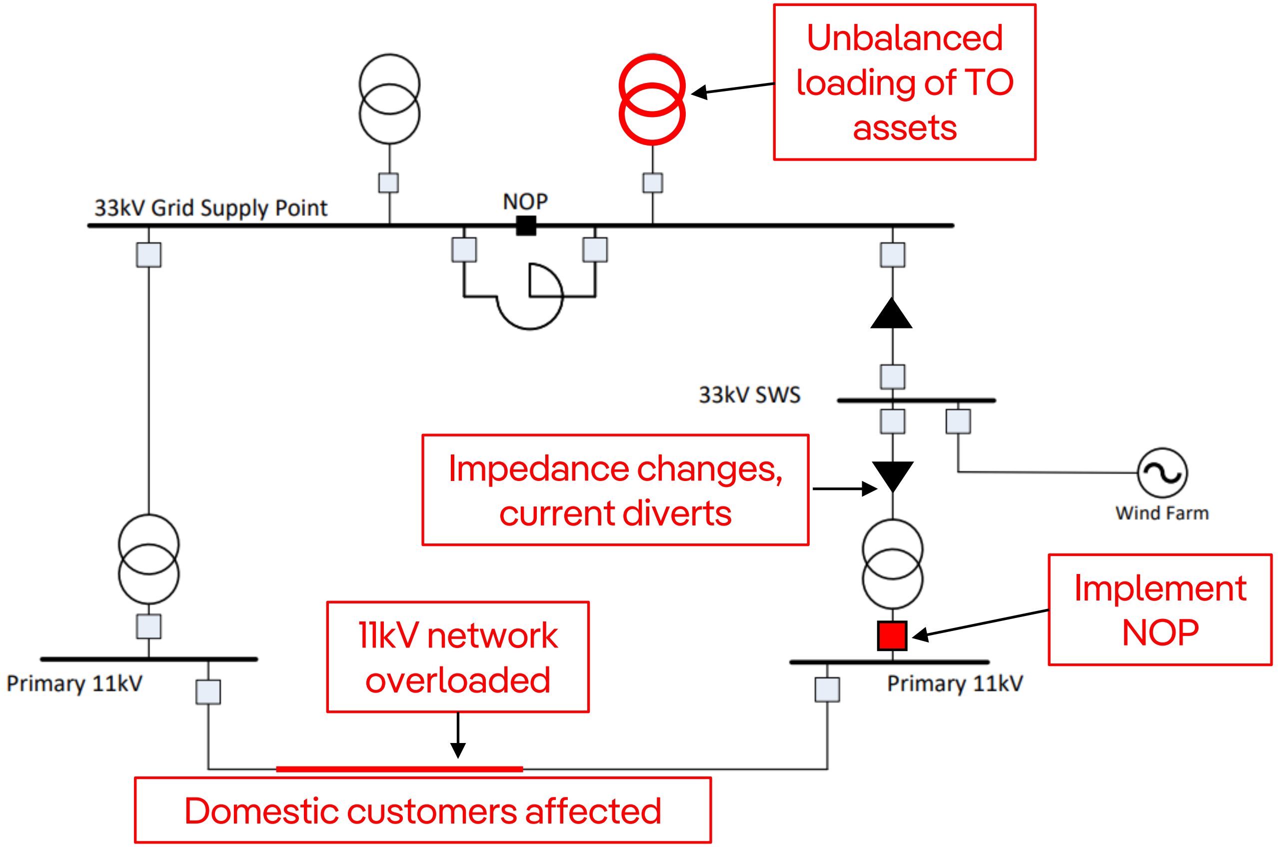
Technical challenges identified from system design and analysis on authorised models of distribution network in DIgSILENT PowerFactory

NOP: Normally Open Point

Abnormal Power Flows

The insertion of new high impedance across bus-section can have unintended effects





Consideration must be given to network balancing and asset capability!

CB: Circuit Breaker | DAR: Delayed Auto Reclose | TO: Transmission Owner | BESS: Battery Energy Storage System

Voltage Excursion Risk

Increase in system impedance can affect voltage change during system events

Substation	Voltage Change (%) - Maximum Demand Scenario			
	Before BSR		After BSR	
	Loss of BESS	Loss of GT	Loss of BESS	Loss of GT
GSP	0.71%	-2.29%	1.85%	-3.25%
Primary A	0.72%	-2.43%	1.99%	-5.10%
Primary B	0.72%	-2.40%	1.87%	-5.07%

Voltage rise upon loss of BESS site almost triples

Voltage drop upon loss of grid transformer doubles

Issue: risk of non-compliance with EREC P28 limits to fast changes in supply voltages

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GSP: Grid Supply Point | GT: Grid Transformer

Optimal Reactor Sizing

Must be sized correctly to ensure desired performance is met

MVA Rating	Reactor Impedance
• Greater rating results in more thermal capacity during system events	• Higher impedance results in greater fault level reduction
• Costs affected by desired MVA rating	• Greater risk of abnormal power flows and excessive voltage excursions
• Increases footprint of reactor	• Potential for BSR to be overloaded if impedance too low

Performance dependant on topology and connections – each network is different!

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Future Recommendations

From challenges identified from network analysis, the following recommendations can be made

Network Impact Studies	Understanding of Asset Performance	Topology Considerations	Reactor Sizing
• Wide range of studies should be undertaken at design stage – fault level, voltage, load flow • Important that all relevant scenarios are studied – loading, outages etc. • Studies can then inform potential requirements of reinforcement or protection schemes	• Vital to have understanding of assets such as tap-changer capability • These limitations should then be built into network impact studies • Commercial considerations – must be picked up at design and quotation stage • Protection of assets – how will LMS operate?	• Topology of network downstream of reactor has large impact • Expand scope of models to lower voltage to study impact • Understanding of topology can rule out BSR interventions	• Important to gain most effective usage of such schemes • Bespoke sizing studies should be conducted at each site • Consideration to amount of fault level headroom created • Create "off the shelf" solution framework

One tool in range of options to create future hosting capacity on path to Net Zero

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In Summary:

- Fault level management key in developing and operating a safe and secure network
- BSRs: technically efficient, cost-effective solution, but not without constraints
- More work required in developing understanding of whole system interactions and models to assess impact of schemes on distribution networks

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