BEAULY 132KV SUPPLY AREA: STRATEGIC DEVELOPMENT PLAN

Our network serving communities across the Northwest Highlands

(Final following 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 to 2050 and translate these requirements into strategic spatial plans of the future 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 (Strategic Development Plan Methodology - January 2025).

The focus area of this SDP is that supplied by Alness, Beauly, Cassley, Grudie Bridge, Lairg, and Shin Grid Supply Points (GSPs), covering the Northwest area of the Highland Council.
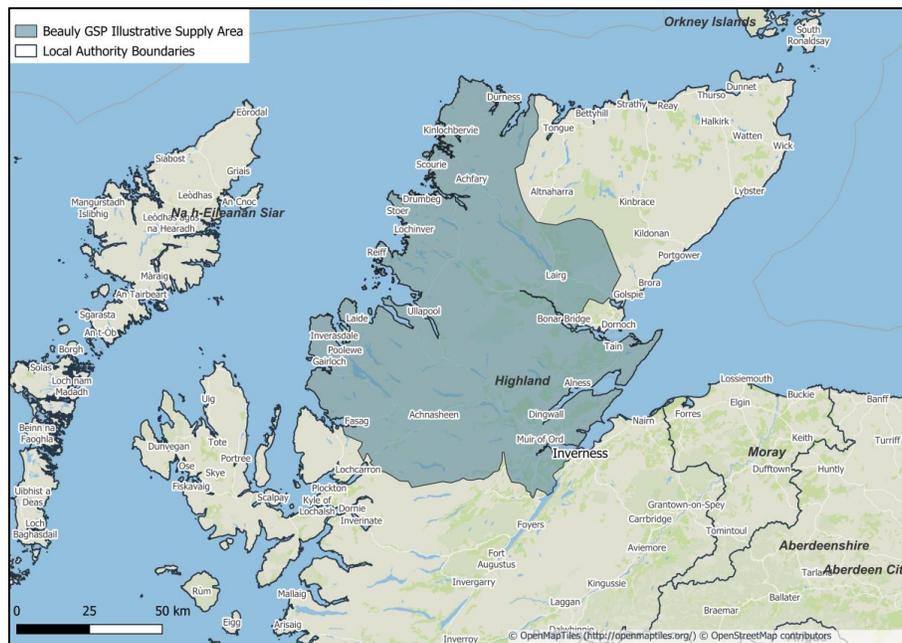
Figure 1 Geographic area covered by this report.

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 the Northwest Highlands area have been considered in preparation of this plan. Some reinforcement 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 pathway 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.

2. INTRODUCTION

The aim of this report is to demonstrate how local, regional, and national targets link with other stakeholder views in the area to provide a robust evidence base for load growth out to 2050 across the Alness, Beauly, Cassley, Grudie Bridge, Lairg, and Shin Grid Supply Points (GSPs) that make up the Beauly 132kV supply area. A GSP is an interface point with the national transmission system where SSEN then take power to local homes and businesses within a geographic area, they have been grouped by electrical connection to cover a larger area. Context for the area this represents is shown above in Figure 1. This report was produced in alignment with SSEN's Strategic Development Plan methodology.[1] The methodology report outlines the process that we follow in the rollout of our Strategic Development Plans and should be referred to alongside this report.

To identify the future requirements of the electricity network, SSEN commission 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 accounting for 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 four different scenarios as we move towards the national 2050 net zero target. Due to the timing of when this report was produced, this SDP has been informed by the analysis undertaken as part of the DFES 2023. DFES 2023 consists for four different scenarios which are summarised in Appendix B. SSEN currently use Consumer Transformation as the central case scenario following stakeholder feedback during the RIIO-ED2 development process. This position is reviewed annually. The 2024 DFES outlines three new pathways (Holistic Transition, Electric Engagement, and Hydrogen Evolution) that achieve net zero by 2050 against a Counterfactual and further detail on DFES 2024 can be found in Appendix B and in the DFES 2024 reports.
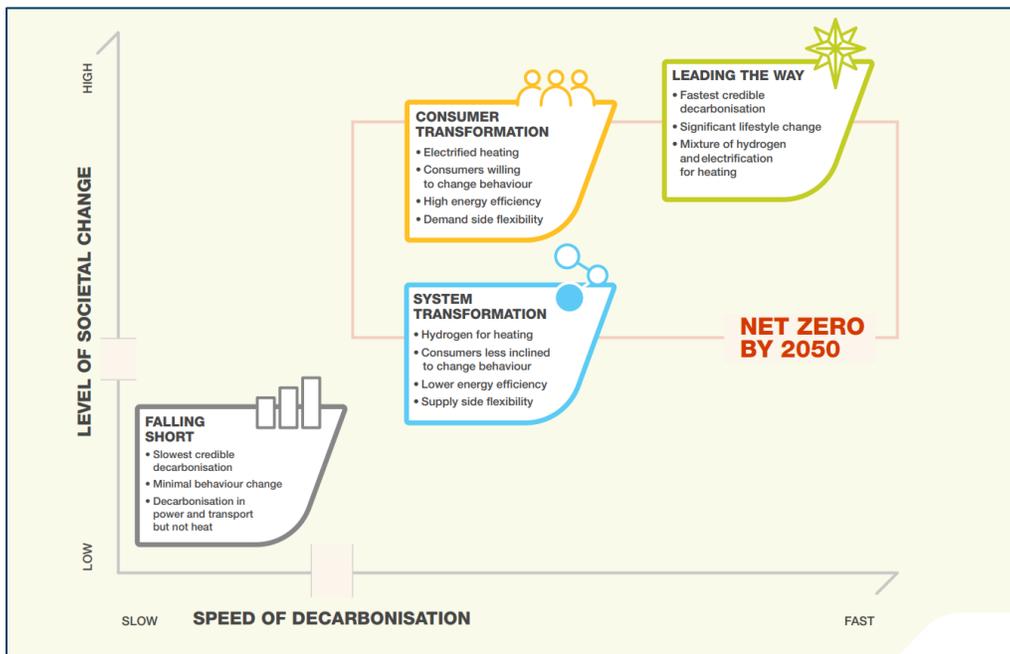
Figure 2 DFES 2023 Scenarios.

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1 Strategic Development Plan Methodology - January 2025

Using the DFES, power system analysis has been carried out to identify the future system needs of the electricity network. These needs are summarized by highlighting the year the need is identified under each of the four scenarios, and the projected 2050 load. Here, system needs are identified through power system analysis using the DFES 2023 Consumer Transformation scenario in alignment with evidence gathered in preparation of the SSEN ED2 business plan. We also model across the other three scenarios to understand when these needs arise and what demand projections should be planned for in the event each of these scenarios is realised.

The DNOA process provides more detailed optioneering for each of these reinforcements, improving stakeholder visibility of the strategic planning process. Opportunities for procurement of flexibility will also be highlighted in the DNOA, to cultivate the flexibility markets, and to align with SSEN's flexibility strategy.

3. STAKEHOLDER ENGAGEMENT AND WHOLE SYSTEM CONSIDERATIONS

3.1. Local Authorities and Local Area Energy Planning

The local authority that is supplied by Beauly 132kV network is the Highland Council local authority, as shown in **Figure 6.** 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.
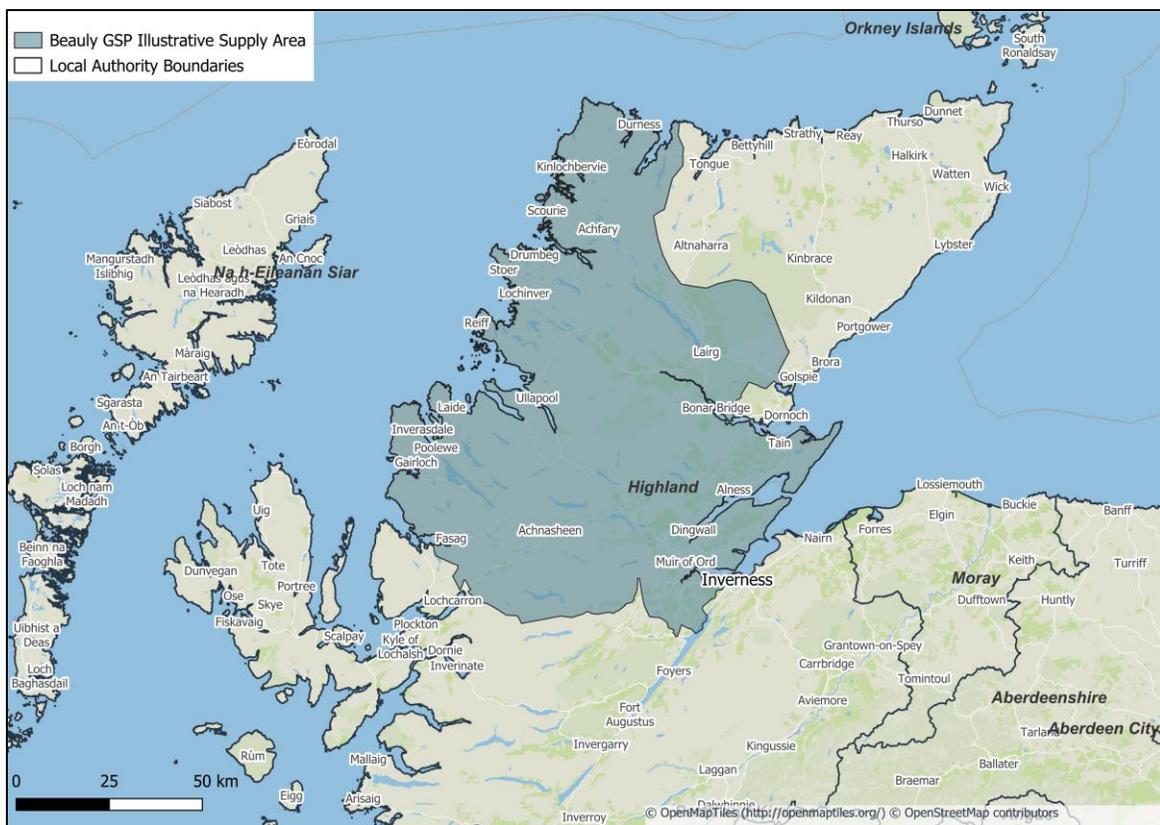
Figure 3 Beauly GSP Supply Area and Local Authority Boundaries

3.1.1. Highland Stakeholders

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[2].

2 City_Region_Deal_Annual_Report_2024.pdf

Highland Council has published their Net Zero Strategy[3] 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[4]. 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[5] 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[6].

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.

3.2. Whole System Considerations

Beauly 132kV supply area is experiencing high levels of battery storage and generation connection applications. The impact of Clean Power 2030 on connections relating to current works and future system needs will need to be carefully considered and this SDP will be updated in future iterations accordingly.

3.2.1. Load Managed Areas

The Beauly 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 Beauly SDP supply area account for approximately 16% of all customers, a break down by GSP is shown in the table below.

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3 Net Zero Strategy | Climate change | The Highland Council

4 Net Zero Strategy | Climate change | The Highland Council

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

6 Electric Vehicle Infrastructure Fund | Transport Scotland

Substation Name	Site Type	% of LMA customers
Alness	Grid Supply Point	18.2
Beauly	Grid Supply Point	14.8
Cassley	Grid Supply Point	18.9
Grudie Bridge	Grid Supply Point	21.2
Lairg	Grid Supply Point	15.8
Shin	Grid Supply Point	15.9

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 several transmission upgrades planned for the Beauly 132kV supply area [7]. Out to 2030, a major reinforcement work to be completed is the upgrade of the Beauly – Denny overhead line circuit connecting to Beauly substation, where the 275kV line will be uprated to 400kV. Two other major works to be completed are the new offshore DC cable running from Beauly substation to Stornoway on the Isle of Lewis and a new 400kV line running through the area from Beauly up to Mybster in the north. There are also several new GSPs that have been triggered by generation connections; however, these projects may be subject to change due to the impact connections reform and Clean Power 2030.

3.2.3. Ports

The Beauly SDP area supplies a significant coastal area including the ports of Ullapool, Cromarty Firth, Nigg, and Highland Deephaven, are looking to new developments to support the offshore wind industry. Furthermore, the Inverness and Cromarty Firth Green Freeport area, developed to accelerate economic growth and support decarbonisation, covers most of these ports. The Shipping sector is a new, large electricity customer, and the UK's target of achieving zero-emissions shipping by 2050 will lead to a substantial increase in the demand for electricity across the maritime industry. Whilst this is not accounted for fully in the DFES 2023 projections here, future insight from SSEN's SeaChange innovation project will provide high quality insights for this in future iterations.[8] Further to the maritime industry, other large demand users connected to the distribution network include car manufacturing sites.

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7 ETYS documents and appendices | National Energy System Operator

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

3.2.4.   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 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 of 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.[9],[10]

SSEN regularly recruits new Flexibility Services providers and increases the procured Flexibility Services with the latest bidding round for long term requirements held in August 2024 and recruitment through the Mini-Competition process in October 2024.[6]

Across the Beauly 132kV supply area 26.68MW[11] of peak contracted capacity has already been procured, with more expected to be needed in the future. The areas where this 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.

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

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

11 SSEN, 02/2024, Flexibility Services Contract Register flexibility-services-contract-register-v2.7.xlsx
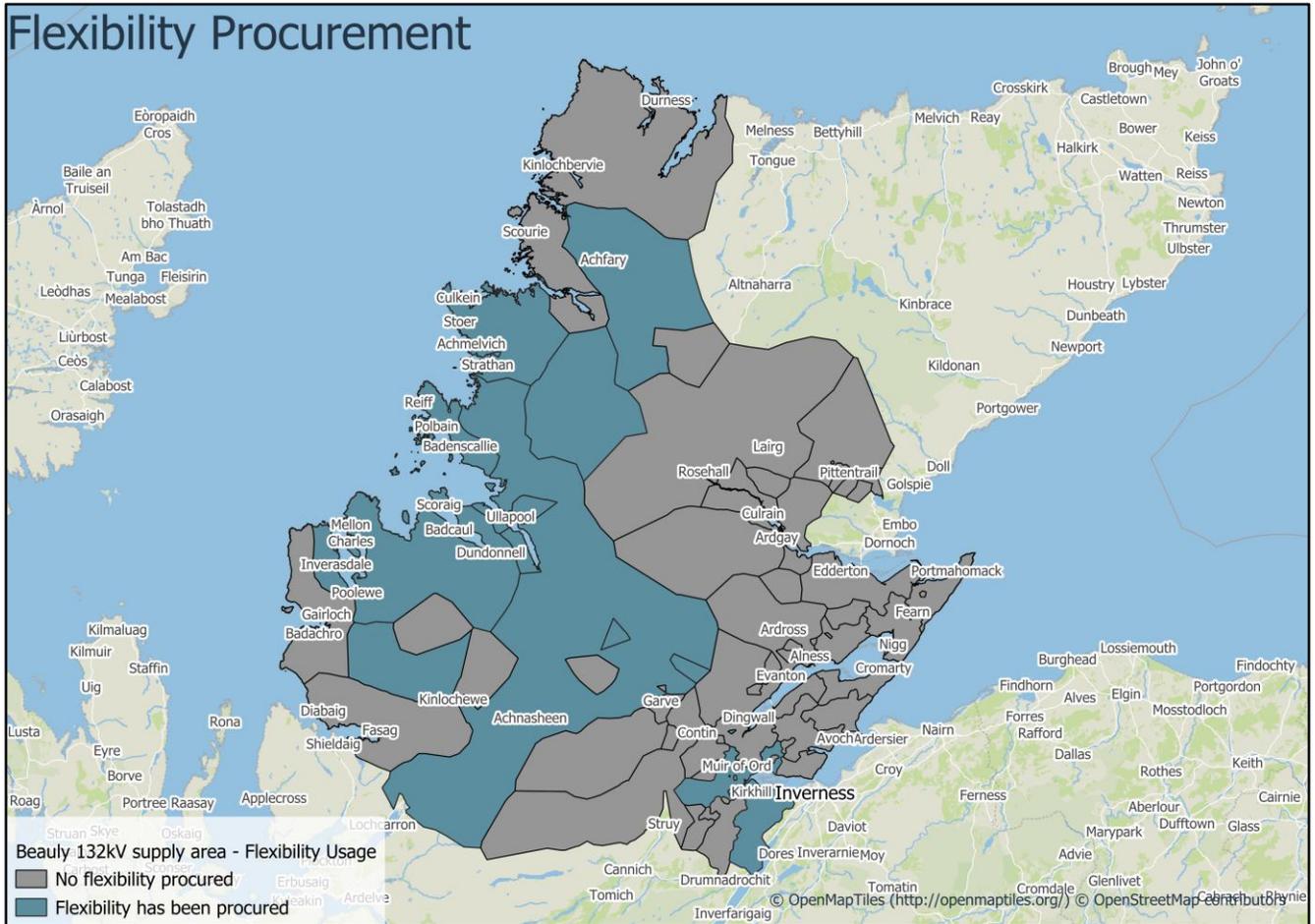
Figure 4 Flexibility procurement across the Beauly SDP supply area

4. EXISTING NETWORK INFRASTRUCTURE

4.1. Beauly 132kV Supply Area Context

The Beauly SDP network is made up of 33kV, 11kV, and LV circuits. It's a very rural network, covering a large part of the Beauly 132kV supply area. In total the GSP serves approximately 39,000 customers. Table 2 shows the values for the Grid Supply Points (GSPs) in the Beauly SDP supply area, for information on primary substations please see 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 each primary to sum to that at the GSPs).

Substation Name	Site Type	Number of Customers Served	2023/24 Substation Maximum demand in MVA (Season)
Alness	Grid Supply Point	12,404	28.50
Beauly	Grid Supply Point	18,103	23.04
Cassley	Grid Supply Point	972	1.76
Grudie Bridge	Grid Supply Point	5,237	12.62
Lairg	Grid Supply Point	1,153	6.14
Shin	Grid Supply Point	1,081	1.75

Table 2 Customer number breakdown and substation peak demand readings (2023)

4.2. Current Network Topology

Figure 5 Geographic Information System view of Beauly SDP electricity network.

4.3.   Current Network Schematic

The existing 33kV network at Alness, Beauly, Cassley, Grudie Bridge, Lairg, and Shin GSPs is shown below in Figures 7, 8, 9, 10, 11, and 12.
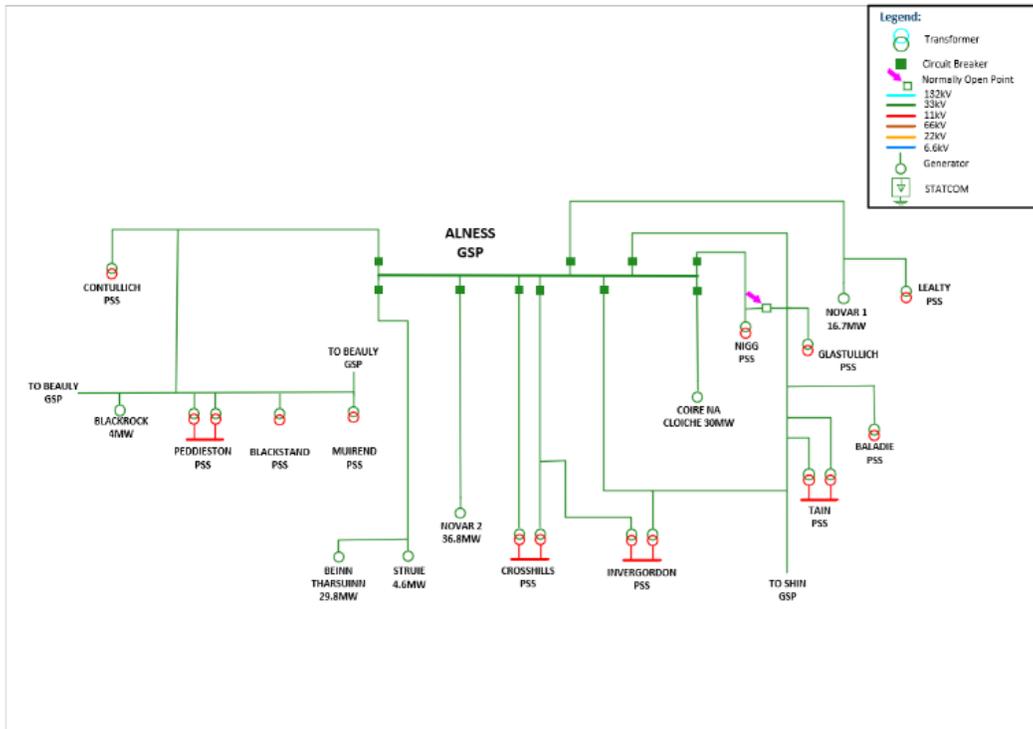

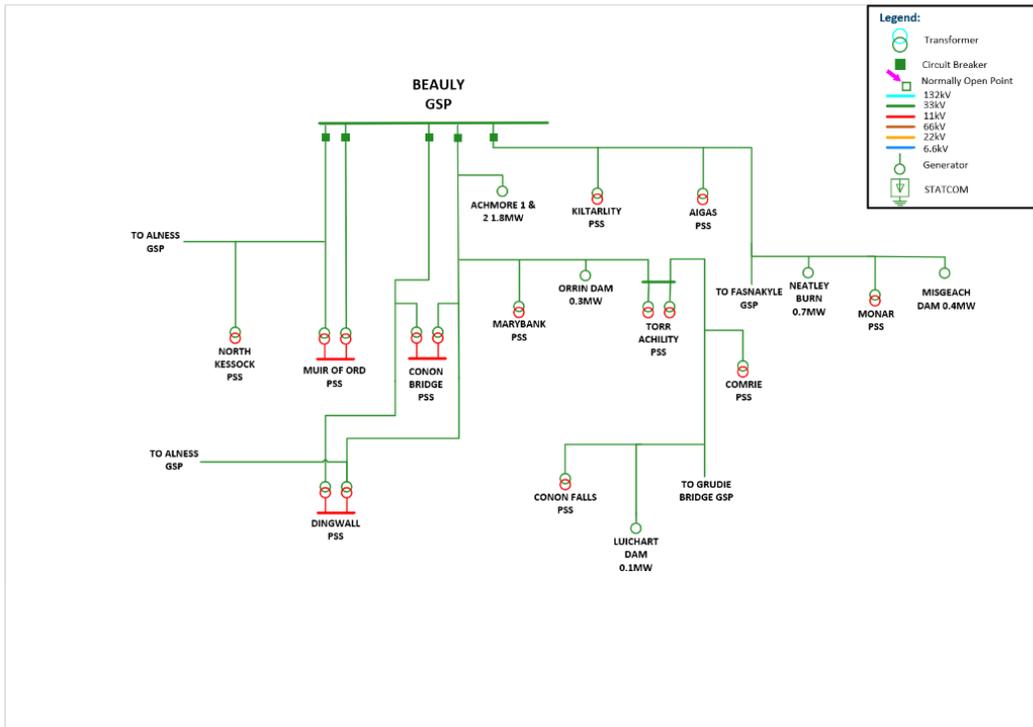Figure 6 Existing 33kV network supplied by Alness GSP

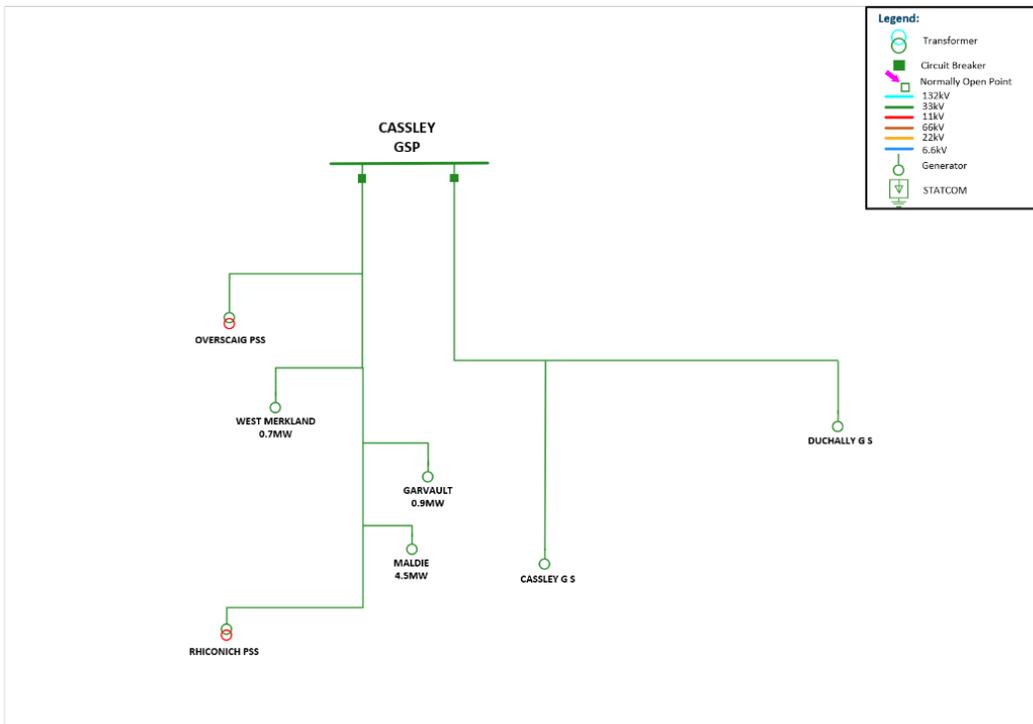Figure 7 Existing 33kV network supplied by Beauly GSP

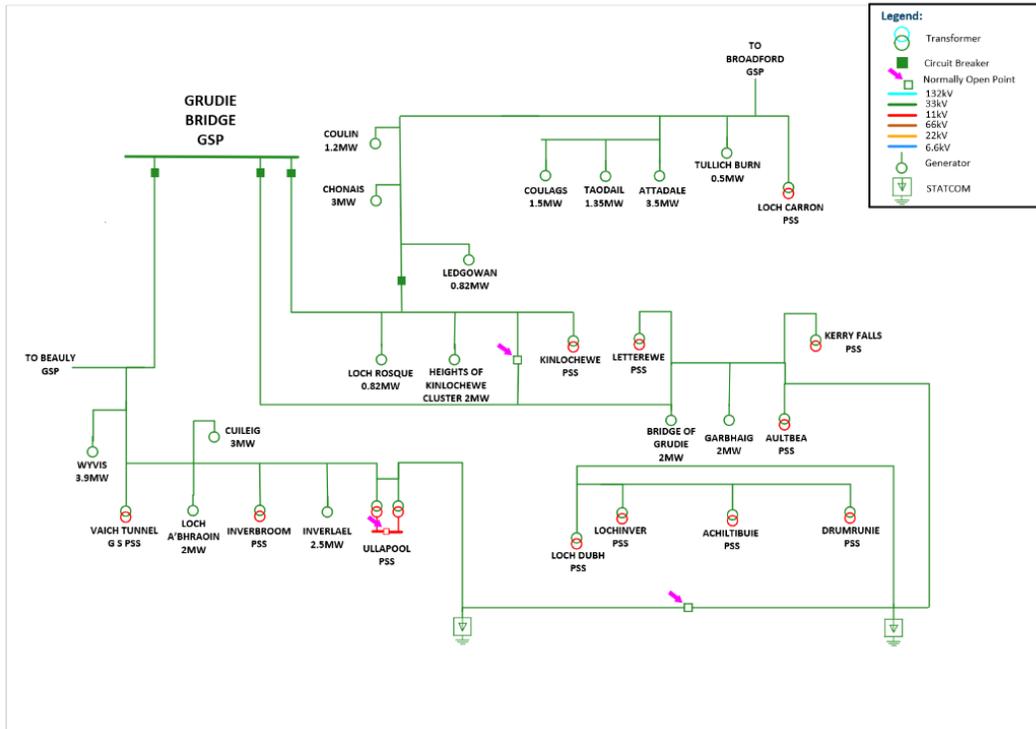Figure 8 Existing 33kV network supplied by Cassley GSP.

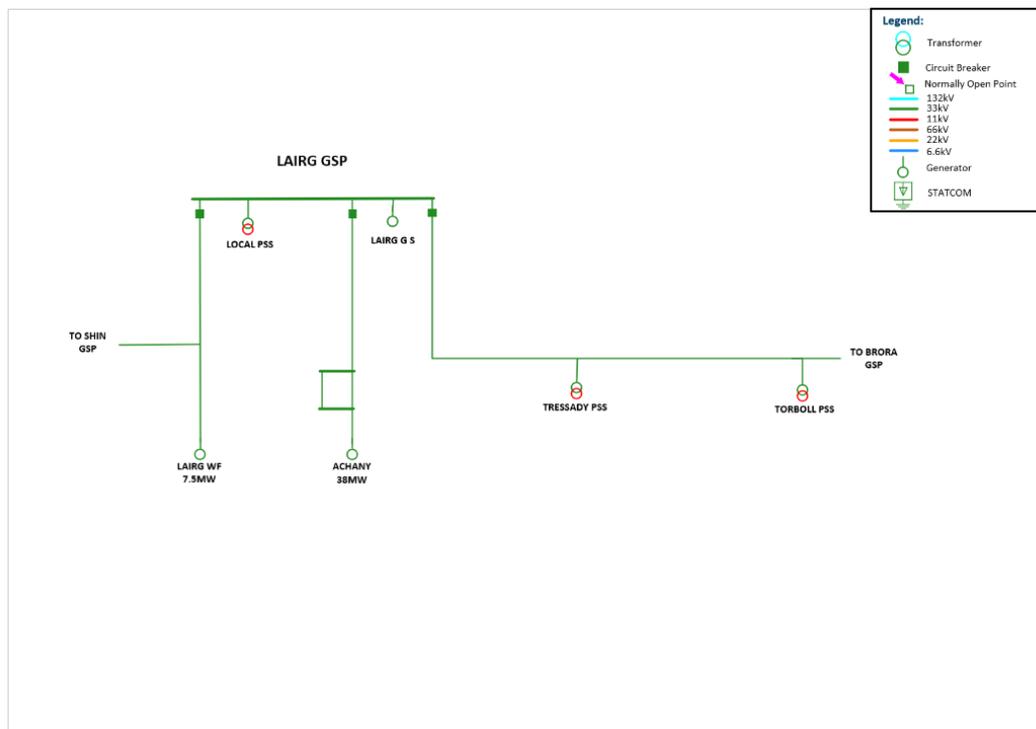Figure 9 Existing 33kV network supplied by Grudie Bridge GSP.

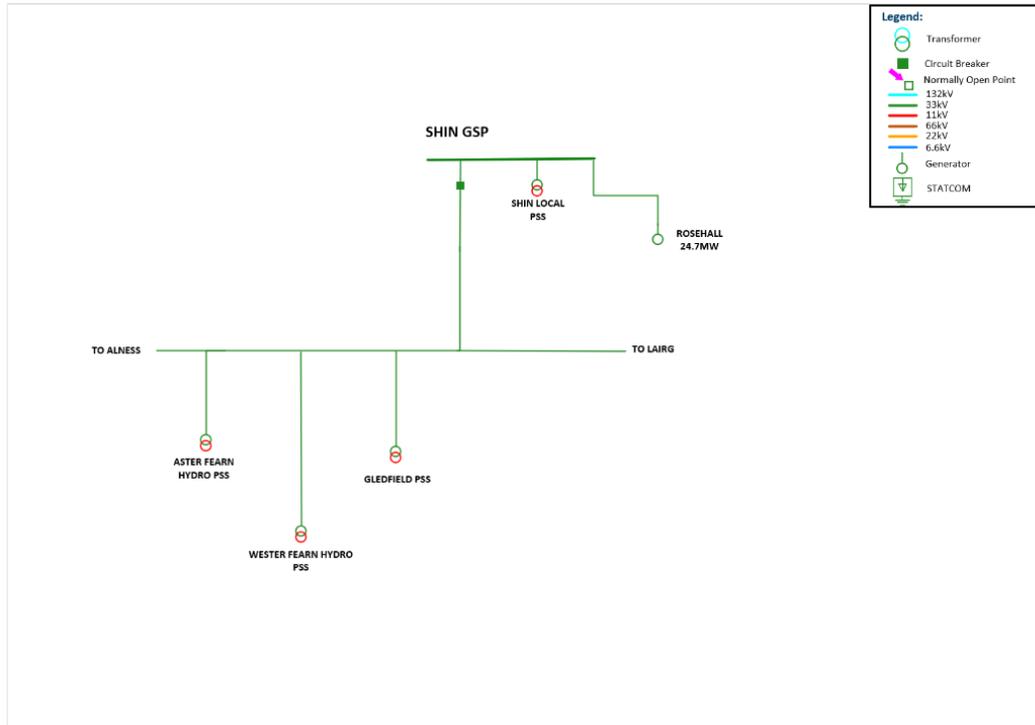Figure 10 Existing 33KV network supplied by Lairg GSP.

Figure 11 Existing 33kV network supplied by Shin GSP.

5. FUTURE ELECTRICITY LOAD FOR THE BEAULY 132KV SUPPLY AREA

The following section details load growth across the technologies projected in the Distribution Future Energy Scenarios 2023[12]. There are important notes on the values presented here:

- The load growth described in this section is based upon DFES 2023 to align with the DFES data used to analyse network needs in this report. DFES 2024 insights are now available and can be found in Appendix B. It should also be noted that the detailed analysis suggested as part of this report will be carried out using DFES 2024.
- 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 3 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 estimate the coincident maximum demand of the entire system rather than the total sum of all demands. This accounts for the fact that not all demand load connected to the network peaks at the same time.

For future iterations of the DFES, additional work should be carried out to ensure that the demand projections are rationalised against any developing LAEPs across the study area.

5.1. Distributed Energy Resource

There is a significant amount of existing zero carbon generation connected within Beauly 132kV supply area. This includes a number of large hydroelectric connections, such as Loch Dubh and Loch Carron. And there is also a significant amount of onshore wind already connected such as, such as Coire na Cloiche windfarm and Beinn Tharsuinn windfarm. We expect to see the amount of onshore wind developments increasing out to 2050, taking advantage of the windy environment. There is also expected to be an increase significant increase in battery storage capacity, especially in generation co-location and standalone grid services.

There is a significant amount of industry work reforming the approach to generation and storage connections and the connections queue. Initiatives such as CP2030 and Connections Reform have the potential to change our current forecasts. We will look to provide updated projections as the outputs of these programmes are understood.

5.1.1. DFES Projections

Generation

In the Beauly 132kV supply area, the energy mix is made up of five sources of distributed energy generation: biomass CHP, hydropower, onshore wind, renewable engines (landfill gas, sewage gas, biogas), and solar pv. The current baseline energy mix is largely made up of hydropower and onshore wind generation. Under the Consumer Transformation scenario, distributed generation across the Beauly 132kV supply area will increase significantly from approximately 360MW in the currently connected baseline to 910MW in 2050 (as shown in Figure 12). By 2050 the energy mix will be dominated by onshore wind, making up approximately 80% of all

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generation, this is then followed by hydropower and solar PV respectively. However, unlike onshore wind and solar, hydropower generation does not see growth but remains constant out to 2050 as it is assumed no new projects are being built. The small amount of Biomass CHP being used will be phased out in all scenarios apart from the Falling Short scenario.
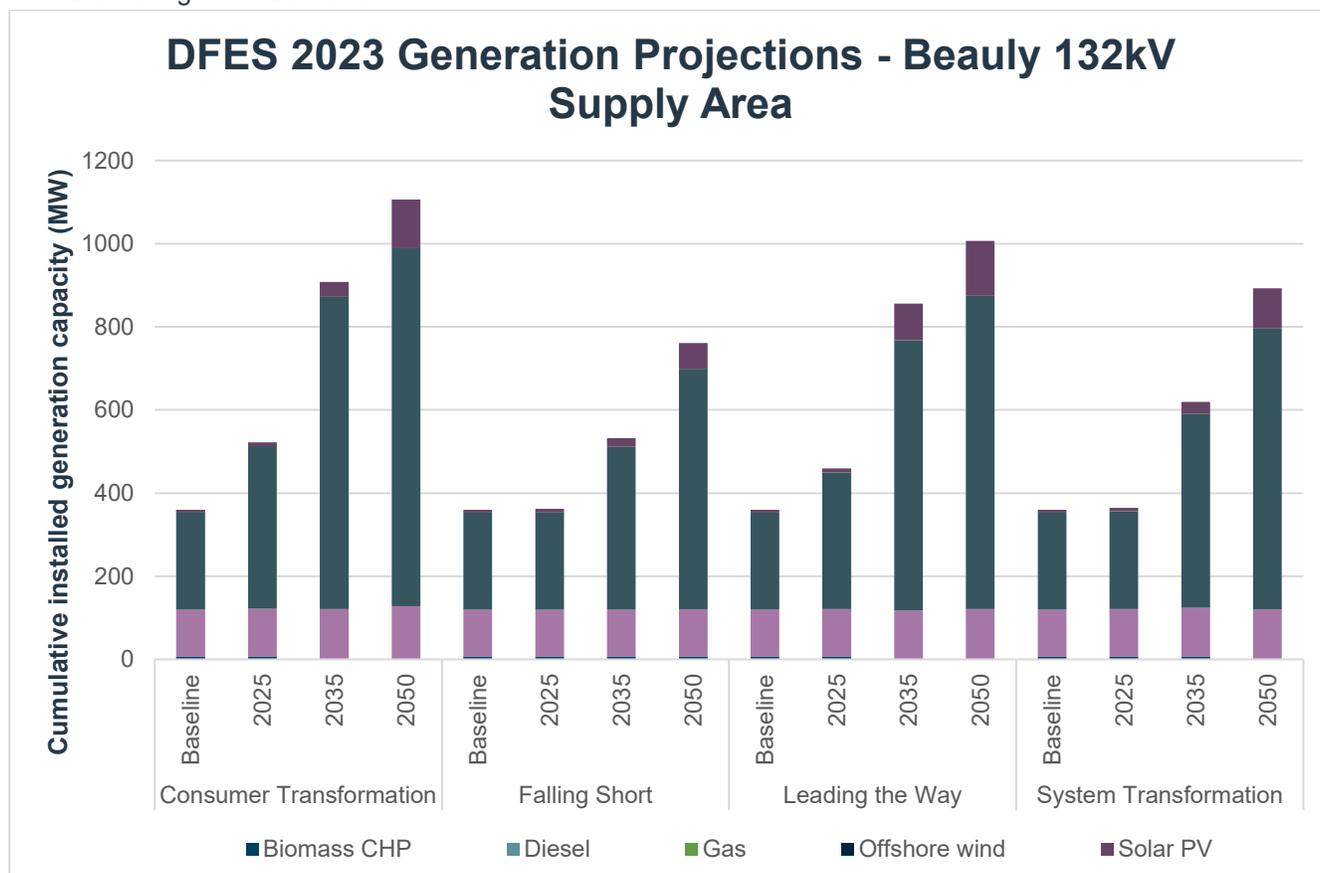
Figure 12 Projected cumulative distributed generation capacity across Beauly 132kV supply area (MW). *Source: SSEN DFES 2023*

Storage

In the Beauly 132kV supply area there is a large increase in the use of battery storage. There is currently a very low baseline for storage of 0.5MW, coming exclusively from domestic storage. In 2050 CT scenario it's projected that there will be 220MW of installed capacity, with generation co-location making the largest proportion, and domestic storage making up the lowest percentage. The Leading the Way scenario sees significantly more battery storage capacity compared to the other scenarios, twice the Consumer Transformation scenario in 2050. this is largely due to storage implemented by standalone grid services which is significantly higher than the other scenarios. However, Leading the Way does not see the same growth in generation co-location batteries as Consumer Transformation, which could be due to the standalone grid services meeting this need.
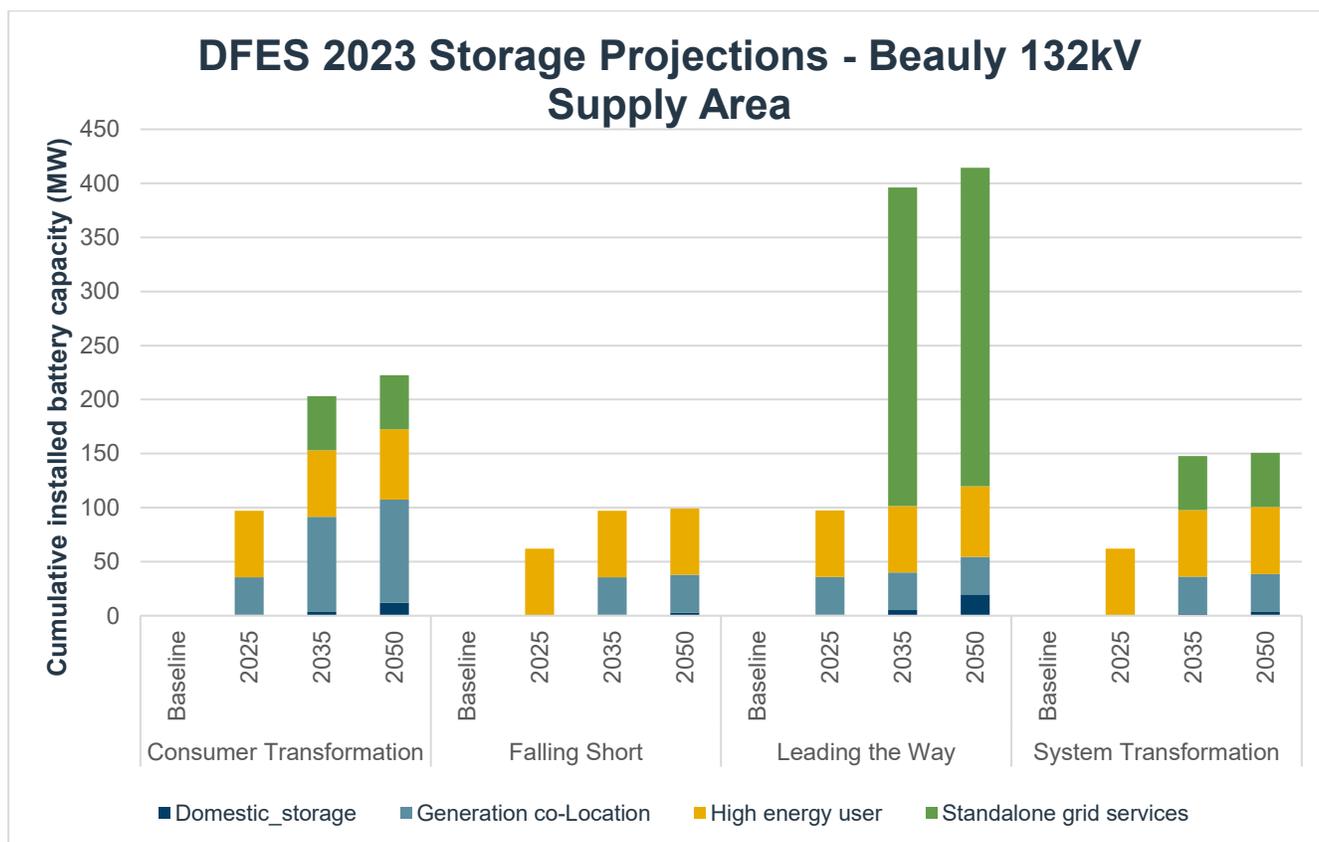
Figure 13 Projected battery storage capacity across Beauly 132kV supply area. *Source: SSEN DFES 2023*

5.2. Transport Electrification

The shift to electrified transport could be a large source of electricity load growth across the Beauly 132kV supply area and will be a key consideration for strategic planning. There are two major roads in the area, the A9 and the A835, there are also two rail lines in the area, the Inverness to Thurso and Wick line and the Inverness to Kyle of Lochalsh line, which will need infrastructure to electrify. The NC500, a popular driving route along the north coast of Scotland will be looking to accommodate electric vehicles as petrol and diesel cars begin to be phased out. There are also ports captured in the Beauly 132kV supply area, such as Lochinver and Ullapool. It is important to consider how further electrification of these different transport vectors may impact the electricity network. While electrification of road travel is captured in DFES building blocks, engagement should take place to better understand the impact of further rail and port electrification in the area.

5.2.1. DFES Projections

The projected EV charger capacity (MW) from SSEN's DFES analysis has been used to understand potential future demand. The total connected EV charge point capacity under the Beauly 132kV supply area is 3.3MW, excluding off-street domestic chargers. As shown in Figure 14, there is expected to be growth across all types of EV chargers with 35MW expected to be connected by 2050. It is important to note that this value represents the

total installed capacity and does not consider diversity. In our studies for future system needs diversity is taken into consideration.
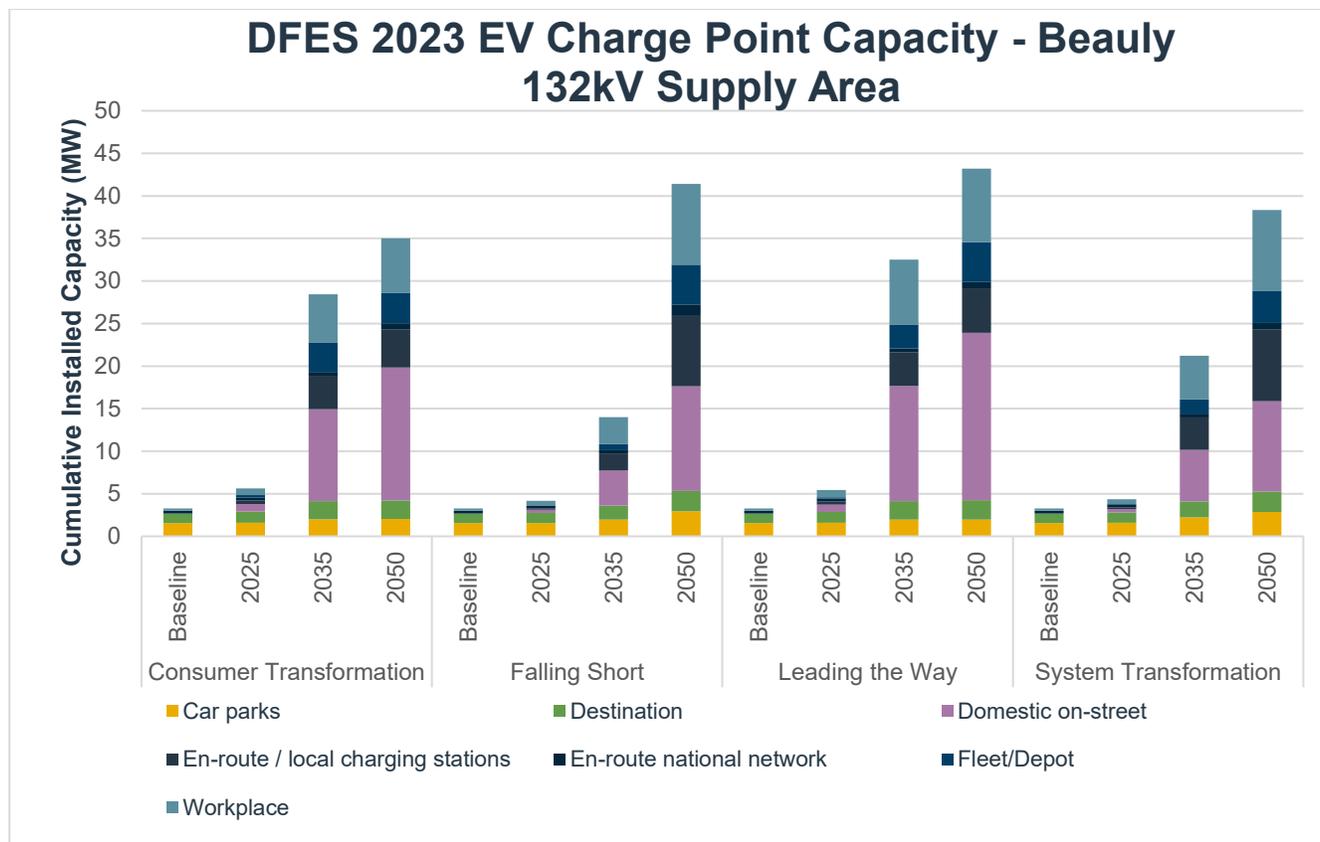
Figure 14 Projected EV charge point capacity across the Beauly 132kV supply area. *Source: SSEN DFES 2023.*

5.3. Electrification of heat

5.3.1. DFES Projections

As Figure 15 shows there is already a high baseline of domestic direct electric heating with approximately 6600 in use, due to most of the area being off the gas grid. There is an increase in all heating/cooling technologies, apart from domestic direct electric heating, with an increase from a baseline of approximately 2,800 heat pumps to approximately 31,000 in 2050 under the CT scenario. The baseline currently shows a high proportion of domestic direct electric heating which is set to reduce out to 2050. Air conditioning is also expected to add load to the network due to behavioral change.

DFES 2023 Heating/Cooling Technologies - Beauly 132kV Supply Area
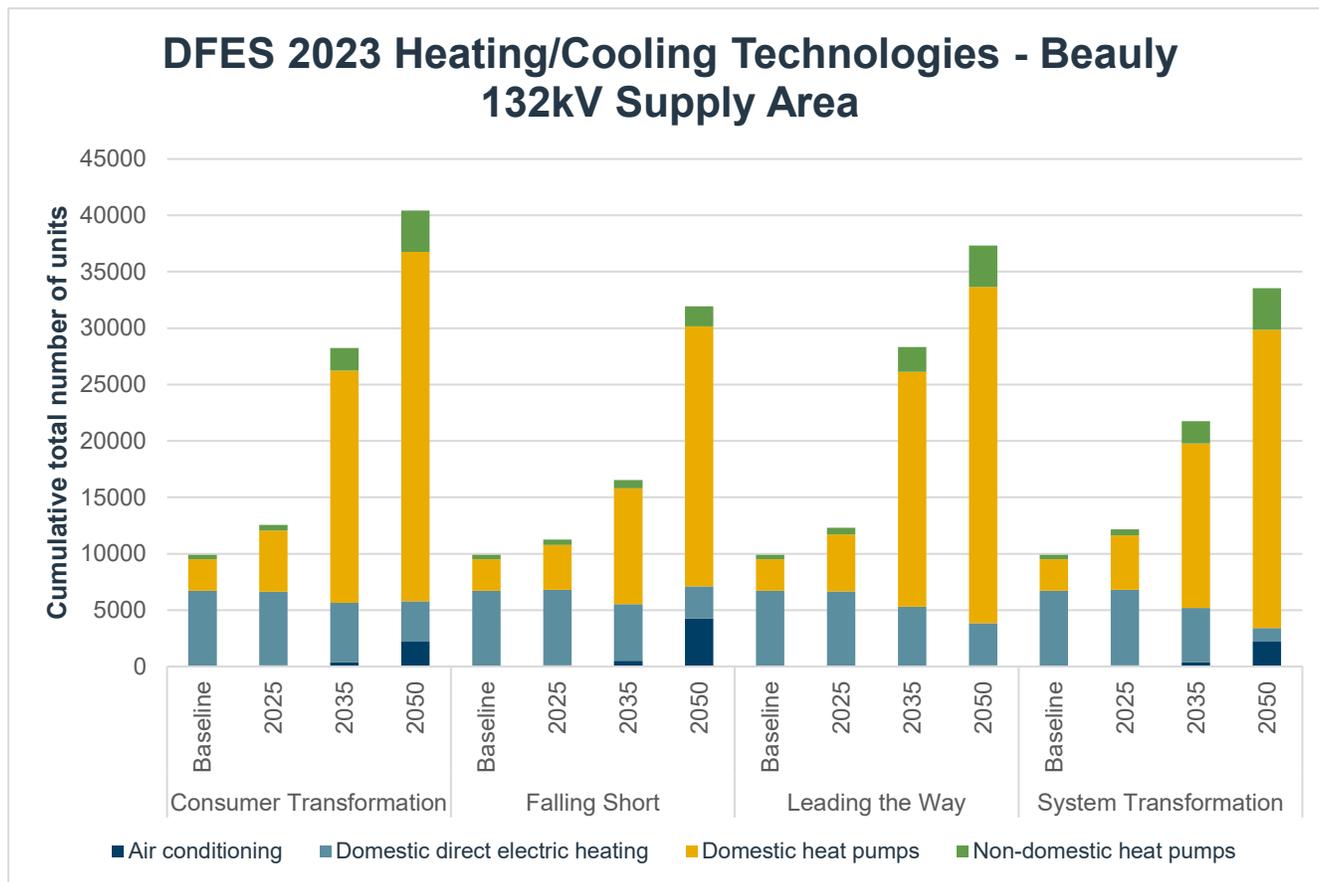
Figure 15 Projected number of heating/cooling technologies across the Beauly 132kV supply area. *Source: SSEN DFES 2023.*

5.4.   New building developments

A key stage in producing the DFES is engagement with Local Authorities. On an annual basis local authorities provide their current best view on new development plans to inform these projections. The results presented here are the information shared by local authorities during the DFES 2023 development process. Where we do not have responses from local authorities these values are determined from published documents for example adopted local plans.

5.4.1.   DFES Projections

In the Beauly 132kV supply area, the total number of new domestic developments (number of homes) is projected to be approximately 2000 by 2050 (under the Consumer Transformation scenario).

The DFES also includes projections for different types of non-domestic floorspace with the breakdown for this presented in Figure 16. Please note that as this information is directly fed from local authorities the projections are closely aligned across the four scenarios.
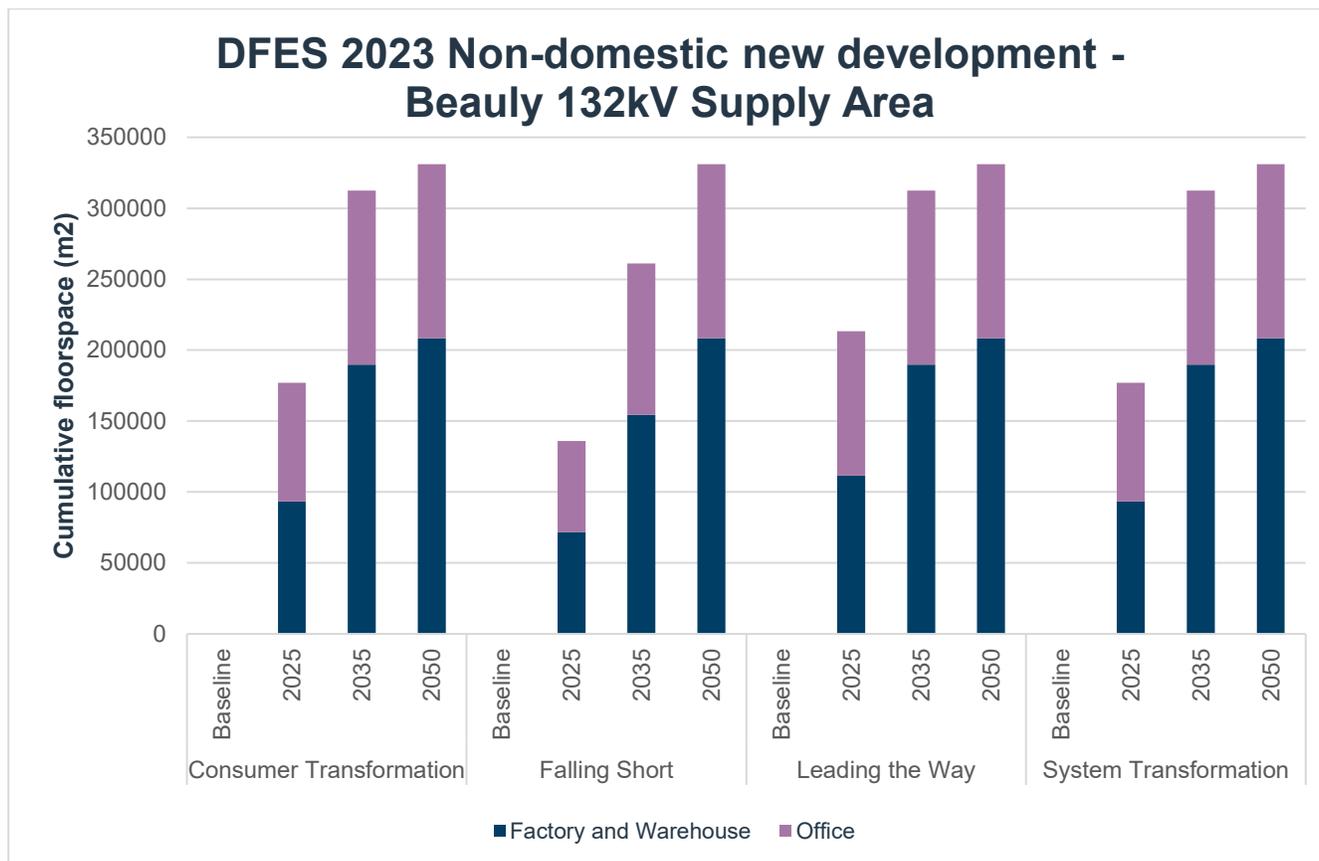
Figure 16 Projected non-domestic new development across the Beauly 132kV supply area. *Source: SSEN DFES 2023.*

5.5.   Commercial and industrial electrification

Outside of the DFES process, SSEN currently has a limited visibility of large scale new commercial and industrial electrification through bilateral discussions and connection applications. However, there are two industries which are considered significant for the forecast, ports and distilleries.

5.5.1.   Ports

It is important to note the importance of the maritime industry in the area of study for this report. Understanding of the potential electricity demands arising from the maritime industry will be key to appropriate sizing of assets and network development in the area. SSEN's SeaChange innovation project has been funded through the Strategic Innovation Fund.[13] This project involves building a 'Navigating Energy Transitions' (NET) tool, which will help ports to plot their most viable pathways for decarbonisation. This tool will then give network operators like SSEN visibility of the predicted electrical load arising from ports. These insights will improve the quality of demand forecasting for subsequent DNOAs and SDP updates.

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

5.5.2.   Distilleries

Within the Beauly 132kV supply area there are eight registered distilleries with all of them located in the east of the supply area shown in the figure below. Distilleries can be the largest sources of demand on these rural networks; therefore, it is important to understand plans for electrification as the industry looks to decarbonise.

The registered distilleries within the Beauly 132kV supply area are:

- Ardross
- Balblair
- Dalmore
- Glen Ord
- Glenmorangie
- Glen Wyvis
- Invergordon
- Teaninich

Figure 17 Distillery locations in the Beauly 132kV supply area.

6. WORKS 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. Summary of existing works shown below:

ID (Schematic Reference)	Substation	Description	Driver	Forecast completion	Fully resolves future strategic needs to 2050?
Alness GSP					
1	Alness GSP to Invergordon PSS Circuits	Reinforcement of 5.6km of 33kV circuit from 0.1in Cu to 100mm Cu.	Customer Connection	2026	✓
2	Alness GSP to Glastullich PSS Circuits	Reinforcement of 10.8km of 33kV circuit between Alness GSP to Glastullich PSS with 150mm2 Cu.	Customer Connection	2029	✗
3	Glastullich PSS to Nigg PSS Circuits	Reinforcement of 9.3km of the existing 33kV circuit from Glastullich PSS to Nigg PSS with 150mm2 Cu. And the installation of an additional circuit 9.3km 33kV circuit between Glastullich and Nigg.	Customer Connection	2029	✓
4	Nigg PSS	Reinforcement of the existing 33/11kV transformer and installation of an additional 33/11kV transformer at the site.	Customer Connection	2029	✓
Beauly GSP					
5	Beauly to Muir of Ord 33kV Circuits.	Reinforcement of the two existing 33kV circuits between Beauly and Muir of Ord that currently have a rating below 18MVA.	DNOA Process	2027	✗

6	Conon Bridge PSS	Reinforcement of 0.46km section of 33kV cicuit from Beauly GSP to Conon Bridge PSS.	DNOA Process	2028	
	Grudie Bridge GSP				
7	Achiltibuie PSS	Installation of 2 x 4MVA STATCOMs at Achiltibuie.	DNOA Process	2027	
8	Kerry Falls PSS Circuits	Reinforcement of an 1.6km section of 33kV circuit on the Kerry Falls PSS spur.	Customer Connection	2029	
9	Ullapool PSS	Reinforce the 33/11kV transformer with a rating of 2.5MVA with a 4MVA transformer.	Asset Replacement	2029	
	Lairg GSP				
10	Lairg GSP	Installation of a new 2500A switchboard to be built on the land adjacent to the Lairg Grid. Installation of a new 1250A circuit breaker at Lairg grid.	DNOA Process	2029	
11	Lairg Local PSS	Installation of one additional 33/11kV 4 MVA transformer.	DNOA Process	2029	
12	North Tressady PSS	Installation of a new pole mounted 33/11kV 315kVA transformer, named Tressady North.	DNOA Process	2030	

Table 3 Works already triggered through customer connections and the DNOA process.

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 provide capacity across the GSP for 2050.

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)

Network Schematic reflecting the network following the completion of the triggered works described above.
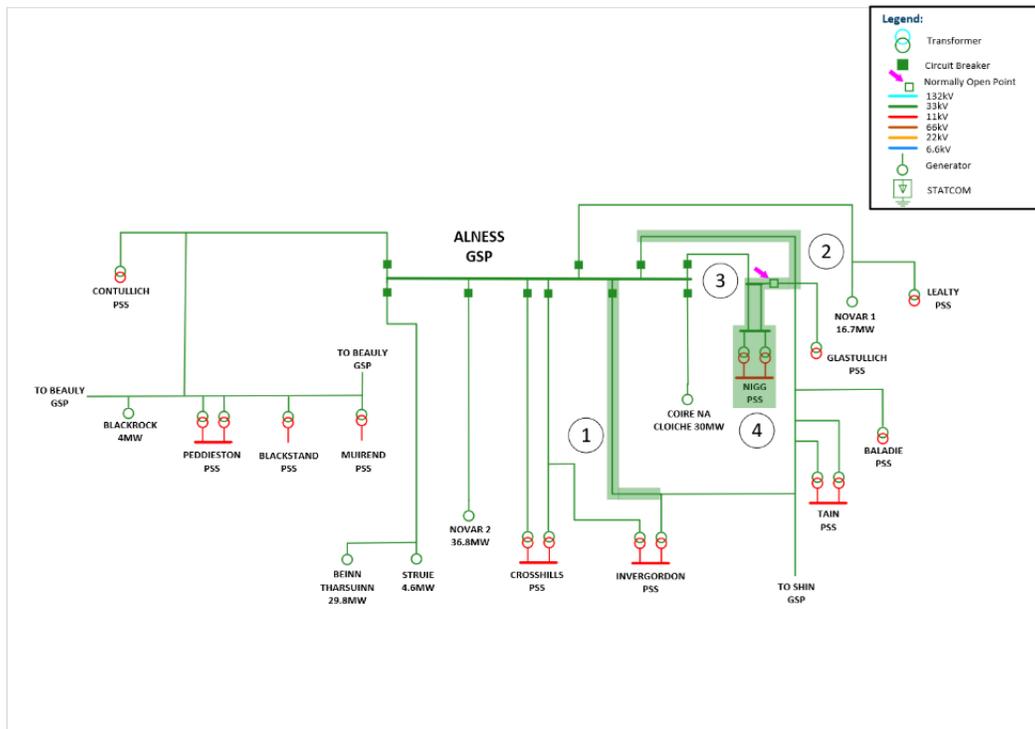

Figure 18 Alness GSP 33kV Network - Following completion of triggered works.
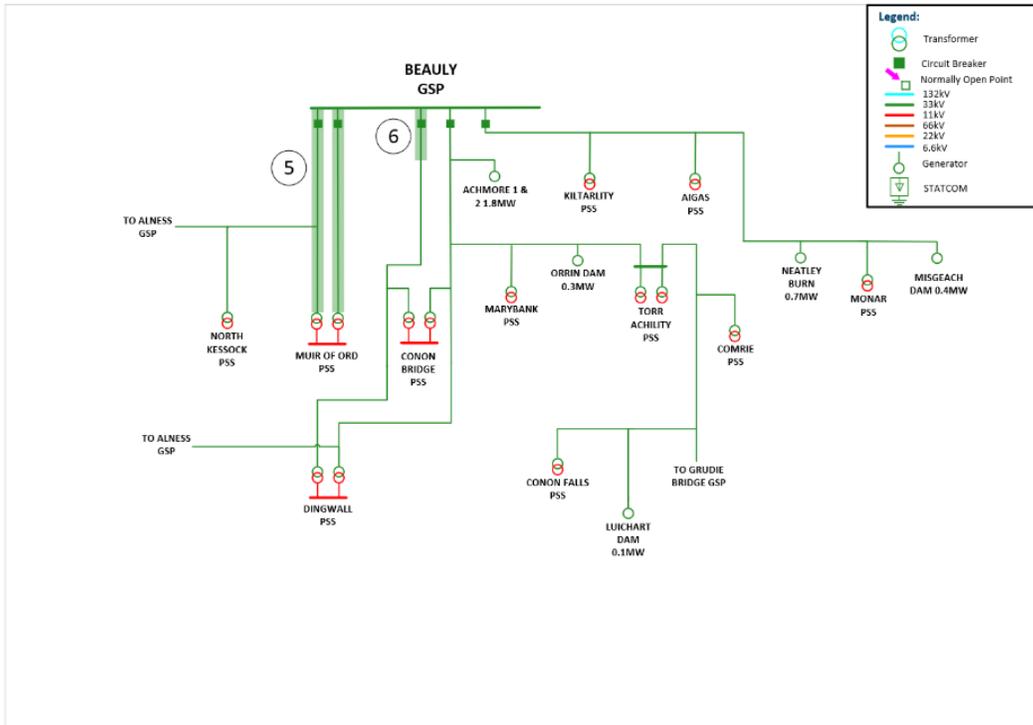
Figure 19 Beauly GSP 33kV Network - Following completion of triggered works.
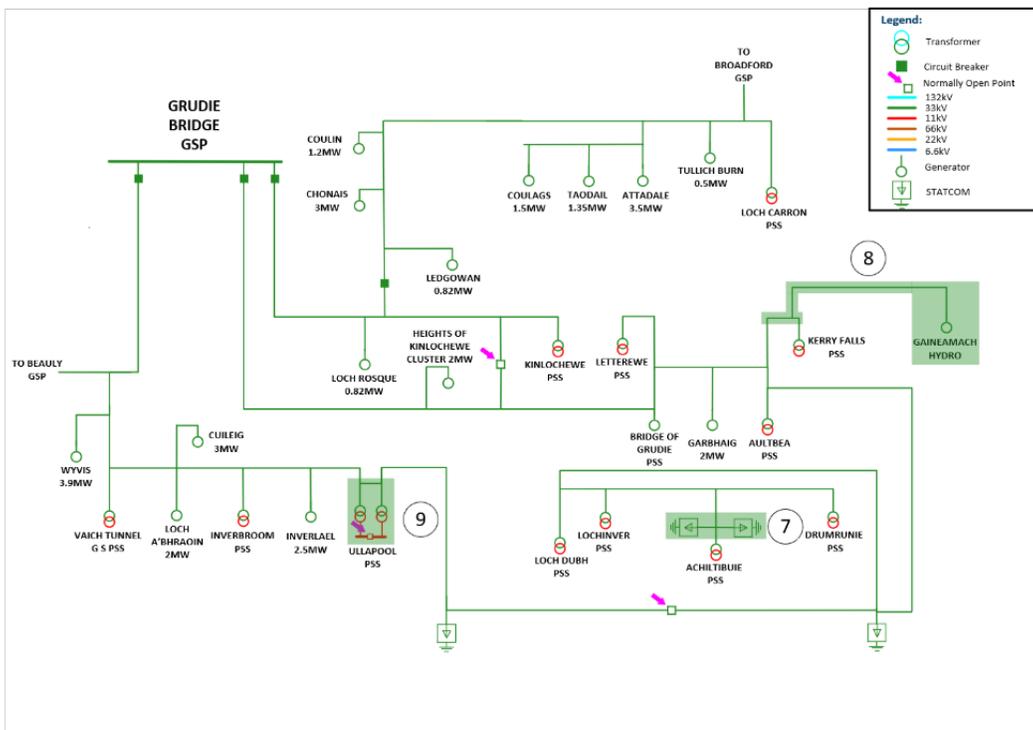
Figure 20 Grudie Bridge GSP 33kV Network - Following completion of triggered works.
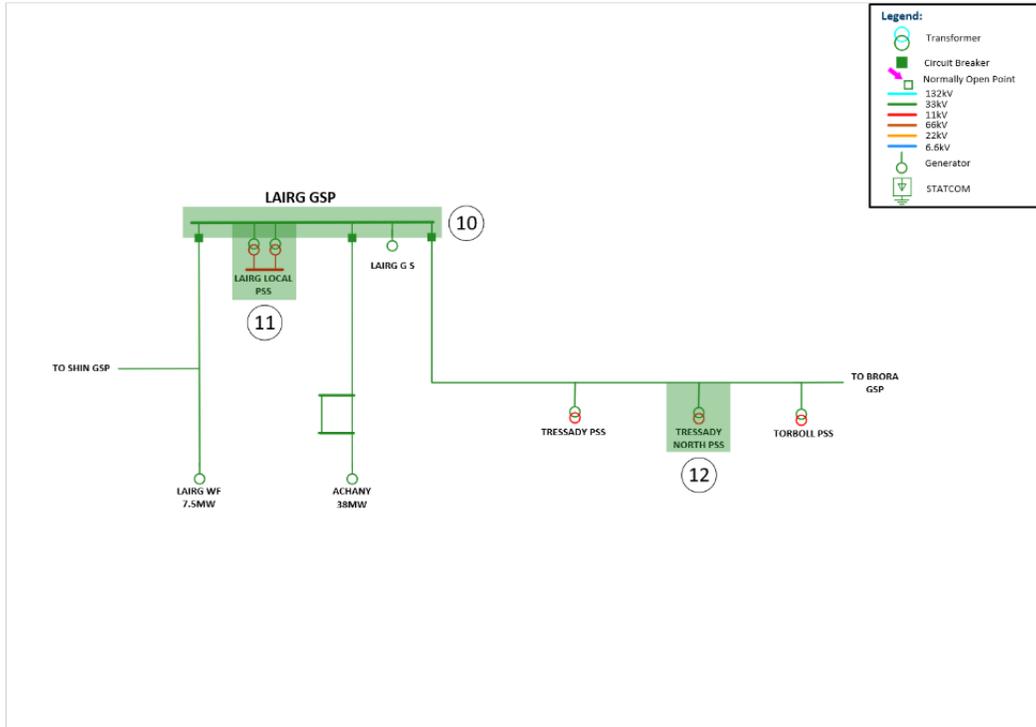
Figure 21 Lairg GSP 33kV Network - Following completion of triggered works.

7. SPATIAL PLANS OF FUTURE NEEDS

7.1. Extra High Voltage / High Voltage spatial plans

The EHV/HV spatial plan shown below in Figure 12 shows the projected headroom or capacity shortfall due to demand increases at primary substations across the Beauly SDP study area. Darker purple shades indicate that there is a projected capacity shortfall whereas lighter shades indicate that there is headroom capacity based on current projections. EHV/HV spatial plans for the other DFES scenarios are presented in appendix D. The values are taken from the Network Scenario Headroom report (NSHR), part of the Network Development plan (NDP). It should be noted that the NSHR is produced annually and was last published in May 2024, where work has been triggered between this date and the time of publication of this report, future capacity may not be reflected.
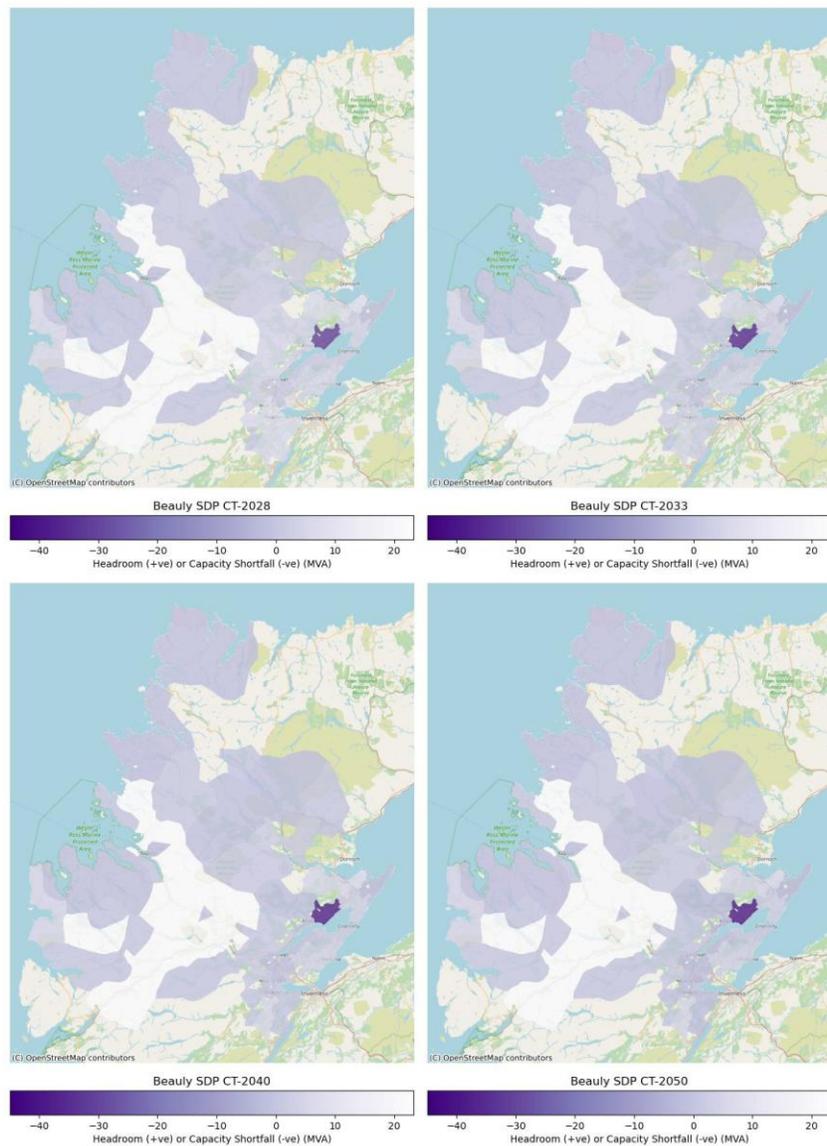
Figure 22 Beauly SDP supply area - EHV/HV Spatial Plans - Consumer Transformation

7.2.   HV/LV spatial plans

The HV/LV spatial plans shown below in Figure 13 show the point locations of secondary transformers in theBeauly 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 scenarios are available in appendix E.

Figure 23 Beauly SDP supply area – HV/LV Spatial Plans - Consumer Transformation

8. SPECIFIC SYSTEM NEEDS AND OPTIONS TO RESOLVE

8.1. Overall dependencies, risks, and mitigations
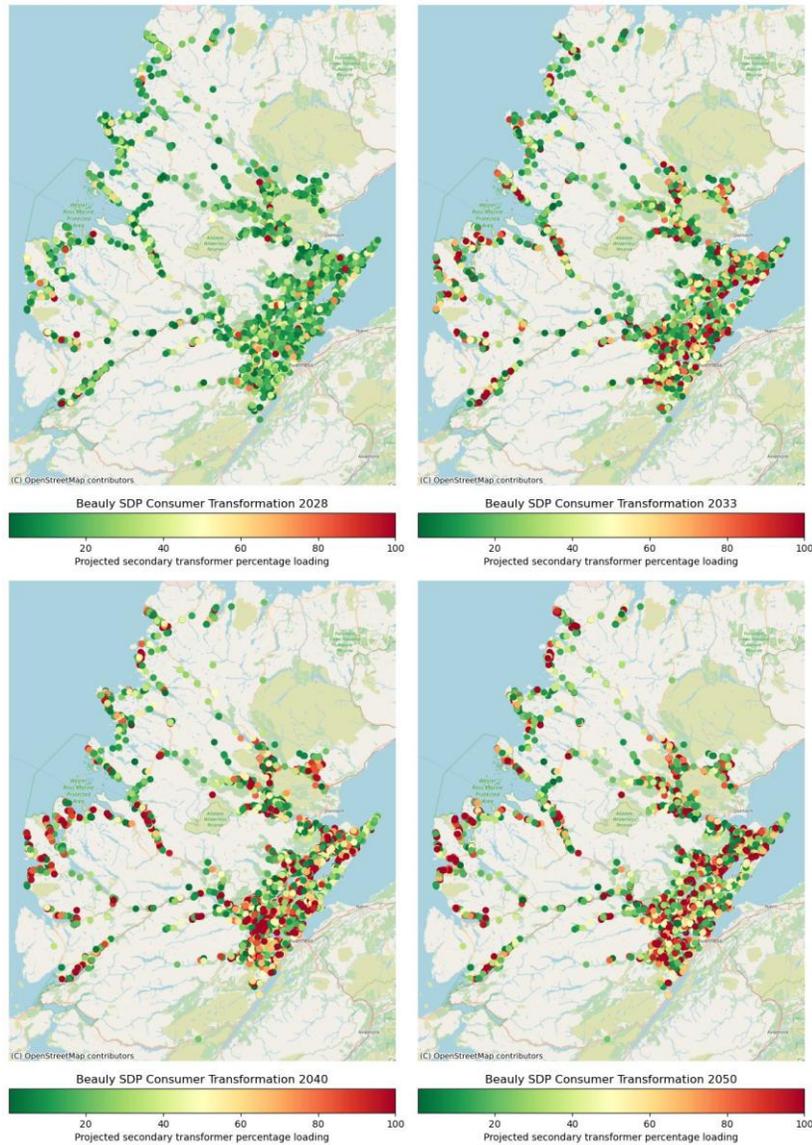
There are a number of overarching risks to the delivery of our strategic plan. Below we list these alongside proposed mitigating actions. We will work with stakeholders to develop these mitigating actions further. Highlight the potential dependencies/risks and what we have done here or plan to do in order to mitigate these risks.

Dependency: Some of the works proposed here are dependent on the completion of works carried out by SSEN Transmission.
Risks: Works delay potential interventions downstream and/or do not provide flexibility of future investment.
Mitigation: Continue productive engagement with SSEN Transmission to enable planning and a better understanding of when capacity will be released in the Beauly 132kV supply area.

Dependency: Connections reform process, which is taking place this year, 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: The future works described in this section are only indicative and further detailed study through the DNOA will be required when delivery of the work needs to be initiated.
Risks: Changes in forecasts and/or practical considerations may result in changing the scope of the high-level solutions detailed here.
Mitigation: The purpose of this section is to highlight the long-term requirements based on current forecasts, annual update of the SDP and more detailed assessment in the DNOA will ensure proposed work that is passed from DSO to the asset owner is appropriate.

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.   Generation impacts on the EHV network.

There is an increasing amount of distribution connected generation projected to connect as we approach 2050. This has the potential to result in a significant shift on the power flows observed on the network and potentially drive some future system needs. All GSPs in the Beauly 132kV supply area are currently experiencing reverse power flow in minimum demand peak generation scenarios and this is projected to increase out to 2050. The effect connections reform and CP2030 will have on generation projects connecting to the network has not yet been concluded, therefore, more detailed assessment on generation impacts will need to take place once this has been finalised.

8.3.   Future EHV System Needs to 2035.

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.

Location of proposed intervention	CT Year	ST Year	LW Year	FS Year	Asset Loading (%)	Network State (see glossary)	Proposed option(s) to resolve
Achiltibuie PSS 33/11kV transformer.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	107	Intact.	All three transformers sit on the same 33kV spur and are all projected to be overloaded ahead of 2030. Because of this, the options to resolve this constraint have been grouped together. There is currently no interconnection on the 11kV network between the three transformers meaning load cannot be shifted between transformers. There are also voltage constraints at Achiltibuie and Lochinver that have been highlighted. High level options to resolve this are:

Drumrunie PSS 33/11kV transformer.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	146	Intact.	• Reinforce all three transformers along the 33kV spur to accommodate for the load growth. However, P2 compliance will need to be considered when reinforcing these transformers. • A new pole mounted transformer(s) or substation could be placed along the 33kV circuit and the 11kV circuit reconfigured, to take load off the existing transformers. Due to the distances between transformers, it may not be possible. • Flexibility assessment should be carried out to determine if the constraint could be resolved at any of the transformers. Flexibility has been determined as a viable option to resolve the constraint at Drumrunie PSS which is on the same 33kV spur.
Lochinver PSS 33/11kV transformer.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	2030 - 2035	100	Intact.	• To resolve the voltage constraints, two 4MVAR STATCOMs are planned to be installed at Achiltibuie PSS. A detailed study should take place to determine whether the planned STATCOMs and circuit upgrades could resolve the voltage constraints at Lochinver PSS.
Lochcarron PSS spur circuits.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	N/A	Voltage	N-1	Lochcarron PSS is at the end of a 33kV spur. There are 6 generators along the spur. Potential options to resolve this constraint are: • Upgrade the circuit feeding Lochcarron, either by reinforcing the lower rated sections of circuit or seeing if it's possible the shorten the circuit, reducing impedance. • Install a STATCOM or voltage regulator along the circuit.
Blackstand PSS to Muirend PSS circuits.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Voltage	N-1	The circuit is at the end of a 33kV spur. There are no generators on the spur and there is an interconnection to Beauly GSP. Potential options to resolve this constraint are: • Upgrade the circuit, specifically there is a lower rated section of circuit on the backfeed from Beauly. • Install a STATCOM or voltage regulator along the circuit.
Conon Bridge PSS and Dingwall PSS circuits.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Voltage	N-1	The circuits around Conon Bridge PSS and Dingwall PSS are projected to experience voltage issues. There planned works in progress, listed in section 6, to resolve thermal issues. A detailed study should be carried out to determine

							whether the voltage constraints will also be resolved. Potential options to resolve this constraint are: • If the circuit upgrades do not solve the constraint, size the assets to resolve the voltage as well as thermal constraints. • Install a voltage regulator or STATCOM in the Conon Bridge/Dingwall area.
Inverbroom PSS 33/11kV transformer.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	2030 - 2035	107	Intact.	Inverbroom PSS is a 200kVA pole mounted transformer. There is no interconnection on the 11kV network so the load can't be transferred. Options to resolve this constraint include: • Upgrading the existing transformer to accommodate load growth out to 2050. The pole mounted transfer can be reinforced to 300kVA, after which a ground mounted substation would need to be installed. (P2 issues only over a 1MW). • Add an additional pole mounted transformer.
Balaldie PSS 33/11kV transformer.	Ahead of 2030.	2030 - 2035	Ahead of 2030.	2030 - 2035	104	Intact.	Balaldie PSS is a single 4MVA transformer and is expected to experience overload in intact conditions. The substation has a P2 exemption and has an 11kV interconnection. Undervoltage issues have also been highlighted on the circuits feeding Balaldie Potential options to resolve this constraint are: • Upgrade the existing transformer to accommodate load growth – but this will not solve the current P2 exemption. • Install an additional transformer at Balaldie PSS, increasing the resilience of the network. • Shift load away from Balaldie on the 11kV network.
Glastullich PSS, Balaldie PSS, and Tain PSS 33kV circuits.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Voltage.	N-1	The circuits feeding Glastullich, Balaldie, and Dingwall PSSs are projected to experience voltage issues. There planned works in progress, listed in section 6, to resolve thermal issues. A detailed study should be carried out to determine whether the voltage constraints will also be resolved. Potential options to resolve this constraint are:

							• If the circuit upgrades do not solve the constraint, size the assets to resolve the voltage as well as thermal constraints. • Install a voltage regulator or STATCOM in the Glastullich/Balaldie/Dingwall area.
Gledfield PSS spur circuits.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	Voltage.	N-1	Gledfield PSS is at the end of a 33kV spur. Two large hydro plants are on the spur. Potential options to resolve this constraint are: • Upgrade the circuit feeding Gledfield from the Alness GSP backfeed, either by reinforcing the lower rated sections of circuit or seeing if it's possible the shorten the circuit, reducing impedance. • Install a STATCOM or voltage regulator along the circuit.
Kinlochewe PSS 33/11kV transformer.	Ahead of 2030.	Ahead of 2030.	Ahead of 2030.	#N/A	Voltage.	N-1	Kinlochewe PSS is at the end of a 33kV spur. It is near several generators and a voltage regulator. Potential options to resolve this constraint are: • Upgrade the backfeed circuit feeding Kinlochewe PSS, either by reinforcing the lower rated sections of circuit or seeing if it's possible the shorten the circuit, reducing impedance. • Reinforce the existing voltage regulator or install a STATCOM.
Comrie PSS and Marybank PSS circuits.	Ahead of 2030.	2030 - 2035	Ahead of 2030.	2030 - 2035	Voltage.	Intact.	The circuits feeding Comrie and Marybank PSSs are projected to experience voltage issues. Potential options to resolve this constraint are: • Upgrade the circuit feeding Comrie and Marybank PSSs either by reinforcing the lower rated sections of circuit or seeing if it's possible the shorten the circuit, reducing impedance. • Install a voltage regulator or STATCOM in the Glastullich/Balaldie/Dingwall area.
Conon Bridge PSS 33/11kV transformers.	Ahead of 2030.	#N/A	Ahead of 2030.	#N/A	104	N-1	Conon Bridge PSS has two 5/6.25MVA transformers. Detailed optioneering has already taken place. The preferred option is: • Replace the two existing 5/6.25 MVA transformers with 7.5/15MVA transformers.

Invergordon PSS 33/11kV transformer.	Ahead of 2030.	2030 - 2035	Ahead of 2030.	2030 - 2035	103	N-1	Invergordon PSS has two 7.5/15MVA 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 Invergordon. • Install another primary along the 33kV network, taking some of the load.
Tressady PSS 33/11kV transformer.	2030 - 2035	2030 - 2035	2030 - 2035	2036 - 2040	107	Intact.	Tressady PSS currently has a single pole mounted transformer and Tressady North PSS is currently being planned. Potential options to resolve this constraint are: • Installation of a third 33/11kV 315kVA transformer (Tressady Central PSS) in 2034.
Peddieston PSS 33/11kV transformers.	2030 - 2035	2030 - 2035	2030 - 2035	2036 - 2040	103	N-1	Peddieston PSS has two 2.5MVA transformers and is expected to be overloaded in N-1 conditions. Potential options to resolve this constraint are: • Reinforcement of the existing transformers at Peddieston PSS. • Shift load on the 11kV network, potentially to Blackstand PSS or over to Conon Bridge PSS on the Beauly GSP network, this work could be considered alongside the work to release capacity at Conon Bridge PSS. • Installation of a new PMT primary to relieve load on Peddieston.
Comrie PSS 33/11kV transformer.	2030 - 2035	2030 - 2035	Ahead of 2030.	2030 - 2035	125	Intact.	Comrie PSS consists of a single 200kVA pole mounted transformer. There is no 11kV interconnection on the network. Potential options to resolve this are: • Upgrade the existing transformer to a 315kVA pole mounted transformer, however this may not accommodate future load growth. • Install additional transformer along the 33kV network, rerouting the 11kV network.
North Kessock PSS 33/11kV transformer.	2030 - 2035	2030 - 2035	2030 - 2035	2036 - 2040	109	Intact.	North Kessock PSS consists of a single 4MVA transformer. Potential options to release capacity are:

							• Install an additional transformer at North Kessock PSS, increasing the resilience of the network. • Interconnect an 11kV line to the Inverness GSP across the A9 bridge, shifting load to the 11kV network.
Beauly GSP to Marybank/Conon Bridge 33kV circuits.	2030 - 2035	2036 - 2040	2030 - 2035	2036 - 2040	104	N-1	The circuit between Beauly GSP and Achmore generator consists of overhead line and a shorter section of underground cable, both of approximately the same rating. Potential options to resolve this constraint are: • Reinforce the cable and circuit with a higher rating. • Utilise demand side flexibility usage during outages subject to availability. • Feed all of Dingwall primary all from the other feeder, reducing load on the overloaded circuit.
Dingwall PSS 33/11kV transformers.	2030 - 2035	2036 - 2040	2030 - 2035	2041 - 2050	106	N-1	Dingwall PSS has two 15MVA transformers and is expected to experience overload in N-1 conditions. Potential options to resolve this constraint are: • Reinforcement of the existing transformers at Dingwall PSS. • Shift load on the 11kV network, potentially over to Conon Bridge PSS.
Alness GSP to Crosshills PSS 33kV circuits.	2030 - 2035	2036 - 2040	2030 - 2035	2036 - 2040	103	N-1	The circuit between Alness GSP and Crosshills PSS which goes on to feed Invergordon PSS is expected to be overloaded in outage conditions. 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. • Unmesh Invergordon PSS from the circuit and feed it directly from Alness GSP, releasing capacity on the Crosshills circuits. • transfer load on the 11kV network.
Gledfield PSS 33/11kV transformer.	2030 - 2035	2036 - 2040	2030 - 2035	2041 - 2050	103	Intact.	Gledfield PSS consists of a single 200kVA pole mounted transformer. There is no interconnection on the downstream 11kV network. Potential options to resolve this are: • Upgrade the existing transformer to a 315kVA pole mounted transformer, however

							this may not accommodate future load growth. • Install additional transformer along the 33kV network and split the load on 11kV network. However, this will require 11kV works.
Glastullich to Balaldie 33kV circuits.	2030 - 2035	2036 - 2040	2030 - 2035	2041 - 2050	102	N-1	The circuit between Glastullich, Balaldie and Tain PSSs are expected to be overloaded in outage conditions. 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. • Feed Balaldie PSS directly from Alness GSP, releasing capacity on the circuits. • Shift load on the 11kV network from Balaldie PSS over to Glastullich PSS.
Beauly GSP to Muir of Ord 33kV circuits.	2030 - 2035	2036 - 2040	2030 - 2035	2041 - 2050	101	N-1	Beauly GSP to Muir of Ord PSS circuits consists of sections that have different ratings. Work is already in progress to reinforce the lower rated sections. Potential options to resolve this constraint are: • Upgrade the circuits to a minimum rating of 33MVA. • Utilise demand side flexibility usage during outages subject to availability. • Shift load on the 11kV network to Conon Bridge PSS. • Install an additional transformer fed directly from Beauly GSP.
Achmore generator to Conon Bridge 33kV circuits.	2030 - 2035	2041 - 2050	2030 - 2035	2041 - 2050	103	N-1	The 33kV circuits between Achmore generator and Conon Bridge are projected to be overloaded in outage conditions. Options to resolve this constraint are: • Reinforce the overloaded section of circuit. Due to the length of circuit (3km) this is very likely to be the most efficient solution.

Table 4 Summary of system needs identified in this strategy through to 2035 along with indicative solutions.

8.4. Future EHV System Needs to 2050.

Location of proposed intervention	CT Year	ST Year	LW Year	FS Year	Asset Loading (%)	Network State (see glossary)	Proposed option(s) to resolve
Crosshills PSS to Invergordon PSS circuits.	2036 - 2040	2036 - 2040	2036 - 2040	2041 - 2050	101	N-1	The 33kV circuit that feeds one Invergordon PSS transformer from Crosshills PSS becomes overloaded in outage conditions. The transformers at Crosshills 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:
Crosshills PSS 33/11kV transformers.	2036 - 2040	2041 - 2050	2036 - 2040	2041 - 2050	102	N-1	
							• Upgrade both transformers at Crosshills PSS to accommodate load growth out to 2050, also reinforce the circuits between Crosshills PSS and Invergordon PSS.
							• Unmesh Invergordon PSS, feeding both transformers directly from Alness GSP. This could potentially release enough capacity at Invergordon to shift load from Crosshills PSS over to Invergordon PSS on the 11kV network, however this may not defer be able to release enough capacity to defer the transformer reinforcements.
							• Transfer load on the 11kV network.
Blackstand PSS 33/11kV transformer.	2036 - 2040	2041 - 2050	2036 - 2040	#N/A	101	Intact.	Blackstand PSS consists of a single transformer and is expected to be overloaded in N-1 conditions. Potential options to resolve this constraint are:
							• Reinforce the existing transformer to a higher rating.
							• Add an additional transformer, increasing resilience of the network.
							• Transfer load on the 11kV network to Peddieston PSS or Muirend PSS.
North Kessock PSS to Muir of Ord PSS 33kV circuits.	2036 - 2040	2041 - 2050	2036 - 2040	#N/A	101	N-1	A section of 33kV circuit between Beauly GSP and North Kessock primary is expected to be overloaded in network intact conditions. 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. • Feed North Kessock PSS from Alness GSP and keep the Beauly circuit as a backfeed, however this may trigger more upgrades on the Alness GSP circuits.
Alness GSP to Invergordon PSS circuits.	2036 - 2040	2041 - 2050	2036 - 2040	2041 - 2050	Voltage.	N-1	The circuits feeding Invergordon PSS from Alness GSP are projected to experience voltage issues. Potential options to resolve this constraint are: • Upgrade the circuit feeding Invergordon PSS either by reinforcing the lower rated sections or alter the current planned reinforcements so it resolves the projected voltage constraints, however this may not be viable. • Install a voltage regulator or STATCOM on the Invergordon circuits.
Beauly GSP to Kiltarlity PSS circuits.	2036 - 2040	2041 - 2050	2036 - 2040	2041 - 2050	Voltage.	N-1	Kiltarlity PSS is at the end of a 33kV spur, and is backfed from Fasnakyle in outage conditions. Potential options to resolve this constraint are: • Upgrade the circuit feeding Kiltarlity, either by reinforcing the lower rated sections of circuit or seeing if it's possible the shorten the circuit, reducing impedance. • Install a STATCOM or voltage regulator along the circuit.
Muir of Ord PSS to Alness GSP / North Kessock PSS 33kV circuits.	2041 - 2050	2041 - 2050	2036 - 2040	#N/A	101	N-1	Beauly GSP to Muir of Ord PSS circuits consist of sections that have different ratings. Work is already in progress to reinforce the lower rated sections. Muir of Ord PSS to North Kessock PSS are also expected to be overloaded in outage conditions. Due to the proximity of the works it's proposed that these works are carried out together. The preferred option is:
Beauly GSP to Muir of Ord PSS 33kV circuits.	2041 - 2050	#N/A	2041 - 2050	#N/A	100	N-1	• Upgrade the circuits to a minimum rating of 33MVA. • Utilise demand side flexibility usage during outages subject to availability. • Feed North Kessock PSS directly from Beauly GSP, removing load from the circuits. • Load shift on the 11kV network to Conon Bridge PSS.

Blackstand PSS to Peddieston PSS 33kV circuits.	2041 - 2050	2041 - 2050	2036 - 2040	#N/A	100.97	N-1	The 33kV circuits between Blackstand PSS and Peddieston PSS are expected to be overloaded in outage conditions. Potential options to resolve this constraint are: • Reinforce the circuit between Peddieston PSS and Blackstand PSS. • Utilise demand side flexibility usage during outages subject to availability. • It's proposed that these upgrades could be grouped with the upgrades to Blackstand PSS.
Alness GSP to Glastullich PSS 33kV circuits.	2041 - 2050	2041 - 2050	2036 - 2040	2041 - 2050	100.615	N-1	A section of circuit between Alness GSP and Glastullich PSS is expected to be overloaded in outage conditions. 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. • Shift load on the 11kV network from Glastullich PSS to Nigg PSS.
Contullich PSS 33/11kV transformer.	2041 - 2050	2041 - 2050	2030 - 2035	#N/A	100.57	Intact.	Contullich PSS consists of a single 100kVA pole mounted transformer. There is no interconnection on the downstream 11kV network. Potential options to resolve this are: • Upgrade the existing transformer to a 315kVA pole mounted transformer, however this may not accommodate future load growth. • Install a higher rated ground mounted substation. • Install additional transformer along the 33kV network, splitting the 11kV network.
Conon Bridge PSS to Dingwall PSS 33kV circuits.	2041 - 2050	#N/A	2051	#N/A	147.036	N-1	Sections of the line between Conon Bridge PSS and Dingwall PSS are expected to be overloaded in outage conditions. Potential options to resolve this constraint are: • Reinforce the circuits between Conon Bridge and Dingwall PSSs. • Shift load on the 11kV network from Conon Bridge PSS to Dingwall PSS.

Table 5 Summary of system needs identified in this strategy through to 2050 along with indicative solutions.

8.5. 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 Beauly 132kV supply area high voltage and low voltage network needs to 2050.

8.5.1. 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.
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 45 primary substations supplied by Beauly 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 24 demonstrates how this percentage changes under each DFES scenario from now to 2050.

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.
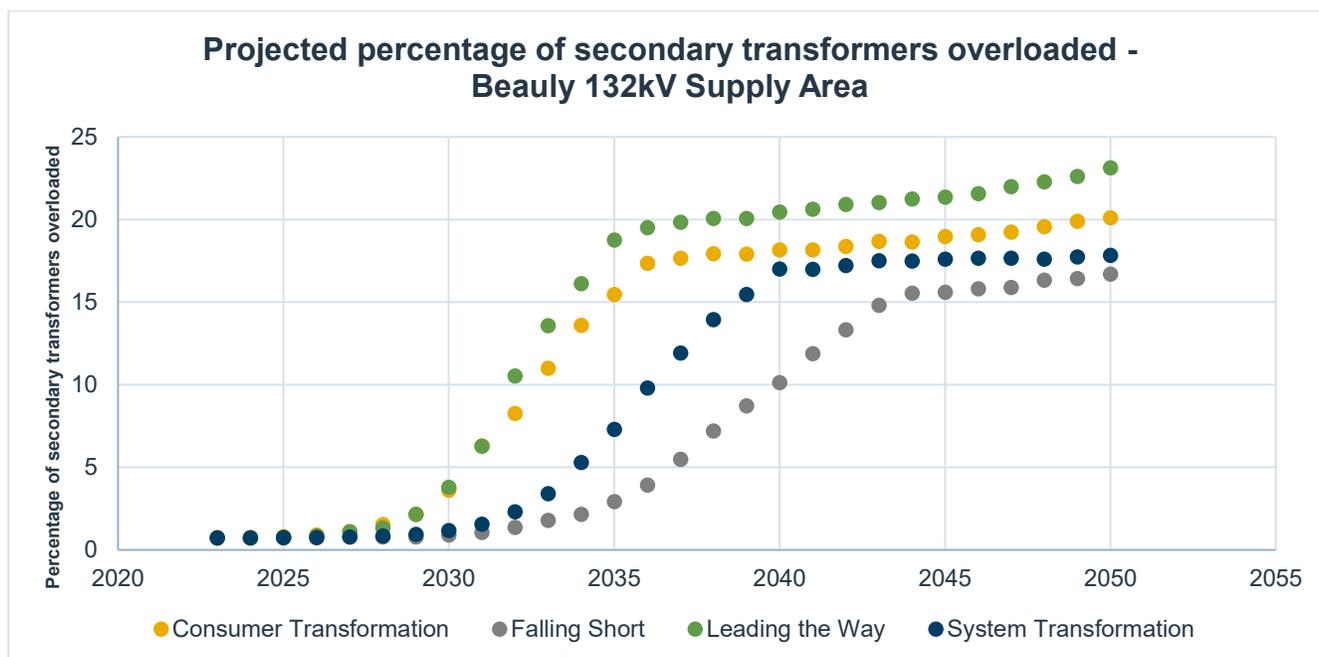
Figure 2424 Example Projected Secondary Transformer Loading. Source: SSEN Load Model

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 foresighting 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 our customers in different locations face.

One of the outputs from this innovation project was the report produced by the Smith Institute.[14] This work groups LSOAs[15] 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.

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.

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

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

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 6 VFES Groupings

As shown in Figure 25, all the VFES groupings defined in the table above are present across the area supplied by Beauly SDP. There are also areas that the VFES has identified as very high vulnerability that are also served by several secondary transformers that are projected to be overloaded by 2028 under the Consumer Transformation scenario. Proactive reinforcement of these assets will ensure that those in the area are less likely to be left behind in the energy transition while also improving the resilience of the network in these areas.
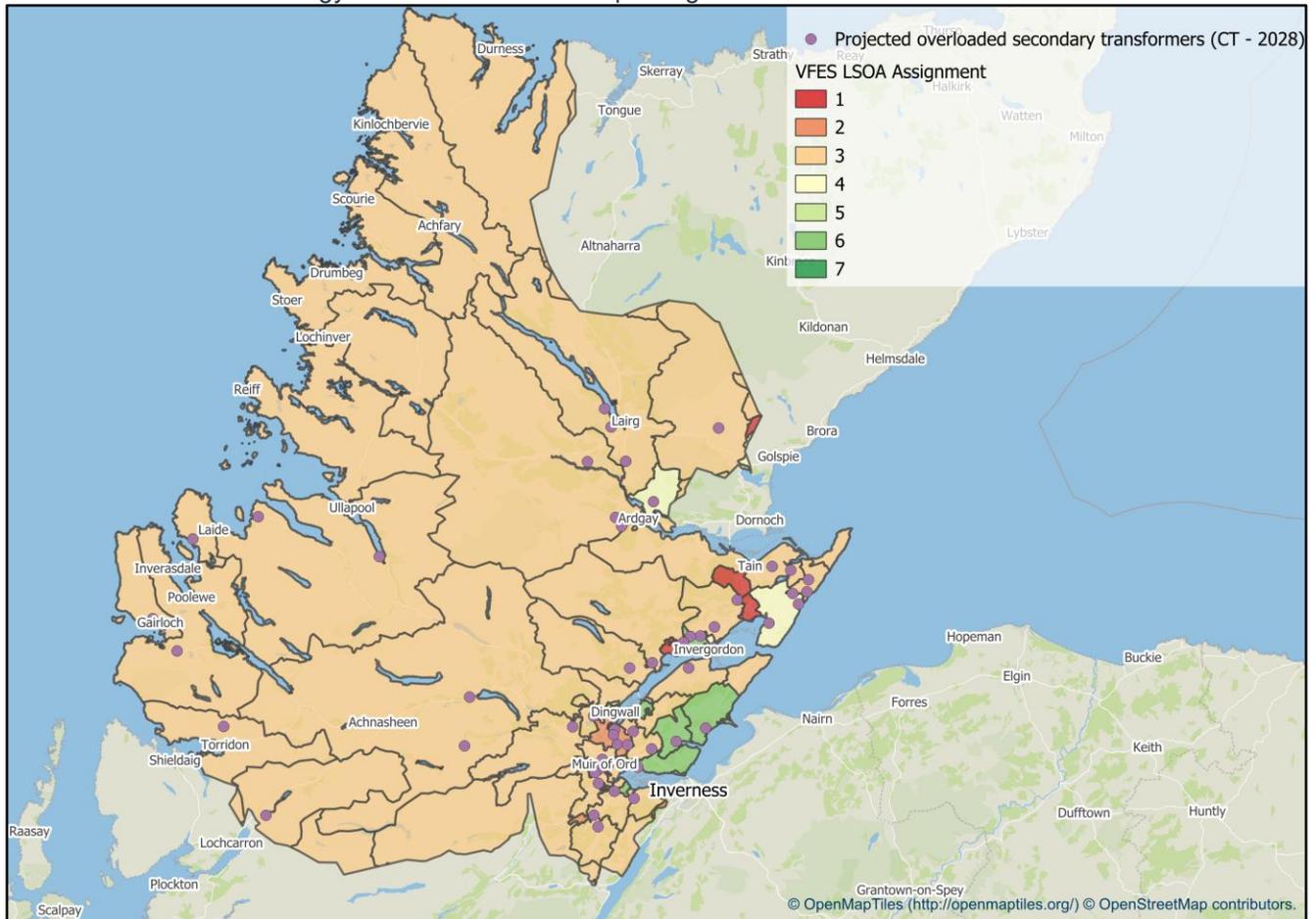
Figure 2525 Beauly SDP supply area VFES output with secondary transformer overlay.

8.5.2.   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 of these 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.

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-liner 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 study area, *3.18*% of low voltage feeders may need intervention by 2035 and *4.02*% by 2050 under the CT scenario as shown in **Figure 26**. Please note the study has used data from rural areas across the north of Scotland for improved data quality. The need is unlikely to be triggered until 2028 onwards. However, due to the timeline to grow the workforce (with jointing skills taking typically four 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.
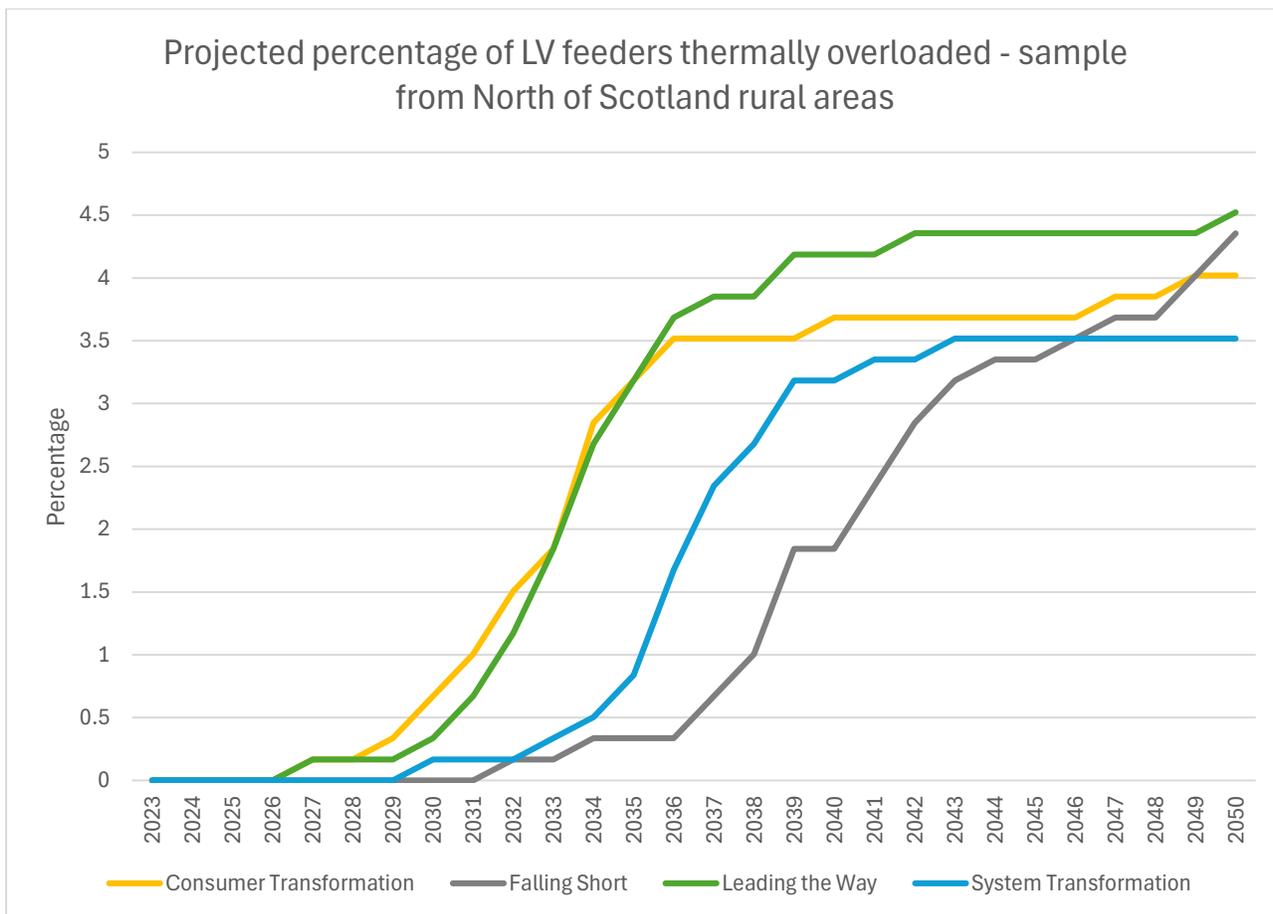
Figure 2626 Percentage of LV feeders projected to be overloaded in rural Scottish areas of the network.

9. RECOMMENDATIONS

The review of stakeholder engagement and the SSEN 2023 DFES analysis provides a robust evidence base for load growth across the Beauly 132kV supply area in both the near and longer term. Drivers for load growth across the Beauly 132kV supply area arise from multiple sectors and technologies. These drivers impact not only our EHV network but will drive system needs across all voltage levels.

Across the Beauly 132kV supply area, a significant volume of work has already been triggered through the DNOA process and published in DNOA Outcomes Reports. This delivers a significant amount of additional capacity in the area over the next decade. These are driven by customer connections and system needs that will arise this decade but are being developed to meet 2050 needs.

The findings from this report have provided evidence for 5 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 Beauly 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. Due to the length of the circuits in the Beauly 132kV supply area a number of future voltage constraints have been identified, and occasionally these 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'.

5. Understanding how rural decarbonisation could impact load on the network. Specifically, the electrification of distilleries and ports along the east coast of the area 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 economic we aim to remove legacy 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 Further detail on existing network infrastructure – Primary Substations

Substation Name	Site Type	Number of Customers Served (approximate)	2023 Substation Maximum demand in MVA (Season)
Achiltibuie	Primary Substation	294	1.003
Aigas	Primary Substation	69	0.111
Ardessie Water	Primary Substation	N/A	N/A
Aultbea	Primary Substation	869	1.414
Badcaul	Primary Substation	N/A	N/A
Badluarach	Primary Substation	N/A	N/A
Badrallach	Primary Substation	N/A	N/A
Baladie	Primary Substation	1589	2.531
Biden Clan Raonaild	Primary Substation	1	N/A
Blackstand	Primary Substation	1570	2.653
Comrie	Primary Substation	10	0.016
Conon Bridge	Primary Substation	2914	3.608
Conon Falls	Primary Substation	133	0.147
Contullich	Primary Substation	14	0.021
Corriehaille	Primary Substation	N/A	N/A
Crosshills	Primary Substation	3747	6.221
Dingwall	Primary Substation	4911	8.964
Drumrunie	Primary Substation	117	0.094
Durnamuck	Primary Substation	N/A	N/A
Garbat Forest	Primary Substation	2	0.002
Glastullich	Primary Substation	881	2.098
Gledfield	Primary Substation	732	1.272
Inverbroom	Primary Substation	86	0.067

Invergordon	Primary Substation	2754	6.055
Kerry Falls	Primary Substation	946	1.353
Kiltarlity	Primary Substation	829	0.248
Kinlochewe	Primary Substation	333	1.163
Lairg Grid	Primary Substation	893	0.003
Letterewe	Primary Substation	4	0.001
Loch Glascarnoch	Primary Substation	1	11.325
Lochcarron	Primary Substation	606	0.911
Lochinver	Primary Substation	862	1.295
Marybank	Primary Substation	681	1.248
Muir of Ord	Primary Substation	4434	11.968
Muirend	Primary Substation	1309	2.431
Nigg	Primary Substation	2	1.726
North Kessock	Primary Substation	979	1.453
Overscaig	Primary Substation	12	0.016
Peddieston	Primary Substation	781	1.691
Rhinconich	Primary Substation	901	1.523
Shin	Primary Substation	234	0.401
Tain	Primary Substation	2482	5.317
Torboll	Primary Substation	5	0.006
Tressady	Primary Substation	255	0.285
Ullapool	Primary Substation	1005	1.415

Table 7 Customer number breakdown and primary substation peak demand readings (2023)

Appendix B   DFES 2024 Projections

NESO publishes the FES framework annually, and this is adopted for the DFES. The 2024 edition outlines three new pathways (Holistic Transition, Electric Engagement, and Hydrogen Evolution) that achieve net zero by 2050 against a counterfactual. The pathways framework is shown below in Figure 28.

The following charts show the latest DFES 2024 projections similar to those in section 5 with the updated pathways.
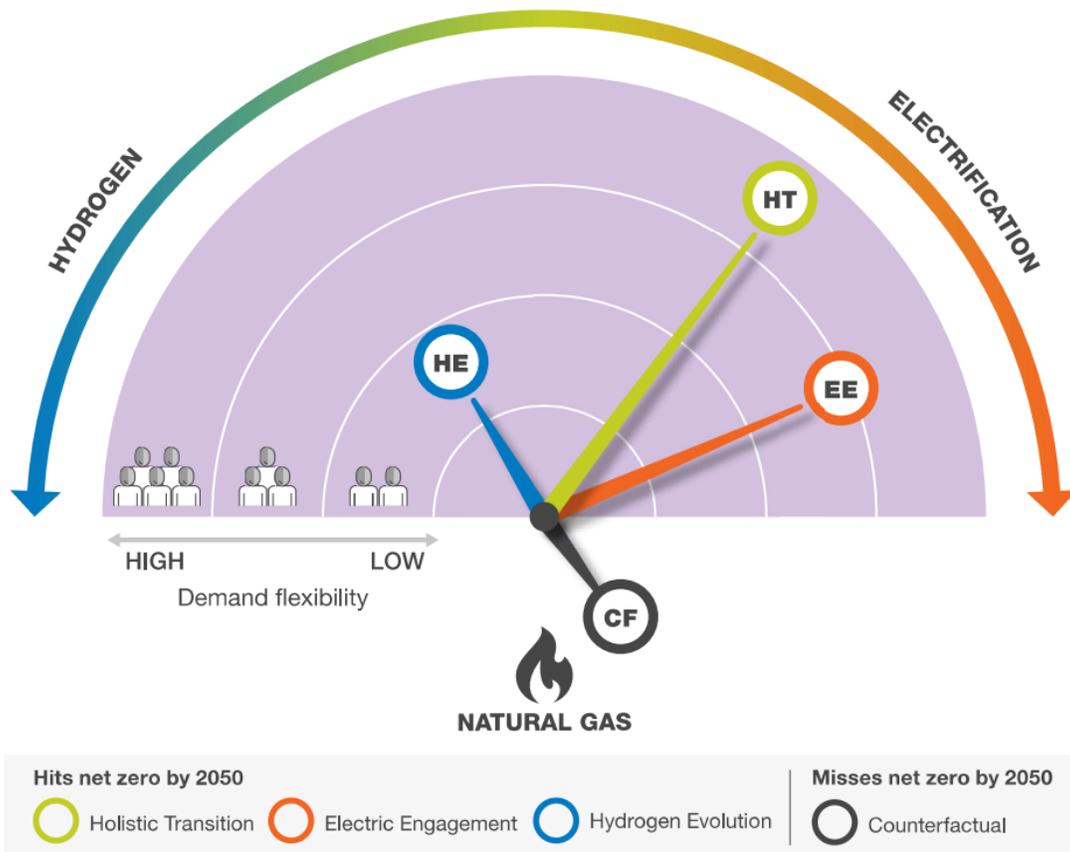

Figure 27 The FES 2024 scenario framework (source: NESO)

DFES 2024 Generation Projections - The Beauly 132kV Supply Area

Legend:
- Biomass CHP
- Hydropower
- Renewable Engines (Landfill Gas, Sewage Gas, Biogas)
- Hydrogen electrolysis
- Onshore wind
- Solar PV
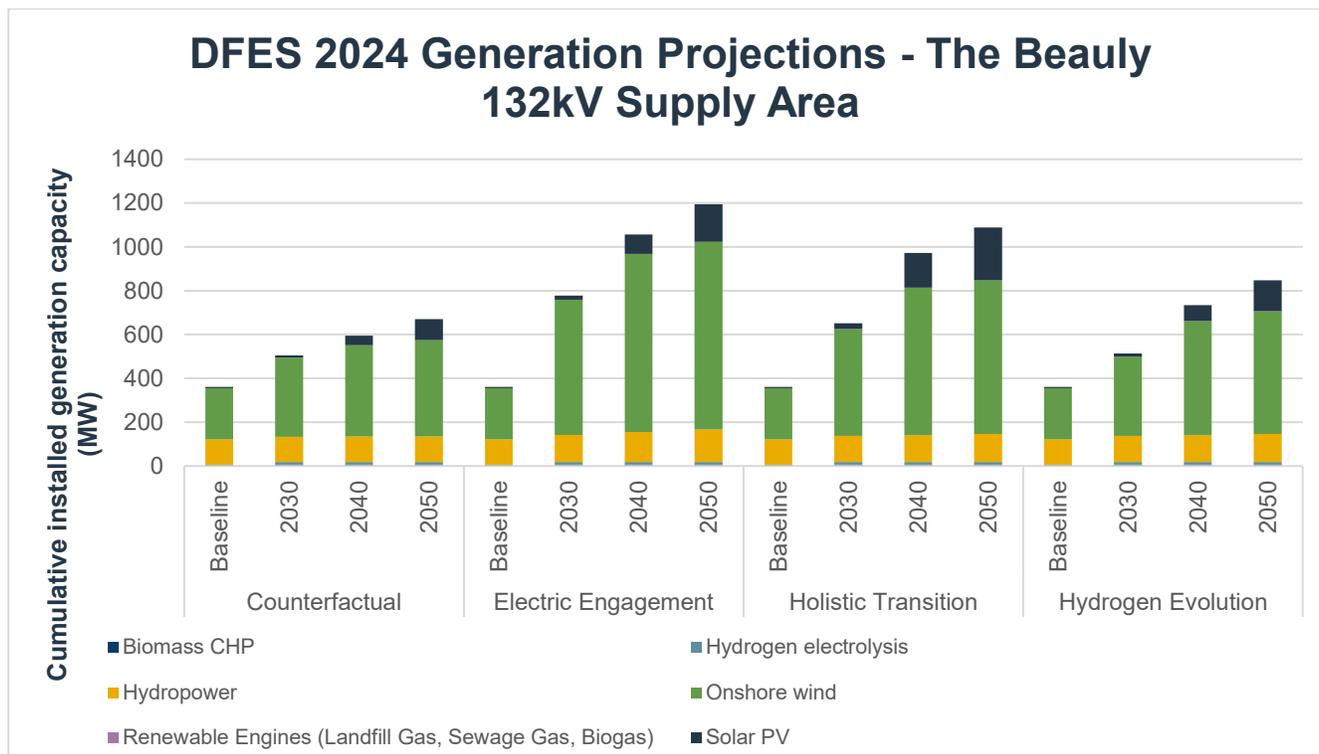
Figure 28 Projected cumulative distributed generation capacity across the Beauly 132kV supply area (MW). *Source: SSEN DFES 2024*

DFES 2024 Storage Projections - The Beauly 132kV Supply Area

Legend:
- Domestic_storage
- Generation co-Location
- High energy user
- Standalone grid services
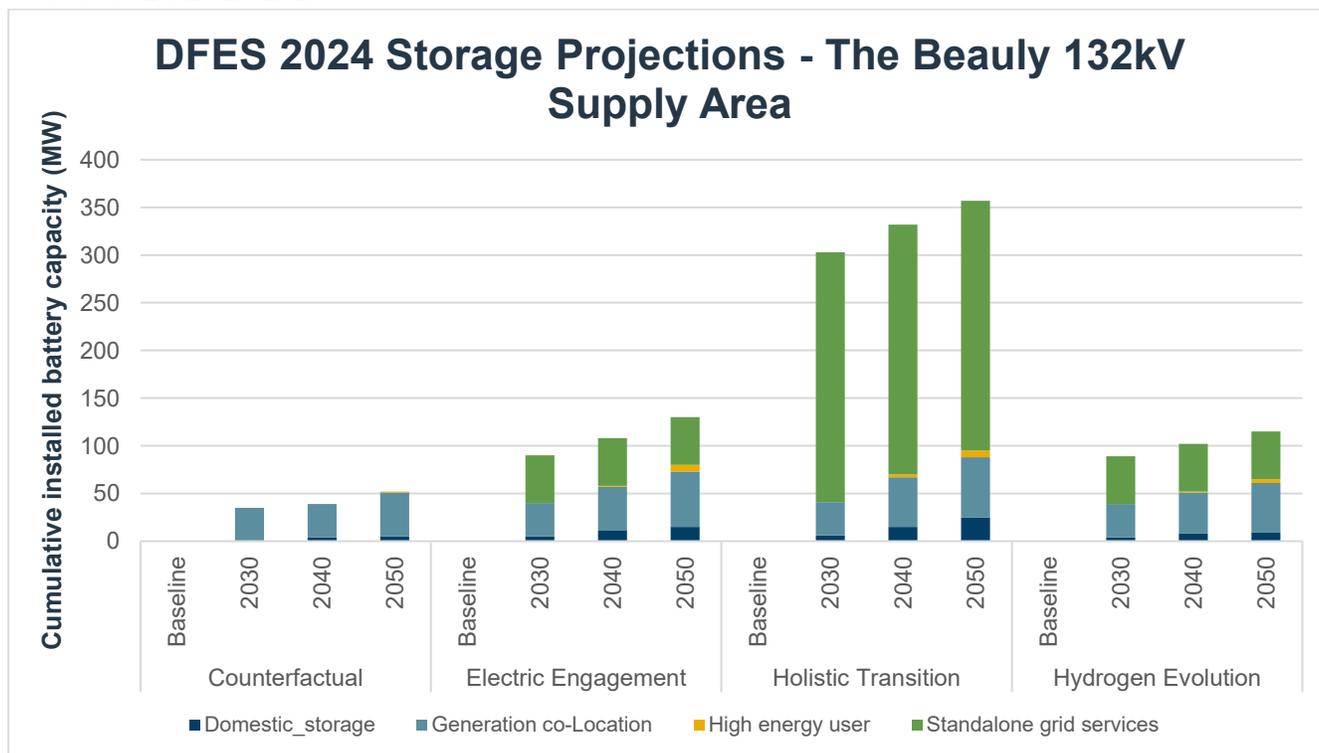
Figure 29 Projected battery storage capacity across the Beauly 132kV supply area (MW). *Source: SSEN DFES 2024*
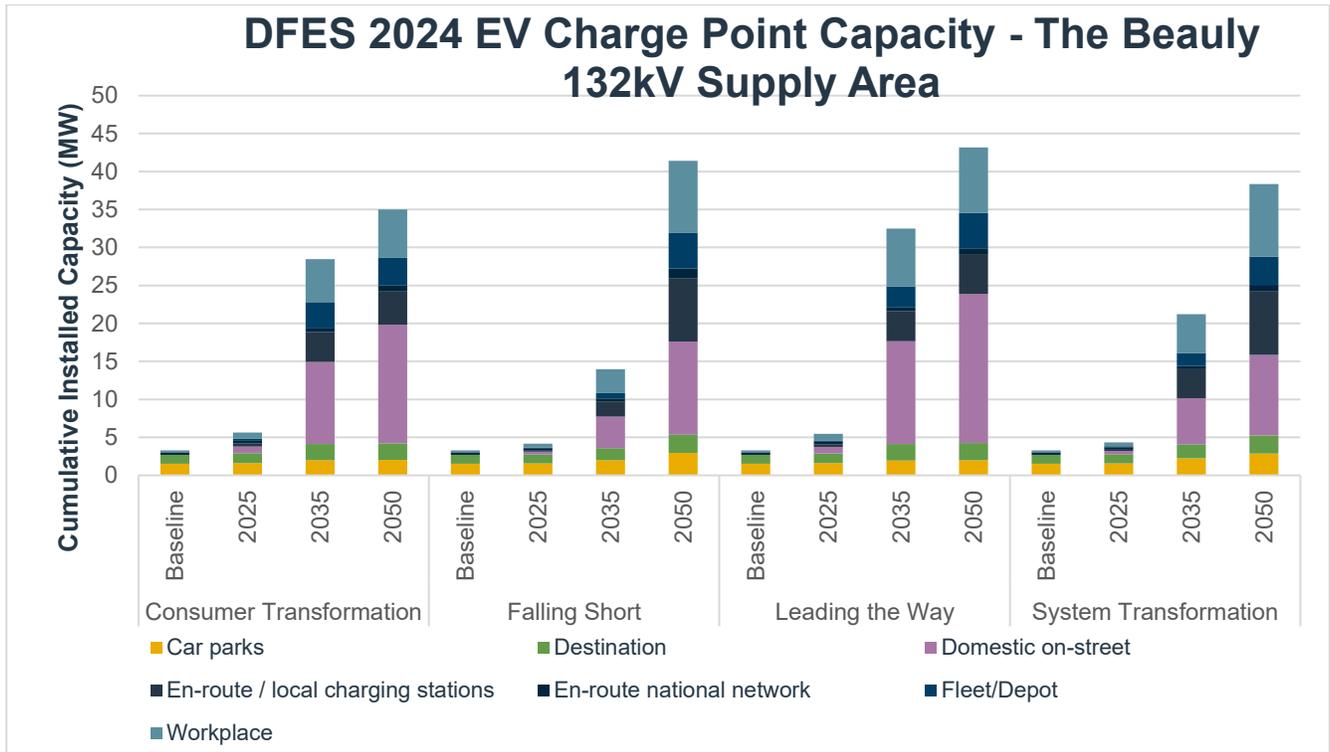
Figure 30 Projected EV charge point capacity across the Beauly 132kV supply area. *Source: SSEN DFES 2024*
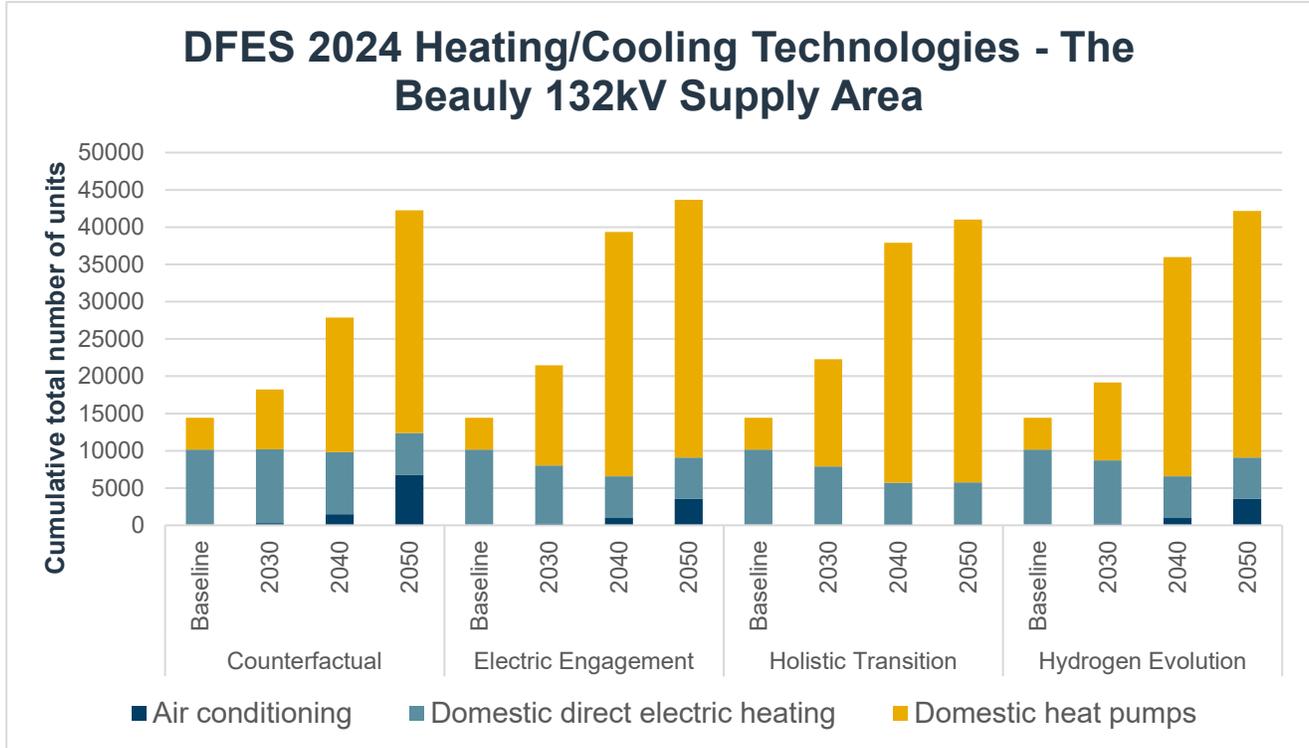
Figure 31 Projected number of heating/cooling technologies across the Beauly 132kV supply area. *Source: SSEN DFES 2024*
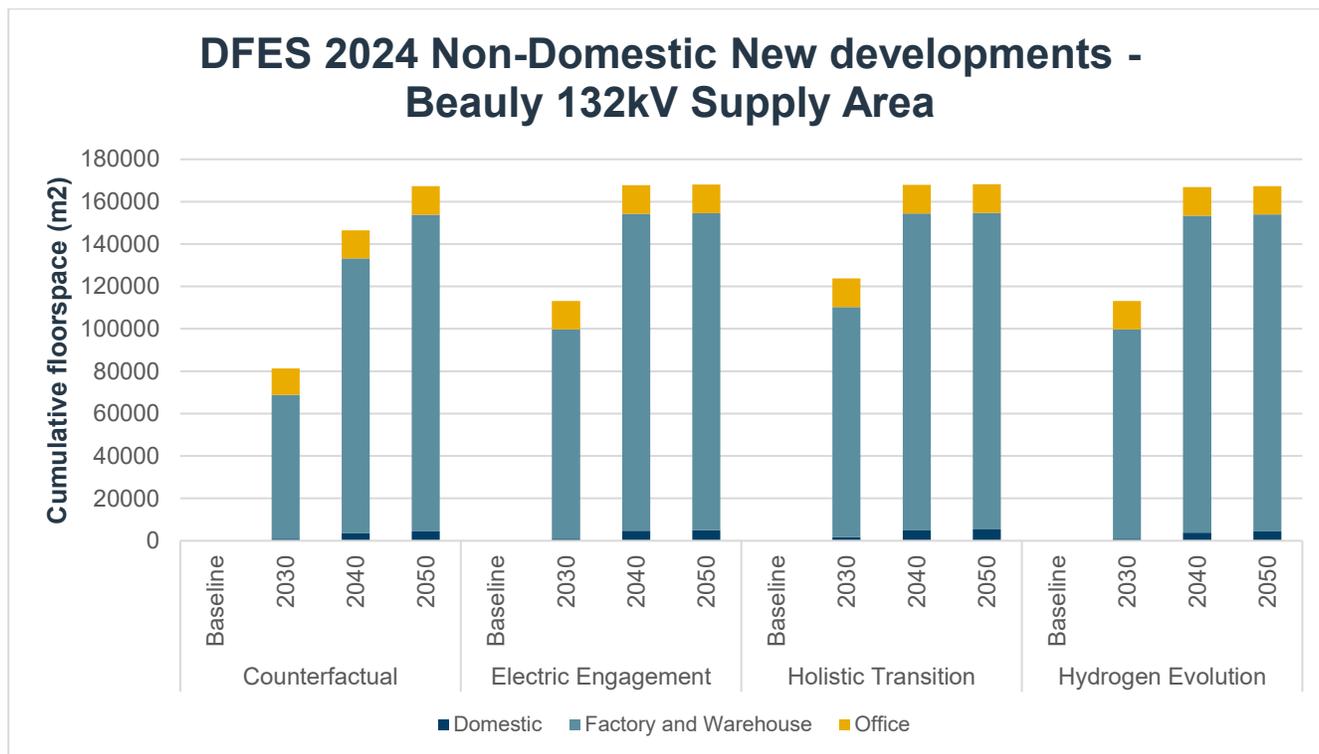
Figure 32 Projected non-domestic new development across the Beauly 132kV supply area. *Source: SSEN DFES 2024*

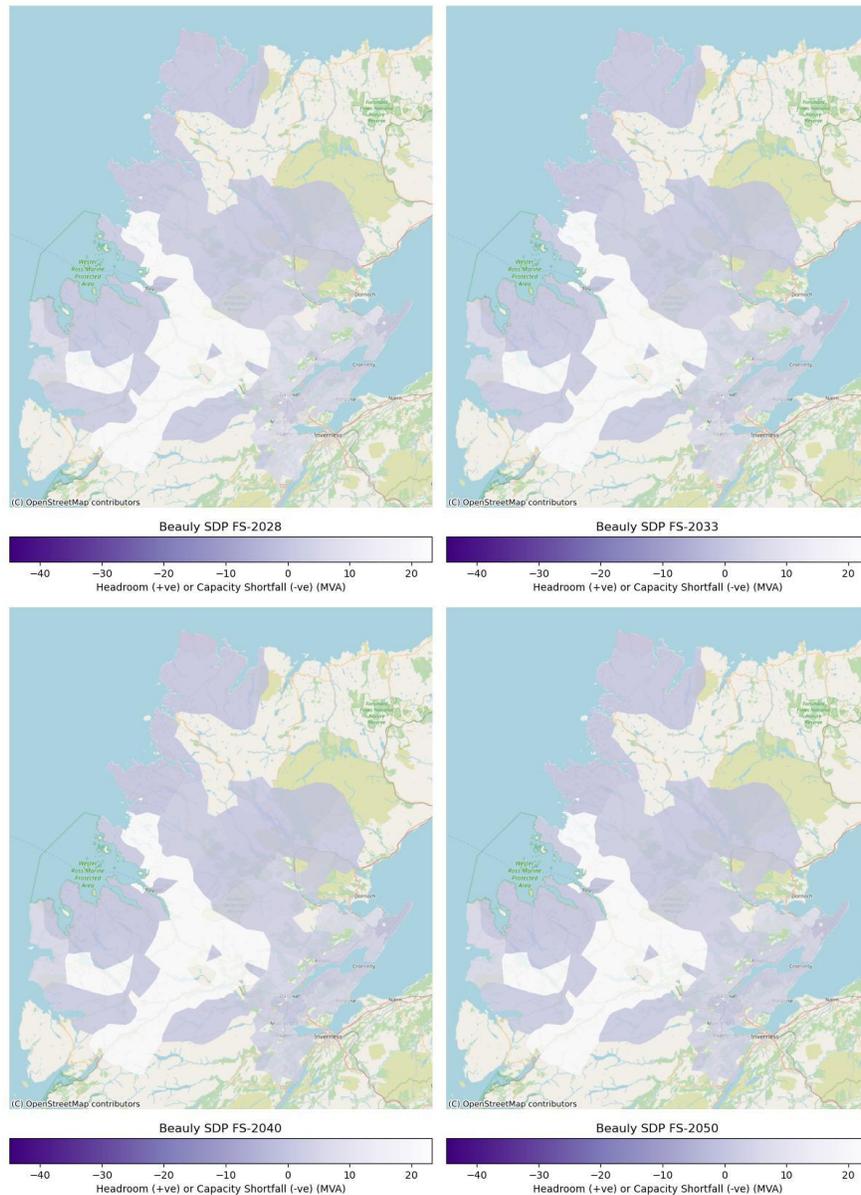# Appendix C   EHV/HV spatial plans for other DFES scenarios

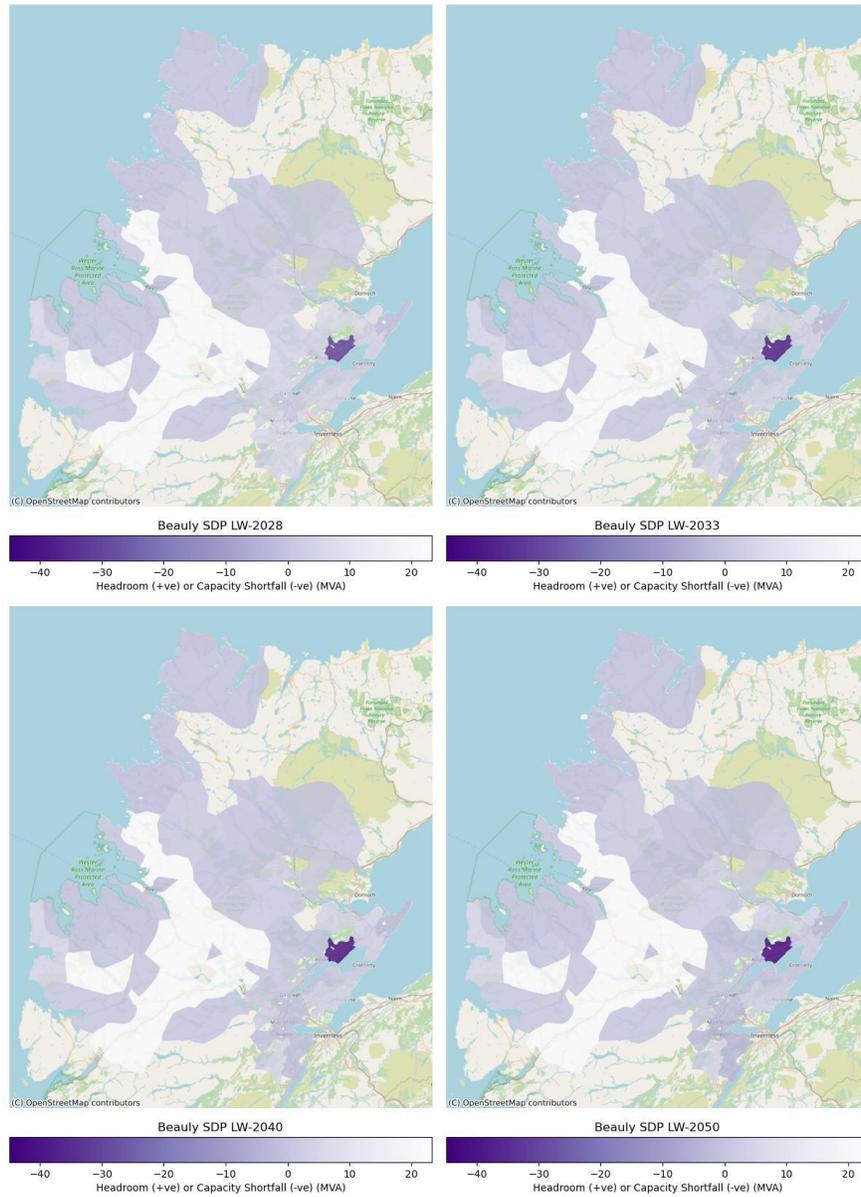Figure 33 Beauly 132kV supply area - EHV/HV Spatial Plan – Falling Short

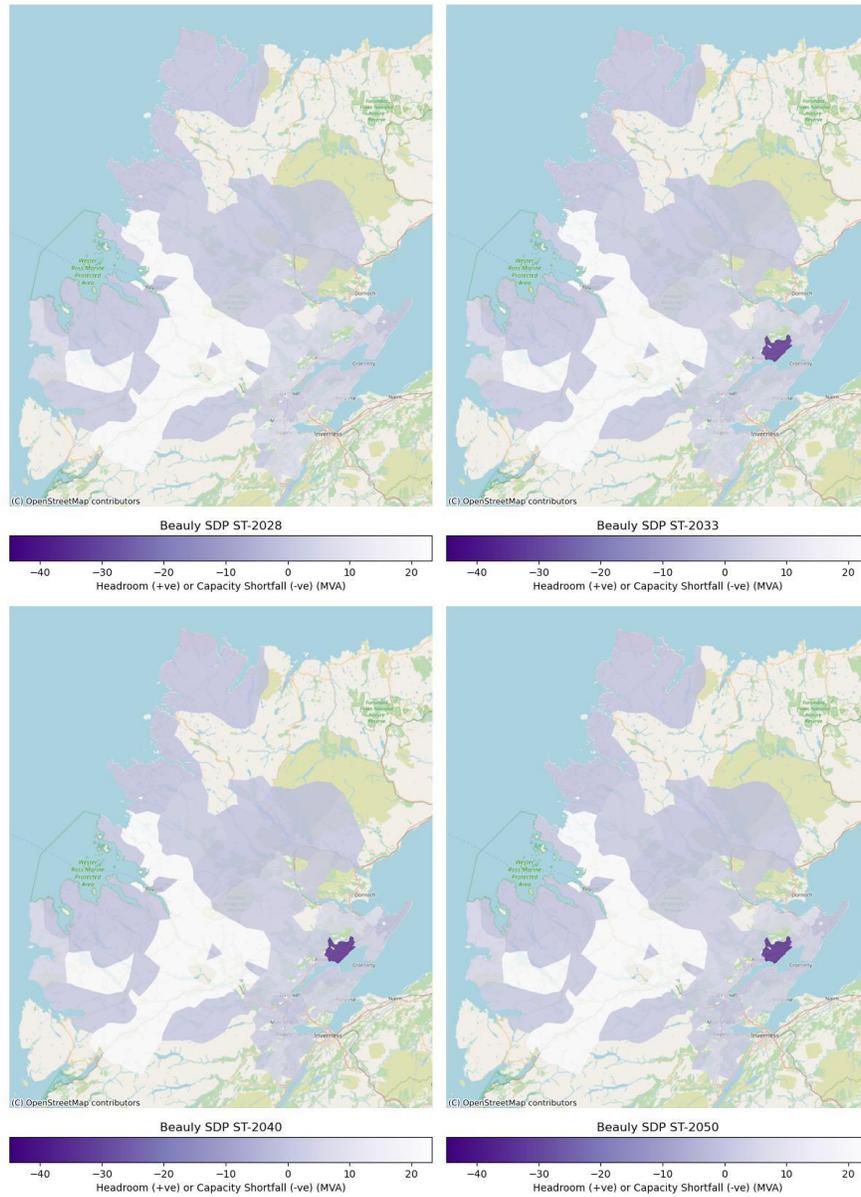Figure 34 Beauly 132kV supply area – EHV/HV Spatial Plan - Leading the Way

Figure 35 Beauly 132kV supply area – EHV/HV Spatial Plan - System Transformation
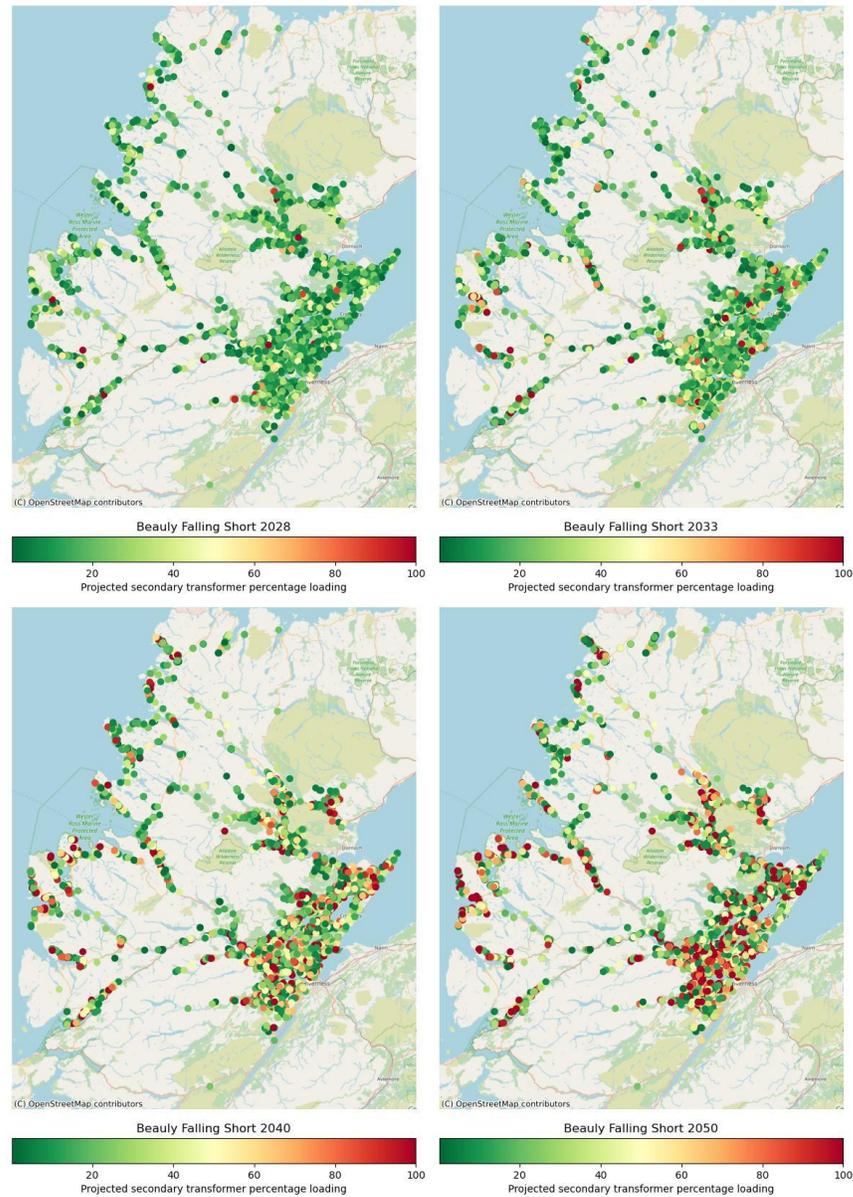
Appendix D HV/LV spatial plans for other DFES scenarios

Figure 36 Beauly 132kV supply area – HV/LV Spatial Plan – Falling Short
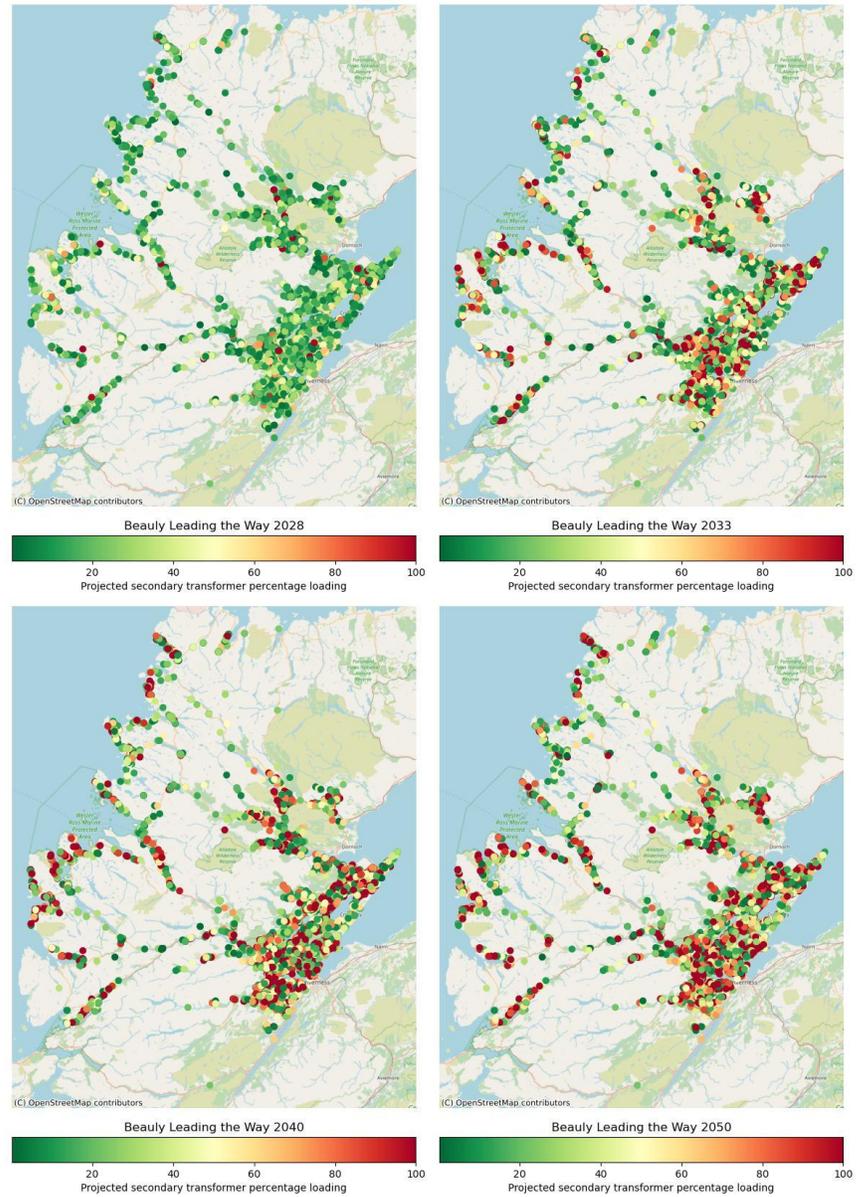
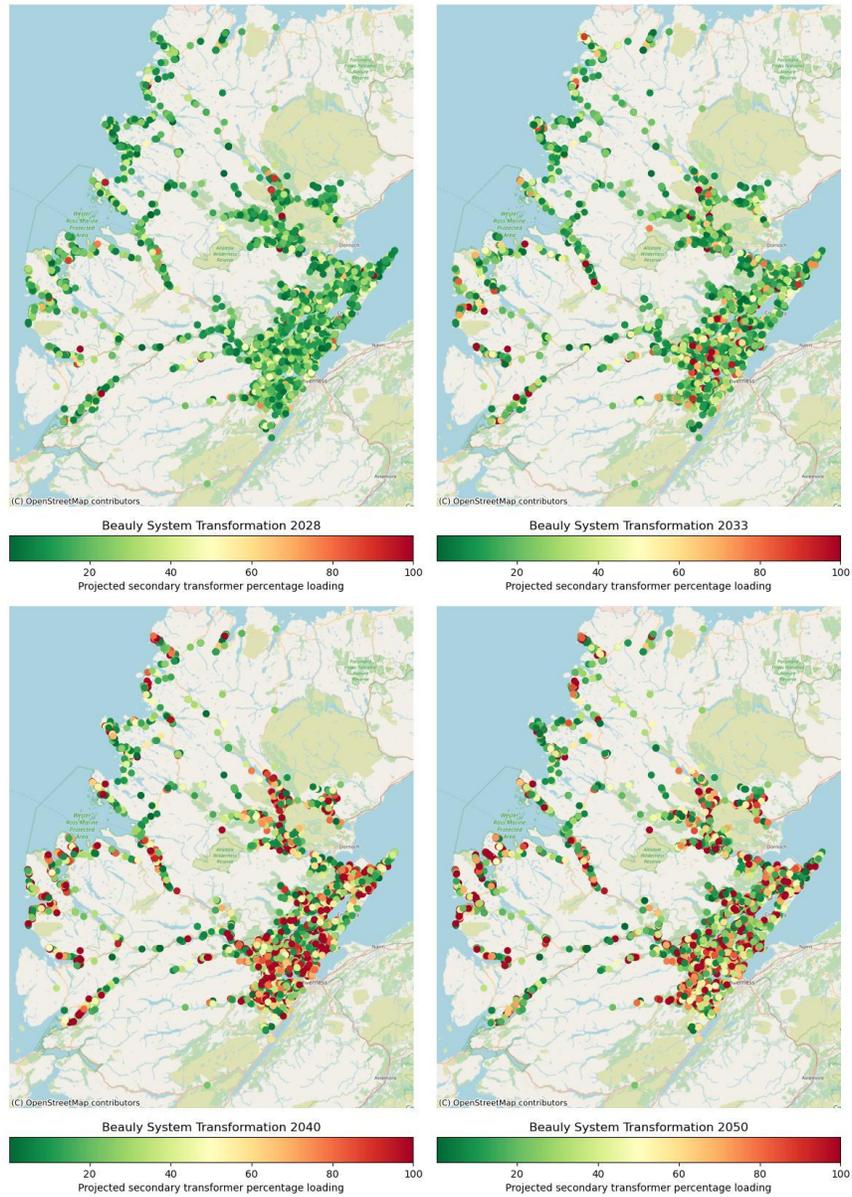Figure 37 Beauly 132kV supply area – HV/LV Spatial Plan – Leading the Way

Figure 38 Beauly 132kV supply area – HV/LV Spatial Plan - System Transformation

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
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
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
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 Network
ST	System Transformation
UM	Uncertainty mechanism
VFES	Vulnerability Future Energy Scenarios
WSC	Worst Served Customers

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