INVERNESS AND AVIEMORE: STRATEGIC DEVELOPMENT PLAN

Our network serving communities across the Inverness and Aviemore area.

Draft for consultation

October 2025

Scottish & Southern Electricity Networks

CONTENTS

1. EXECUTIVE SUMMARY

SSEN is taking a strategic approach in the development of its distribution networks. This will help to enable the net zero transition at a local level to the homes, businesses, and communities we serve. Our Strategic Development Plans (SDPs) take the feedback we have received from stakeholders on their future energy needs from today out to 2050 and translate these requirements into strategic spatial plans of distribution network needs. This helps us transparently present our future conceptual plans and facilitate discussion with local authorities and other stakeholders. The overall methodology and how it fits into our wider strategic planning process is presented in the Strategic Development Plan methodology. The focus area of this SDP is the area that is supplied by the Boat of Garten, Inverness, and Nairn Grid Supply Points (GSPs), shown below in Figure 1.

This report documents the stakeholder led plans that are driving net zero and growth in the local area, the resulting electricity demands, and the network needs arising from this. Plans across Highlands, Moray, Perth and Kinross, and Aberdeenshire councils have been considered in preparation for this plan. A significant amount of work has been triggered in this area through the Distribution Network Options Assessment (DNOA) process.

This SDP utilises the Distribution Future Energy Scenarios (DFES) to understand the pathways to a 2050 network that can support net zero and growth in the local economy. Recommendations from this report outline the initial steps that we believe should be taken on that pathway to develop the network in an efficient and stakeholder-led way.

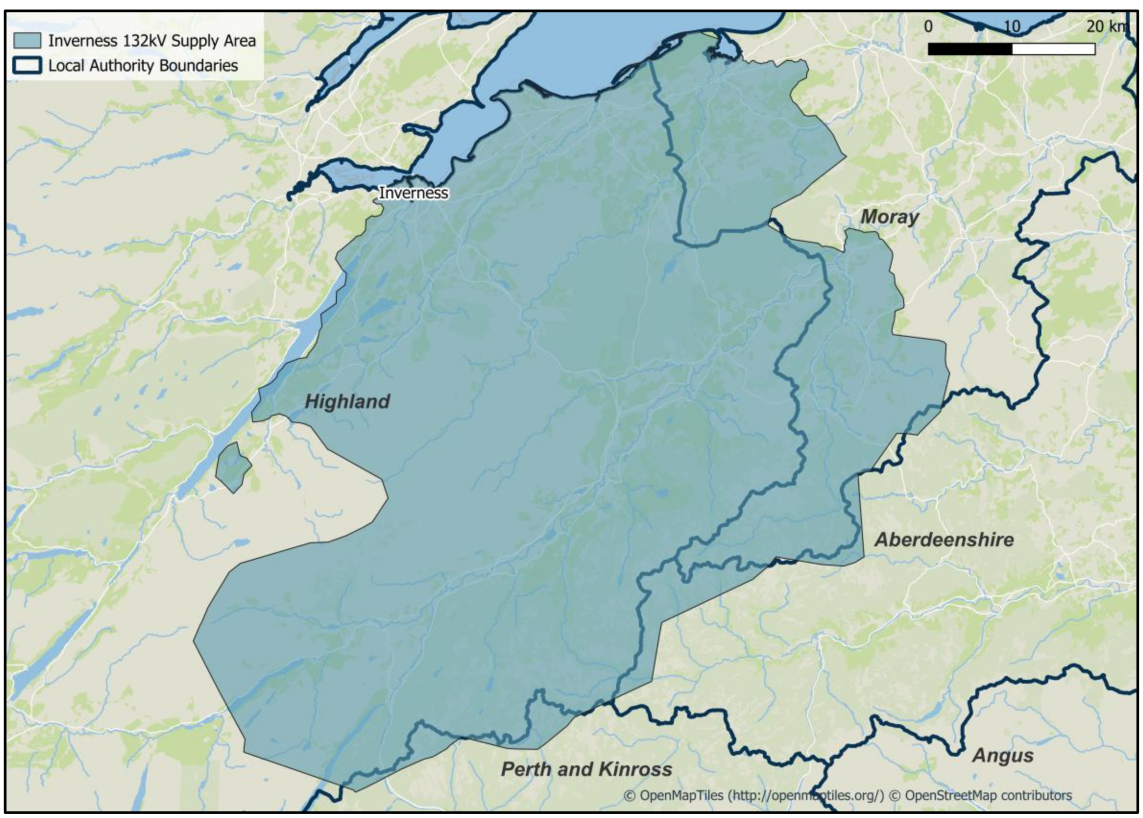

Figure 1 - Area of focus for this SDP.

2. INTRODUCTION

The aim of this report is to demonstrate how local, regional, and national targets align with stakeholder ambitions in the area to provide a robust evidence base for load growth out to 2050 across the area served by the Boat of Garten, Inverness, and Nairn Grid Supply Points (GSPs). A GSP is an interface point with the national transmission system where SSEN Distribution then takes power to local homes and businesses within a geographic area. Context for the area this represents is shown above in Figure 1.

To identify the future requirements of the electricity network, SSEN commissions Regen to produce the annual Distribution Future Energy Scenarios (DFES). The DFES analysis is based on the National Energy System Operator (NESO) Future Energy Scenarios (FES), while incorporating more granular stakeholder insights from agencies such as local authorities and new demand and generation connection applications. The DFES provides a forward-looking view of how demand and generation may evolve under different scenarios as we move towards the national 2050 net zero target. These scenarios are summarised in Figure 2. SSEN uses Holistic Transition as the central case scenario, reviewing this position annually. Any more recent unforeseen demand changes, for example customer connection requests, are also considered in our forecasts to ensure that the projected load more accurately reflects what we expect to see in the future.

Further information on the FES framework can be found in the DFES 2024 introductory report.

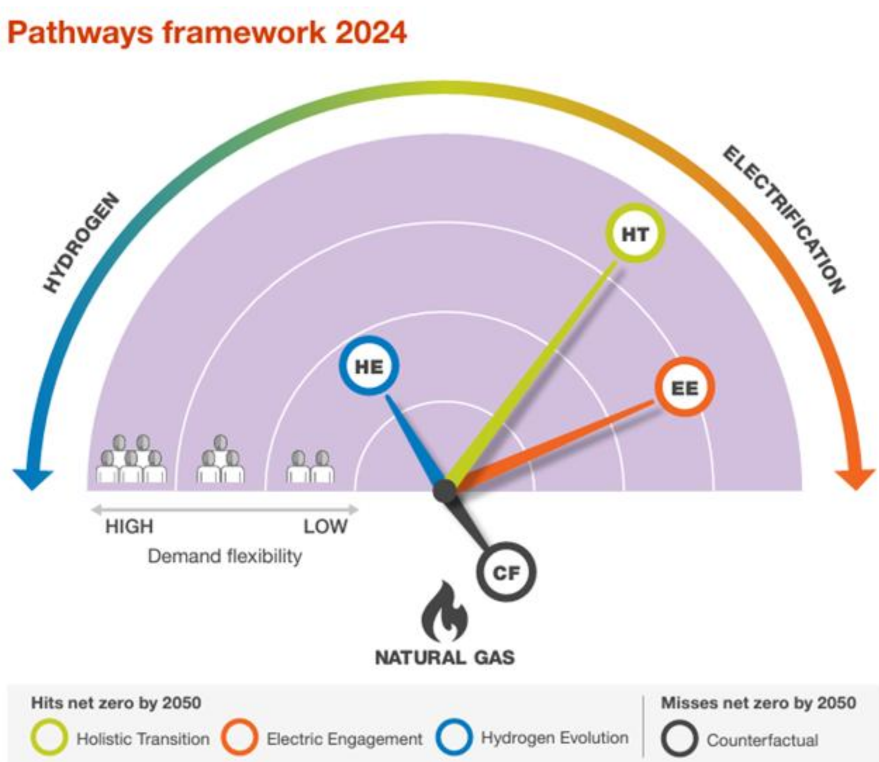

Figure 2 The FES Scenario framework (source: NESO)

Using the DFES, power system analysis has been carried out to identify the future system needs of the electricity network. These needs are summarised by highlighting the year the need is identified under each of the scenarios, and the projected 2050 load. System needs are identified through power system analysis. We also model across the other scenarios to understand when these needs arise and what network capacity should be planned for in the event each scenario is realised.

The DNOA process will provide more detailed optioneering for each of these system needs, improving stakeholder visibility of the strategic planning process. Opportunities for the procurement of flexibility are also highlighted in the DNOA to cultivate the flexibility markets.

3. STAKEHOLDER ENGAGEMENT AND WHOLE SYSTEM CONSIDERATIONS

3.1. Local Authorities and Local Area Energy Planning

The local authorities that are supplied by the Inverness and Aviemore 132kV Supply Area includes Highland, Moray, Aberdeenshire, and Perth and Kinross councils as shown in Figure 3. The development plans for these local authorities will have a significant impact on the potential future electricity load growth on SSEN's distribution network. As such, it is vital for SSEN to engage with these plans when carrying out strategic network investment.

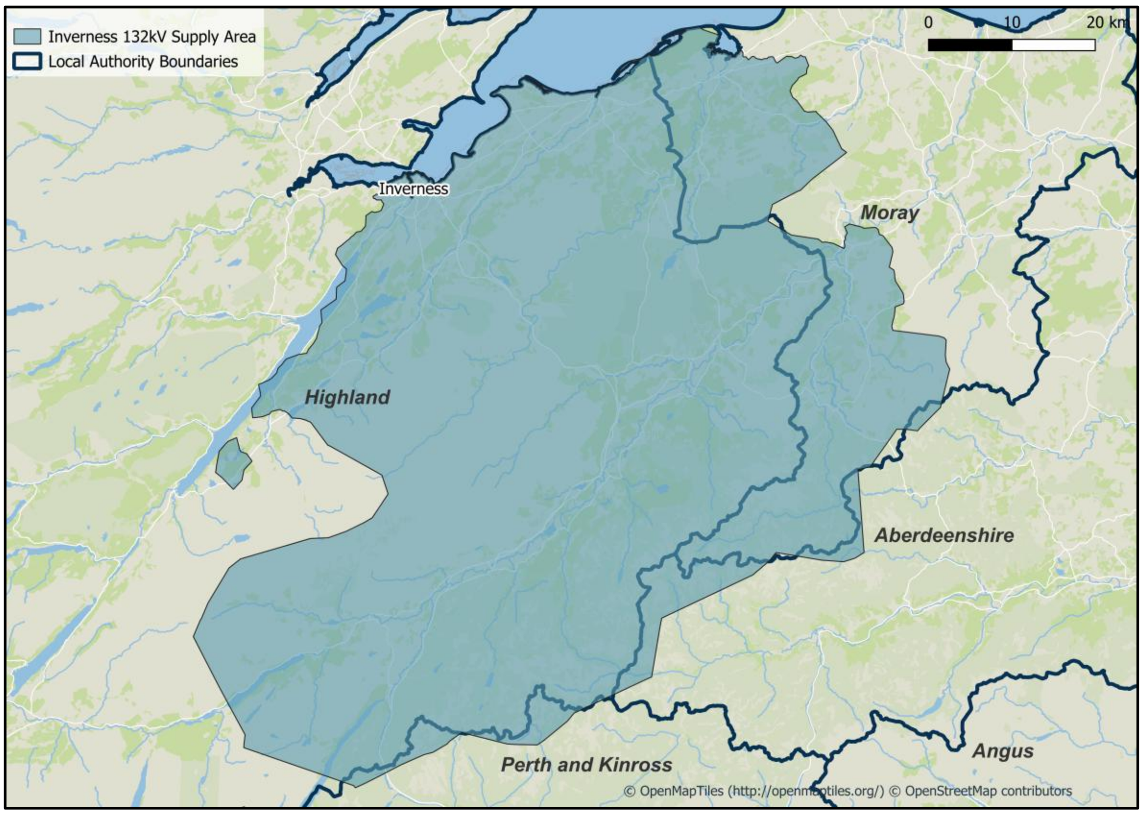

Figure 3 – Inverness and Aviemore 132kV Supply Area and Local Authority Boundaries.

3.1.1. Highland Council

The Highland Council serves a third of the land area of Scotland, which includes some of the most remote and sparsely populated parts of the UK mainland. The total estimated population at mid-year 2023 for Highland Council was 236,330, which is the seventh highest population of the 32 local authorities in Scotland. The Highlands have seen significant population growth over the past 30 years by 13.9% between 2001 and 2021[1].

1 City_Region_Deal_Annual_Report_2024.pdf

Highland Council has published their Net Zero Strategy[2] which includes a route map to net zero by 2045, with key interim targets to reduce emissions by at least 75% by 2030 and at least 90% by 2040[3]. This is in line with the Scottish Government's national target. Areas of focus from this strategy that are of particular interest to SSEN include:

- Improving energy efficiency across the Council's estate.
- Identifying and developing opportunities arising from renewable energy generation.
- Rationalising the fleet and replacing vehicles with low-emission alternatives.

Highland Council has also published their Local Heat and Energy Efficiency Strategy (LHEES) and Delivery Plan[4] which sets out their ambition for a place-based approach to planning and delivery of heat decarbonisation in the region. The North of Scotland, encompassing Aberdeen City, Aberdeenshire, Moray, and Highland Councils, have also been awarded £6.86 million in grant funding from the £30 million Scottish Government Electric Vehicle Infrastructure Fund, effective from Spring 2025[5].

SSEN also work closely with regional stakeholders such as the Highlands and Islands Enterprise (HIE), an economic and community development agency for the area, which is a non-departmental public body of the Scottish Government.

3.1.2. Moray Council

In the 2011 Census, the population of Moray was estimated to be 93,000. The 2017 Mid-Year estimate was 95,780, representing a slight increase[6]. This report covers Elgin, Keith, Buckie and Cullen which are key hubs in Moray.

Moray Council has an ambition to reach net zero carbon emissions by 2030, as outlined by the Council's Climate Change Plan and Routemap to Net Zero. Progress towards this target is reported annually, with the most recent update in 2024[7]. The target will be reviewed in 2025, taking into consideration the current policy and funding landscape. Between 2022/23 and 2023/24, the Council reported a 29% reduction in emissions, predominately due to the NESS Energy from Waste facility[8]. In July 2024, it was announced that the Scottish Government will be providing over £7 million across Aberdeenshire Council, Aberdeen City, Moray Council, The Highland Council and Dundee City Council[9]. The Council have also launched the Bus Revolution project, which aims to increase reduce the environmental impact of transport in Moray, as well as a LED streetlamp programme.

2 Net Zero Strategy | Climate change | The Highland Council

3 Net Zero Strategy | Climate change | The Highland Council

4 Local Heat and Energy Efficiency Strategy and Delivery Plan | The Local Heat and Energy Efficiency Strategy | The Highland Council

5 Electric Vehicle Infrastructure Fund | Transport Scotland

6 Facts and Figures - Moray Council

7 moray.gov.uk/downloads/file159012.pdf

8 Climate Change - Moray Council

9 Over £7 million to support electric vehicle infrastructure | Transport Scotland

3.1.3. Aberdeenshire Council

Persley 132kV supplies parts of Aberdeenshire Council. Some of the areas within the marked region on the map lie within Cairngorms National Park, including Braemar and Ballater. This area is largely rural, featuring notable sites such as Royal Lochnager distillery, Balmoral Castle and Lecht Ski Centre. There are also parts of Aberdeenshire, both north and south of Aberdeen City in scope of this SDP, including the towns of Ellon and Westhill.

Aberdeenshire has an estimated population of 264,320[10] (0.2% increase from the year before), making it the 6th highest population out of all 32 council areas in Scotland. Aberdeenshire Council aims to reach net zero by 2045, in line with Scotland's national target. Aberdeenshire Council has developed a 'Route Map to 2030 and Beyond' which sets out their plans to decarbonise 75% of its emissions by the end of 2030 and to net zero by 2045.

Aberdeenshire was the first local authority in Scotland to develop and approve a carbon budget in 2017/18. The carbon budget is set in February each year and is monitored throughout the year by the Sustainability Committee. The Council have committed to identifying funding opportunities to support decarbonisation[11]. In July 2024, it was announced that the Scottish Government will be providing over £7 million across Aberdeenshire Council, Aberdeen City, Moray Council, The Highland Council and Dundee City Council[12].

3.1.4. Perth and Kinross

Perth and Kinross is a predominantly rural region in Scotland, characterised by a high proportion of properties located off the gas grid. As the fifth-largest unitary authority in the country, it spans an area of 5,285 km² and had an estimated population of 150,953 according to the 2022 Census. The city of Perth serves as the area's largest urban centre.

In 2021, Perth and Kinross Council (PKC) introduced its Climate Change Action Plan, outlining their commitment to achieving net zero carbon emissions by 2045 or sooner[13]. Building on this, the Council developed both a Local Area Energy Plan (LAEP) and a Local Heat and Energy Efficiency Strategy (LHEES), which together form a comprehensive roadmap for decarbonisation in the region[14]. Notably, PKC is one of only two Scottish local authorities to have produced a LAEP (alongside Dundee City Council), which adopts a whole-systems approach to meet their net zero ambition. Perth and Kinross Council are enrolled on SSEN's LENZA platform and have actively used the tool for strategic planning.

3.2. Whole System Considerations

The Inverness and Aviemore 132kV Supply Area is currently experiencing a significant volume of battery storage and generation connection applications. As Clean Power 2030 progresses, its implications for both ongoing projects and future system requirements must be carefully evaluated. The Inverness and Aviemore 132kV

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10 Population statistics - Aberdeenshire Council

11 Aberdeenshire's decarbonisation plans for 2030 and beyond - Aberdeenshire Council

12 Over £7 million to support electric vehicle infrastructure | Transport Scotland

13 Climate Change Strategy and Action Plan

14 Local Heat and Energy Efficiency Strategy (LHEES) - Perth & Kinross Council

Supply Area Strategic Development Plan (SDP) will be updated annually, and we will consider the latest outputs from the Connection Reform process and CP2030.

3.2.1. Load Managed Areas

The Inverness and Aviemore 132kV Supply Area is subject to mandated load scheduling under the DCUSA Schedule 8, Load Managed Areas (LMAs), currently delivered by the legacy Radio Tele Switching (RTS) system and its smart meter-based successor. The move to a Smart meter-based solution for providing LMA based diversity does not, on its own, provide a solution that is compatible with the development of domestic flexibility markets. Consequently, and in the spirit of a Smart and Fair transition, SSEN have committed to removing LMAs during ED2 and ED3. Three methods being used are:

- Ensuring that any reinforcements driven by LCT growth are sized to ensure that they are not a driver for the continuation of an LMA.
- Improving network monitoring to allow the reduction of the scale of existing LMAs.
- Introducing a new market-based replacement for LMAs, this is expected to take the form of a diversity service.

Load managed domestic properties in the Inverness and Aviemore 132kV Supply Area account for approximately 14.2% of all customers, a break down by GSP is shown in the table below.

Substation Name	Site Type	% of LMA customers
Boat of Garten	Grid Supply Point	25.0
Inverness	Grid Supply Point	12.4
Nairn	Grid Supply Point	9.8

Table 1 Percentage of customers fed by the GSP that are covered by LMAs.

3.2.2. Transmission interactions

Due to the large amount of generation sites being developed in Scotland, NESO and SSEN Transmission have some major transmission upgrades planned in Scotland[15]. In the Inverness and Aviemore 132kV Supply Area, as well as the existing 132kV and 275kV lines that run through the area, a new 400kV circuit running from the Beauly to Peterhead substations is planned to be completed in the early 2030s. There are also new GSPs triggered by generation connections in the area; however, these projects may be subject to change due to the impact connections reform and Clean Power 2030.

3.2.1. Security of Supply

Engineering Recommendation P2/8 requires Distribution Network Operators to maintain security of supply to its connected customers in line with the standards laid out in that document, depending on the total demand of the substation. Scottish Hydro Electric Power Distribution (SHEPD) electricity distribution network includes a number of networks that were installed in the period 1950 - late 1980s to provide the first mains electricity supplies to rural communities. These networks were installed on a minimum cost basis and did not meet the standards laid

15 ETYS documents and appendices | National Energy System Operator

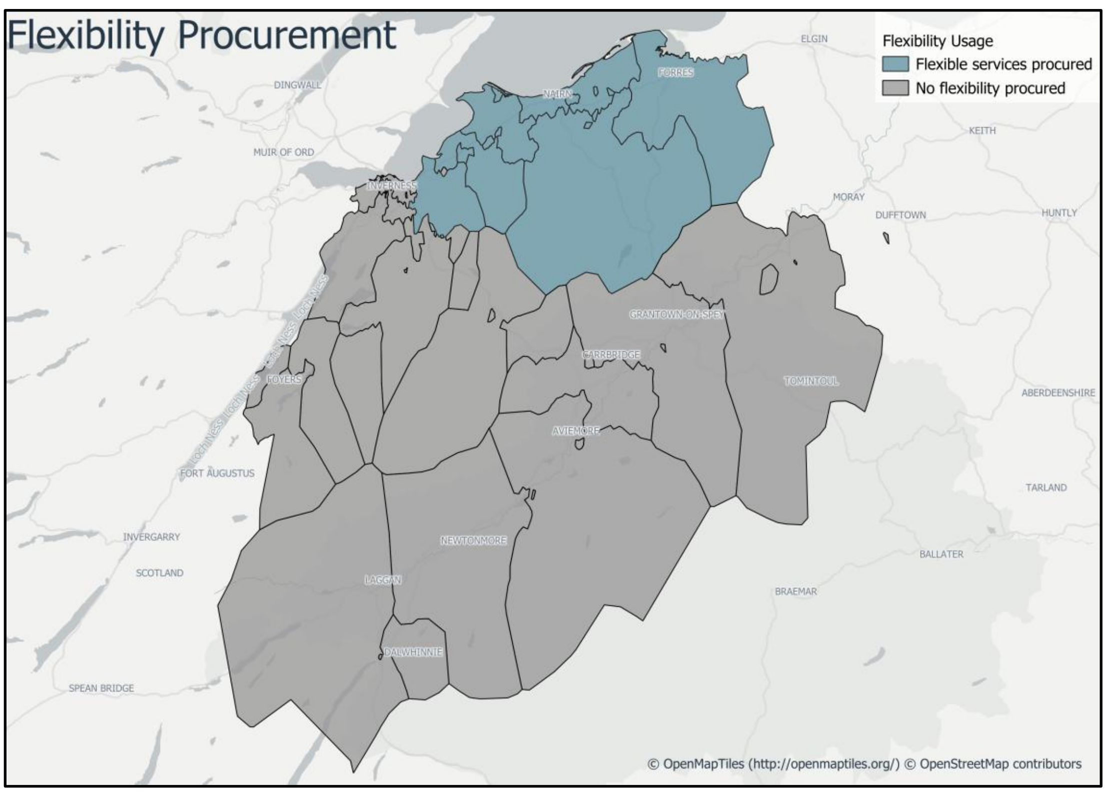
out in Engineering Recommendation P2/8. It was previously considered uneconomic to improve them and these were therefore determined to be exempt from the Engineering Recommendation P2/8. In the context of decarbonisation and increased reliance on electricity, as demand rises in these areas, this position will be reviewed for larger demand groups and where justified the exemption will be removed.

3.3. Flexibility Considerations

SSEN procures Flexibility Services from owners, operators, or aggregators of Distributed Energy Resources (DERs) or Consumer Energy Resources (CERs), which can be generators, storage, or demand assets. These services are needed in areas of the network which have capacity constraints at particular times or under certain circumstances. SSEN purchases Flexibility Services from all types of providers (e.g. domestic or commercial). Information on the process for procurement and how to participate are published on the Flexibility Services website and information on real time decision making on which providers are dispatched can be found in the Operational Decision-Making document.[16,17]

SSEN regularly recruits new Flexibility Services providers and increases the procured Flexibility Services with the latest bidding round for long term requirements held in May 2025 and recruitment through the Mini-Competition process most recently opening in mid-July 2025.[2]

Areas across Inverness and Aviemore 132kV Supply Area where flexibility has been procured is shown below in Figure 4. This map shows all Flexibility Services procured, which covers requirements beyond those identified for managing the deferral of reinforcement.



16 SSEN, Flexibility Services Procurement (Flexibility Services Procurement - SSEN)

17 SSEN, 02/2024, Operational Decision Making (ODM), SSEN Operational Decision Making ODM

Figure 4 - Flexibility procurement across Inverness 132kV supply area.

4. EXISTING NETWORK INFRASTRUCTURE

4.1. Inverness and Aviemore 132kV Supply Area Context

The Inverness and Aviemore 132kV Supply Area network is made up of 33kV, 11kV, and LV circuits. It supplies the city of Inverness and the rural area surrounding it. In total, the GSP serves approximately 64,200 customers. Table 2 shows the values for the GSP, values for the primary substations supplied by the GSP can be found in Appendix A. The peak maximum demand refers to the peak at each individual substation which may not be at a coincident time as the others (meaning we would not expect the values for all primary substations to sum to that at the GSP).

Substation Name	Site Type	Number of Customers Served (approximate)	2024/25 Substation Maximum demand in MVA (Season)
Boat of Garten	Grid Supply Point	11,000	24.63
Inverness	Grid Supply Point	37,100	58.33
Nairn	Grid Supply Point	16,100	31.56

Table 2 - Customer number breakdown and substation peak demand readings for the GSPs in the Inverness and Aviemore 132kV Supply Area.

4.2. Current Network Topology

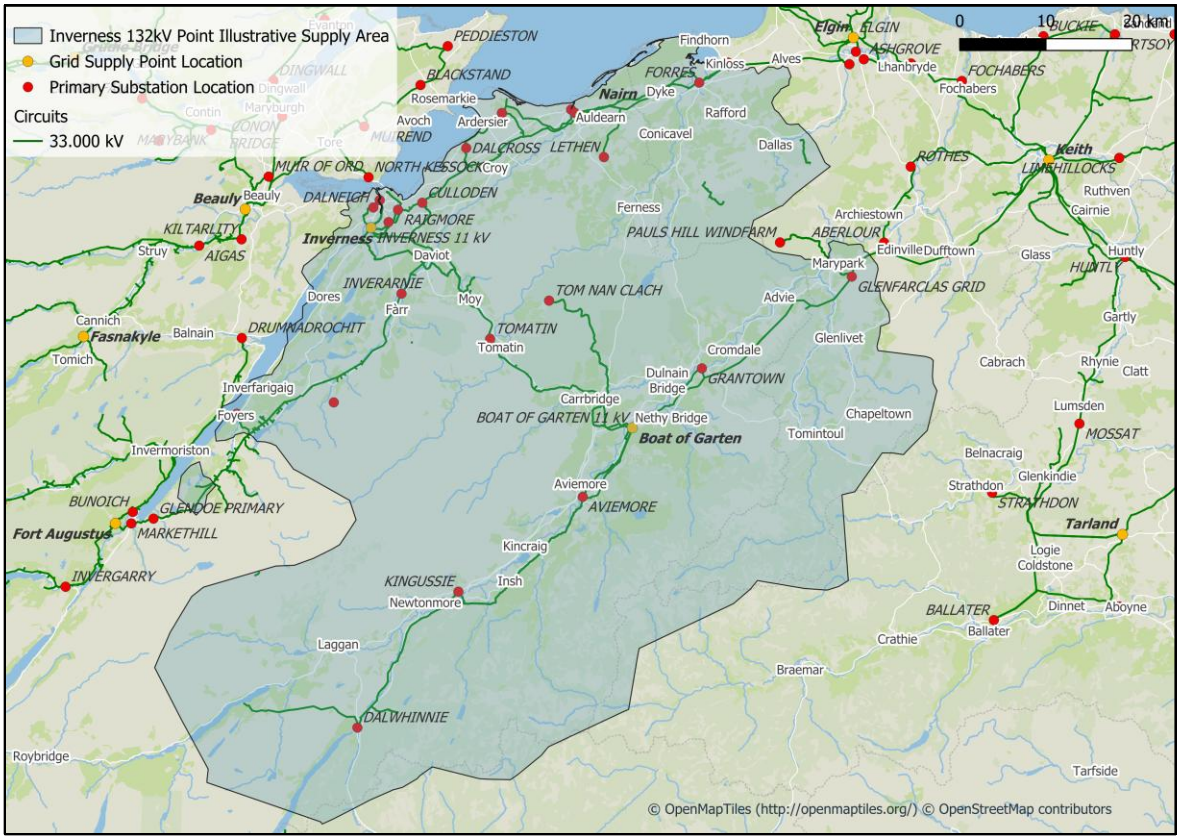


Figure 5 Current network topology of the Inverness and Aviemore 132kV supply area.

4.3. Current Network Schematic

The existing 33kV network at for the Boat of Garten, Inverness, and Nairn GSPs is shown below in Figure 6.

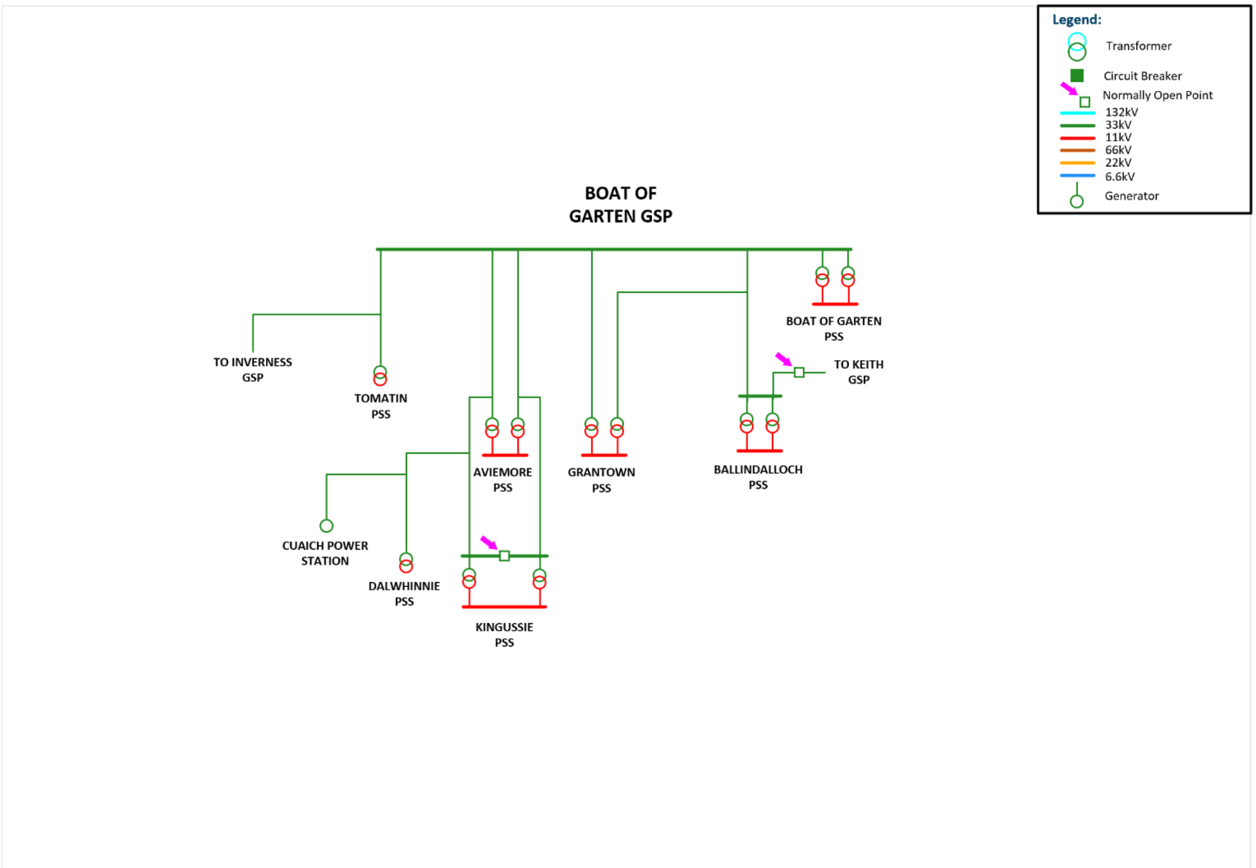


Figure 6 - Existing network supplied by Boat of Garten GSP.

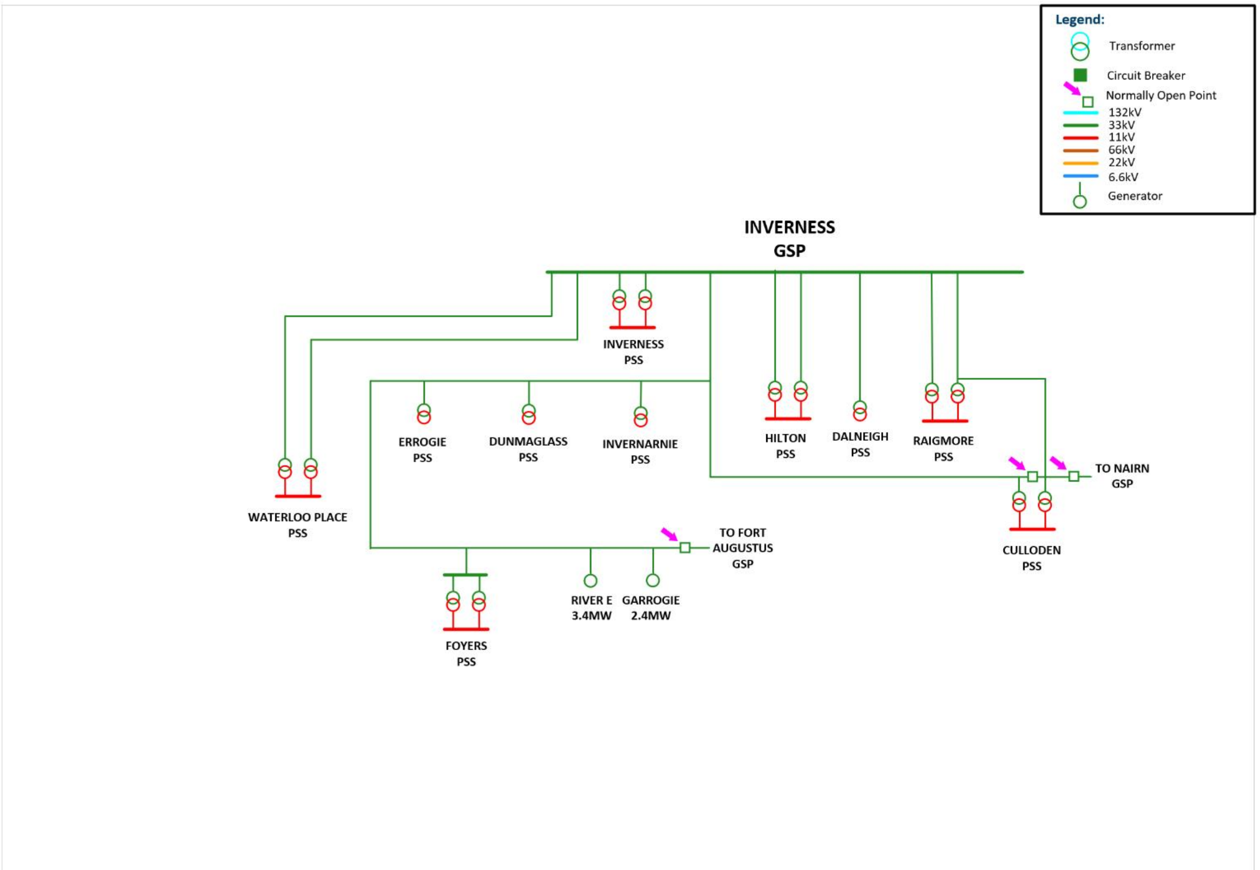


Figure 7 - Existing network supplied by Inverness GSP.

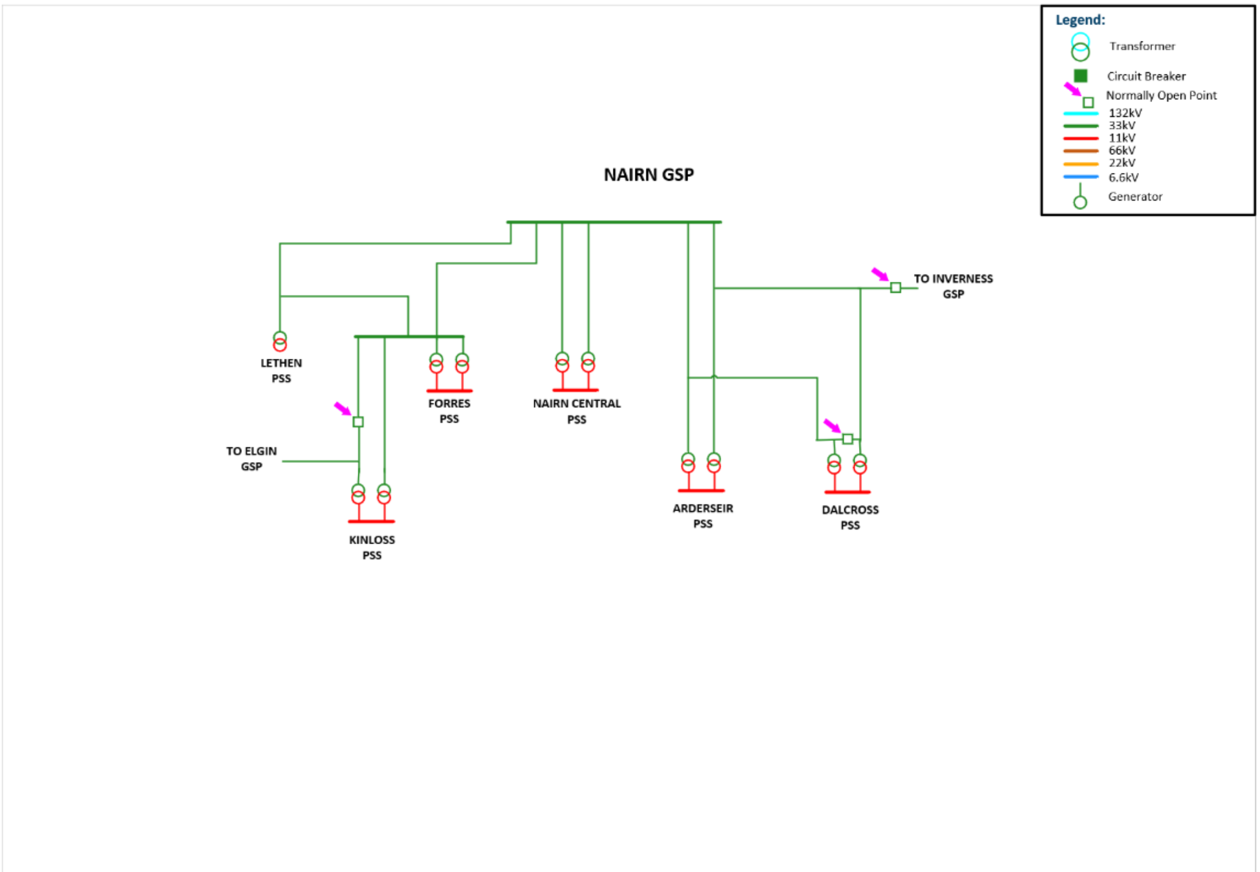


Figure 8 - Existing network supplied by Nairn GSP.

5. FUTURE ELECTRICITY LOAD IN THE INVERNESS AND AVIEMORE 132KV SUPPLY AREA

The following section details load growth across the technologies projected in the Distribution Future Energy Scenarios. There are important notes on the values presented here:

- This SDP and the analysis conducted has been completed ahead of any changes arising from Clean Power 2030.
- These projections relate to the GSP supply area highlighted in Figure 1 and are not directly aligned to a particular local authority.
- Where MW values are presented in this section, they represent total installed capacity. When conducting network studies these values are appropriately diversified to represent the coincident maximum demand of the entire system rather than the total sum of all demands.
- For projections specific to individual primary substations or local authorities, please refer to our online dashboard.[18]

18 SSEN DFES Technology Projections - Microsoft Power BI

5.1. Generation and Storage

DFES Scenario	Generation capacity				Electricity storage capacity			
	Baseline	**2030**	**2040**	**2050**	**Baseline**	**2030**	**2040**	**2050**
Holistic Transition	153MW	356MW	502MW	686MW	0MW	281MW	326MW	357MW
Electric Engagement		355MW	551MW	760MW		187MW	222MW	252MW
Hydrogen Evolution		342MW	451MW	620MW		181MW	212MW	231MW
Counterfactual		258MW	388MW	512MW		55MW	63MW	80MW

Table 3 - Projected cumulative distribution connected generation capacity and electricity storage capacity across Inverness and Aviemore 132kV Supply Area (MW). Source: SSEN DFES 2024

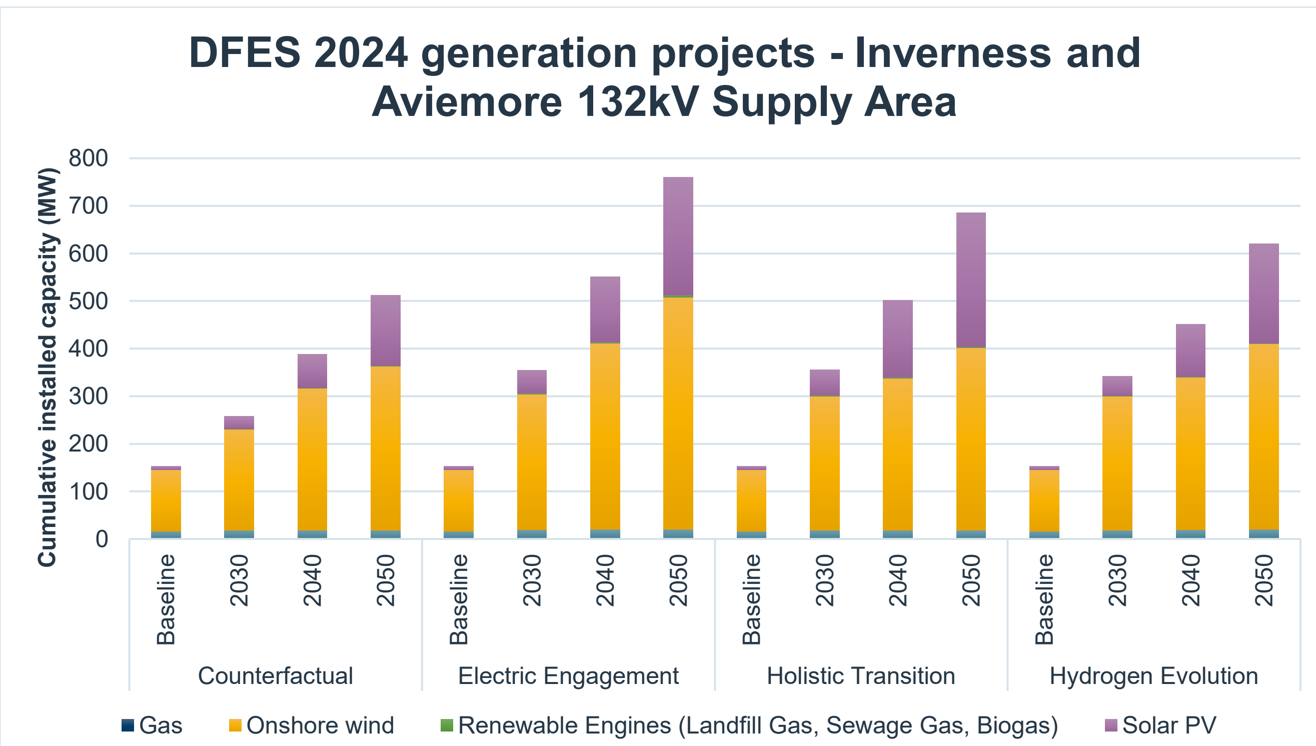


Figure 9 - Projected cumulative distributed generation capacity Inverness and Aviemore 132kV Supply Area (MW). *Source: SSEN DFES 2024*

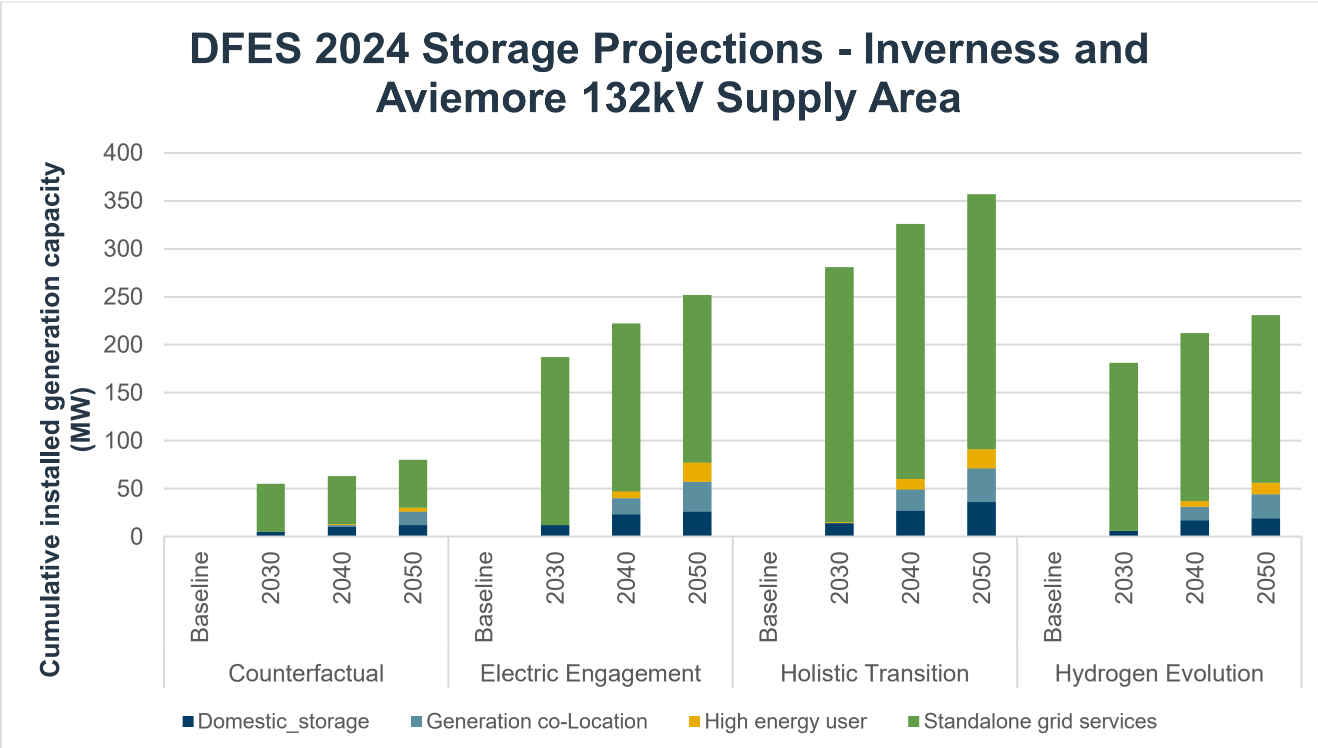


Figure 10 Projected battery storage capacity across the Inverness and Aviemore 132kV Supply Area (MW). *Source: SSEN DFES 2024*

5.2. Transport Electrification

DFES Scenario	Domestic EV chargers – off-street (number of units)				Non-domestic EV chargers & domestic on-street EV chargers (MW)			
	Baseline	2030	2040	2050	Baseline	2030	2040	2050
Holistic Transition	1,355	11,385	42,209	43,384	1MW	17MW	73MW	84MW
Electric Engagement		18,367	42,175	43,094		25MW	83MW	88MW
Hydrogen Evolution		11,293	42,015	43,067		21MW	104MW	117MW
Counterfactual		9,286	33,725	43,111		10MW	68MW	112MW

Table 4 - Projected cumulative number of domestic EV chargers (off-street) and non-domestic and domestic (on-street) EV charge point capacity across the Inverness and Aviemore 132kV Supply Area. Source: SSEN DFES 2024

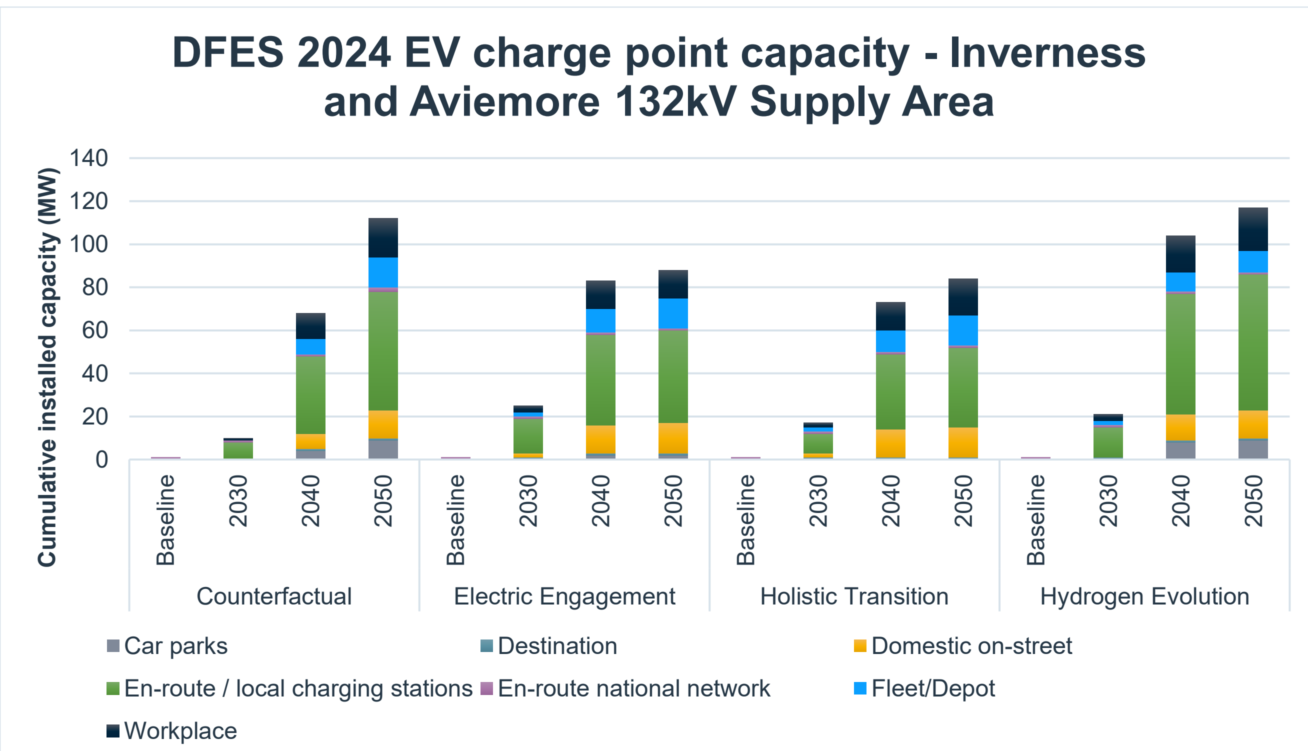


Figure 11 Projected EV charge point capacity across the Inverness and Aviemore 132kV Supply Area. *Source: SSEN DFES 2024*

5.3. Electrification of Heat

DFES Scenario	Non-domestic heat pumps and resistive electric heating (m^2 of floorspace)				Domestic heat pumps (number of units)			
	Baseline	2030	2040	2050	Baseline	2030	2040	2050
Holistic Transition	607,578m^2	757,376m^2	1,019,936m^2	1,106,241m^2	17,739	32,073	60,723	66,060
Electric Engagement		735,477m^2	1,028,338m^2	1,114,643m^2		31,147	61,556	71,003
Hydrogen Evolution		749,863m^2	967,558m^2	1,028,336m^2		27,086	51,852	67,256
Counterfactual		690,462m^2	848,283m^2	920,205m^2		24,048	37,273	65,248

Table 5 - Projected non-domestic heat pumps and resistive electric heating floorspace and number of domestic heat pumps across the Inverness and Aviemore 132kV Supply Area. Source: SSEN DFES 2024

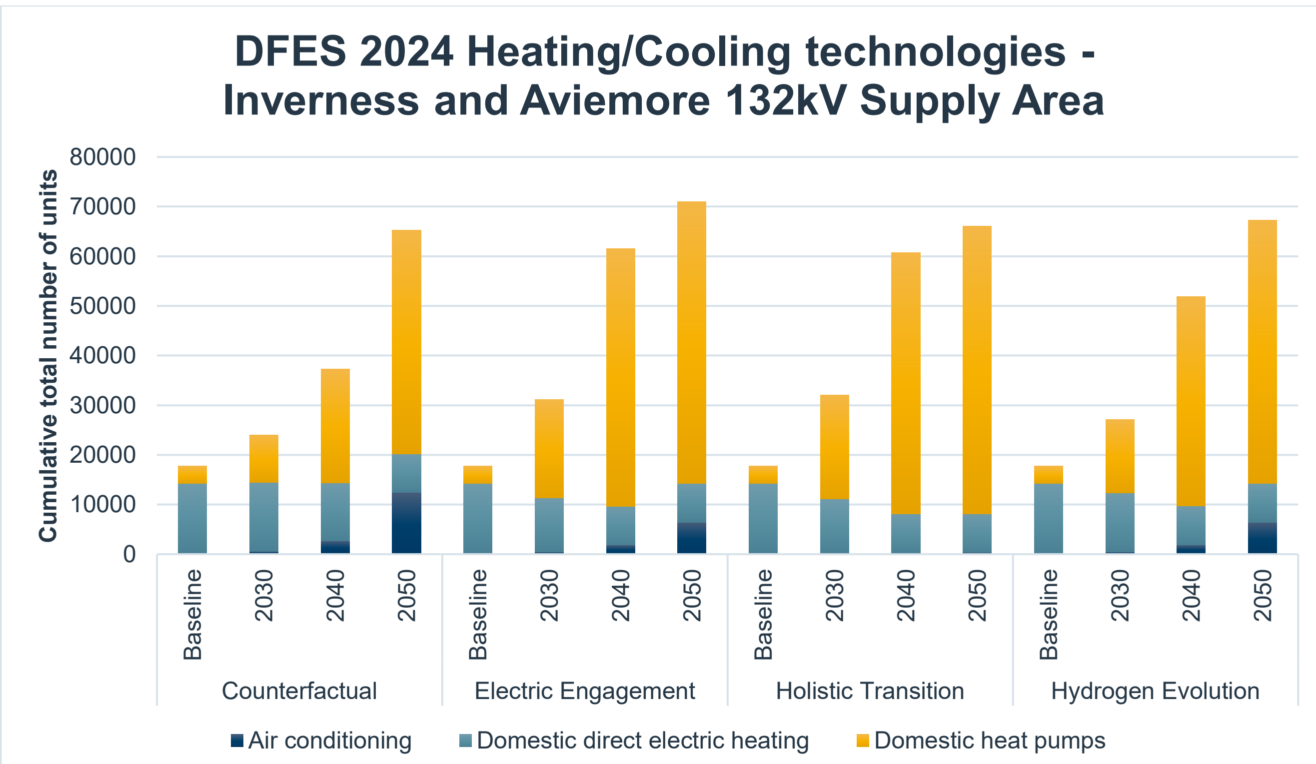


Figure 12 Projected number of heating/cooling technologies across the Inverness and Aviemore 132kV Supply Area. *Source: SSEN DFES 2024*

5.4. New Building Developments

Through engagement with local authorities, we have developed an understanding of new development across our licence areas. This has allowed us to gauge an insight into future electricity demand for new developments ahead of a formal connection application. Below we investigate the non-domestic new developments across the study area for this SDP.

We understand that Nairn and Inverness GSP areas are expected to see substantial housing development. We are actively engaging with key housing developments in the area to understand their future capacity requirements.

DFES Scenario	New domestic development (number of homes)			New non-domestic development (m^2)		
	2030	2040	2050	2030	2040	2050
Holistic Transition	5,518	10,050	10,670	209,257m2	307,072m2	307,072m2
Electric Engagement	5,027	9,792	10,314	192,654m2	307,072m2	307,072m2
Hydrogen Evolution	5,046	8,613	9,492	192,654m2	307,072m2	307,072m2
Counterfactual	4,798	8,497	9,415	148,010m2	269,292m2	307,072m2

Table 6 - Projected new domestic and non-domestic development across the Inverness and Aviemore 132kV Supply Area. Source: SSEN DFES 2024

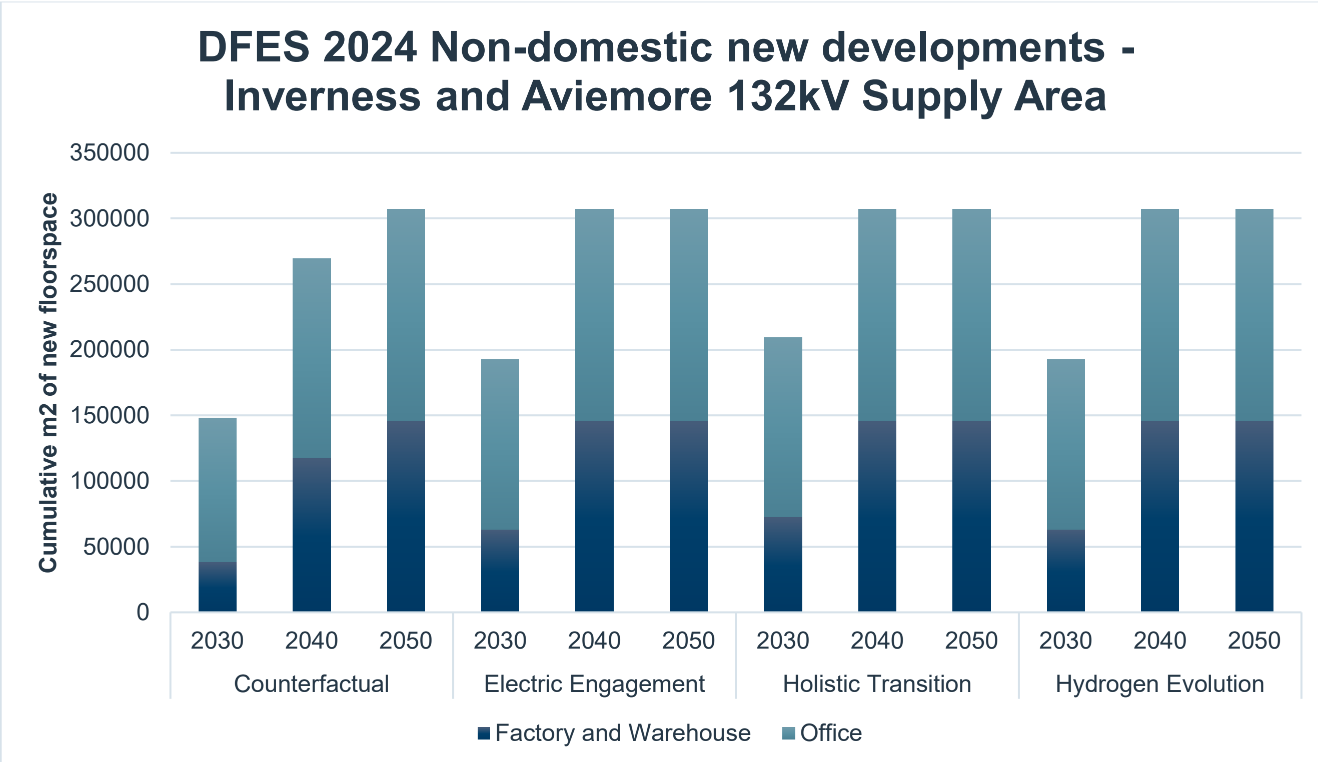


Figure 13 Projected non-domestic new development under Inverness and Aviemore 132kV Supply Area. *Source: SSEN DFES 2024*

5.5. Commercial, Industrial, and Rural Electrification

The decarbonisation of industries specific to Northern Scotland and broader industries indicate there could be a range of potential electrification outcomes for the Inverness and Aviemore 132kV Supply Area. We have identified a number of industries below as areas of potential significant future industrial demand growth for the region.

5.5.1. Ports

Both Ardersier and Inverness ports are designated as key sites within the Inverness and Cromarty Firth Green Freeport, which have been established to drive economic growth, attract investment, and advance decarbonisation initiatives across the region. Ardersier Port is being developed as a major hub for offshore renewable energy infrastructure and decommissioning, while Inverness Port primarily supports commercial shipping, cargo handling, and regional maritime trade. In particular we are engaging with Ardersier Port to understand their future capacity requirements.

As well as this, SSEN leads an innovation project aimed at better understanding the potential electricity demands arising from the maritime industry, so assets and network in the area can be sized appropriately. SSEN's SeaChange innovation project has been funded through the Strategic Innovation Fund.[19] This project

19 SeaChange, SSEN Innovation Project, 10/2024, SSEN's nature and shipping innovation projects win £1m in new development funding - SSEN

involves building a ‘Navigating Energy Transitions’ (NET) tool, which will help ports to plot their most viable pathways for decarbonisation.

5.5.1. Agricultural Decarbonisation

Decarbonisation of the agricultural sector is an important consideration in this geographic area. SSEN leads the innovation project 'Future Agricultural Resilience Mapping' (FARM) which aims to understand the future energy requirements and means of decarbonising the domestic farming industry[20]. This sector is currently still largely dependent on fossil fuels, and the project will support its investigations into the impact of food production on the electricity distribution system, to work out where reinforcement is needed. A data-driven tool to inform network planning will be devised and through this work, FARM will address the gap between the energy demands for food production and future network planning.

5.5.2. Distilleries

Within the Inverness and Aviemore 132kV Supply Area there are 18 registered distilleries with most located close to the river Spey that runs through the supply area. Speyside in Moray and Highlands, which is partly in this report’s supply area, is home to the greatest concentration of whisky distilleries in Scotland. The majority of these distilleries rely on fossil fuels for heat production. The Scotch Whisky Association (SWA) has set an ambitious target to achieve net zero emissions across the Scotch whisky industry by 2040, aligning with broader climate goals and driving sustainability throughout its supply chain. The decarbonisation of these distilleries could significantly increase demand on local distribution networks.

SSEN have been approached by a number of whisky production companies in the area to request upgraded 33kV supplies to electrify their distilling processes. The primary driver for this transition is to meet evolving regulatory requirements around carbon intensity. Target completion timelines for these upgrades span from the mid-2020s into the 2030s.

SSEN are actively engaging with distilleries in the Speyside region to understand their future demand projections. This included a workshop in August 2025, in collaboration with the Scotch Whisky Association, setting out SSEN's strategic planning process and upcoming SDPs to feed into. We are considering information provided by distilleries in our network planning processes and will continue to engage with distilleries to understand their future capacity requirements.

The Scotch Whisky Association (SWA) member distilleries within the Inverness and Aviemore 132kV Supply Area are shown in Figure 14 below:

20 FARM | SSEN Innovation

Figure 14 Distillery locations in the Inverness and Aviemore 132kV Supply Area.

5.5.3. Other large industrial consumers

In addition to the ports, the Inverness and Aviemore 132kV Supply Area supports a range of large demand consumers with long-term decarbonisation ambitions that will drive increased electricity requirements. These include proposed data centres, Inverness Airport, Inverness Airport Business Park, and major manufacturing facilities, such as West Fraser in the Dalcross area. We also acknowledge the Highland and Islands Enterprise publication, *Regional Transformation Opportunities in the Highlands and Islands*, which outlines strategic projects and investments planned between 2025 and 2040. The potential investment pipeline identified exceeds £1 billion, highlighting the scale of future development and the importance of aligning network planning with regional growth.

6. WORK IN PROGRESS

Network interventions can be caused by a variety of different drivers. Examples of common drivers are load-related growth, specific customer connections, and asset health. Across these drivers have already triggered network interventions that have now progressed to detailed design and delivery. For this report, these works are assumed to be complete, with any resulting increase in capacity considered to be released. The drivers listed in the below table are predominantly where a customer connection application has driven the work or where investment proposals developed through our DNOA process are driving the reinforcement work.

The published DNOA outcomes relevant to the Inverness and Aviemore 132kV supply area are included in Appendix D. The work included below in Table 2 is a summary of the work that has passed through the ID2 gate of our Distribution Governance and Investment Framework (DGIF), further information on this process is available in the DSO service statement 2025.[21] Building on this, the network considered for long-term modelling is shown in Figures 15 and 16.

ID	Substation	Description	Driver	Forecast completion	Resolves future strategic needs to 2050?
Inverness GSP					
1	Culloden Primary transformers.	Reinforce the two existing 33/11kV transformers from 2 x 7.5/15MVA units to 2 x 15/30MVA units.	DNOA process.	2028	
2	New Primary Substation and 33kV circuit rerouting.	Construction of a new primary substation to relieve a thermal constraint at Raigmore Primary. The new substation will consist of 2 x 15/30MVA transformers. New 33kV circuits will also be laid from Inverness GSP to the new substation and circuits from the new substation to Raigmore PSS.	DNOA process.	2030	
3	Waterloo Place PSS transformers.	Reinforce the two existing 33/11kV transformers from 2 x 11.5/23MVA units to 2 x 20/40MVA units.	DNOA process.	2027	
4	Longman Drive PSS.	Construction of a new primary substation, Longman Drive PSS. The new substation will consist of 2 x 12/24MVA transformers and will be fed using two new 33kV circuits from Waterloo Place PSS.	DNOA process.	2026	

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		There will also be an additional 33kV circuit between Longman Drive PSS and Culloden PSS.			
Nairn GSP					
5	Forres PSS transformers.	Reinforce the existing 2 x 7.5/15MVA transformers with 2 x 20/40MVA transformers, along with the reinforcement of the existing the dual 33kV overhead lines with lines of a higher rating of 53.7MVA.	DNOA process.	2030	
6	Nairn GSP to Ardersier PSS 33kV circuit section.	Reinforcement of a 0.45km section of a 33kV circuits between Inverness GSP and Ardersier PSS.	Customer connection.	2029	
7	Nairn GSP to Ardersier/Norbord tee 33kV circuits.	Reinforce the existing overhead 33kV line with a cable of higher rating of 38MVA.	DNOA process.	2027	

Table 7 - Works already triggered through customer connections and the DNOA processes.

Where the above works are marked as not providing sufficient capacity for 2050 peak demands, it is important to note that this relates to the individual primary substation’s firm capacity. When considering the further works identified in this report, the holistic plans aim to provide capacity across the GSP for 2050 based on current projections.

Alongside these asset solutions being deployed, flexibility solutions are also being used to release additional capacity.

6.1. Network Schematic (following completion of above works)

The network schematic below in Figure 11 shows the 33kV network with changes highlighted and referenced to the in Table 2.

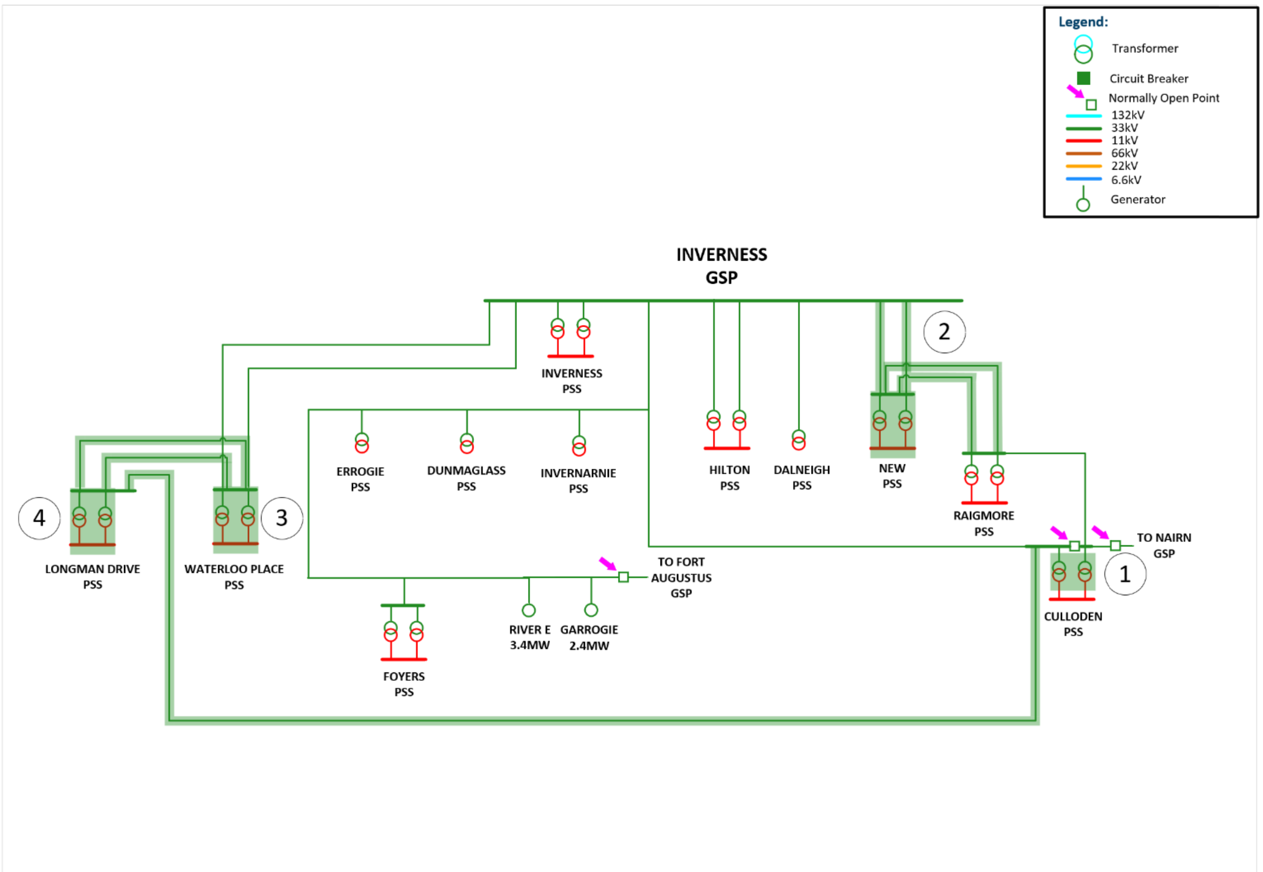


Figure 15 – Inverness GSP network schematic following completion of triggered works.

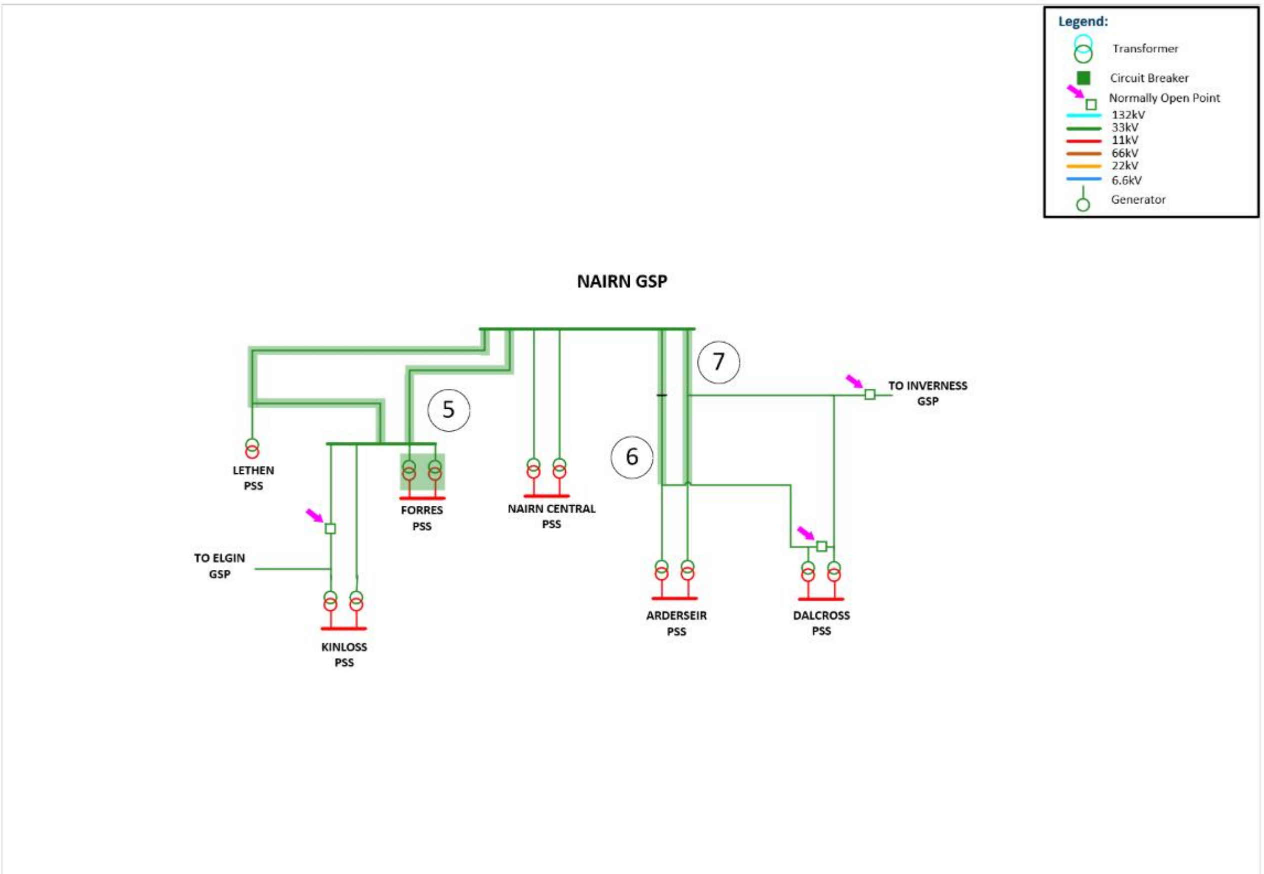


Figure 16 Nairn GSP network schematic following completion of triggered works.

7. SPATIAL PLANS OF FUTURE NEEDS

7.1. Extra High Voltage / High Voltage Spatial Plans

The EHV/HV spatial plans shown below in Figure 12 shows the projected headroom or capacity shortfall due to demand increases at primary substations across the Inverness and Aviemore 132kV Supply Area. Darker shades indicate that there is a projected capacity shortfall whereas lighter blue shades indicate that there is headroom capacity based on current projections. EHV/HV spatial plans for the other DFES scenarios are presented in appendix B.

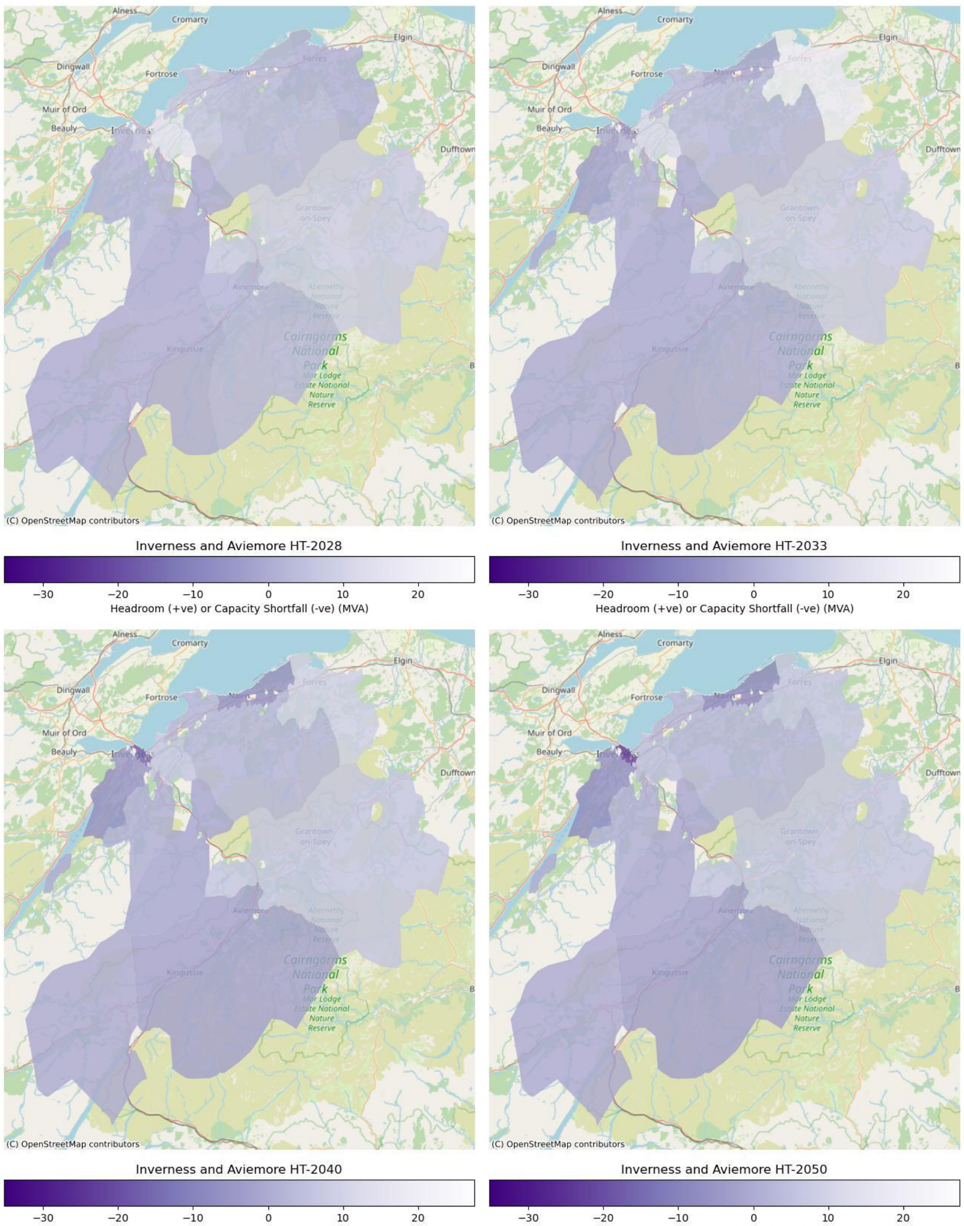


Figure 17 - Inverness and Aviemore 132kV Supply Area - EHV/HV Spatial Plans – Holistic Transition.

7.2. HV/LV Spatial Plans

The HV/LV spatial plans shown below in Figure 13 show the point locations of secondary transformers supplied by the Inverness and Aviemore 132kV supply area. The points are colourised based on the projected percentage loading with red meaning higher percentage loading and green being lower percentage loading. The HV/LV spatial plans for the other DFES 2024 scenarios are available in Appendix C.

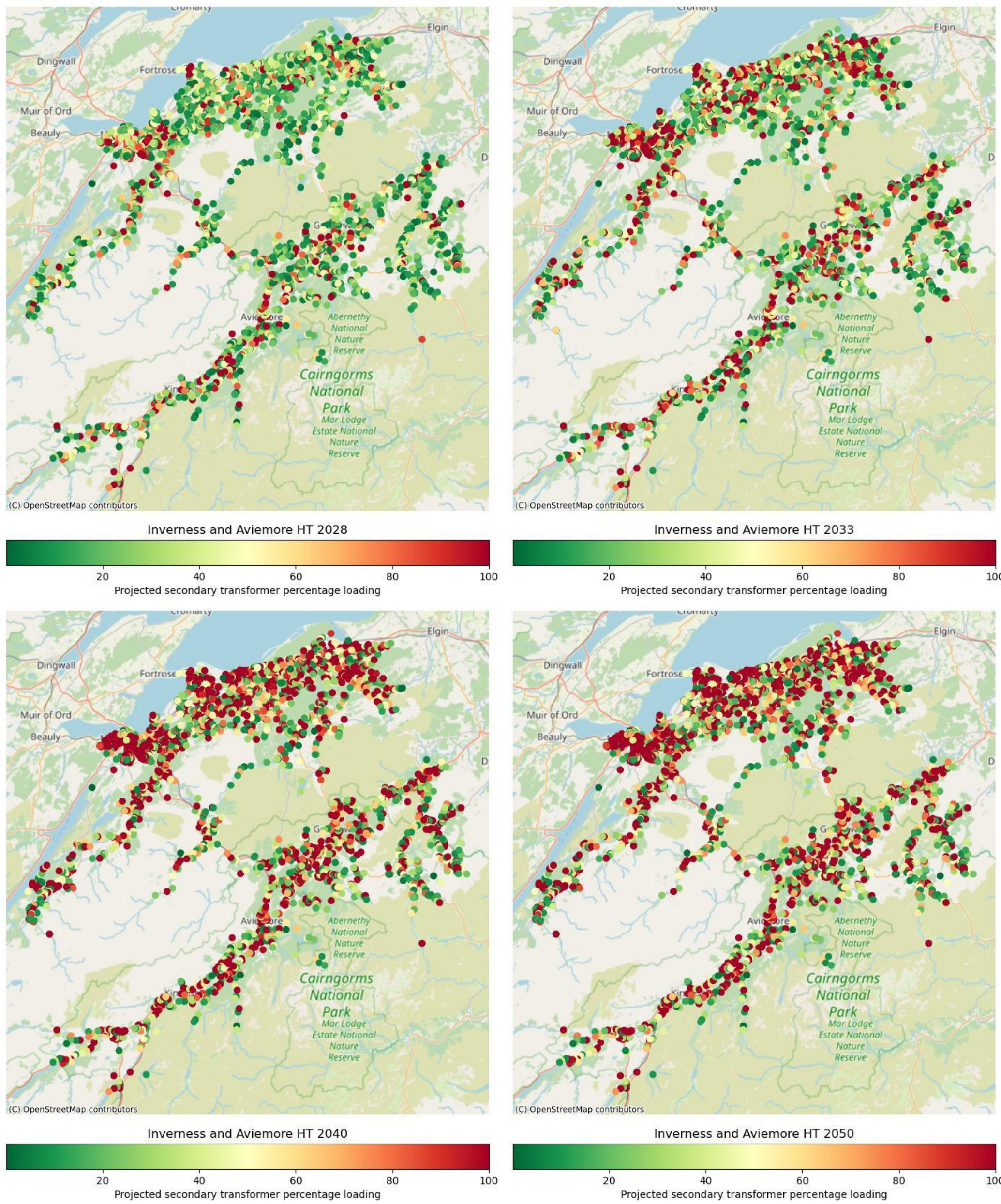


Figure 18 - Inverness and Aviemore 132kV Supply Area - HV/LV Spatial Plans – Holistic Transition.

8. SPECIFIC SYSTEM NEEDS AND OPTIONS TO RESOLVE

In this section we summarise the specific needs arising from our future spatial plans. The outputs of the power system analysis in this section show where we may observe the need for further intervention on the distribution network. This could be through asset solutions or flexibility services including access products which may be used to enable connection of projects ahead of reinforcement delivery. We also propose some initial options to resolve the needs forecasted. If required during the next ten years, these will be further developed through the DNOA process.

The section consists of three sets of results:

- Future EHV system needs to 2035 – these needs are more certain and therefore we have more clearly defined options to meet the requirements, and we recommend that these are progressed through the DNOA process. In all cases, we are proposing solutions that meet the projected requirements for 2050 and where appropriate, system needs arising beyond this period are considered to ensure a holistic solution.
- Future EHV system needs to 2050 – there is a greater degree of uncertainty of outcomes in this time frame. This also provides more opportunities to work with stakeholders to develop strategic plans, and our outline solutions reflect this initial phase of the work as we look to engage with interested parties.
- Future HV/LV system needs to 2050 – the future needs of the HV and LV networks are locationally specific but can be considered as an aggregated volume. In this section we provide information on our future forecasts for local HV and LV network needs.

8.1. Overall Dependencies, Risks, and Mitigations

There are several overarching risks to the delivery of our strategic plan. Below we list these alongside proposed mitigating actions. We will work with stakeholders to develop these mitigating actions further.

Dependency: Delivery of the reinforcement work highlighted in the works in progress section (section 6) will be required to enable capacity in the near-term but may also enable the proposed future options in this system needs section.
Risks: Delays or changes to triggered works fail to release capacity in the near-term and/or do not provide flexibility of future investment.
Mitigation: Current reinforcement projects are included in this strategic development plan, and dependencies are identified as part of the DNOA process and form part of the handover of work to delivery teams for consideration. Proposed work should also ensure that it is enabling future network development such as considering space constraints at the site.

Dependency**: The** connections reform process is likely to change the number and composition of generation/storage projects currently in the connections queue.
Risks**:** The reinforcements currently planned, that have been triggered by generation connections, may not be necessary if the generation projects drop out of the connections queue.
Mitigation**:** Works triggered by generation projects that have a level of uncertainty have not been included in the works in the progress or the network modelling. This assumes these works will not release capacity so network can be planned for worst-case scenario in terms of these works going ahead. Network models will be rerun when there is more clarity.

Dependency: Growth of generation in the area may begin to cause reverse power flow on the network. It should be ensured that the assets currently on the network are able to handle the projected levels of reverse power flow and increased fault level.
Risks: Further reinforcement than identified here is required to enable connection of generation. Increasing fault levels leads to damaged distribution network assets.
Mitigation: We should further assess the near-term generation requirements to ensure that we are in a position to facilitate the Clean Power 2030 targets set by DESNZ. Consideration of future fault level to prevent the risk of damaged assets should be considered when designing future schemes.

Dependency: SSEN has committed to removing Load Managed Areas (LMAs) during the ED2 and ED3 price control period.
Risks: Firstly, some of the smart meters being used to replace the radio tele switching may not be able to connect to the smart network. Secondly, participation in flexibility markets from previous LMA customers is not as high as expected.
Mitigation: Technical support is given for the installation of smart meters. Detailed network studies are undertaken for areas most impacted by the removal of LMAs to determine whether flexibility solutions or reinforcements will be required.

8.2. Future EHV System Needs

The following table details the near-term to medium-term distribution network system needs that have been identified through power system analysis. While asset solutions are described in the table below it is important to note that the use of flexibility will be evaluated for all schemes to ensure the best possible solution is progressed. For the projects shown in Table 4 we recommend that these are progressed through the DNOA process so that there is sufficient time for solutions to be designed and delivered. The interactions between possible options have been considered to identify potential synergies and efficiencies. As such, constraints have been grouped strategically to be considered alongside each other and any additional interactions between constraints referenced.

8.2.1. System needs to 2035

Location of proposed intervention	HT Year	EE Year	HE Year	CF Year	Network State	Comments and potential options to resolve the system need
Boat of Garten GSP.						
Aviemore PSS to Kingussie PSS circuit breaker.	2025–2030	2025–2030	2025–2030	2025–2030	N-1 (voltage).	Aviemore and Kingussie PSSs sit along a rural circuit spur from the Boat of Garten GSP. There is also a backfeed to Keith GSP. Potential options to resolve this constraint are: • Upgrade the circuits, either by reinforcing the lower rated sections of circuit or reducing length thereby reducing impedance. • Alter the distribution of load along the spur through load transfers. • Install a STATCOM or voltage regulator along the circuit.

Location of proposed intervention	HT Year	EE Year	HE Year	CF Year	Network State	Comments and potential options to resolve the system need
Boat of Garten GSP to Ballindalloch PSS 33kV circuits.	2025–2030	2025–2030	2031–2035	2031–2035	N-1 (voltage).	Ballindalloch PSS is at the end of a long and rural circuit from the Boat of Garten GSP. There is also a NOP to Keith GSP. Potential options to resolve this constraint are: • Upgrade the circuits, either by reinforcing the lower rated sections of circuit or reducing the length thereby reducing impedance. • Feed all or part of Ballindalloch PSS from Keith GSP, reducing load on the network. • Install a STATCOM or voltage regulator along the circuit.
Ballindalloch PSS transformers.	2031–2035	2031–2035	2031–2035	2036–2040	Intact (voltage).	
Kingussie PSS transformers.	2031–2035	2031–2035	2031–2035	2036–2040	N-1 (thermal).	Kingussie PSS consists of two 7MVA transformers and experiences an overload in N-1 conditions. Potential options to resolve this constraint are: • Reinforce the existing transformers to a higher rating. • Shift load on the 11kV network, reducing the 11kV load connected to Aviemore or Dalwhinnie PSS. • Install another primary along the 33kV network, splitting the 11kV load.
Inverness GSP.						
Inverness GSP to Dalneigh PSS 33kV circuit section.	2025 - 2030	2025 - 2030	2025 - 2030	2025 - 2030	Intact (thermal).	The circuit between Inverness GSP and Dalneigh PSS is expected to be overloaded during intact conditions. The circuit consists of lower rated overhead lines and higher rated cables, with the cables also expected to be overloaded in 2036 - 2040. Potential options to resolve this constraint are: • Reinforce the section of circuit to a higher rating. • Utilise demand side flexibility usage during outages subject to availability. • Transfer load on the 11kV network to Waterloo Place PSS.
Longman Drive PSS to Culloden PSS.	2025 - 2030	2025 - 2030	2025 - 2030	2031 - 2035	N-1 (thermal).	The circuit between Longman Drive PSS and Culloden PSS are expected to be overloaded during outage conditions. The circuit consists of cables with different ratings, with different sections projected to be overloaded before 2050. Potential options to resolve this constraint are: • Reinforce the sections of circuit in stages when constraints arise or reinforce the whole section of circuit to meet 2050 demand. • Utilise demand side flexibility usage during outages subject to availability. • Transfer load on the 11kV network over to Raigmore PSS.

Location of proposed intervention	HT Year	EE Year	HE Year	CF Year	Network State	Comments and potential options to resolve the system need
Inverness GSP to new Raigmore PSS 33kV circuits.	2031 - 2035	2025 - 2030	2025 - 2030	2031 - 2035	N-1 (thermal).	The circuit between Inverness GSP and the new Raigmore PSS are expected to be overloaded during outage conditions. It should also be considered that voltage constraints were also projected for 2041 – 2045. Potential options to resolve this constraint are: • Reinforce the circuit to a higher rating. • Utilise demand side flexibility usage during outages subject to availability. • Transfer load on the 11kV network to Waterloo Place PSS or Culloden PSS.
Inverness GSP to Inverarnie \ Culloden tee 33kV circuit section.	2031 - 2035	2025 - 2030	2031 - 2035	2031 - 2035	N-1 (thermal).	The circuit between Inverness GSP and the Inverarnie \ Culloden tee is expected to be overloaded during outage conditions. The circuit consists of cables with different ratings, with different sections projected to be overloaded before 2045. Potential options to resolve this constraint are: • Reinforce the sections of circuit in stages when constraints arise or reinforce the whole section of circuit to meet 2050 demand. • Utilise demand side flexibility usage during outages subject to availability. • Transfer load off the circuit to either Nairn or Fort Augustus GSPs.
Invernanie \ Culloden tee to Culloden first 33kV circuit section.	2031 - 2035	2031 - 2035	2031 - 2035	2036 - 2040	N-1 (thermal).	The circuit between Invernanie \ Culloden tee and the Culloden PSS is expected to be overloaded during outage conditions. The circuit consists of cables with different ratings, with different sections projected to be overloaded before 2040. Potential options to resolve this constraint are: • Reinforce the sections of circuit in stages when constraints arise or reinforce the whole section of circuit to meet 2050 demand. • Utilise demand side flexibility usage during outages subject to availability. • Transfer load off the circuit by partly or fully running Culloden from Nairn GSP.

Table 8 - Summary of system needs identified in this strategy through to 2035 along with indicative solutions.

8.2.2. System needs to 2050

Location of proposed intervention	HT Year	EE Year	HE Year	CF Year	Network State	Comments and potential options to resolve the system need
Boat of Garten GSP.						
Dalwhinnie PSS transformer.	2036–2040	2036–2040	2036–2040	2041–2045	Intact (thermal).	Dalwhinnie PSS is a single 1MVA transformer and is expected to experience overload during intact conditions. Potential options to resolve this constraint are: • Upgrade the existing transformer to accommodate load growth. • Install an additional transformer at Dalwhinnie PSS, increasing the resilience of the network. • Shift load away from Dalwhinnie on the 11kV network.
Tomatin PSS transformers.	2046–2050	N/A	N/A	N/A	N-1 (thermal).	Tomatin PSS is a single 2MVA transformer and is projected to experience thermal constraints. Potential options to resolve this constraint are: • Upgrade the existing transformer and reinforce or shorten circuits to accommodate load growth. • Install an additional transformer at Tomatin PSS, increasing the resilience of the network. • Shift load away from Tomatin, potentially using backfeeds from Inverness GSP.
Inverness GSP.						
Hilton PSS transformers.	2036 - 2040	2036 - 2040	N/A	2046 - 2050	N-1 (thermal and voltage).	The 33kV circuit feeding Hilton PSS from Inverness GSP becomes overloaded in outage conditions. The transformers at Hilton PSS also become overloaded in the same time period and it's recommended work is done to resolve both these constraints together. Potential options to resolve this constraint are: • Upgrade both transformers at Hilton PSS to accommodate load growth out to 2050, also reinforce the circuits between Hilton PSS and Inverness GSP. • If the uprating of assets does not resolve the voltage issues, the installation of a voltage regulator or STATCOM along the circuits should be considered. • Transfer load on the 11kV network to Raigmore PSS or Inverness 11kV PSS.
Inverness GSP to Hilton PSS 33kV circuit section.	2036 - 2040	2036 - 2040	N/A	2046 - 2050	N-1 (thermal and voltage).	
Waterloo Place PSS to Longman Drive PSS 33kV circuit section.	2046 - 2050	N/A	N/A	N/A	N-1 (thermal).	The circuits between Waterloo Place PSS and Longman Drive PSS are projected to experience thermal constraints from 2036. There are also projected to be voltage constraints at Waterloo Place PSS transformers.

Location of proposed intervention	HT Year	EE Year	HE Year	CF Year	Network State	Comments and potential options to resolve the system need
Waterloo Place PSS transformers.	2041 - 2045	2041 - 2045	2036 - 2040	2046 - 2050	N-1 (voltage).	Because of this, the options to resolve this constraint have been grouped together. High level options to resolve this are: • Reinforce the circuit with that of a higher rating. • Flexibility assessment should be carried out to determine if voltage and thermal constraints could be resolved through flexibility. • Installation of a voltage regulator or STATCOM along the circuits. • Place Culloden PSS on its own feeder, taking load from the Waterloo PSS to Longman Drive PSS 33kV circuits.
Longman Drive PSS transformers.	2036 - 2040	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	Longman Drive PSS is a new primary substation. Potential options to resolve this constraint are: • Upgrade the circuit feeding Longman Drive PSS, potential upgrades between Inverness GSP and Waterloo Place could resolve this by reducing impedance. • Install a voltage regulator or STATCOM.
Errogie PSS transformers.	2036 - 2040	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	All circuits and transformers sit on the same 33kV spur and are projected to experience voltage issues from 2036 - 2045. Because of this, the options to resolve this constraint have been grouped together. High level options to resolve this are: • Reinforce all lower rated sections of circuit along the network or see if it's possible the shorten the circuit, reducing impedance. • Flexibility assessment should be carried out to determine if voltage constraints could be resolved through flexibility. • Installation of a voltage regulator or STATCOM along the circuits. • Transfer load over to Fort Augustus GSP by transferring some of the primary substations.
Dunmaglass PSS to Errogie PSS 33kV circuits.	2036 - 2040	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	
Dunmaglass PSS transformer.	2036 - 2040	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	
Inverarnie PSS to Dunmaglass PSS 33kV circuits.	2036 - 2040	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	
Inverarnie PSS transformers.	2036 - 2040	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	
Inverness GSP to Inverarnie PSS 33kV circuits.	2041 - 2045	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	

Location of proposed intervention	HT Year	EE Year	HE Year	CF Year	Network State	Comments and potential options to resolve the system need
Inverness GSP to Boat of Garten GSP 33kV circuits backfeed.	2041 - 2045	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	
Culloden PSS transformers.	2041 - 2045	2036 - 2040	2036 - 2040	2041 - 2045	N-1 (voltage).	Culloden PSS projected to experience voltage and then thermal constraints. Potential options to resolve this constraint are: • Upgrade the existing transformer and reinforce or shorten circuits to accommodate load growth and voltage issues. • Shift load away from Culloden PSS, perhaps to Raigmore PSS or Nairn GSP.
Culloden PSS transformers.	2041 - 2045	N/A	N/A	N/A	N-1 (thermal).	
Inverness GSP to Dalneigh PSS first 33kV circuit section.	2041 - 2045	2041 - 2045	2036 - 2040	2046 - 2050	Intact (voltage).	The circuit between Inverness GSP and Dalneigh PSS are projected to experience voltage issues, as is the Dalneigh PSS transformer. It should also be noted that reinforcements have already been suggested to resolve thermal constraints, therefore it should be checked to see if these constraints are also resolved. Potential options to resolve this constraint are: • Reinforce the circuit with that of a higher rating or see if it's possible the shorten the circuit, reducing impedance. • Flexibility assessment should be carried out to determine if the voltage and thermal constraints could be resolved through the use of flexibility. • Installation of a voltage regulator or STATCOM.
Dalneigh PSS transformers.	2041 - 2045	2036 - 2040	2036 - 2040	2046 - 2050	Intact (voltage).	
Inverness GSP to new Raigmore PSS circuit.	2041 - 2045	2041 - 2045	2041 - 2045	2041 - 2045	N-1 (voltage).	The circuit between Inverness GSP and the new Raigmore PSS is forecast to experience voltage issues in outage conditions. It should also be considered that reinforcements have already been proposed due to a thermal constraint arising in the period 2031 - 2035, therefore it should be checked to see if these voltage constraints are also resolved. Potential options to resolve this constraint are: • Reinforce the circuit to a higher rating or see if it's possible to shorten the circuit length to reduce impedance. • Utilise demand side flexibility usage during outages subject to availability. • Install a voltage regulator or STATCOM. • Transfer load on the 11kV network to Waterloo Place PSS or Culloden PSS.

Table 9 - Summary of system needs identified in this strategy through to 2050 along with indicative solutions.

8.3. Future Requirements of the High Voltage and Low Voltage Networks

Our HV/LV spatial plans have shown that there is no clear pattern to future demands on these lower voltage networks. We are therefore planning on a forecast volume basis, and this section provides further context on this work for both the Inverness and Aviemore 132kV supply area high voltage and low voltage network needs to 2050.

8.3.1. High Voltage Networks

As well as the EHV system needs identified in the previous section, increased penetration of low carbon technologies (LCTs) connecting to the distribution network will result in system needs on the High Voltage (HV) and Low Voltage (LV) networks. To provide a view on the impact of these technologies on the distribution network here we have used the load model that is produced by SSEN's Data and Analytics team.[22]
The load model is a machine learning product which estimates a half-hourly annual demand profile for each household based on a series of demographic, geographic and heating type factors. This enables us to estimate capacity on the electricity network while protecting individual customers data privacy by using modelled data. These views are then aggregated up the network hierarchy based on the combinations of customers associated with each asset. This view is supplemented with the DFES to highlight the projected impact of LCTs on the network.

For the 10 primary substations supplied by Inverness and Aviemore 132kV supply area, the percentage of secondary substations where projected peak loading exceeds the nameplate rating of the secondary transformer was taken from the load model data. Figure 14 demonstrates how this percentage changes under each DFES scenario from now to 2050 where it is projected that without intervention, 34% of secondary transformers will be overloaded under the HT pathway.

To satisfy these requirements a variety of solutions will need to be investigated. It is likely that a combination of flexibility and asset replacement will be employed to resolve the projected HV system needs. It is important to note that for HV needs, flexibility is likely to be provided through Distributed Energy Resources (DER), Consumer Energy Resources (CER), and domestic/commercial Demand Side Response (DSR). One of the challenges associated with procuring flexibility to High Voltage and Low Voltage system needs is that only a small number of customers can provide a flexible service due to the requirement to be supplied by a specific secondary transformer. As the role of aggregators develops, we may see a shift in the potential for flexibility in an area. Where the magnitude of an overload is too large for flexibility to be feasible, addition of new assets or asset replacement will be necessary.

22 SSEN Open Data Portal, 2023, SSEN Secondary Transformer – Asset Capacity and Low Carbon Technology Growth.

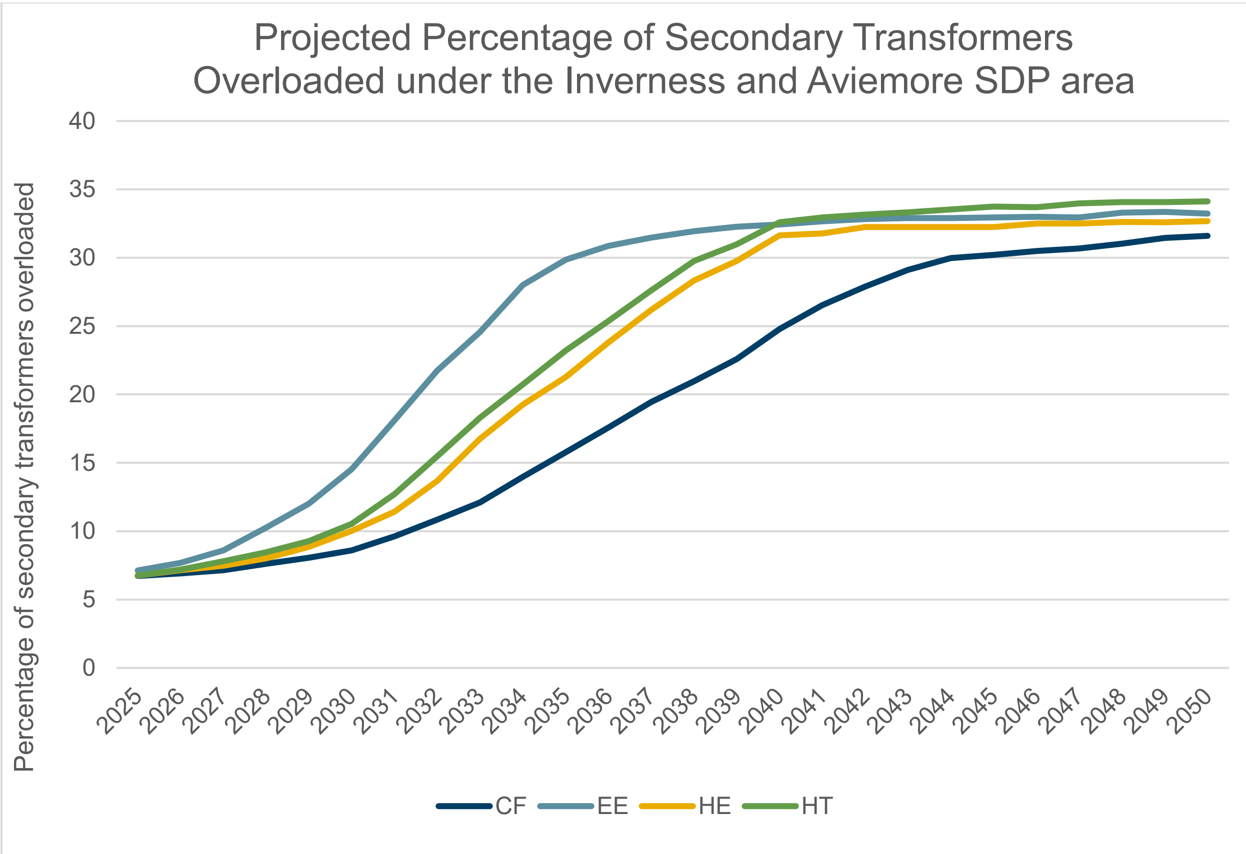


Figure 19 - Inverness and Aviemore 132kV Supply Area projected secondary transformer loading. *Source: SSEN Load Model*

Considering the Just Transition in HV development

SSEN are building on the findings from the Vulnerability Future Energy Scenarios (VFES). This innovation project investigated how the use of new forecasting techniques, along with data analytics and expert validation could be used to identify and forecast consumers in vulnerable situations as we move toward net zero. Use of the outputs from the VFES enable SSEN to develop the network in a way that truly accounts for the levels of vulnerability their customers in different locations face. Inclusion of the use of the VFES also acts as an example of how this data can be used more broadly by SSEN as well as other organisations for spatial planning. For example, it can help us identify areas where energy efficiency mechanisms could help reduce the need for network investment.

One of the outputs from this innovation project was the report produced by the Smith Institute.[23] This work groups LSOAs[24] that share similar drivers of vulnerability. The groupings were informed by mathematical analysis of demographic data and of SSEN's priority service register, using machine learning to model the complex relationships that exist between the two. The resulting group numbers and descriptions are shown in Table 6
.

23 VFES Machine Learning Discovery of Vulnerability Signatures Report, Smith Institute, 08/11/2022, (NIA SSEN 0063: VFES – Vulnerability Future Energy Scenarios | SSEN Innovation)

24 Lower layer Super Output Areas (LSOAs) (Statistical geographies - Office for National Statistics)

Group Number & Level of Vulnerability	Description of Group
1 – Very high	Driven up by higher levels of poor health and disability/mental health benefit claimants, reduced by smaller household sizes.
2 – High	Driven up by larger household sizes, reduced by lower elderly population levels.
3 – High	Driven up by larger elderly population levels, reduced by lower levels of disability and mental health benefit claimants.
4 – Slightly higher than average	Driven up by larger elder population levels and moderately higher provision of care, reduced by smaller household sizes.
5 – Slightly lower than average	Driven down by lower elderly population levels and larger levels of ethnic diversity, increased by higher household sizes and greater provision of care.
6 – Low	Driven down by lower level of bad health and disability/mental health benefit claimants, increased by moderate elderly population levels and household sizes.
7 – Very low	Driven down by substantially lower elderly population levels, less provision of care and a higher level of households in private rented dwellings.

Table 10 - VFES Groupings

To understand the vulnerability groupings across Inverness and Aviemore 132kV supply area we have visualised the LSOA categorisation for the study area. By overlaying secondary transformers that are projected to be overloaded by 2028 (under the Holistic Transition scenario), we begin to understand the crossover between network capacity needs and areas categorised as high vulnerability through the VFES work. This is shown below in Figure 20.

The majority of the Inverness and Aviemore 132kV supply area falls into category 3 or less with higher vulnerability levels. There is a notable cluster of projected overloaded secondary transformers by 2028 under HT around Inverness which coincide with areas of very high vulnerability (category 1).

By overlaying the point locations of secondary transformers projected to be overloaded (in 2028 under the Holistic Transition scenario) we identify areas that are categorised as more vulnerable and also may have capacity shortfalls at the secondary network level. More vulnerable groups may have a lower level of adoption of LCTs and therefore provide less ability to manage overloads through flexibility services. Further they may point towards areas of social housing where there could be a more sudden rollout of LCTs such as heat pumps in the future. They may also highlight areas where there is an evidential need for energy efficiency measures.

We recommend the use of these insights to prioritise work in heavily loaded areas of our network ensuring the network remains secure, stable, and resilient in the areas where vulnerable customers would be most disadvantaged by power outages.

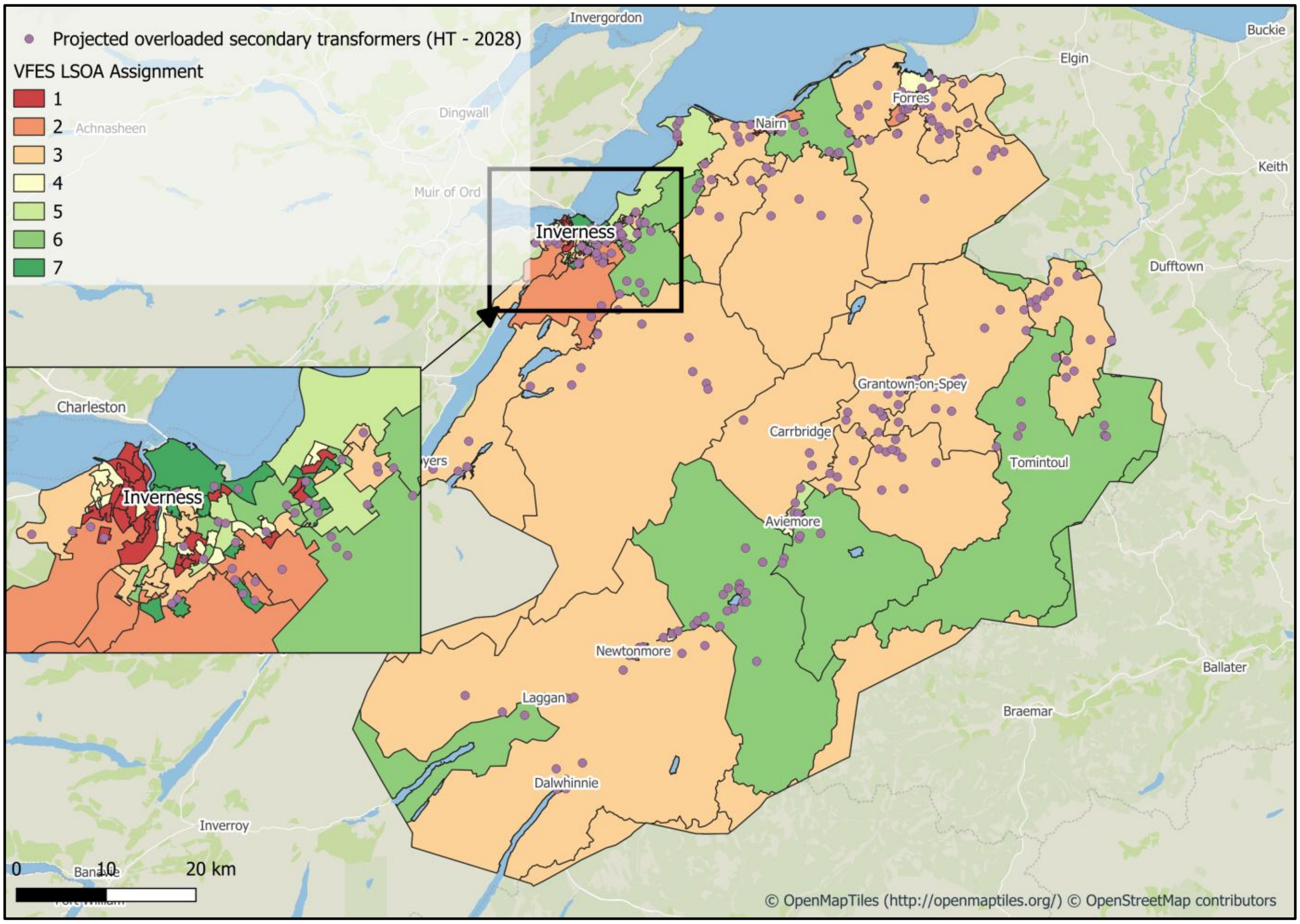


Figure 20 – Inverness and Aviemore 132kV supply area VFES heat map with overloaded secondary transformers.

8.3.2. Low Voltage Networks

Drivers for interventions in low voltage networks may be either capacity related or be driven by voltage requirements. We are progressing options to resolve both drivers. From a network perspective the solution typically involves upgrading the number of LV feeders to split/ balance the load and improve voltage or to install another substation at the remote end of the LV network to balance load and improve voltage. In both instances, flexibility at a local level, especially voltage management products linked to battery export and embedded generation such as solar is likely to be required alongside traditional reinforcement.

We are leveraging recent innovation work through Project LEO (Local Energy Oxfordshire) and My Electric Avenue to inform this strategy. Enhanced network visibility through Smart meter data analytics and low-cost substation feeder monitoring is also necessary to enable appropriate dispatch of services and network reconfiguration.

Capacity driven needs – Thermal constraints tend to materialise in the sections of cable leading to the substation (transformer) where multiple customer loads join together. We are modelling requirements out to 2050 leveraging low voltage monitoring and metering equipment combined with analytical techniques. This will demonstrate how the magnitude of the system need of the LV network across Inverness and Aviemore 132kV Supply Area changes across scenarios and years out to 2050.

Voltage driven needs – Generally, connection of Low Carbon Technology and large loads such as heat pumps is limited by voltage constraints before thermal constraints when located more than around 150m from the local secondary transformer. Increased loading on our low voltage networks can reduce the voltages to consumer premises. This is a non-linear relationship and as such requires more complex analysis. We are currently undertaking analysis to better understand the extent of this future need.

Initial analysis indicates that across the Inverness and Aviemore 132kV supply area 18% of low voltage feeders may need intervention by 2035 and 31% by 2050 under the CT scenario as shown in Figure 21. The need is unlikely to be triggered until 2028 onwards. However, due to the timeline to grow workforce, with jointing skills taking typically 4 years to be fully competent, it is necessary to start recruitment and initiate programmes ahead of need to be able to deliver the required volumes from 2028 onwards.

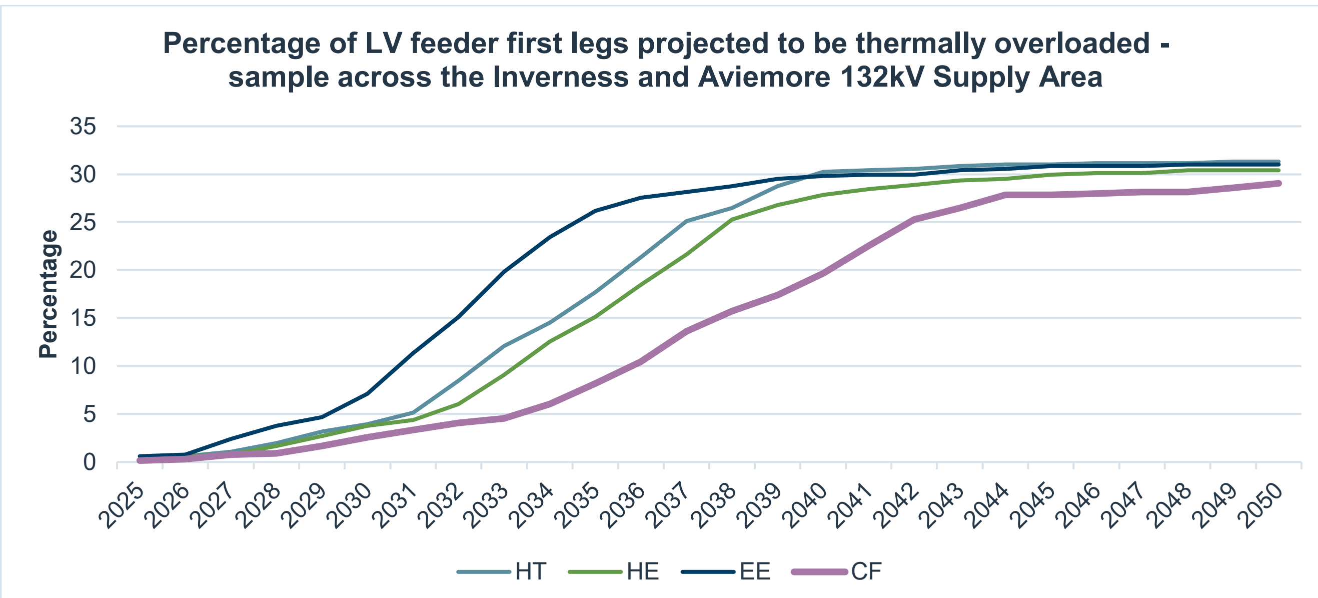


Figure 21 - Percentage of LV feeders projected to be overloaded in the Inverness and Aviemore 132kV supply area.

9. RECOMMENDATIONS

The review of stakeholder engagement and the SSEN 2024 DFES analysis provides a robust evidence base for load growth across the Inverness and Aviemore 132kV supply area group in both the near and longer term. Drivers for load growth across the Inverness and Aviemore 132kV supply area arise from multiple sectors and technologies. These drivers impact not only the EHV network but will drive system needs across all voltage levels.

The findings from this report have provided evidence for 6 key recommendations:

1. System needs that have been identified at earlier timescales (ahead of 2035) should be studied in more detail and these should be progressed through the DNOA process. This relates to the assets tabulated in section 8.2.

2. Considering the significant generation growth expected across the Inverness and Aviemore 132kV supply area, engagement with SSEN Transmission and NESO should be proactive creating a long-term plan for the area which incorporates the outputs of CP2030 and connections reform. More detailed network studies should also be carried out to determine how growth in generation will impact the network, especially in summer minimum demand maximum generation conditions.

3. As the move away from LMAs develops, continued work should take place to understand the impact of households not participating in flexibility markets and the network reinforcements triggered by this. The move away from radio tele switching (RTS) to smart meters should also be supported if technical difficulties arise.

4. Industrial decarbonisation and domestic developments across the Inverness and Aviemore 132kV supply area will increase the electricity demand out to 2050. It's recommended that continued engagement with these stakeholders should take place to understand planned new sites for data centres, industrial sites, and domestic developments.

5. Due to the length of the circuits in the more rural areas in the Inverness and Aviemore 132kV supply area several future voltage constraints have been identified, and occasionally circuits will have both thermal and voltage constraints. Detailed studies should be carried out to determine where reinforcements could resolve both constraints, creating the most cost-effective solution and ensuring network does not have to be 'touched twice'.

6. Understanding how rural decarbonisation could impact load on the network. Specifically, the electrification of distilleries and how to capture those plans in load forecasts. It will also be important to understand how substations <1MW or covered by security of supply exemptions will be affected by increased demand. Where justified we will remove historic exemptions.

Actioning these recommendations will allow SSEN to develop a network that supports local net zero ambitions and enables growth in the local economy. By doing so, this will ultimately contribute to net zero targets at a national level.

Appendix A: Existing Network Infrastructure

Substation Name	Site Type	Number of Customers Served (approximate)	2024/25 Substation Maximum demand in MVA (Season)
Ardesier	Primary Substation	1035	2.2
Aviemore	Primary Substation	3103	10
Ballindalloch	Primary Substation	1138	4.6
Boat of Garten 11kV	Primary Substation	1326	2.9
Culloden	Primary Substation	6399	9.6
Dalcross	Primary Substation	848	3.3
Dalneigh	Primary Substation	7743	8.3
Dalwhinnie	Primary Substation	293	0.7
Errogie	Primary Substation	75	0.1
Forres	Primary Substation	6977	9.9
Foyers	Primary Substation	137	0.4
Grantown	Primary Substation	2630	5.9
Hilton	Primary Substation	9673	10.9
Inverarnie	Primary Substation	441	0.9
Inverness 11 kV	Primary Substation	5733	8.1
Kingussie	Primary Substation	2218	4.2
Lethen	Primary Substation	899	1.7
Nairn Central	Primary Substation	6303	9.4
Raigmore	Primary Substation	4034	17
Tomatin	Primary Substation	326	0.9
Waterloo Place	Primary Substation	2831	16.1
Wester Drummond	Primary Substation	13	0

Appendix B: EHV/HV spatial plans for other DFES scenarios

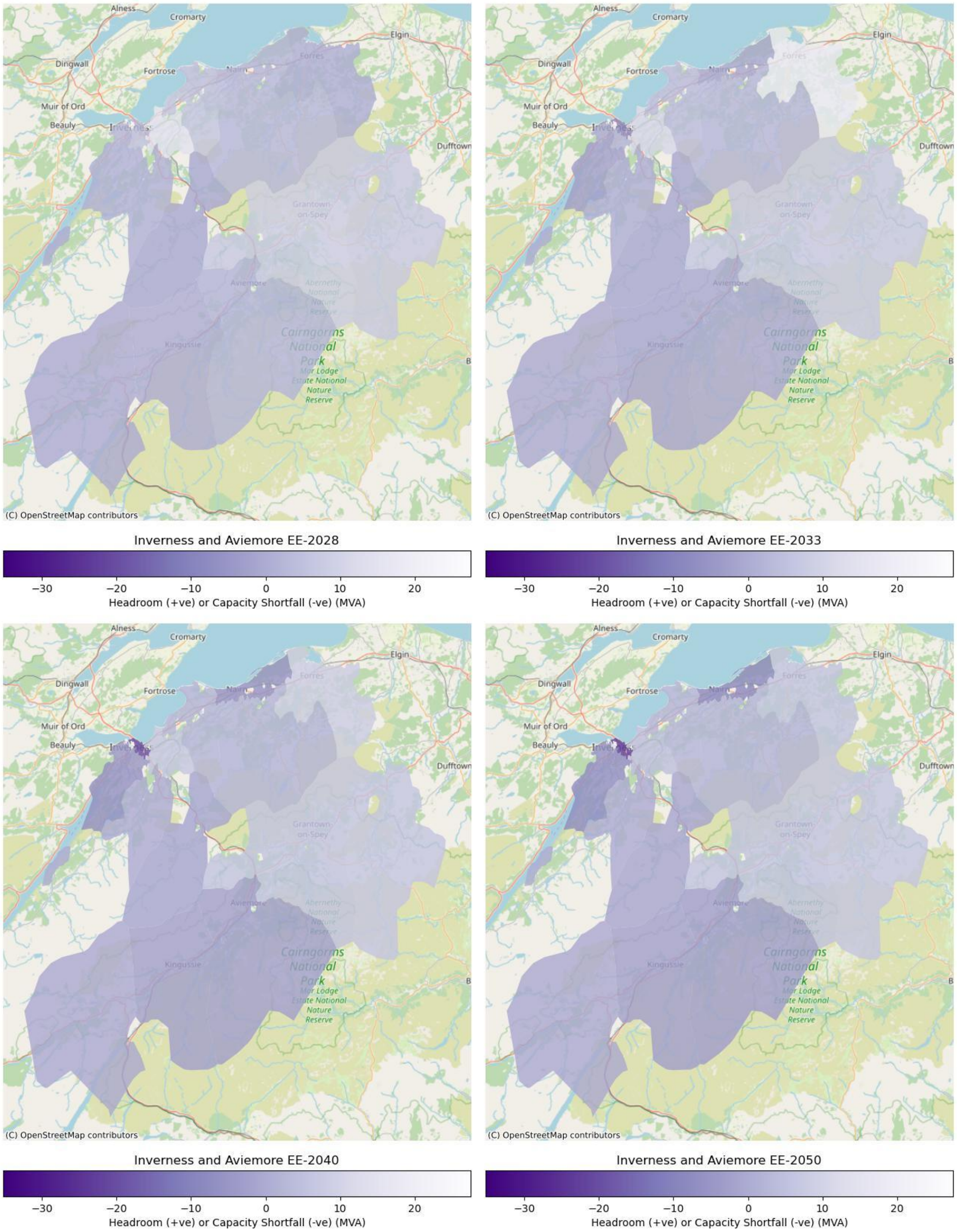


Figure 22 Inverness and Aviemore 132kV supply area - EHV/HV Spatial Plan - Electric Engagement

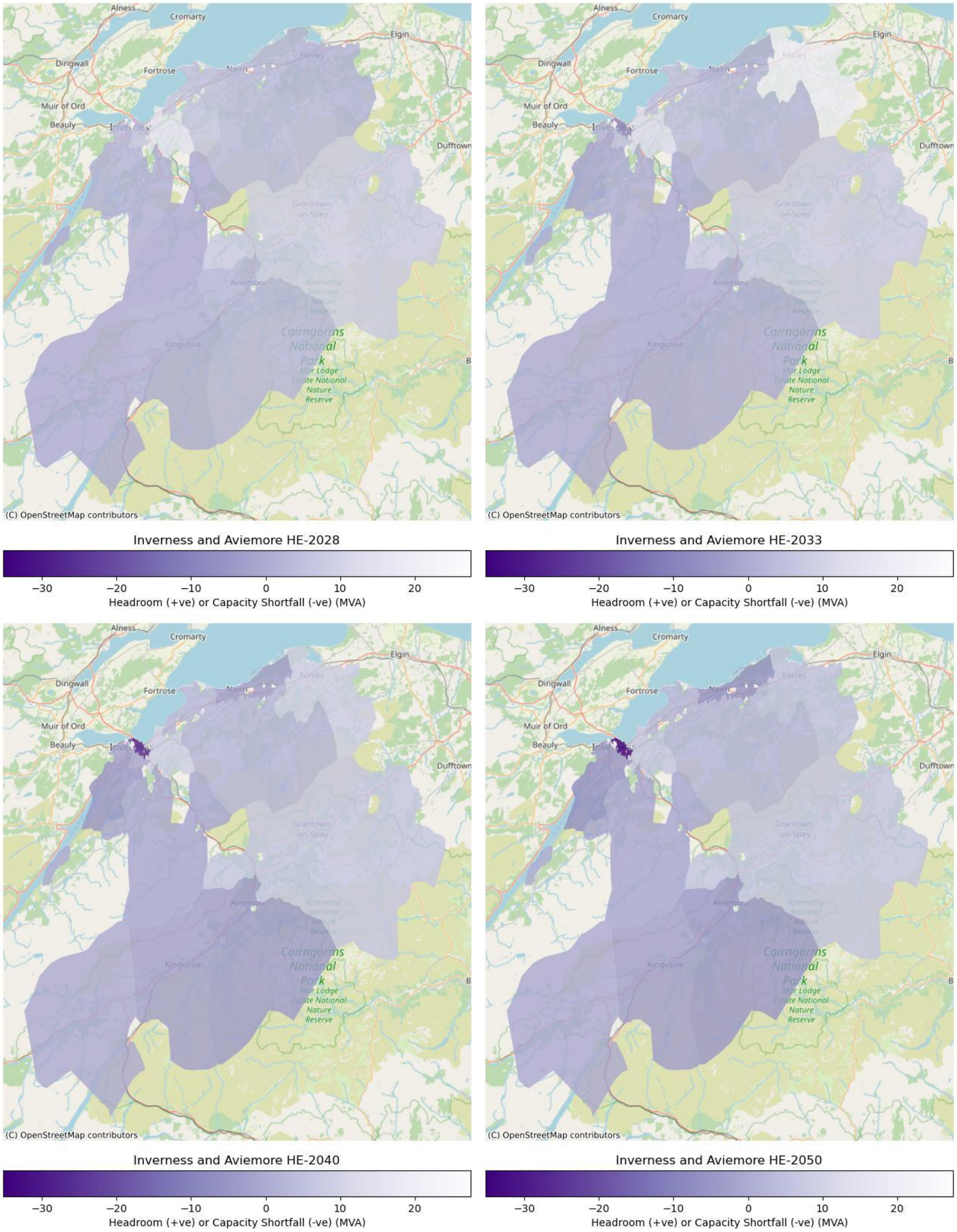


Figure 23 Inverness and Aviemore 132kV supply area - EHV/HV Spatial Plan – Hydrogen Evolution

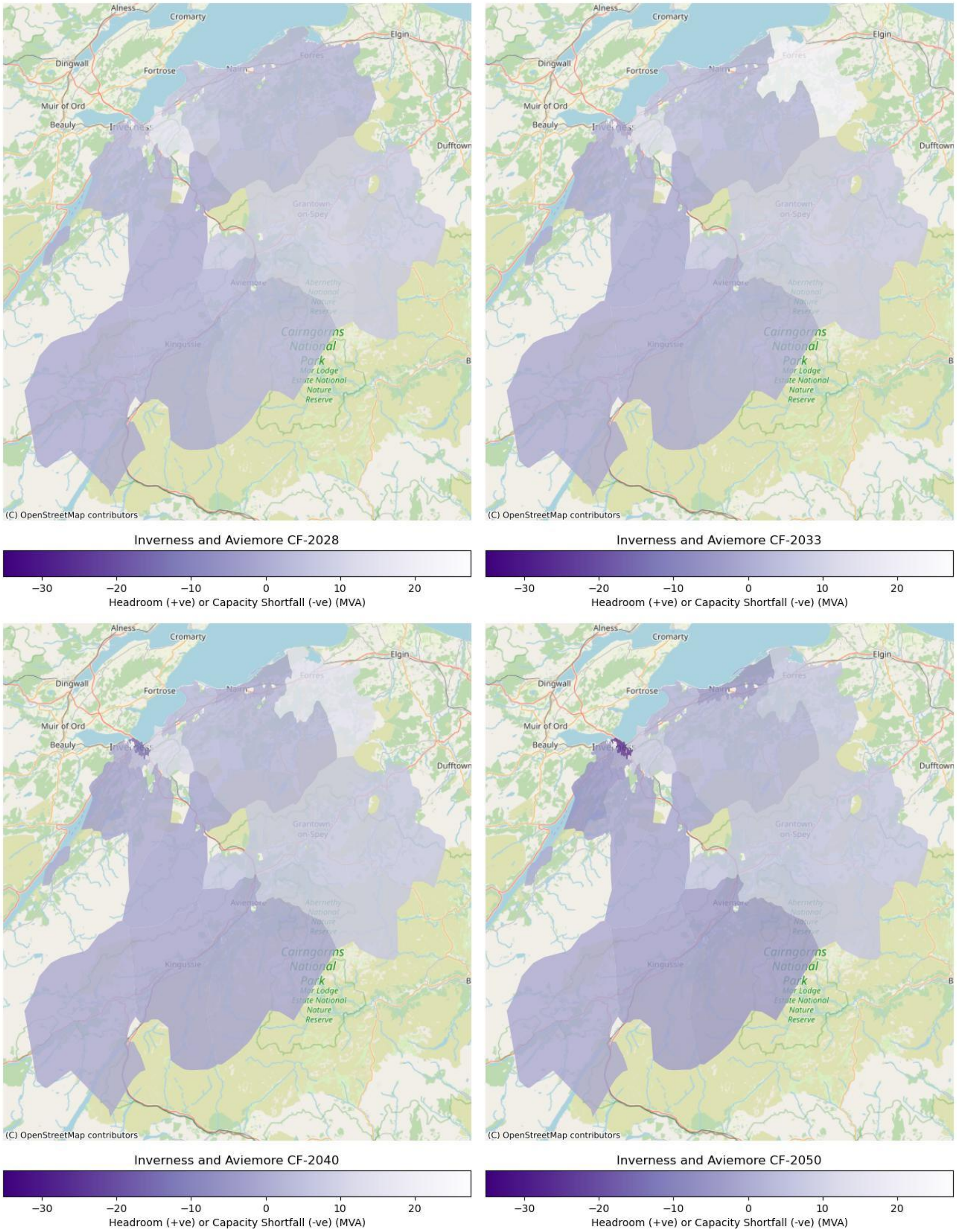


Figure 24 Inverness and Aviemore 132kV supply area - EHV/HV Spatial Plan – Counterfactual

Appendix C: HV/LV spatial plans for other DFES scenarios

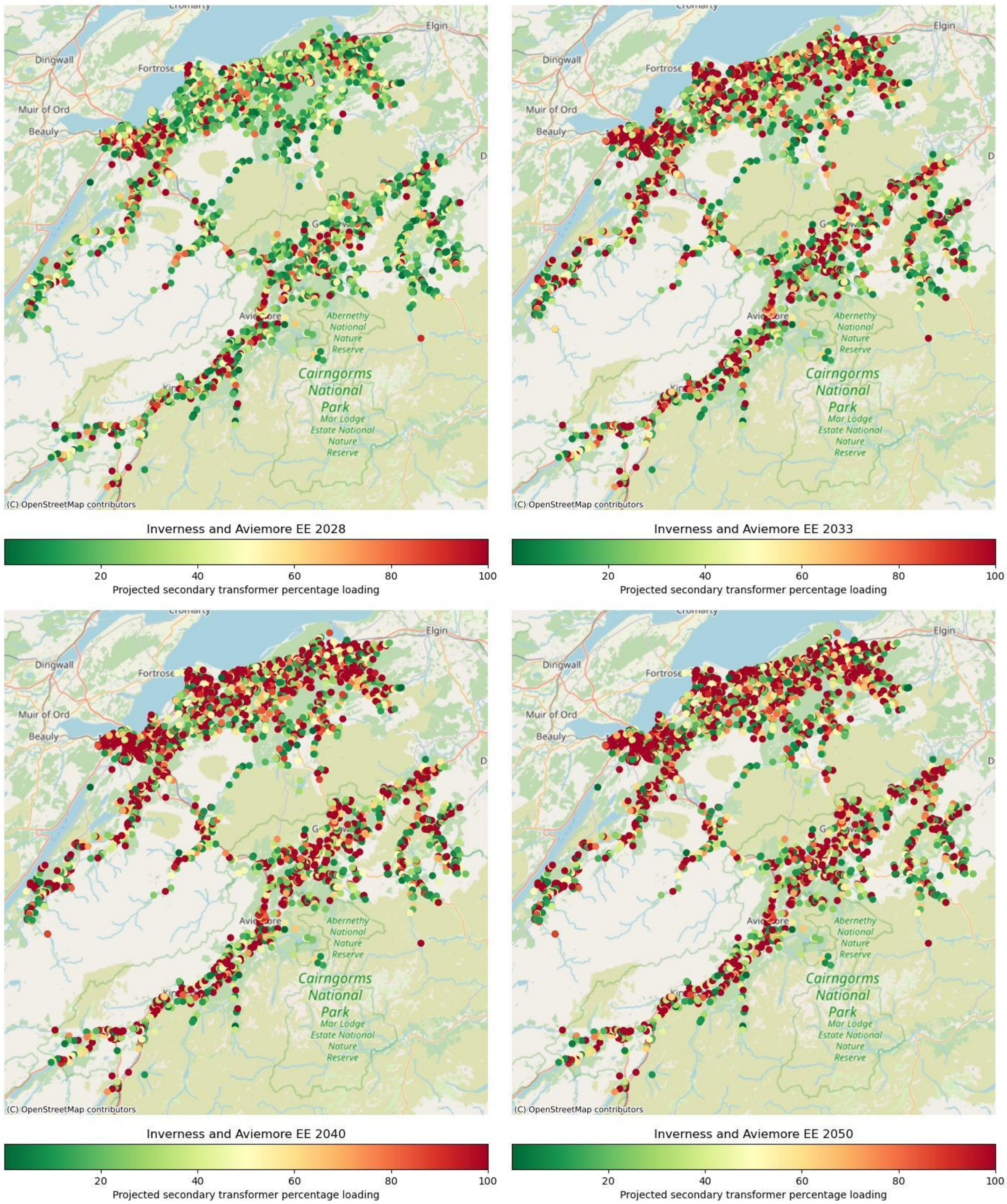


Figure 25 Inverness and Aviemore 132kV supply area - HV/LV Spatial Plan – Electric Engagement

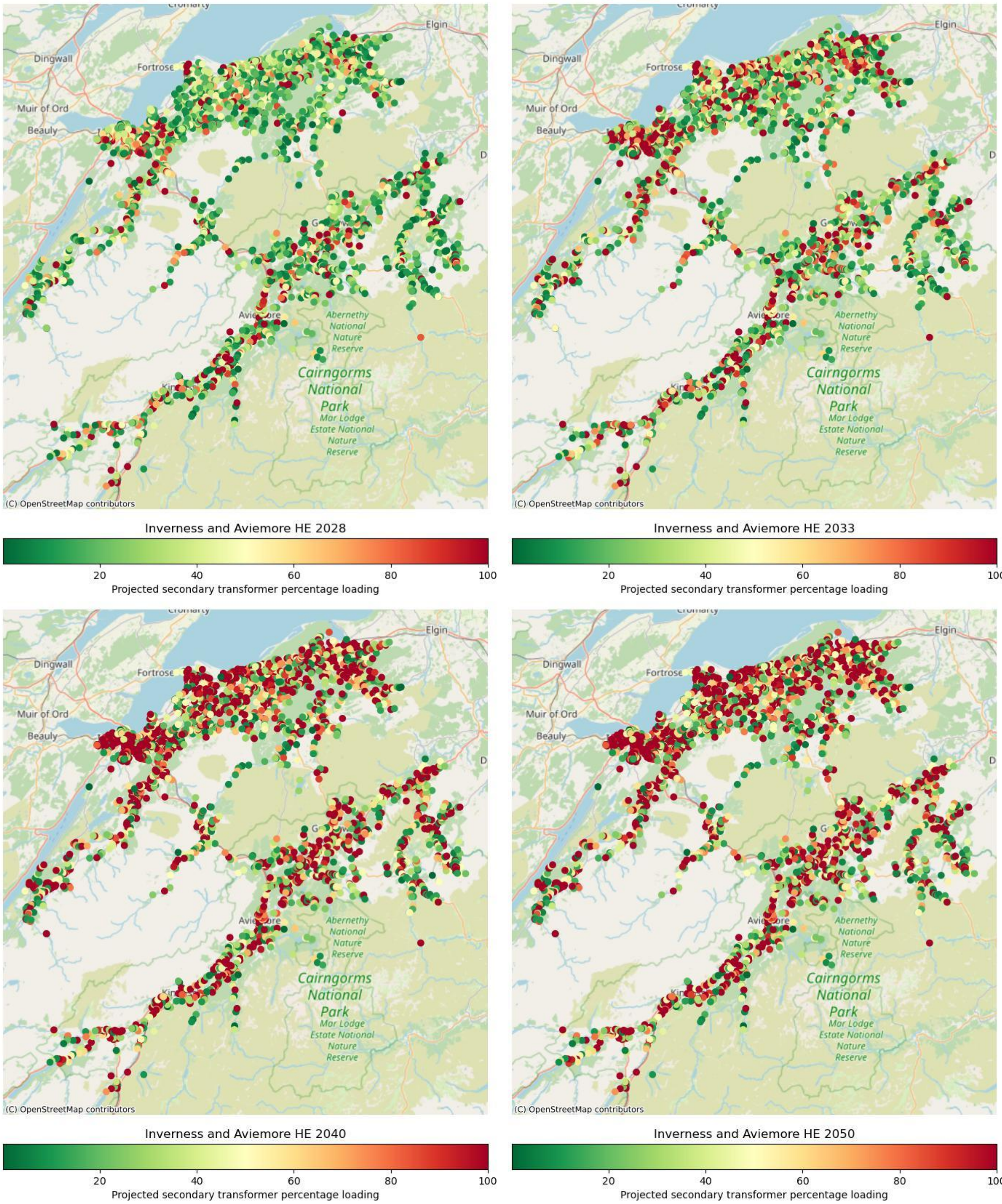


Figure 26 Inverness and Aviemore 132kV supply area - HV/LV Spatial Plan – Hydrogen Evolution

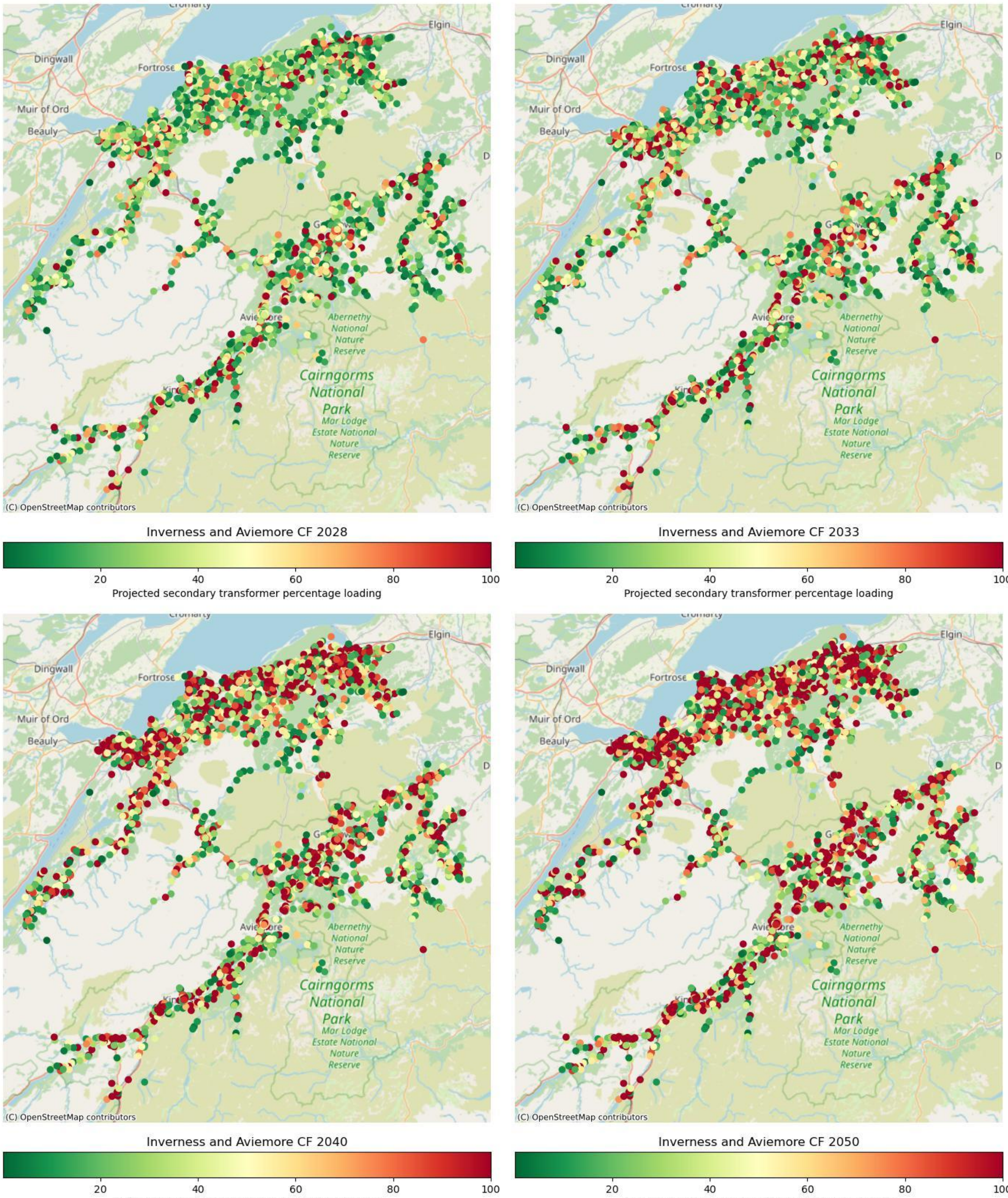


Figure 27 Inverness and Aviemore 132kV supply area - HV/LV Spatial Plan - Counterfactual

Appendix D: Relevant DNOA Outcome Reports

DNOA Outcome Report

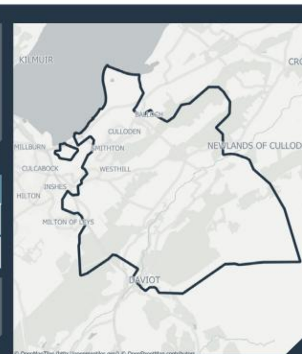
Culloden (Inverness)

Scheme description

- Culloden 33/11kv primary substation is located within the Inverness area. Postcodes – IV1 , IV2
- Load related – thermal overloading of primary substation & circuits beyond minimum standard for security of supply by 2026 (LTW) and 2027 (CT).

Proposed option

- Flexibility in 2025/26 and 2026/27 ahead of reinforcement works to build new 33/11kv primary substation and reconfigure existing circuits.
- This option provides the most economic & sustainable solution to preventing thermal overloading.



Sysem need requirement

J	F	M	A	M	J	J	A	S	O	N	D

DNOA History

2023/24	2024/25	2025/26	2026/27	2027/28
Initial assessment				

Indicative flexibility price (if available):

- Availability £150/MWh
- Utilisation £200/MWh

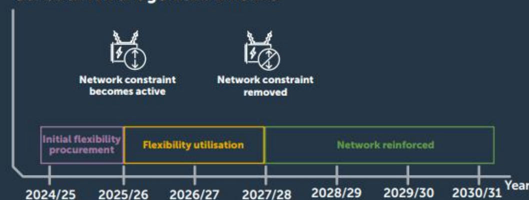
Reinforcement timeline

- Flexibility utilisation 2025/26 & 2026/27
- Reinforcement delivery by end 2027/28

Estimated peak MW outside firm network capacity under each scenario
Grey text relates to estimated peak MW without reinforcement delivery

	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31
CT	-	-	0.76	- (1.96)	- (3.06)	- (4.16)	- (5.26)
ST	-	-	-	- (0.36)	- (0.86)	- (1.46)	- (1.86)
LTW	-	0.46	1.66	- (3.06)	- (4.26)	- (5.66)	- (7.06)
FS	-	-	-	-	-	- (0.46)	- (0.96)

Constraint management timeline



DNOA Outcome Report

Inverness (Waterloo Place PSS)

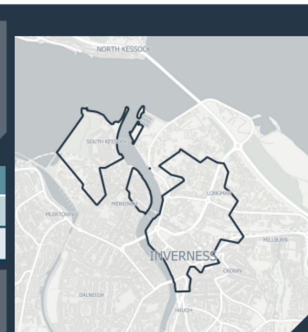
Ref. 0724-10

Scheme description

- Waterloo Place primary substation is situated in Inverness. Postcode(s): IV1, IV2.
- Load related - Future thermal overloading of substation during FCO conditions due to forecasted demand growth.

Proposed option

- Upgrade existing primary transformers and 11KV switchboard at Waterloo place primary substation.
- 20/40MVA transformers to be installed based on 2050 demand forecasts. Due to step change in demand, this has been identified as the most efficient solution.
- Capacity released: 17MVA



System need requirement

J	F	M	A	M	J	J	A	S	O	N	D

DNOA History

2024/25	2025/26	2026/27	2027/28	2028/29
Initial assessment				

Indicative flexibility price (if available):

- Availability: N/A
- Utilisation: N/A

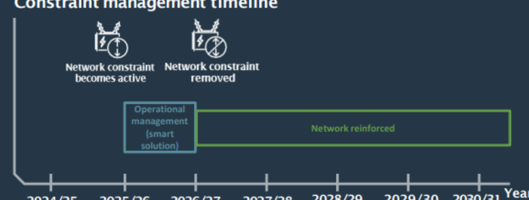
Reinforcement timeline

- Reinforcement delivery complete by 2026/27.

Estimated peak MW outside firm network capacity under each scenario
Grey text relates to estimated peak MW without reinforcement delivery

	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31
CT	-	1.35	- (1.83)	- (2.35)	- (3.10)	- (4.18)	- (5.18)
ST	-	0.45	- (0.79)	- (0.88)	- (1.06)	- (1.47)	- (1.80)
LTW	-	1.05	- (1.39)	- (1.62)	- (2.08)	- (2.61)	- (3.91)
FS	-	0.3	- (0.49)	- (0.29)	- (0.33)	- (0.32)	- (0.39)

Constraint management timeline



DNOA Outcome Report

Ardersier
(Ardersier and Dalcross PSS)

Scheme description

- The reinforcement of the 33kV overhead line from Nairn to Ardersier and Dalcross PSSs will increase capacity in the Ardersier area. Postcode(s): IV1, IV2, IV12.
- Local authority: Highland
- Load related – substation and circuit thermal overload and voltage issues during intact conditions due to forecasted demand growth.

Proposed option

- Smart/Asset Solution: Replacement of the existing overhead line from Nairn busbar to Ardersier tee with underground cable.
- Flexibility was unable to be utilised due to being uneconomical from CEM output.
- This option addresses the forecasted thermal overload on the 33kV overhead line out to 2050.
- Capacity released: 15.7MVA

System need requirement

J	F	M	A	M	J	J	A	S	O	N	D

DNOA History

2024/25	2025/26	2026/27	2027/28	2028/29
Initial assessment				

Indicative flexibility price (if available):

- Availability price: N/A
- Utilisation price: N/A

Reinforcement timeline

- Reinforcement delivery by the end of 2026/27.

Estimated peak MW outside firm network capacity under each scenario
Grey text relates to estimated peak MW without reinforcement delivery

	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31
CT	1.27	1.74	2.37	- (3.12)	- (4.10)	- (5.18)	- (6.00)
ST	1.26	1.68	2.23	- (2.88)	- (3.71)	- (4.68)	- (5.40)
LTW	1.33	1.85	2.51	- (3.27)	- (4.26)	- (5.38)	- (6.27)
FS	1.25	1.67	2.15	- (2.74)	- (3.54)	- (4.43)	- (5.11)

Constraint management timeline

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DNOA Outcome Report

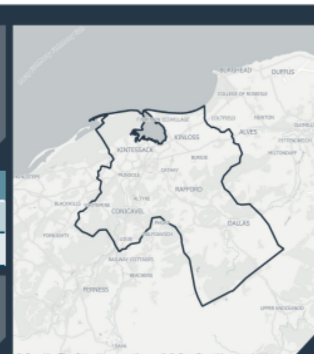
Forres and Kinloss
(Forres and Kinloss PSS)

Scheme description

- The reinforcement of the Forres and Kinloss PSSs will increase capacity in the Forres and Kinloss area. Postcode(s): IV36.
- Local authority: Moray
- Load related – substation and circuit thermal overload and voltage issues during FCO and intact conditions due to forecasted demand growth.

Proposed option

- Flexibility/Asset Solution: Reinforce the 33kV supply circuits to Forres and Kinloss PSSs.
- This option addresses the forecasted thermal and voltage issues at Forres and Kinloss PSSs out to 2050.
- Capacity released: 36.8MVA



System need requirement

J	F	M	A	M	J	J	A	S	O	N	D

DNOA History

2024/25	2025/26	2026/27	2027/28	2028/29
Initial assessment				

Indicative flexibility price (if available):

- Availability price: £150/MW/h
- Utilisation price: £200/MWh

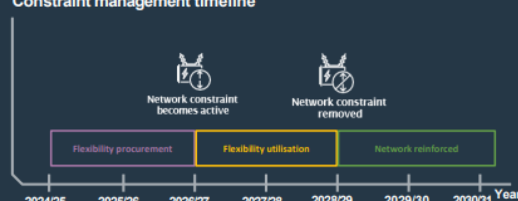
Reinforcement timeline

- Flexibility solution utilised from start of 2026/27 until end of 2027/28.
- Reinforcement delivery by the end of 2027/28.

Estimated peak MW outside firm network capacity under each scenario
Grey text relates to estimated peak MW without reinforcement delivery

	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31
CT	-	-	0.04	1.59	- (3.43)	- (5.35)	- (6.88)
ST	-	-	-	-	- (0.92)	- (2.31)	- (3.35)
LTW	-	-	0.84	2.48	- (4.38)	- (6.51)	- (8.45)
FS	-	-	-	-	-	- (0.37)	- (1.14)

Constraint management timeline



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DNOA Outcome Report

Forres (Forres PSS)

Scheme description

- The reinforcement of the Forres PSS will increase capacity in the Forres area. Postcode(s): IV36.
- Local authority: Moray
- Load related – substation thermal overload issues during intact conditions due to forecasted demand growth.

Proposed option

- Flexibility/Asset Solution: Replacement of the Forres 33/11 kV transformers.
- This option addresses the forecasted thermal overload at the transformers feeding Forres PSS out to 2050.
- Capacity released: 25MVA

System need requirement

J	F	M	A	M	J	J	A	S	O	N	D

DNOA History

2024/25	2025/26	2026/27	2027/28	2028/29
Initial assessment				

Indicative flexibility price (if available):

- Availability price: £150/MW/h
- Utilisation price: £200/MWh

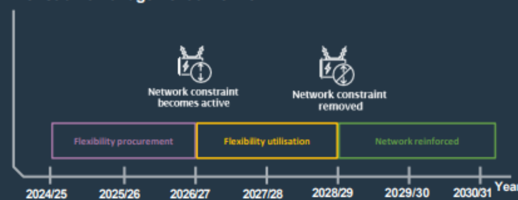
Reinforcement timeline

- Flexibility solution utilised from start of 2026/27 until end of 2027/28.
- Reinforcement delivery by the end of 2027/28.

Estimated peak MW outside firm network capacity under each scenario
Grey text relates to estimated peak MW without reinforcement delivery

	2024/25	2025/26	2026/27	2027/28	2028/29	2029/30	2030/31
CT	-	-	1.21	3.03	- (5.20)	- (7.47)	- (9.26)
ST	-	-	0.08	1.28	- (2.50)	- (4.20)	- (5.45)
LTW	-	0.25	2.08	3.99	- (6.22)	- (8.73)	- (10.95)
FS	-	-	-	0.12	- (1.11)	- (2.10)	- (3.07)

Constraint management timeline



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Northeast Inverness (Raigmore PSS)

DNOA Outcome Report

Related SDP: Inverness and Aviemore

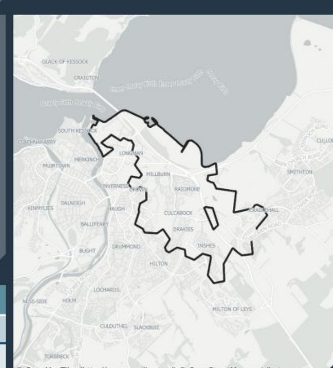
DNOA outcome: Flexibility followed by asset solution.

Scheme description

- The reinforcement of the Raigmore PSS will increase capacity in the Northeast Inverness area. Postcode(s): IV1, IV2, IV3.
- Local authority: Highland
- Load related – substation thermal overload during FCO conditions due to forecasted demand growth.

Proposed option

- Flexibility/Asset Solution: Build a new PSS with new shared 33kV circuits to Raigmore PSS and the new PSS to decrease the load on Raigmore PSS.
- This option addresses the forecasted thermal overload at Raigmore PSS out to 2050.
- Capacity released: 34MVA



Indicative flexibility price (if available)

Availability price: £ 123 /MW/h Utilisation price : £ 169 /MWh

System need requirement

J	F	M	A	M	J	J	A	S	O	N	D

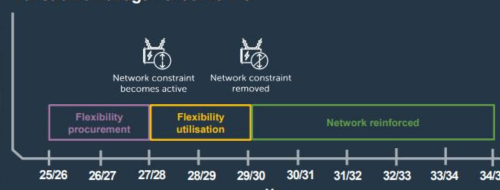
DNOA History

2024/25	2025/26	2026/27	2027/28	2028/29
Initial assessment				

Estimated peak MW outside firm network capacity under each scenario

	25/26	26/27	27/28	28/29	29/30	30/31	31/32	32/33	33/34	34/35
CT	-	-	0.55	1.13	(1.97)	(2.63)	(3.33)	(3.99)	(4.62)	(5.31)
ST	6.20	6.77	7.31	7.66	(8.39)	(8.83)	(9.34)	(10.07)	(10.93)	(11.93)
LTW	12.91	13.55	14.25	15.15	(16.25)	(17.37)	(18.31)	(19.33)	(20.38)	(21.39)
FS	-	-	-	-	-	-	-	-	-	(0.12)

Constraint management timeline



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Appendix E: Glossary

Acronym	Definition
AIS	Air Insulated Switchgear
ANM	Active Network Management
BAU	Business as Usual
BSP	Bulk Supply Point
CB	Circuit Breaker
CBA	Cost Benefit Analysis
CER	Consumer Energy Resources
CF	Counterfactual
CMZ	Constraint Managed Zone
CT	Consumer Transformation
DER	Distributed Energy Resources
DESNZ	Department for Energy Security and Net Zero
DFES	Distribution Future Energy Scenarios
DNO	Distribution Network Operator
DNOA	Distribution Network Options Assessment
DSO	Distribution System Operation
DSR	Demand Side Response
EE	Electric Engagement
EHV	Extra High Voltage
EJP	Engineering Justification Paper
ER P2	Engineering Recommendation P2
NESO	National Energy System Operator
NGET	National Grid Electricity Transmission
ENA	Electricity Networks Association
EV	Electric Vehicle
FES	Future Energy Scenarios
FS	Falling Short

GIS	Gas Insulated Switchgear
GSPs	Grid Supply Point
HE	Hydrogen Evolution
HT	Holistic Transition
HV	High Voltage
kV	Kilovolt
LAEP	Local Area Energy Planning
LCT	Low Carbon Technology
LENZA	Local Energy Net Zero Accelerator
LV	Low Voltage
LW	Leading the Way
OHL	Overhead Line
PSS	Primary Substation
PV	Photovoltaic
NSHR	Network Scenario Headroom Report (part of the Network Development Plan)
MW	Megawatt
MVA	Mega Volt Ampere
ODM	Operational Decision Making
RESOP	Regional Energy System Operation Planning
RIIO-ED1/2	Revenue = Incentives + Innovation + Outputs, Electricity Distribution 1 / 2 (regulatory price control periods)
SDP	Strategic Development Plan
SEPD	Southern Electric Power Distribution
SLC	Standard Licence Condition
SSEN	Scottish and Southern Electricity Networks
ST	System Transformation
UM	Uncertainty mechanism
VFES	Vulnerability Future Energy Scenarios
WSC	Worst Served Customers

CONTACT

whole.system.distribution@sse.com

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