Smart Network Design Methodologies

Use cases

June 2018

Contents

0. Document control

0.1. Document history

Version	Status	Issue Date	Authors
1.0	Complete document ready for review	30/04/18	A. Grissonnanche C. Higgins
1.1	Respond to Northern Powergrid comments	15/05/18	A. Grissonnanche C. Higgins
2.0	Updates further to Northern Powergrid comments	01/06/18	A. Grissonnanche C. Higgins

0.2. Document review

Name	Responsibility	Date
Francis Shillitoe	Project Manager	06/06/18
Alan Creighton	Technical Lead	06/06/18

0.3. Document sign-off

Name	Responsibility	Date
Mark Nicholson	Project Sponsor	12/06/18

1. Introduction

1.1. Background

As part of its horizon scanning phase, the project has shortlisted and completed a set of eleven use cases. These uses cases were considered as a 'high priority' given their high potential to improve the planning and design of the distribution network by leveraging advanced network modelling using smart meter data. These Use Cases will help to inform the functional specification of the new modelling tool.

ID	Use cases	Benefits summary
1.1	Identify and mitigate thermal violations - LV	- Improved customer satisfaction enabled by a better network performance - Improved selection of appropriate reinforcement solutions - e.g. smart solutions - Facilitates a more co-ordinated and economical approach to managing thermal violations
1.2	Identify and mitigate thermal violations - HV/EHV	
2.1	Identify and mitigate voltage violations - LV	- Reduced customers complaints - Improved customer satisfaction enabled by a better network performance - Facilitates a more co-ordinated and economical approach to managing voltage violations - Improved selection of appropriate reinforcement solutions - e.g. smart solutions
2.2	Identify and mitigate voltage violations - HV/EHV	
3.1.1	Model new connections - Generation - LV	- Improved customer services through more efficient connection process and the identification the most economical intervention where required - Improved identification of capacity for the connection of Low Carbon Technology - Improved workflow for connection application
3.1.2	Model new connections - Generation - HV/EHV	
3.2.1	Model new connections - Demand Load - LV	
3.2.2	Model new connections - Demand Load - HV/EHV	
4	Maintain the network model - HV/LV	- Enabling the delivery of benefits deriving from the other use cases
5	Monitor and manage alternative supply arrangements - LV	- Improved customer satisfaction enabled by a better application of alternative supply arrangements to minimise outages / potential outages - Operational planning activities made more efficient
6	Perform Strategic Network Modelling Analysis	- More informed decision making on long-term network investment strategy - Facilitates the development of an efficient, economical and co-ordinated system - Development of investment scenarios enabling to better deal with increased uncertainty - including the evolution toward a more devolved system operation role

Prior to completing the use cases with 'high priority' above, the project developed a long list of use case themes. The summary table below captures the main themes considered, their priority and to which extent the eleven use cases completed have enabled to make progress on these themes.

In addition, a long list of use cases developed internally by NPg was provided (as shown in Appendix A) and these were consolidated and reflected in the 'high priority' use cases where appropriate.

Use case theme	Priority	Progress	Comments
Thermal limits violations	High	●	See use case 1.x
Voltage violations	High	●	See use case 2.x
New connections	High	●	See use cases 3.x
Network model maintenance	High	●	See use cases 4
Alternative supply arrangement	High	●	See use case 5
Strategic Network Modelling	High	●	See use cases 6
Understanding Customer Demand	High	●	Covered through use cases 1.x to 6
Network Reinforcement	High	●	Covered through use cases 1.x to 6
Losses assessment	High	●	Covered through use cases 1.x to 6
System Reliability	Medium	◑	Fault detection using smart meter data is out of scope, the real-time monitoring and management of system integrity has not been covered
Outage Management	Medium	◑	Outage planning has been covered but not the real-time outage management aspect since network operations are out-of-scope
Load Switching	Medium	◑	Network planning aspect associated with switching Customers Load is covered in use case 5 for the LV networks and in use case 1.2, 2.2 and 6. Network operations not covered as out-of-scope of the project
Phase Balancing	Medium	●	Covered through use case 1.1 and 2.1
Fault Response	Low	○	Not covered as it is mainly related to Network Operations and not Network Planning. The principles are covered off in Use Case 5
Customer Contact	Low	○	Out-of-scope
Load Index Reporting	Low	◑	Some the analysis will support the regulatory reporting of the load index, particularly that related to use case 1.x
DUoS Charging	Low	○	The novel analysis techniques may provide a better view of network use of system charges

Key:

- ● fully covered
- ◑ partially covered – foundations in place
- ○ not covered

1.2. Document purpose

The purpose of this document is to present the use cases that have been developed in order to trial how smart metering data in combination with other sources of smart monitoring and existing network data can be used to improve the planning and design of the distribution network. It is these Use Cases that will help to inform the functional specification of the new modelling tool developed to implement these improvements.

2. Scope

2.1. In Scope

- Network planning
- Network design

2.2. Out of Scope

- Network operations

3. Thermal constraints

3.1. Identify and mitigate thermal constraint risks – LV

Use Case ID	1.1	Version	1	Task effort	~ 1 day
Owner	Anuj Chhettri	Frequency	Annually		
Use Case Name	Identify and mitigate thermal constraint risks – LV				

Primary actor	Network planner
Goal	Avoid exceeding thermal ratings of assets
Scope	▪ In-scope - LV network - Thermal ratings - Network planning - Network modelling ▪ Out-of-scope: - Network operations - Voltage limits
Stakeholders and interests	▪ Customer – Reliability and availability of supply, safety ▪ HSE – ensuring ESQCR compliance ▪ Ofgem – Assessment of the Distribution Load Index ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ Smart meter data available ▪ Network model and model data available ▪ HV/LV substation maximum demand data available (sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ LV feeder way data if available from substation LV Monitoring
Post-conditions	▪ Presence of any thermal issues established and optimum mitigation solution identified and validated (as per the model) where appropriate
Triggers	▪ Risk identified from substation inspection – MDI reading ▪ Risk identified from substation LV Monitoring measurement alerts – where available ▪ Risk identified from Smart Meter Report from EIP e.g. clusters of under / over voltage alerts ▪ Risk identified from the OMS report which highlights the operational incidents such as cable faults or fuse blowing.

Main flow of events	1. Identify and rank the most highly loaded networks for further analysis 1.1. Query peak demand of all LV substations and LV feeders in the network being assessed 1.1.1. Check MDI readings of transformers during substation inspection recorded in eAM Spatial 1.1.2. Check the loading of the distribution substation and LV feeder ways from the substation monitoring device wherever installed 1.1.3. Check the calculated / estimated loading based on information from the modelled max demand 1.1.4. Run annual report on smart meter load data for LV feeders and LV networks (use appropriate assumptions for customers without smart meters). Consider alongside metric on smart meter uptake on specific LV feeder/network e.g. 20%, 50% etc 1.2. Trigger for initiating appropriate action based on the initial analysis in 1.1 exceeding the limits set out in IMP/001/011 (OHL), IMP/001/013 (Cables), or IMP/001/918 (Transformers) 2. Collate data on the thermally constrained parts of the LV network including: 2.1. For customer categorisation, collate location, type and capacity of LV connected demand low carbon technology i.e. heat pumps, electric vehicles, energy storage 2.2. Customer load profiles based on LV network smart meter data or analytics 2.3. Network voltage characteristics (source substation target voltage, smart meter readings, voltages from substation monitoring device where installed) 2.4. Network asset electrical parameters and connectivity from eAM Spatial data e.g. impedance, ratings, cable lengths and cross-sectional areas 2.5. Network configuration (link box configuration), customer phase connectivity if recorded (or estimated) 2.6. Location, type, capacity and export profile data if available of LV connected generation (Generators above 55kW rated capacity are recorded in PI, before November 2015 this was generators above 100kW rated capacity) 2.7. Any faults and locations from the OMS report 2.8. If highly loaded, deploy monitoring on secondary substation to collect further data (possibly) 3. Analyse thermally constrained parts of the LV network 3.1. If constraints are limited to a single or two LV feeders, model individual feeders in power flow model using approach from LV model methodology 3.2. Otherwise, model LV network in power flow model using approach from LV model methodology 3.3. Create and analyse seasonal load flow scenarios (including forecasts) that capture range of demand and generation load variation on the network including peaks 3.4. Validate modelling with network measurements where available 3.5. Also, assess network LV voltage to check if it is within statutory voltage limits 3.6. Confirm the violations and when they occur 4. Identify potential thermal constraint mitigation actions 4.1. These may include: 4.1.1. Change phase connection of single phase customer 4.1.2. Load shifting or curtailment (demand side response) 4.1.3. Transfer load to a new / different existing LV feeder or substation 4.1.4. Provide interconnection with adjacent network 4.1.5. Replace existing circuit with higher rating if overloaded or add new circuit to split a feeder 4.1.6. s

	4.1.7. If the constraint has been identified on single phase or two phase cable or OH line (open wire network) section then add standard three phase cable or aerial bundled conductor and retain existing circuits unless in poor condition 4.1.8. Replace transformer with a transformer of higher rating 4.1.9. Thermal monitoring (and cooling solution) of transformer to enable enhanced thermal rating 4.2. Shortlist the appropriate solutions depending on typical thermal capacity gained, cost, number of customers affected, anticipated CI/CML etc 5. Analyse thermally constrained parts of the LV network to test selected mitigation solutions 5.1. Model solutions in power flow model of LV network 5.2. Identify the most cost-effective solution(s) that reduces thermal constraints to acceptable level during all scenarios taking into account the factors set out in 4.2

Alternative flow of events	For those parts of the LV network where there is a constraint: >>Fuse operation either at substation or intermediate fuse section on LV feeder >> Persistent transient faults on network >> LV cable faults

Assumptions
• Smart meters are thought to have a meter voltage accuracy tolerance of +/- 2% in the readings i.e. 250V could be 245-255V on ground. Actual accuracies to be confirmed during implementation • Siemens EIP system operating with appropriate thresholds of voltage alerts and query systems implemented • Level of aggregation of smart consumption data does not limit its usefulness • LV Phase connectivity information is available • Details of customers such as point of connection, type and installed & contracted capacity of LV connected generation and low carbon demand are available and accurate

3.2. Identify and mitigate thermal constraint risks – HV/EHV

Use Case ID	1.2	Version	1	Task effort	~ 5 days
Owner	Anuj Chhettri	Frequency	Annually		
Use Case Name	Identify and mitigate thermal constraints risks – HV/EHV				

Primary actor	Network planner
Goal	Avoid exceeding thermal ratings of assets
Scope	▪ In-scope - Multi-voltage level network - Thermal ratings - Network planning - Network modelling ▪ Out-of-scope: - LV network - Network operations - Voltage limits
Stakeholders and interests	▪ Customer – Reliability and availability of supply, safety ▪ HSE – ensuring ESQCR compliance ▪ Ofgem – Assessment of the Distribution Load Index ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ Smart meter data available ▪ Network model and model data available ▪ HV/LV substation maximum demand data available (sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ HV & EHV circuit load information available from SCADA
Post-conditions	▪ Presence of any thermal issues established and optimum mitigation solution identified and validated (as per the model) where appropriate
Triggers	▪ Risk identified from SCADA alarms i.e. Primary and SP/GSP transformer and feeder loadings ▪ Risk identified from operational incidents ▪ Risk identified by Control Engineers, Network Designers and Network Planners during BAU activity

Main flow of events	1. Identify and rank the most highly loaded networks for further analysis 1.1. Query loading of the HV/EHV networks 1.1.1. Check SCADA readings over a one-year period for Primary and SP/GSP transformers and HV/EHV feeders 1.1.2. Evaluate “gross” transformer and feeder demand where generation is connected 1.1.3. Check loading for maximum demand / minimum generation and minimum demand / maximum generation under single circuit outage conditions 1.2. Trigger for initiating appropriate action based on the initial analysis in 1.1 exceeding the limits set out in IMP/001/011 (OHL), IMP/001/013 (Cables), or IMP/001/918 (Transformers) 2. Collate data on the thermally constrained parts of the HV/EHV networks including: 2.1. Obtain relevant HV/EHV network models for the analysis 2.1.1. Obtain existing HV/EHV network models and validate them 2.1.2. If the required HV/EHV network models do not exist, create them using network asset electrical parameters and connectivity from appropriate databases e.g. impedance, ratings, cable lengths and cross-sectional areas, reactive compensation equipment, based on multi-level model methodology, tap position for distribution transformers 2.1.3. Obtain the asset ratings from eAM Spatial or other sources e.g. where bespoke rather than generic ratings have been established 2.2. HV/EHV Network loading from SCADA and secondary substation loading based on smart meter data and/or substation monitoring devices wherever installed or modelled max demand 2.3. Network voltage characteristics (e.g. voltage set-points) 2.4. Network configuration (network open point configuration) 2.5. HV/EHV demand customer capacity and typical profile and location 2.6. HV/EHV generation customer capacity and typical profile and location 3. Analyse thermally constrained parts of the HV/EHV network 3.1. Define bounds of network area to be modelled 3.2. Define suitable interface conditions for adjacent networks 3.3. Create and analyse seasonal load flow scenarios (including forecasts) that capture range of demand and generation load variation and seasonal network asset capability on the network including peaks 3.4. Define appropriate contingency conditions 3.5. Undertake load flow analysis for each of the contingency conditions 3.6. Validate modelling with network measurements where available 3.7. Also, assess HV/EHV network voltage to check if it is within a) statutory voltage limits for directly connected customers and b) network design voltage limits for assessment of voltages connected to LV networks 4. Identify potential thermal constraint mitigation actions 4.1. These may include: 4.1.1. Change of phase connection / phase balancer for HV networks with single phase connections 4.1.2. Load shifting or curtailment (demand side response) 4.1.3. Transfer load to a new / different HV/EHV feeder or substation 4.1.4. Provide interconnection with adjacent network 4.1.5. Replace existing circuit with higher rating if overloaded or add new circuit 4.1.6. Replace Primary or SP/GSP transformer with transformer of higher rating

	4.1.7. Thermal monitoring (and cooling solution) of transformer or circuit to enable enhanced thermal rating 4.2. Shortlist the appropriate solutions depending on typical thermal capacity gained, cost, number of customers etc 5. Analyse thermally constrained parts of the HV/EHV network to test mitigation solutions 5.1. Model solutions in power flow model of HV/EHV network 5.2. Identify the most cost-effective solution(s) that reduces thermal constraints to acceptable level during all scenarios. Taking into account the factors set out in 4.2

Alternative flow of events	For those parts of the HV/EHV network where there is a constraint: >> Protection operation either at substation or along HV/EHV feeder >> Breaching of safety clearances for overhead lines >> Non-compliance with ESQCR >>Increased risk of load / heat related failures of cables, transformers and switchgear

Assumptions
• Profile of the secondary substation demand derived from smart meter data is representative • HV overhead lines phase connectivity information available

4. Voltage violations

4.1. Identify and mitigate voltage constraint risks – LV

Use Case ID	2.1	Version	1	Task effort	~ 1 day
Owner	Anuj Chhettri	Frequency	Annually		
Use Case Name	Identify and mitigate voltage violations risks – LV				

Primary actor	Network planner
Goal	Avoid voltage outside of statutory limits
Scope	▪ In-scope - LV network - Network planning - Network modelling ▪ Out-of-scope: - Network operations - Thermal limits
Stakeholders and interests	▪ Customer – Quality of supply ▪ Ofgem – Assessment of the quality of supply ▪ HSE and BEIS – ESQCR compliance ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ Substation LV Monitoring measurements – where available ▪ Smart meter data available ▪ Network model and model data available
Post-conditions	▪ Presence of any voltage issues established and optimum mitigation solution identified and validated (as per the model) where appropriate
Triggers	▪ Risk identified from Smart Meter Report from EIP e.g. clusters of under / over voltage alerts or voltage profile trends ▪ Risks identified from customer enquiries / complaints (LV)

Main flow of events	1. Identify and rank LV networks of concern and select the ones that require further analysis 1.1. Query the smart meter voltage alert counters and identify those Smart Meters with > [20] voltage alerts in the previous 12 months. Use the Connectivity Model to map these affected meters to an LV feeder. Meter accuracy to be considered when evaluating voltages. 1.2. Query the EIP Voltage Alert Log (Average RMS) and identify those Smart Meters with > [20] voltage alerts in the previous 12 months. Use the Connectivity Model to map these affected meters to an LV feeder. Accuracy to be considered when evaluating voltages. 1.3. Query the EIP Voltage Alert Log (Extreme) and identify those Smart Meters with > [10] voltage alerts in the previous 12 months. Use the Connectivity Model to map these affected meters to an LV feeder. Accuracy to be considered when evaluating voltages. 1.4. Query the smart meter / EIP system for the Voltage Profile and identify those smart meters with a significant trend in [increasing high voltages / reducing low voltages] over the last [3] years where the voltage may be approaching Statutory Voltage. Use the Connectivity Model to map these affected meters to an LV feeder. Accuracy to be considered when evaluating voltages. 1.5. Query the LV voltage complaints log for the previous 12 months. Use the Connectivity Model to map these affected customers to an LV feeder. Accuracy to be considered when evaluating voltages. 1.6. Combine all / some of the above queries to identify LV networks of concern. 1.7. Deploy additional network monitoring if required, to further characterise voltage conditions 1.8. Trigger appropriate action based on voltage exceeding statutory limits set out in IMP/001/909 and IMP/001/915 or at risk of exceeding statutory limits in the planning period 2. Collate data on the voltage constrained parts of the LV networks including: 2.1. For customer categorisation, collate location, type and capacity and export profile of LV connected generation – potentially HV generation as well if it exists in so far as it influences the LV voltage 2.2. For customer categorisation, collate location, type and capacity of LV connected demand low carbon technology i.e. heat pumps, electric vehicles, energy storage. 2.3. Customer load profiles based on LV network smart meter data analytics 2.4. Network voltage characteristics (source substation target voltage, smart meter readings, voltages from substation monitoring devices where installed) 2.5. HV/LV substation maximum demand data available (Sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) 2.6. Network asset electrical parameters and connectivity from eAM Spatial data e.g. impedance, ratings, cable lengths and cross-sectional areas, customer phase connectivity if recorded (or estimated) 2.7. Network configuration (link box configuration). 3. Analyse voltage constrained parts of the LV network 3.1. If constraints are limited to a single or two LV feeders, model individual feeders in power flow model using approach from LV model methodology. 3.2. If constraints are wider than the specific LV network being studied and extend to HV network, use the multi-level methodology 3.3. Otherwise, model LV network in power flow model using approach from LV model methodology. 3.4. Create and analyse seasonal load flow scenarios (including forecasts) that capture range of demand and generation load variation on the network including peaks. Extend the analysis to a voltage assessment. 3.5. Validate modelling with network measurement if deployed 3.6. Confirm the violations and when they occur / prospective violations and when they are likely to occur

	4. Identify potential voltage constraint mitigation actions 4.1. These may include: 4.1.1. Install LV capacitor 4.1.2. Change tap setting at the distribution substation 4.1.3. Change phase connection of single phase load 4.1.4. Change the target voltage of 20kV and 11kV primary substation 4.1.5. Use of in-line LV (or HV) voltage regulator (multi-voltage level network modelling required. 4.1.6. Installing HV to LV transformer (distribution transformer) with On Load tap changer (OLTC). 4.1.7. Provide interconnection with adjacent network 4.1.8. Load shifting or curtailment (demand side response) 4.1.9. Generation export management (curtailment) 4.1.10. Transfer load to a new / different existing LV feeder or substation 4.1.11. Reduce the impedance of LV feeder by replacing the existing mains for an appropriate length to address voltage issues 4.1.12. Reduce the impedance of transformer by replacing the existing transformer with lower impedance type 4.2. Shortlist the appropriate solutions depending on voltage profile (high/low voltage), typical voltage headroom / legroom gained, cost, likely number of customers affected etc 5. Analyse voltage constrained parts of the LV network to test selected mitigation solutions. 5.1. Model solutions in power flow model of LV network. 5.2. Identify the best solution(s) that maintains the voltage within the required thresholds during all scenarios and takes into account the factors set out in 4.2

Alternative flow of events	For those parts of the LV network where there is a constraint: >> Low and high voltage complaints, customer equipment damaged >> Embedded generation tripping off excessively >> Extensive smart meter voltage alerts (out of limit alert)

Assumptions
• Smart meters are thought to have a meter voltage accuracy tolerance of +/- 2% in the readings i.e. 250V could be 245-255V on ground. Actual accuracies to be confirmed during implementation • Siemens EIP system operating with appropriate thresholds of voltage alerts and query systems implemented • LV phase connectivity information available • Details of customers such as point of connection, type and installed & contracted capacity of LV connected generation and low carbon demand are available and accurate • Smart meter voltage alert threshold are set outside of Statutory Limits

4.2. Identify and mitigate voltage constraint risks – HV/EHV

Use Case ID	2.2	Version	1	Task effort	~ 5 days
Owner	Anuj Chhettri	Frequency	Annually		
Use Case Name	Identify and mitigate voltage violations risks – HV/EHV				

Primary actor	Network planner
Goal	Avoid voltage outside of statutory limits
Scope	▪ In-scope - HV/EHV network - Network planning - Network modelling ▪ Out-of-scope: - Real-time network operation - Thermal limits
Stakeholders and interests	▪ Customer – Quality of supply ▪ Ofgem – Assessment of the quality of supply ▪ HSE and BEIS – ESQCR compliance ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ HV & EHV circuit load information available from SCADA ▪ HV & EHV node voltage information available from SCADA ▪ Half-hourly Grid Supply Point, Supply Point and Primary substation SCADA measurements available ▪ Network data from substation monitoring equipment where available and voltage recorders (installed in response to HV customer enquiries) where available ▪ HV/LV substation maximum demand data available (Sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ Smart meter data available ▪ Network model and model data available
Post-conditions	▪ Presence of any voltage issues established and optimum mitigation solution identified and validated (as per the model) where appropriate
Triggers	▪ Risk identified from SCADA alarms – voltage measurements at primary substation or Supply Point / Grid Supply Point substations ▪ Risk identified from operations incidents ▪ Risk identified from Smart Meter Report from EIP e.g. clusters of under / over voltage alerts or voltage profile trends ▪ Risks identified from customer enquiries / complaints (EHV/HV/LV) ▪ Risk identified by Control Engineers, Network Designers and Network Planners during BAU activity

Main flow of events	1. Identify and rank HV/EHV networks of concern and select the ones that require further analysis 1.1. Query the SCADA alert log and identify those nodes on the HV/EHV network with > [100] voltage alerts in the previous 12 months 1.2. Query the SCADA /PI for the Voltage Profile and identify those nodes on the HV/EHV network with a significant trend in [increasing high voltages / reducing low voltages] over the last [3] years where the voltage may be approaching Statutory Voltage / Design Limits 1.3. Query the HV voltage complaints log for the previous 12 months. Use the Connectivity Model to map these affected customers to an LV feeder. Accuracy to be considered when evaluating voltages 1.4. Issues may also be raised for HV/EHV networks corresponding to LV networks analysed in Use Case 2.1 1.5. Combine all / some of the above queries to identify HV/EHV networks of concern 1.6. Trigger appropriate action based on voltage magnitude – see IMP/001/909 / IMP/001/915 2. Collate data on the voltage constrained parts of the HV/EHV networks including: 2.1. Obtain relevant HV/EHV network models for the analysis 2.1.1. Obtain existing HV/EHV network models and validate them 2.1.2. If the required HV/EHV network models do not exist (or are not updated), create (or update) them using network asset electrical parameters and connectivity from DINIS & IPSA e.g. impedance, ratings, cable lengths and cross-sectional areas, reactive compensation equipment, based on multi-level model methodology, tap position for distribution transformers 2.1.3. Obtain the asset ratings from eAM Spatial of other sources e.g. where bespoke rather than generic ratings have been established. 2.2. Network loading from SCADA and secondary substation loading based on smart meter data or substation monitoring devices where installed (or LV network models from Use Case 2.1 where relevant to voltage violation study) 2.3. Network voltage characteristics (source substation target voltage, voltages from substation monitoring device where installed) 2.4. Network configuration (normally open point configuration) 2.5. HV/EHV demand customer capacity and typical profile and location 2.6. HV/EHV generation customer capacity and typical profile and location 3. Analyse voltage constrained parts of the HV/EHV network 3.1. Define bounds of network area to be modelled 3.2. Define suitable interface conditions for adjacent networks 3.3. Create and analyse seasonal load flow scenarios (including forecasts) that capture range of demand and generation load and seasonal network asset capability and voltage variation on the network including peaks 3.4. Define appropriate contingency conditions 3.5. Undertake load flow and voltage analysis for each of the contingency conditions 3.6. Assess HV/EHV network voltage to check if it is within a) statutory voltage limits for directly connected customers and b) network design voltage limits for assessment of voltages connected to LV networks 3.7. Validate modelling with network measurements where available 3.8. Also, assess network thermal loading to check if it is within asset ratings 4. Identify potential voltage constraint mitigation actions 4.1. These may include: 4.1.1. Install HV/EHV reactive compensation equipment

	4.1.2. Change the target voltage of primary or SP substations 4.1.3. Change tap-changer bandwidth at the primary or SP substation 4.1.4. Apply Load Drop Compensation at the primary or SP substation 4.1.5. Use of in-line HV (EHV) voltage regulator 4.1.6. Provide interconnection with adjacent network 4.1.7. Apply Active Network Management of generation to manage real / reactive power export / import 4.1.8. Change the generators operational power factor (lead / lag) 4.1.9. Load shifting or curtailment (demand side response) 4.1.10. Transfer load to a new / different existing HV/EHV feeder or substation 4.1.11. Where the generator is exporting more than the contracted capacity, impose the contacted limits 4.1.12. Where the demand customer is importing more than the contracted capacity, impose the contacted limits 4.1.13. Reduce the impedance of HV/EHV feeder by replacing the existing circuits to address voltage issues 4.1.14. Reduce the impedance of transformer by replacing the existing transformer with lower impedance type 4.1.15. Replace the transformer with one with different nominal voltage or different tap range 4.2. Shortlist the appropriate solutions depending on voltage profile (high/low voltage), typical voltage headroom / legroom gained, cost, likely number of customers affected etc 5. Analyse voltage constrained parts of the HV/EHV network to test selected mitigation solutions 5.1. Model solutions in power flow model of HV/EHV network 5.2. Identify the best solution(s) that maintains the voltage within the required thresholds during all scenarios and takes into account the factors set out in 4.2

Alternative flow of events	For those parts of the HV/EHV network where there is a constraint: >> Low and high voltage complaints, customer equipment damaged >> Embedded generation tripping off excessively >> Extensive smart meter voltage alerts (out of limit alert)

Assumptions
• Suitable accuracy of SCADA voltage data • Details of location, type, capacity and import / export profile of HV/EHV connected generation and demand are available and sufficiently accurate. • Profile of secondary substation loading derived from smart meter data or from LV monitoring equipment is representative

5. New connections

5.1. New connection – Generation

Use Case ID	3.1.1	Version	1	Task effort	~1–2 days
Owner	Anuj Chhettri	Frequency	As required with new connection (Daily)		
Use Case Name	Assess impact of new connections – new generation connection on the network and the connection of new or additional generation to an existing connection (LV)				

Primary actor	Network designer
Goal	Ensure that thermal duty, voltages, fault levels and earth loop impedance remain within design limits for new or additional generation connection applications
Scope	▪ In-scope - LV/HV Network - Thermal ratings - Voltage requirements - Fault Level ratings - Network design - Network modelling ▪ Out-of-scope: - Protection requirements - The Main flow of events items 1, 6 & 7 are out of scope for the project as smart meter data and SCADA data does not provide benefits in these particular areas. However, they are included in the main flow of events to provide an overall context for the use case. Event 4 will be considered in the development of the modelling tool functional specification but not specifically analysed in the project as smart meter data and SCADA data do not provide direct benefits to fault level modelling.
Stakeholders and interests	▪ Generator customer – Reliability and availability of supply, safety. Provision of an economical and efficient connection ▪ Ofgem – customer receives a robust connection offer within the prescribed timescale ▪ HSE – ensuring ESQCR compliance ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ Smart meter data available ▪ Network model and model data available ▪ Existing generation data available from eAM Spatial and Heatmaps (or other sources as appropriate e.g. PI, Connection Agreement Library spread sheet) ▪ HV/LV substation maximum demand data available (Sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ Substation LV Monitoring measurements – where available ▪ Network data from substation monitoring equipment and voltage data recorders (installed in response to LV customer enquiries) where available
Post-conditions	▪ New connection assessment completed New connection design complies with NPg technical requirements
Triggers	▪ New connection application received for generation within the scope of EREC G59 (or G99) or Multiple G83 (or G98)

Main flow of events	1. Check that all the required data has been provided in the application 1.1. Check that the application is complete 2. Check that there is thermal capacity on the network 2.1. Determine the provisional Point of Connection (PoC). 2.2. Check the local substation for capacity 2.3. Refer to use case UC 1.1 – Identify and mitigate thermal violations 2.4. If the power flows exceed asset ratings with the proposed connection consider a revised PoC 3. Check that there is voltage capacity in the network 3.1. Refer to use case UC 2.1 – Identify and mitigate voltage violations 3.2. If voltages are outside limits consider a revised PoC 4. Check faults level with the model 4.1. Run a fault level evaluation 4.2. Check that the duty on network assets is less than their rating and that the requirements of the Fusing CoP IMP/00/921 and / or the Protection CoP IMP/001/014 are complied with 4.3. Check that that the earth loop impedance is within limits set out in IMP/001/911 5. Confirm the PoC 5.1. Select the optimum PoC and any associated remedial work from stages 2, 3 and 4 6. Assess cost of connections 6.1. Provide the list of equipment required 6.2. Evaluate cost of the equipment required 7. Make a Connection Offer

Alternative flow of events	Failure to comply with Distribution Licence obligations

Assumptions
• Smart meters are thought to have a meter voltage accuracy tolerance of +/- 2% in the readings i.e. 250V could be 245-255V on ground. Actual accuracies to be confirmed during implementation • Siemens EIP system operating with appropriate thresholds of voltage alerts and query systems implemented • Level of aggregation of smart consumption data does not limit its usefulness • LV Phase connectivity information is available • Details of customers such as point of connection, type and installed & contracted capacity of LV connected generation and low carbon demand are available and accurate

Use Case ID	3.1.2	Version	1	Task effort	~5-10 days
Owner	Anuj Chhettri	Frequency	As required with new connection		
Use Case Name	Assess impact of new connections – new generation connection on the network and the connection of new or additional generation to an existing connection (HV/EHV)				

Primary actor	Network designer
Goal	Ensure that thermal duty and voltages remain within design limits for new and additional generation connection.
Scope	▪ In-scope - HV/EHV Network - Thermal ratings - Voltage requirements - Fault Level ratings - Network planning - Network modelling ▪ Out-of-scope: - Protection Requirements - The Main flow of events items 1, 6 & 7 are out of scope for the project as smart meter data and SCADA data does not provide benefits in these particular areas. However, they are included in the main flow of events to provide an overall context for the use case. Event 4 will be considered in the development of the modelling tool functional specification but not specifically analysed in the project as smart meter data and SCADA data do not provide direct benefits to fault level modelling.
Stakeholders and interests	▪ Generator customer – Reliability and availability of supply, safety. Provision of an economical and efficient connection ▪ HSE – ensuring ESQCR compliance ▪ Ofgem – customer receives a robust connection offer within the prescribed timescale ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ Network model data available ▪ Existing generation data available from eAM Spatial and Heatmaps (or other sources as appropriate e.g. PI, Connection Agreement Library spread sheet) ▪ Half-hourly Grid Supply Point, Supply Point and Primary substation SCADA measurements available ▪ Smart meter data available
Post-conditions	▪ New connection assessment completed ▪ New connection design complies with NPg technical requirements
Triggers	▪ New connection application received

Main flow of events	1. Check that all the required data in the request has been provided in the application 1.1. Check that the letter of authority is valid 1.2. Check that the application is complete 1.2.1. Check the proposed generation customer is export or non-export type. 1.2.2. Check if the proposed generation customer is to be connected on a network substation or not. 1.2.3. Check if the customer has asked for a firm or a non-firm connection. Check that the import & export requirements have been stated under firm / non-firm conditions as appropriate 2. Check that there is thermal capacity on the network 2.1. Determine the provisional Point of Connection (PoC). 2.2. Check the capacity of the Primary Substation and the Supply Point / Grid Supply Point 2.3. Check if the new load or increased generation is likely to exceed the thermal rating of the HV/EHV circuit under N and N-1 requirements as appropriate 2.4. Refer to use case UC 1.2 – Identify and mitigate thermal violations 2.5. If the power flows exceed asset ratings with the proposed connection consider a revised PoC 3. Check that there is voltage capacity in the network 3.1. Refer to use case UC 2.2 – Identify and mitigate voltage violations 3.2. Check voltage step change complies with Engineering Recommendation P28 3.3. If voltages are outside limits consider a revised PoC 4. Check faults level with the model 4.1. Run a fault level evaluation 4.2. Check that the proposed fault level duty on network assets is less than their capability 5. Confirm the PoC 5.1. Select the optimum PoC and any associated remedial work from events 2, 3 and 4 6. Assess cost of connections 6.1. Provide the list of equipment required 6.2. Evaluate cost of the equipment required 6.3. Calculate apportionment of cost to the customer 7. Make a Connection Offer

Alternative flow of events	Failure to comply with Distribution Licence obligations

Assumptions
• Details of customer such as proposed point of connection, type and installed & contracted capacity of HV/EHV connected generation are available and accurate.

5.2 New connection – Demand load

Use Case ID	3.2.1	Version	1	Task effort	~1-2 days
Owner	Anuj Chhettri	Frequency	As required with new connection		
Use Case Name	Assess impact of new connections –new load (demand) connection to the network and additional load (demand) to an existing connection (LV)				

Primary actor	Network designer
Goal	Ensure that thermal duty, voltages, fault level and earth loop impedance remain within design limits for new and additional demand connection requests.
Scope	▪ In-scope - LV/HV Network - Thermal ratings - Voltage requirements - Earth Loop Impedance - Fault Level ratings - Network design - Network Modelling ▪ Out-of-scope: - Protection Requirements - The Main flow of events items 1, 6 & 7 are out of scope for the project as smart meter data and SCADA data does not provide benefits in these particular areas. However, they are included in the main flow of events to provide an overall context for the use case. Events 4 and 5 will be considered in the development of the modelling tool functional specification but not specifically analysed in the project as smart meter data and SCADA data do not provide direct benefits to earth loop impedance / fault level modelling.
Stakeholders and interests	▪ Demand load customer – Reliability and availability of supply, safety. Provision of an economical and efficient connection ▪ HSE – ensuring ESQCR compliance ▪ Ofgem – customer receives a robust connection offer within the prescribed timescale ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ Smart meter data available ▪ Network model and model data available ▪ Existing generation data available from eAM Spatial and Heatmaps (or other sources as appropriate e.g. PI, Connection Agreement Library spread sheet) ▪ HV/LV substation maximum demand data available (Sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ Substation LV Monitoring measurements – where available
Post-conditions	▪ New connection / additional demand assessment completed ▪ New connection design complies with NPg technical requirements ▪ Design completed ready to be incorporated in a Connection Offer
Triggers	▪ New demand / additional demand connection application received

Main flow of events	1. Check that all the required data in the request has been provided in the application 1.1. Check that the application form is complete. 1.2. If the customer request is greater than 60kVA, check that there is a valid letter of authority 2. Check that there is thermal capacity on the network 2.1. Check the existing customer supply if applicable, the local substation and local LV feeder for capacity to make an informed view of the provisional PoC 2.2. Determine the provisional PoC 2.3. Refer to use case UC 1.1 – Identify and mitigate any thermal violation 2.4. If the power flows exceed asset ratings with the proposed connection consider a revised PoC 3. Check that there is voltage capacity in the network 3.1. Refer to use case UC 2.1 – Identify and mitigate voltage violations 3.2. If voltages are outside limits consider a revised PoC 4. Check the Earth Loop Impedance is within design limits 4.1. Refer to UC2.1 and use the model to establish the Earth Loop Impedance 4.2. Consider a revised PoC or remedial work if the Earth Loop Impedance is outside the design limits with the proposed PoC 5. Check faults level with the model 5.1. Run a fault level evaluation 5.2. Check that the duty on network assets is less than their rating and that the requirements of the Fusing CoP IMP/001/921 and / or the Protection CoP IMP/001/014 are complied with 5.3. Check that the earth loop impedance is within limits set out in IMP/ 001/911 6. Confirm the PoC 6.1. Select the optimum PoC and any associated remedial work from events 2, 3, 4 and 5 7. Assess cost of connections 7.1. Provide the list of equipment required 7.2. Evaluate cost of the equipment required 8. Make a Connection Offer

Alternative flow of events	Failure to comply with Distribution Licence obligations

Assumptions
• Smart meters are thought to have a meter voltage accuracy tolerance of +/- 2% in the readings i.e. 250V could be 245-255V on ground. Actual accuracies to be confirmed during implementation • Siemens EIP system operating with appropriate thresholds of voltage alerts and query systems implemented • Level of aggregation of smart consumption data does not limit its usefulness • LV Phase connectivity information is available • Details of customers such as point of connection, type and installed & contracted capacity of LV connected generation and low carbon demand are available and accurate

Use Case ID	3.2.2	Version	1	Task effort	~5-10 days
Owner	Anuj Chhettri	Frequency	As required with new connection		
Use Case Name	Assess impact of new connections –new load (demand) connection to the network and additional load (demand) to an existing connection (HV/EHV)				
Primary actor	Network designer (or operator)				
Goal	Ensure that thermal duty, voltages and fault level remain within design limits for new and additional demand connection requests.				
Scope	▪ In-scope - HV/EHV Network - Thermal ratings - Voltage requirements - Fault Level ratings - Network design - Network modelling ▪ Out-of-scope: - LV network - Protection Requirements - Real-time network operations - The Main flow of events items 1, 6 & 7 are out of scope for the project as smart meter data and SCADA data does not provide benefits in these particular areas. However, they are included in the main flow of events to provide an overall context for the use case. Event 4 will be considered in the development of the modelling tool functional specification but not specifically analysed in the project as smart meter data and SCADA data do not provide direct benefits to fault level modelling.				
Stakeholders and interests	▪ Demand load customer – Reliability and availability of supply, safety. Provision of an economical and efficient connection ▪ HSE – ensuring ESQCR compliance ▪ Ofgem – customer receives a robust connection offer within the prescribed timescale ▪ Network planning team – visibility on the network				
Pre-conditions	▪ Network model and model data available ▪ Existing generation data available from eAM Spatial and Heatmap (or other sources as appropriate e.g. PI, Connection Agreement Library spread sheet) ▪ Half-hourly Grid Supply Point, Supply Point and Primary substation SCADA measurements available ▪ HV/LV substation maximum demand data available (Sources include MDI data, LV substation monitoring equipment, modelled max demand etc.)				
Post-conditions	▪ New connection / additional demand assessment completed ▪ New connection design complies with NPg technical requirements ▪ Design completed ready to be incorporated in a Connection Offer				
Triggers	▪ New demand / additional demand connection application received				

Main flow of events	1. Check that all the required data in the request has been provided in the application 1.1. Check that the letter of authority is valid 1.2. Check that the application form is complete 2. Check that there is thermal capacity on the network 2.1. Check the existing customer supply if applicable 2.2. Check the firm capacity of the Primary Substation and the Supply Point 2.3. Check if the new load or increased demand is likely to exceed the thermal rating of the HV/EHV circuit under N and N-1 requirements as appropriate 2.4. Determine the provisional Point of Connection (PoC) for new load based on above. Depending upon the load the PoC may need to be revised/ altered 2.5. Refer to use case UC 1.2 – Identify and mitigate thermal violations 2.6. Check if the proposed connection complies with Engineering Recommendation P2/6 3. Check that there is voltage capacity in the network 3.1. Refer to use case UC 2.2 – Identify and mitigate voltage violations 3.2. Check that the proposed PoC complies with both N and N-1 requirements condition for voltage 3.3. Check voltage step change complies with Engineering Recommendation P28 for both planned and unplanned outages 3.4. Also consider a revised PoC if the voltage is outside the limits with the proposed PoC 4. Check faults level with the model 4.1. Check if the proposed load consists of large motoring loads or the small induction motor contribution to fault level may be material and if yes model the load for fault infeed 4.2. Run a fault level evaluation 4.3. Check that the duty on network assets is less than their rating 4.4. Also consider a revised PoC as a potential fault level violation solution if the fault level is outside the limits with the proposed PoC 5. Confirm the PoC 5.1. Select the optimum PoC and any associated remedial work from events 2, 3, 4 and 5 6. Assess cost of connections 6.1. Provide the list of equipment required 6.2. Evaluate cost of the equipment required 7. Make a Connection Offer

Alternative flow of events	Failure to comply with Distribution Licence obligations

Assumptions
• Details of customer such as proposed point of connection, contracted capacity and typical load profiles of HV/EHV connected demand are available and accurate.

6. Model maintenance

Use Case ID	4	Version	1	Task effort	tbd
Owner	Anuj Chhettri	Frequency	Ongoing		
Use Case Name	Maintain the network model				

Primary actor	Network planner/designer
Goal	Ensure that the model parameters and assumptions are up to date if an existing model is used in Use Cases 1.x, 2.x and 3.x
Scope	▪ In-scope - LV/HV/EHV Network - Network Model ▪ Out-of-scope: - Network planning - Network operations
Stakeholders and interests	▪ Generator/Demand customer – Reliability and availability of supply, safety. Provision of an economical and efficient connection offers ▪ HSE – ensuring ESQCR compliance ▪ Ofgem – Assessment of the Distribution Load Index and assessment of the quality of supply, provision of an economical and efficient connection offers. ▪ Customer - Reliability and availability of supply, safety. Quality of supply ▪ NPg System Design and System Strategy teams
Pre-conditions	▪ Smart meter data available ▪ Network model data available ▪ Existing generation data available from eAM Spatial and Heatmaps (or other sources as appropriate e.g. PI, Connection Agreement Library spread sheet). ▪ Maximum demand data available (Sources included MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ Substation LV monitoring measurements - where available ▪ Low carbon technology demand data ▪ Half-hourly Grid Supply Point, Supply Point and Primary substation SCADA measurements available ▪ HV & EHV circuit load information available from SCADA ▪ HV & EHV node voltage information available from SCADA ▪ Network data from substation monitoring equipment where available and voltage recorders (installed in response to HV or LV customer enquiries) where available
Post-conditions	▪ Key parameters and assumptions updated
Triggers	▪ As required for Network Planning – e.g. new connection & network reinforcement, identification of thermal and voltage issues

Main flow of events	1. Check for any changes to network assets or topology 1.1. Check for any network reinforcements 1.2. Check for updates to customer phase connectivity 1.3. Check for any changes to thermal ratings – e.g. dynamics thermal ratings 1.4. Check for any additional reactive power compensation equipment 1.5. Check for any temporary change in network configuration or and (temporary) load shifting to identify non-normal demands 1.6. Check for any permanent change in network configuration 1.7. Check for any new protection equipment related to network reconfiguration 1.8. Check for any changes in the network voltage characteristics – transformer or regulator target voltage 2. Check for any changes to network connections 2.1. Check for new generations and demand connections / additional demand or generation on existing connections 2.2. Check for customer disconnection schemes 2.3. Check for any new or modifications to an existing Active Network Management scheme 3. For those parameters that have changed as identified in 1 and 2 above obtain the latest data 3.1. Obtain the latest network asset, topology and connection information 3.2. Obtain the latest demand / generation data 3.3. Obtain the latest voltage data 3.4. Get the latest loading data e.g. customer loads (including forecasts), ANM scheme constraint rules, DSR constraint rules 4. Update the model with the latest data 4.1. Upload data 4.2. Input parameters 5. Validate the updated multi-level model 5.1. Run the model for representative validation profiles 5.2. Compare the modelling results with appropriate measurements to validate 6. Validate the updated LV model 6.1. Run the model for representative validation profiles 6.2. Compare the modelling results with appropriate measurements to validate

Alternative flow of events	Network designs and plans are invalid if the model is materially out of date.

Assumptions
• Data available

7. Alternative supply arrangements

Use Case ID	5	Version	1	Task effort	~ 1 day
Owner	Anuj Chhettri	Frequency	As required		
Use Case Name	Plan and manage temporary alternative supply arrangements - LV				

Primary actor	Network designer (or operator)
Goal	Ensure that the network remains within voltage and thermal limits with an alternative supply arrangement
Scope	▪ In-scope - LV Network - Network planning - Network operations ▪ Out-of-scope: - HV/EHV Network
Stakeholders and interests	▪ Network designers – understanding power flow and voltage with the alternative supply arrangement
Pre-conditions	▪ Smart meter data available ▪ Network model data available ▪ Existing generation data available from eAM Spatial and Heatmaps (or other sources as appropriate e.g. PI, Connection Agreement Library spread sheet) ▪ HV/LV substation maximum demand data available (Sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ Timing and duration of the planned outage is known
Post-conditions	▪ Confirmation that the alternative supply arrangement is appropriate
Triggers	▪ Planned maintenance or construction outage on the LV network

Main flow of events	1. Obtain data related to the network area where the outage is planned to take place or where there is a need to assess the security of supply (in addition to the requirements of Use Case 1-1 / 2-1) 1.1. LV network models 1.2. Network substation monitoring measurements for a similar time period representative of the network behaviour 1.3. Customer Smart Meter data 1.4. HV/LV substation maximum demand data available (sources include MDI data, LV substation monitoring equipment, modelled max demand etc.) 1.5. Check for any local network automation scheme (HV/LV). 1.6. Check existing back-feed arrangements. 2. Identify alternative supply arrangements that require to be analysed 2.1. Decide on the proportion of customer demand to be maintained whilst the network is configured in the alternative arrangement (typically 100%) 2.2. Identify potential specific alternative supply arrangements 2.3. Check if the LV feeders are interconnected (e.g. via link box) between two substations or on the same substation 2.4. Check if the LV network between two substations can be paralleled 2.5. Check voltage control arrangements for any potential conflicts 3. Analyse the network model under alternative supply arrangement 3.1. Check for thermal or voltage violations during specific time periods – see use cases 1.1 and 2.1 respectively 3.2. Check the loading of the original substation and alternative substations (may be more than one). In some cases, load may need to be transferred to more than one alternative substation. 3.3. Check the loading of the original and alternative LV feeder to back feed reflective of the total load that needs to be picked up. 3.4. Check for potential conflicts with any local automation scheme 3.5. Check potential impact on customer supply interruption and minutes lost 3.6. Check dependency on network reliability 4. Assess feasibility of alternative supply arrangement 4.1. If there are no violations or conflicts 4.1.1. Approve the arrangement 4.1.2. If the network is running close to voltage or thermal limits under the alternative supply arrangement then take an action to monitor the network more closely during the outage 4.2. If there are violations or conflicts, assess criticality of arrangement 4.2.1. If critical, then explore reinforcement solutions. 4.2.2. If non-critical, then explore other alternative supply arrangement 4.2.3. If the alternative feeders/substations cannot pick up the entire load of the substation then temporary substation or generation may be required
Alternative flow of events	Customer supplies interrupted during the outage

Assumptions
• Smart meters are thought to have a meter voltage accuracy tolerance of +/- 2% in the readings i.e. 250V could be 245-255V on ground. Actual accuracies to be confirmed during implementation • Siemens EIP system operating with appropriate thresholds of voltage alerts and query systems implemented • Level of aggregation of smart consumption data does not limit its usefulness • LV Phase connectivity information is available • Details of customers such as point of connection, type and installed & contracted capacity of LV connected generation and low carbon demand are available and accurate • Smart meter voltage alert threshold are set outside of Statutory Limits • Reliability study is out-of-scope of the use case • Assessment of a local automation scheme is out-of-scope of the use case • Network measurements are available from LV monitoring at HV/LV substations)

8. Strategic Network Modelling Analysis

Use Case ID	6	Version	1	Task effort	~ 3 months
Owner	Anuj Chhettri	Frequency	3-5 years		
Use Case Name	Perform Strategic Network Modelling Analysis				

Primary actor	Network planner
Goal	Define the long-term investment requirement for NPg licence areas
Scope	▪ In-scope - LV/HV/EHV Network - Strategic network development ▪ Out-of-scope: - Network operations - Network design - Financial analysis - Scenario development - Fault level and harmonics
Stakeholders and interests	▪ Ofgem – price control ▪ Business planning and operation – visibility on the strategy and its implication to the wider business ▪ System Strategic Design or System Planning department ▪ Customers – future network reliability and security, interaction with the DSO network, expected changes in the infrastructure
Pre-conditions	▪ There are sufficient representative network models that can be used to reasonably reflect all NPg circuits (The number needs to be sufficiently low to be manageable and sufficiently large to reasonably represent each sub network / circuit groups. ▪ Strategic Planning Scenario developed ▪ Smart meter data available ▪ Network model data available ▪ Existing generation data available from eAM Spatial and Heatmaps (or other sources as appropriate e.g. PI, Connection Agreement Library spread sheet). ▪ Maximum demand data available (Sources included MDI data, LV substation monitoring equipment, modelled max demand etc.) ▪ Substation LV monitoring measurements - where available ▪ Low carbon technology demand data ▪ Half-hourly Grid Supply Point, Supply Point and Primary substation SCADA measurements available ▪ HV & EHV circuit load information available from SCADA ▪ HV & EHV node voltage information available from SCADA ▪ Network data from substation monitoring equipment where available and voltage recorders (installed in response to HV or LV customer enquiries) where available
Post-conditions	▪ Long term load related investment scenarios assessed ▪ Development plan for an area that can be implemented
Triggers	▪ Upcoming price control review ▪ Business Plan review ▪ Significant change in the assumptions related to the future load scenarios ▪ Initiation of development plan for an area

Main flow of events	1. Select the representative multi-level models 1.1. Define criteria for the selection of the most appropriate representative network models to apply 1.2. Apply criteria to suitable representative network models and select best candidates 2. Initialise and validate the model 2.1. Refer to Use Cases 1.1, 1.2, 2.1 and 2.2 as appropriate to ensure that the selected models are populated with the correct data and are validated against network measurements to represent the baseline for the scenarios 3. Define and validate the modelling scope 3.1. Obtain scenario data for the timeframe under consideration e.g. forecasts for EVs, heat pumps, embedded generation, underlying demand 3.2. Obtain the technical data required to incorporate the scenarios into the network models e.g. range / typical sizes for heat pumps, the type of housing stock where they would be installed 3.3. Check that the key scenario assumptions are appropriate over this timeframe and associated uncertainty 3.3.1. Include both technical and financial assumptions 3.4. Scale scenarios down to individual representative network level 3.5. Define and validate scope of probabilistic analysis and/or sensitivity analysis to assess future uncertainty 4. Develop network strategy plan based on modelling scope in 3. 4.1. Check for thermal or voltage violations – see use cases 1.1, 1.2, 2.1 and 2.2 respectively 4.2. Check fault level and power quality implications 4.3. Propose and recommend solutions to thermal, voltage, fault level and power quality violations based on technical and cost criteria 4.3.1. May include range and sequence of application of solutions available in the future (from a DSO transition for example) as well as existing conventional and smart solutions 4.3.2. Include assessment of required network enablers e.g. communications, advanced control systems, monitoring etc. 4.4. Model financial impact of implementation of network solutions across scenario timeframe 4.5. Determine investment requirements for representative models for each scenario (capex, opex) 4.6. Scale up investment requirements to NPg licence area by relating the selected representative networks to the entirety of NPg network.

Alternative flow of events	None

Assumptions
• The range representative models available are sufficiently representative of the entire network, so that they can be scaled up. The representative network models are not an exhaustive representation of the network

Appendix A - Northern Powergrid Use Cases Long List

Table A-1 is the long list of use cases developed internally by NPg, these are consolidated and reflected in the 'high priority' use cases where appropriate.

No.	Use Case Name
1.01	Assess Network Performance
	Identify parts of the network operating close to thermal limits
	Identify parts of the network operating close to voltage limits (profile data)
	Identify parts of the network operating close to voltage limits (alert data)
	Identify parts of the network where customers are receiving supplies outside statutory limits
	Calculate LIs for distribution transformers
	Identify P2 non-compliances (bulk LV >1MW)
	Identify P2 non-compliances (HV)
	Develop load 'heat map'
	Develop generation / export 'heat map'
	Assess network losses and verify improvements arising from improved network design and operation (ED1 output measures)
	Assess if a customer exceeds the capacity of his connection e.g. requires a 3 phase rather than single phase supply
	Analyse power outage information to assess long term network performance trends
1.02	Determine network impact of proposed new demand / generation connection
	Model new demand connection
	Model new generation connection
	Model new demand & generation connection
1.03	Determine network impact of proposed increase in demand / generation at an existing connection
	Model increase in demand
	Model increase in generation
	Model increase in demand and generation
1.04	Monitor demand and generation profiles for network load forecasting
	Model change in demand profile
	Model change in generation profile

	Model net change in power flow
1.05	Determine latent demand due to embedded generation
	Determine latent demand due to embedded generation
1.06	Identify voltage quality issues
	Identify parts of the network experiencing excessive voltage sag / swell (Power Quality) issues
1.07	Collect data for Active Network Management (future)
1.08	Active Management of Network Voltage (future)
1.09	Active Management of Network Power Flows (future)
	Optimise Off-peak load switching times (RTS replacement and mechanical / electronic time switching) by proposing / agreeing times with suppliers
1.1	DSO System Balancing (future)
1.11	Check effectiveness of ANM / System Balancing (future)
1.12	Notify Customers of Planned Outage (future)
	Use Case related to sending planned outage & other customer service messages to customers. Unlikely to be available to DNOs
1.13	Check meter energisation status
	Check the status of the Load Switch in a single SM
	Check the status of the Load Switch on multiple SM on a feeder / geographic area
	Check for planned / unplanned outages in the CSP / DSP system
	Implement modified processes for Use Cases 01.14, 01.15 and 01.16 to cater for CSP / DSP outages
1.14	Receive Last Gasp (and First Breath) alert
	Map single LG alert to TMS
	Map single LG alert to planned single customer outage work (e.g. meter changer & electrician disconnection)
	Map multiple LG alerts to TMS and OMS (taking into account issues associated with concurrent and incomplete smart meter data.)
	Map multiple LG alerts to planned HV and LV outages
	Map multiple LG alerts to planned and fault related HV and LV switching
	Use LG alerts & Customer Calls to establish the most likely fault type / location and dispatch appropriate crew
	Proactively analyse outage start times for seemingly related faults to identify hidden / nested faults (e.g. LV fault occurring just before an upstream HV fault
	Use LG & FB alerts, Customer Calls and reports from a) Restoration Teams in fault scenarios and b) Field Staff in planned scenarios to verify / update LV network connectivity model and in particular phase connectivity. (currently carried out manually)

	Map multiple LG alerts to planned and unplanned outages on the CSP communications service provider network (review based on CSP failure mechanisms)
	Manage scenario when volume of LG and FB alerts overwhelms TMN / OMS systems
1.15	Verify restoration post outage (Receive First Breath alert)
	Match Supply Verification reports with NMS restoration actions (faults)
	Match Supply Verification reports with Restoration Team on-site actions (faults)
	Match Supply Verification reports with planned single customer outage work (e.g. meter changer & electrician disconnection)
	Map multiple LG alerts to planned and fault related HV and LV switching
	Confirm all customer supplies restore following all planned and unplanned outages
	Identify any customers who's supply has not been restored
1.16	Regulatory Outage Reporting
	Use Supply Verification reports to identify all outages including SDIs (differentiate between outage time included in alert and message received time as the latter provides the clock start for RIG reporting)
	Use Supply Verification reports to compile CI / CML data
	Reconcile LG reports to Supply Verification reports
1.17	Restore and maintain supply during outage
	Use Case related to switching customer load on /off to maximise the number of customers that could be supplied via a depleted post fault network. Functionality now unavailable to DNOs.
	Use Case related to load limiting customer load to maximise the number of customers that could be supplied via a depleted post fault network. Functionality now unavailable to DNOs.
	Monitor load on LV network when supplied via alternative feeder
	Monitor load on HV network when supplied via alternative feeder (enhanced understanding load along HV feeder)
	Integration with HV network automation (enhanced understanding load along HV feeder)
	Monitor customer voltages on LV network when supplied via alternative LV and HV feeding arrangements
	Manage restoration of customer supplies using network modelling (inc. state estimation) and LV automation of LV fuseboards and link boxes
1.18	Manage meter safety alarm
	Respond to Anti Tamper alert (availability / requirement for alert TBC)
	Manage extreme voltage at meter
	Establish and set extreme voltage alerts at appropriate thresholds
	Respond to extreme high voltage alert
	Respond to extreme low voltage alert

	Confirm voltages are restored with acceptable range on completion of remedial action
1.2	Configure Smart Meter system
	Establish alert thresholds (potentially separate Use Case for each threshold). Process for agreeing thresholds to be agreed.
	Establish response to events e.g. alert / log only (potentially separate Use Case for each event). Process for agreeing behaviours to be agreed.
	Establish and download standard/generic Smart Meter configuration data set on enrolment
	Ad-hoc download of Smart Meter configuration when a Smart Meter is replaced
1.21	Manage Asset Management Data Model
	Manage (Review and update) Network LV Connectivity Model (Linkage to GIS / eAM Spatial) following a Continual Learning approach from all planned and unplanned smart meter operations.
	Establish / manage phase connectivity (Linkage to GIS?) following a Continual Learning approach from all planned and unplanned smart meter operations.
	Populate LV model with actual / estimated / assumed data
	Populate HV model with actual / estimated / assumed data (aggregation of LV data)
	Update LV model with new connected demand customers
	Update LV model with new connected generation customers
	Develop / Update generic load profiles for customer types
	Develop / Update generic generation profiles for customer types
1.22	Manage Smart Meter system
	Manage security keys
	Manage data upload schedules
	Manage (set / read) Smart Meter configurations
	Manage interfaces between the Smart Meter systems and other relevant DNO systems and processes (TBC)
1.23	'Additional' Customer Service benefits
	Monitor vulnerable customer demand for abnormal activity
	Facilitating customer service / social responsibility initiatives (Placeholder)
	Manage an integrated system using customer calls and smart meter LG data to trigger IVR messaging