Distribution Future Electricity Scenarios in the North of Scotland

Distributed generation and demand technology growth to 2032

SSEN SHEPD North of Scotland

This report was produced for:	Scottish and Southern Electricity Networks
Issue date:	07.11.2019
Version:	Final
Written by:	Poppy Maltby, Regen Frankie Mayo, Regen
Approved by:	Merlin Hyman, Regen

Regen, Ground floor, Bradninch Court, Castle Street, Exeter, EX4 3PL

T +44 (0)1392 494399 E admin@regen.co.uk www.regen.co.uk

Registered in England No: 04554636

Acronym	Definition
CfD	Contract for Difference
EfW	Energy from Waste
ESA	Electricity Supply Area
EV	Electric Vehicle
FES	(National grid) Future Energy Scenarios
GIS	Geographic Information System
GSP	Grid Supply Point (33 kV : 132kV transformer)
GW	Gigawatt
ha	Hectares
kW / kWh	Kilowatt / kilowatt hour
MW	Megawatt
PV	Photovoltaics
RHI	Renewable Heat Incentive
SSEN	Scottish and Southern Electricity Network
SHEPD	Scottish Hydro Electricity Power Distribution (distribution licence area)

Table of contents

1. Introduction

This report summarises the findings of Regen's study of how electricity generation and demand could change over the next decade in SSEN's SHEPD North of Scotland licence area. The study developed future energy scenarios at distribution level to support SSEN's planning for how their network can meet the needs of both generation and demand customers in the north of Scotland. The detailed dataset produced through the analysis will help SSEN identify possible network issues and identify cost effective solutions for addressing future problems through flexibility markets or investment in the network.

Over the last decade the distribution electricity network, which serves demand customers and smaller generators, has seen an unprecedented increase in new, mainly renewable generation connections. Previously almost all generation had been very large and connected onto the transmission network. However, since 2010, around 50% of all onshore wind connected in the north of Scotland has connected at the distribution level, totalling over 1.2 GW. This shift means that there are challenges in connecting new generation in almost all the SHEPD network, as shown in Figure 1-1.

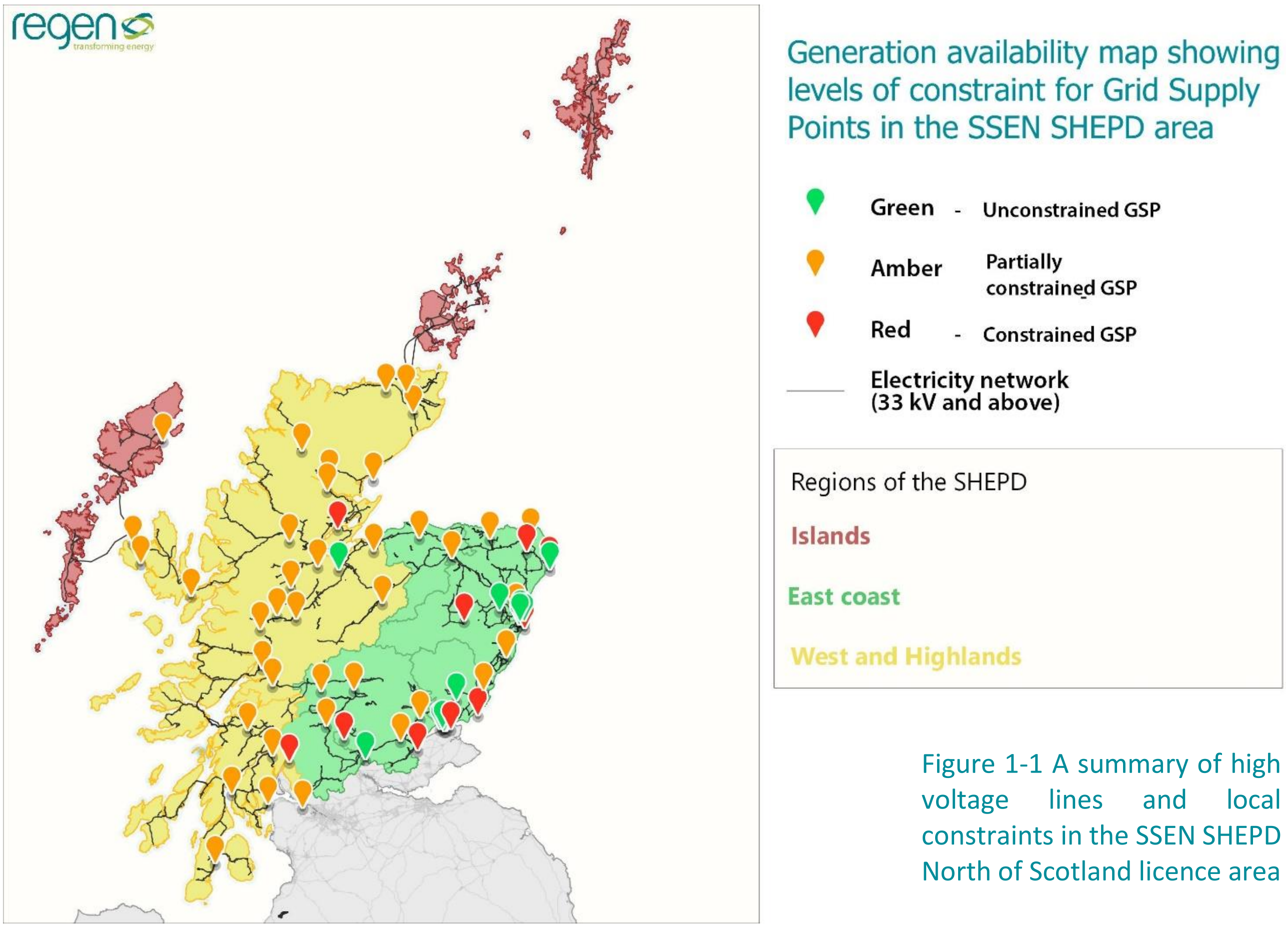


Figure 1-1 A summary of high voltage lines and local constraints in the SSEN SHEPD North of Scotland licence area

The urgent need to decarbonise the UK's electricity generation to meet the UK's climate change targets means that it is inevitable that the demands on the distribution network will continue to change rapidly. The pathway to achieving our carbon reduction targets and how fast the transition will occur remains uncertain and depends on a variety of factors, from performance of the global economy to local congestion charging. The use of multiple future scenarios helps network operators to explore and manage this uncertainty in their network planning.

This study provides a range of credible scenarios for how the distribution electricity network will be used by 2032, including changes to generation, battery storage and technologies such as electric vehicles and heat pumps. The baseline data is correct at the end of 2018 and the analysis uses the framework of the National Grid Future Energy Scenarios 2018 study. However the study also reflects key technology changes from FES 2019 which was released towards the end of the project. Both FES 2018 and 2019 were completed prior to the government's net zero target. However the net zero sensitivity in FES 2019 suggests that the trajectories for Community Renewables and Two Degrees used in this study would be broadly consistent with that goal.

The study is based on a detailed bottom-up analysis of the resources of the licence area, projects already built and projects in the pipeline, and expectations of potential growth. Further detail on the methodology is presented at the end of this report.

Stakeholder engagement is fundamental to the analysis. As well as contacting individual local authorities and generation developers, Regen and SSEN invited stakeholders from community energy groups, local authorities, network operators, and the Scottish Government to an event in July 2019. The information we gathered through these processes has fed directly into the analysis and report.

Under all scenarios further renewable generation will need to connect to the network. At the same time, increasing electrification of heat and transport will introduce new demands on the system, particularly if this increases the evening peak load. As SSEN evolves into a system operator it will need to plan for these changing demands and use flexibility solutions alongside traditional network assets to reduce the need for extensive network upgrades and investment.

Scope of the electricity network in this report

This study is focussed on the distribution network and, therefore, has only assessed the generation projects and demand customers that are currently connected, or may connect onto the lower voltage levels of the electricity network that are served and maintained by SSEN SHEPD.

Unlike the rest of GB, where distribution networks also include the 132 kV network, the Scottish distribution networks are defined as the network **below** 132 kV. Therefore, in Scotland the 132kV network is part of the transmission network. Consequently, there are few very large generators connected to the SHEPD distribution network. For example, the large hydropower plants in the north of Scotland are connected at the transmission level and are not included in the hydropower capacity totals in the analysis.

2. SHEPD North of Scotland licence area

The SSEN SHEPD area stretches northwards from Loch Lomond and Dundee up to Orkney and the Shetland Islands. It contains the cities of Aberdeen, Dundee, Perth, Inverness and around a quarter of the total population of Scotland. It is a unique region, containing the farthest western and northern mainland points in Great Britain, populated islands including Na h-Eileanan Siar, Orkney, and the Shetland Islands, and a diverse mix of cities and sparsely populated regions as shown in Figure 2-1.

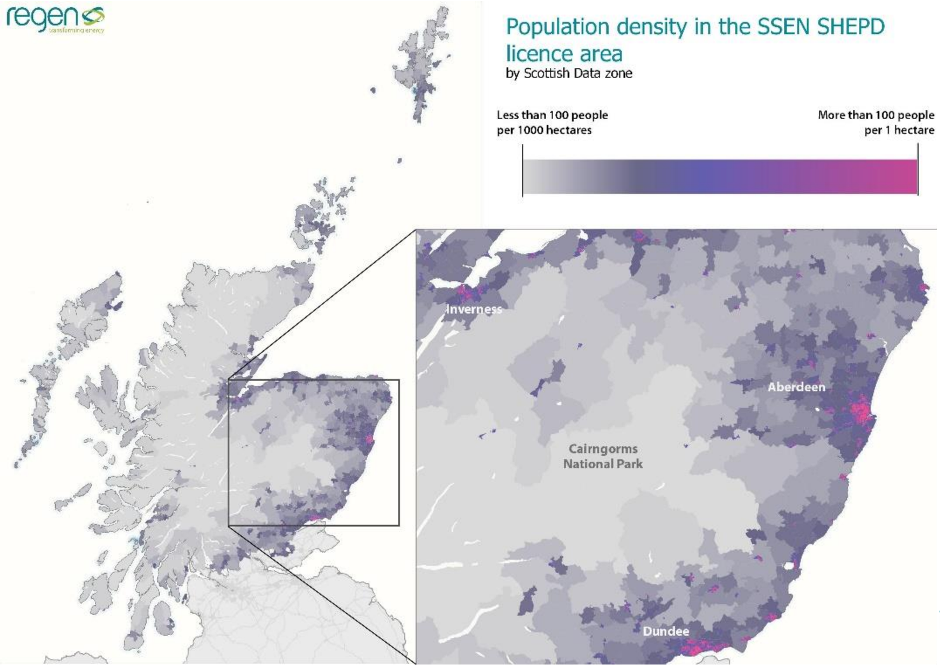


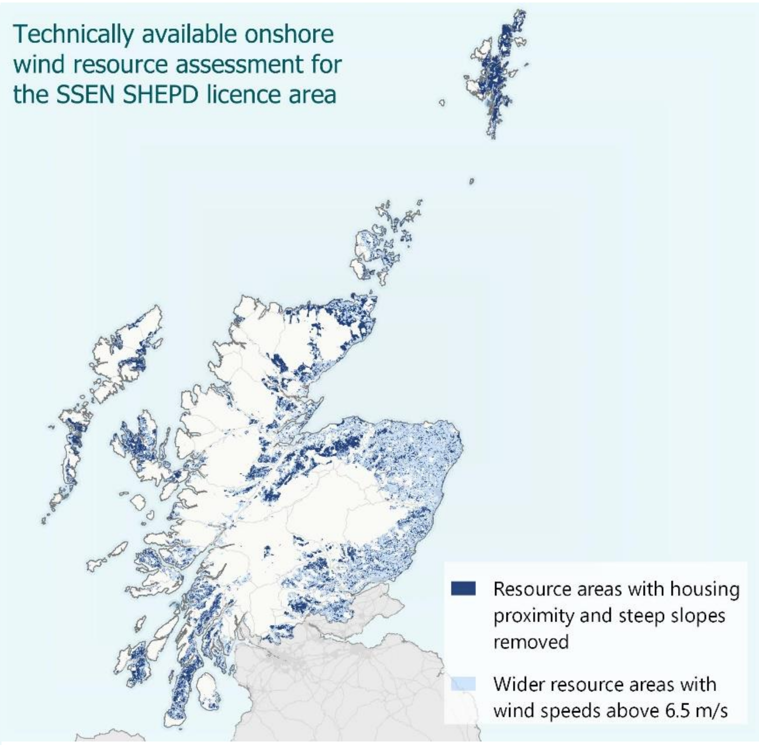
Figure 2-1 Population density in SHEPD licence area

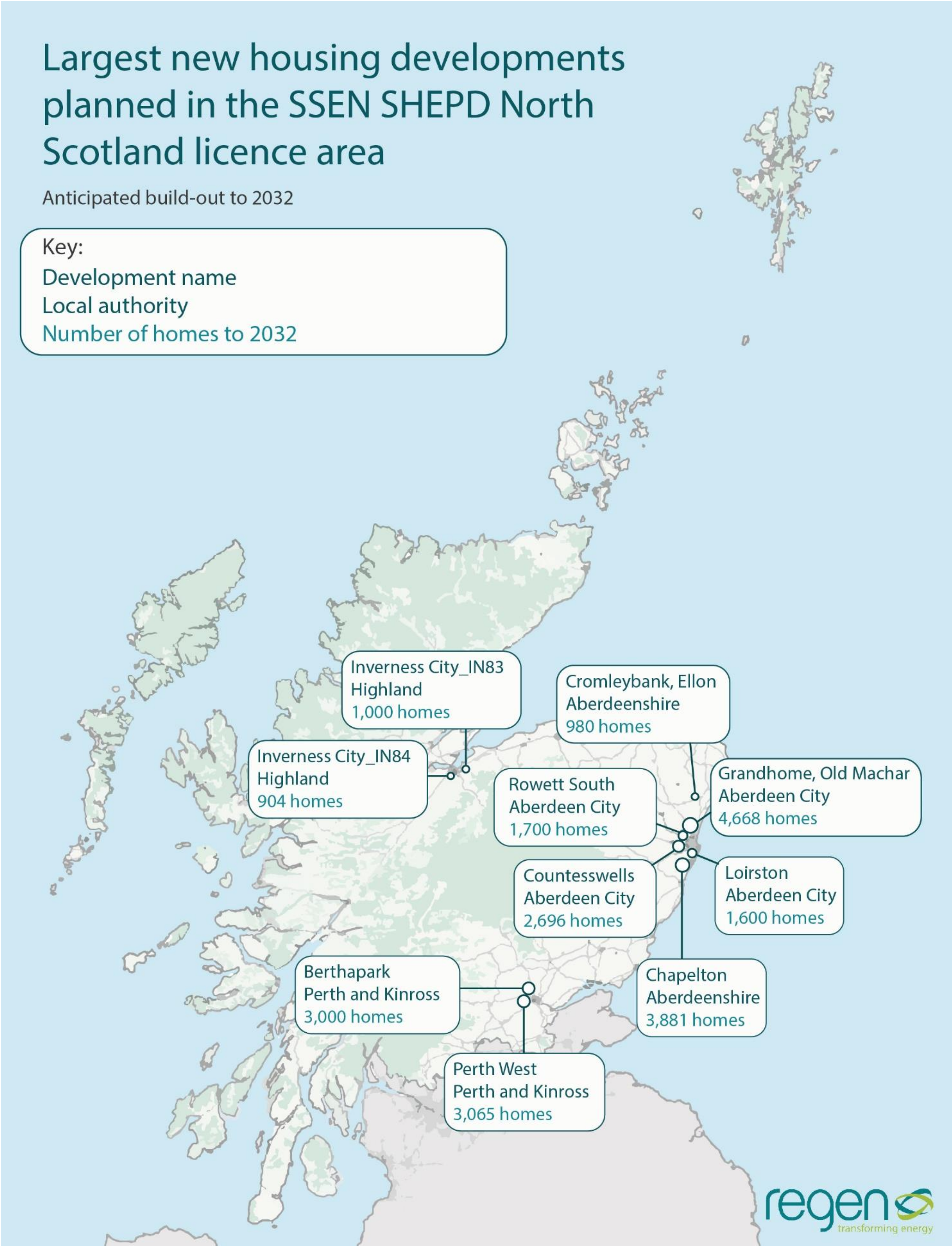
SHEPD onshore wind resource

The area has seen high deployment of renewable technologies, particularly onshore wind and hydropower due to the widely available renewable resource in the licence area.

A map of the technically available wind resource in SHEPD is shown in on the right.

For this study a desktop resource analysis has been completed, taking into account spatial factors such as wind speed, national parks, the proximity to housing and electricity network.




Largest new housing developments planned in the SSEN SHEPD North Scotland licence area
Anticipated build-out to 2032
Key:
Development name
Local authority
Number of homes to 2032
Inverness City_IN83
Highland
1,000 homes
Inverness City_IN84
Highland
904 homes
Cromleybank, Ellon
Aberdeenshire
980 homes
Rowett South
Aberdeen City
1,700 homes
Grandhome, Old Machar
Aberdeen City
4,668 homes
Countesswells
Aberdeen City
2,696 homes
Loirston
Aberdeen City
1,600 homes
Berthapark
Perth and Kinross
3,000 homes
Chapelton
Aberdeenshire
3,881 homes
Perth West
Perth and Kinross
3,065 homes
regen
transforming energy

3. Government and policy context

The UK Government has legislated to commit to achieving net zero emissions by 2050. The route to net zero will, however, be very different across the UK depending on the political, geographic, social and economic factors.

In Scotland the Committee on Climate Change recommended a target of net zero greenhouse gas emission by 2045 reflecting the greater progress and resources available in Scotland[1]. In September 2019 this was put into law through the Scottish Climate Change Bill. The Bill also legislated to reduce greenhouse gas emissions by 75% from 1990 levels by 2030. This is the most stretching target in the world for this date.

The Climate Change Bill adds to a number of existing energy targets in Scotland. These included the equivalent of 50% of total energy demand across heat, transport and electricity to be met from renewables in 2030 and the equivalent of 100% of electricity demand to be met by renewable electricity generation by 2020[2].

The north of Scotland's uniquely high renewable energy resource, coupled with Scottish policy ambition, is likely to mean continued high deployment of established and new renewable technologies in SHEPD. At present, however, the data shows a recent slowdown in new distributed generation connections in the licence area, mainly as a result of the reduction in subsidies since 2016. The remaining renewables support policy, Contracts for Difference (CfD)[3] is providing support for a pipeline of offshore wind projects and, more recently, onshore island schemes in Scotland.

Without subsidies, developers have struggled to build new projects as they need to rely on an increasingly volatile electricity market price to make a financially viable investment. They are also currently faced with uncertainty about how generators will be charged in future for using the electricity network[4]. Reversing the hiatus in new generation will need renewed policy and price support from the UK and Scottish Government in the next few years, along with further reductions in technology and installation costs.

The licence area is also unique from a demand perspective with relatively low domestic and commercial electricity demand in comparison to generation. Around 37% of households in the region are currently without gas central heating[5], meaning that there is a strong case for heat pumps, flexible electric heating and other low carbon heating technologies. The Scottish Government also have an ambition to 'phase out the need for petrol and diesel cars by 2032', eight years earlier than the UK wide target. The potential for electrification of heating and transport is, therefore, high in the north of Scotland meaning demand for electricity, which has in general been falling for over a decade, may start to increase sooner than the rest of the UK.

The policy context and the unique factors affecting electricity generation and demand in the North of Scotland means that the future energy scenarios for the region will be significantly different to elsewhere in the UK.

---

[1] https://www.parliament.scot/parliamentarybusiness/Bills/108483.aspx

[2] https://www.gov.scot/news/scotland-to-become-a-net-zero-society/

[3] Contract for Difference guarantees a certain level of income for generators should the market price drop below the level required for the generator to operate profitably. Prospective generators bid into a periodic auction to receive support at a specified price level.

[4] www.chargingfutures.com

[5] https://www.gov.uk/government/statistics/lsoa-estimates-of-households-not-connected-to-the-gas-network

4. The scenarios

The pathway to achieving our carbon reduction targets remains uncertain and range of credible scenarios helps stakeholders manage this uncertainty in their future planning. The key variables in National Grid Future Energy Scenarios are how decentralised the system will be and how fast decarbonisation will occur. In the most part this will be determined by how the UK and Scottish government's policy support and planning regimes develop and change over the next decade, as they respond to the net zero challenge.

This study is based on FES 2018 but was updated to reflect key changes in FES 2019 which was released during the analysis process. However it does not reflect the trajectories now required to meet net zero by 2050 and it is expected that there will be significant changes in FES 2020 to account for this new policy. However, the net zero sensitivity in FES 2019 suggests that the trajectories for Community Renewables and Two Degrees within this study's timescale, would be broadly consistent with the UK's new legally binding targets.

The four scenarios explored in this analysis, in summary, are:

- **Community Renewables,** which explores how the 2045 decarbonisation target can be achieved through a more decentralised energy landscape with high levels of smaller scale, local and domestic activity. This scenario tends to have the highest levels of new generation and demand connected at distribution level.
- **Two Degrees,** which explores how the decarbonisation target can be achieved with a focus on larger, more centralised development. It features changes to the energy landscape such as hydrogen fuelled heat networks and transmission connected generation technologies such as nuclear and offshore wind
- **Consumer Evolution,** which is a decentralised scenario that makes progress towards the decarbonisation target but fails to achieve it. Deployment is focused on smaller scale, local and domestic projects.
- **Steady Progression,** which is a centralised scenario that makes progress towards the decarbonisation target but fails to achieve it. In the timescale of this study, the scenario sees very low deployment of renewable technologies with gas generation continuing to play a significant role.

In total there are 14 local authorities wholly or partially within the SSEN SHEPD area. For the purposes of this report only, these have been grouped into three area as defined below. The East and Lowlands area contains two thirds of the licence area population.

Islands

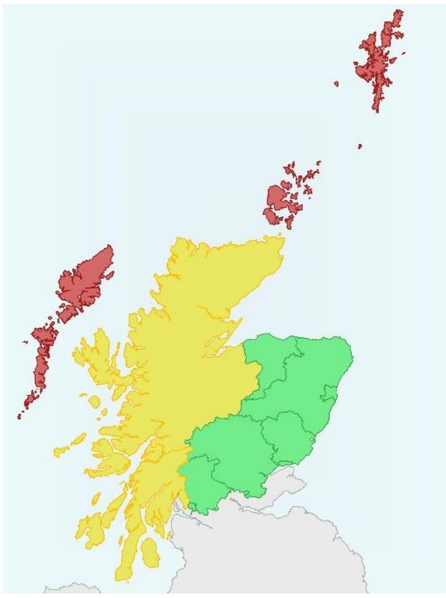
Na h-Eileanan Siar
Orkney
Shetland

West and Highlands

Argyll and Bute
Highland
North Ayrshire

East and lowlands

Aberdeen City
Aberdeenshire
Angus
Dundee City
Moray
Perth and Kinross
Stirling
West Dunbartonshire
Clackmannanshire



5. Existing distributed generation

There was a total of 2.5 GW of distributed power generation installed in SHEPD at the end of 2018, the vast majority of which (1,918 MW) was onshore wind, followed by 253 MW of hydropower. Around three quarters of the installed capacity on the distribution network in the area has connected in the past 10 years. Although some renewable generators have been operating for much longer, the 20 MW Kinlochleven hydropower station has been operating since 1909. The European Marine Energy Centre also has a connection agreement for up to 17.5 MW of marine energy demonstrator projects.

A map of installed distribution generation sites at all voltage levels is shown in Figure 5-1. This shows the wind farms prominent in the east coast and north highlands, with hydropower projects clustered around the central and western regions. There is relatively little solar photovoltaics with a small number of projects located in the eastern coastal regions. The total installed capacity for each technology is shown in

Figure 5-1 The distribution of renewable generation technologies in the SSEN SHEPD licence area.

Note this is both transmission and distribution-network connected sites.

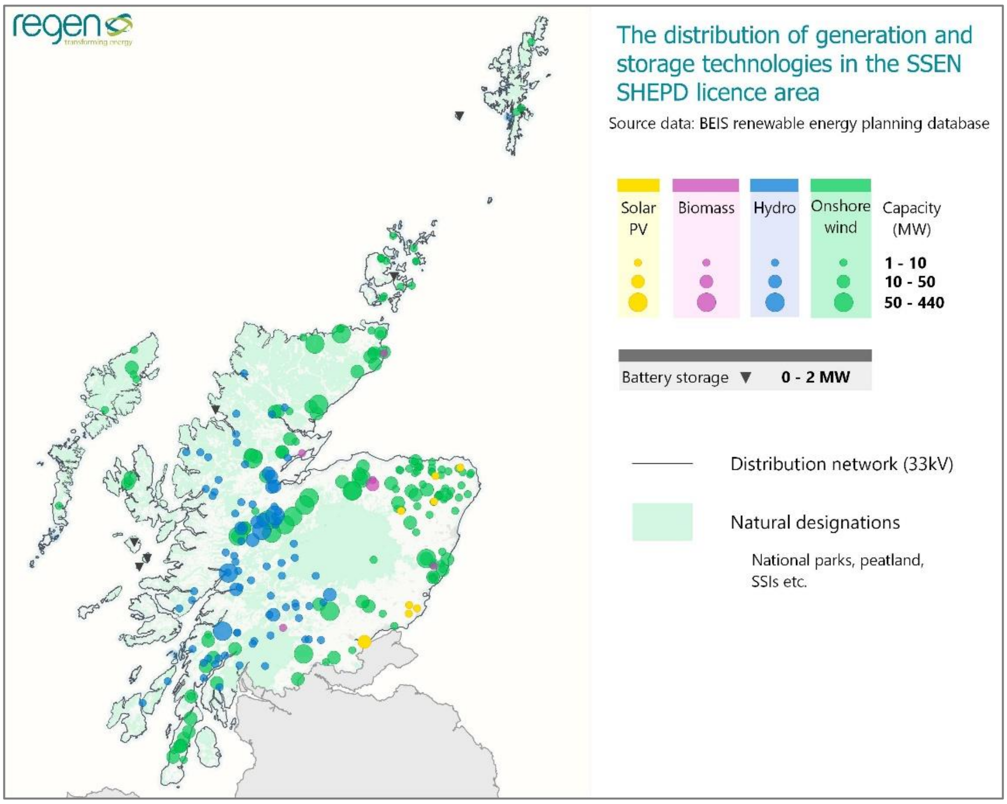


Table 5-1.

Table 5-1 Connected generation capacity (2018) on the distribution network in the SSEN SHEPD area[6]

Technology	Baseline capacity (MW)	Technology	Baseline capacity (MW)
Anaerobic digestion	9.1	Hydropower	252.9
Battery storage	-	Offshore wind	32.0
Biomass	37.6	Onshore wind	1,877.9
Diesel	128.6	Photovoltaics	137.0 (utility-scale and rooftop)
Energy from waste	15.7	Tidal	17.5 (demonstrator sites)

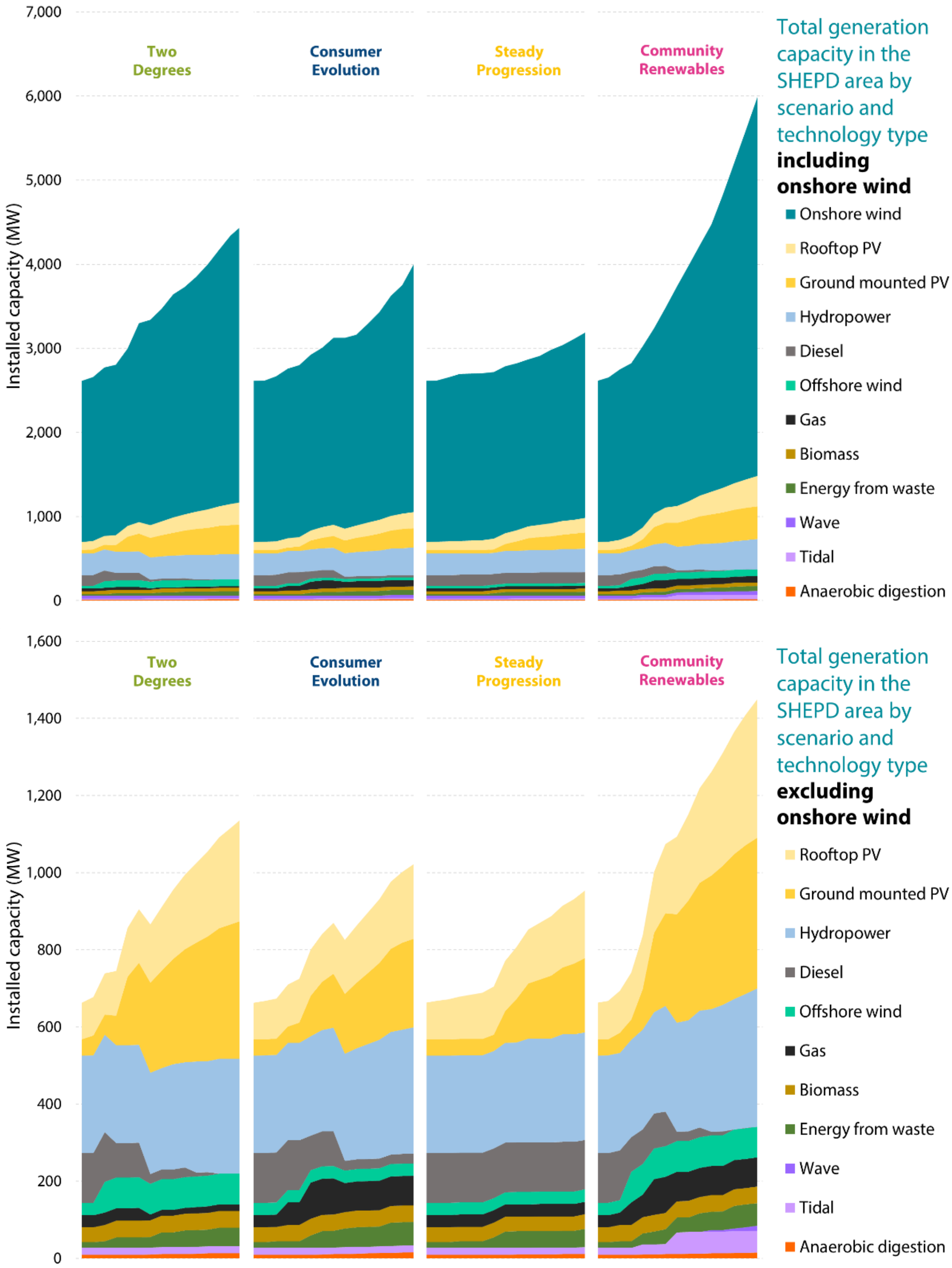
[6] Excluding behind the meter generation

Gas-fired	31.9	Wave	-

6. New distributed generation

In Community Renewables, the most decentralised and decarbonised scenario, the total distribution generation connected onto the SHEPD distribution network more than doubles to nearly 6 GW by 2032. There would still be an increase in a Steady Progression scenario, but much more slowly to 3.2 GW. The generation capacity in the licence area remains dominated by onshore wind in all scenarios but solar also makes inroads in the greener scenarios where renewable generation has higher policy support.

Figure 6-1 (area



Over 120 pipeline electricity generation projects were assessed for this study, a total potential capacity of 1.6 GW. The pipeline includes those with an accepted connection agreement that haven't yet connected and planned developments.

Figure 6-1 illustrates the projected capacity growth of the various generation technologies by scenario. The chart excluding onshore wind highlights how the smaller technologies may fare, with diesel power coming offline in some scenarios and growth in the capacity of tidal and ground mounted PV in other scenarios. The total capacity increase is shown in Table 6-1.

Table 6-1 Total installed generating capacity in 2018 and 2032 across all scenarios

Scenario	Total generation capacity 2018 – MW	Total generation capacity 2032 - MW	Increase on 2018
Two Degrees	2,602	4,449	71%
Community Renewables	2,602	5,977	130%
Consumer Evolution	2,602	3,986	53%
Steady Progression	2,602	3,178	22%

Key findings from the distribution generation scenarios are:

- **Onshore wind** remains the dominant technology across all scenarios, and regions out to 2032, however there is a wide range of new deployment, from around 570 MW in Steady Progression to nearly 2 GW under Community Renewables.

- Future **hydropower** capacity increase is not expected to match recent rapid growth, however between 30 MW and 100 MW is expected to connect by 2032, mainly in the West and Highlands region.

- **Ground-mounted solar PV** increases significantly from a low baseline to reach between 200 - 400 MW of capacity by 2032. The capacity increase comes mainly from 272 MW in the existing pipeline projects, which are predominately located on the east coast.

- **Rooftop solar PV** continues increasing capacity across all scenarios, driven by building regulations and weighted towards areas with new build developments.

- The vast majority of **diesel and gas** capacity is installed on the islands. This either stays the same (in Steady Progression) or decreases over the period, as older gas and diesel plants are decommissioned. The timescale is influenced by the potential for new island interconnectors.

- There is no **battery storage** in the licence area baseline but there is a pipeline of 424 MW. Reflecting the uncertainty in the business case for storage and, in particular, for co-location with renewables, battery storage capacity could increase to between 300 MW and 1.5 GW by 2032.

- The waste technologies, **Energy from Waste (EfW)** and **Anaerobic Digestion and Biomass** all see minimal capacity increase over the period, reflecting the low densities of population and agriculture over much of the licence area.

- **Marine renewables** remain in development stages during the scenario period. In Community Renewables some new projects connect towards 2032.

7. Existing low-carbon technologies

The analysis also looks at disruptive demand technologies, heat pumps and electric vehicles (EVs), which may be installed in the licence area's over 750,000 households or commercial and industrial properties.

The high number of properties (37%) which are not connected to the gas network means that the licence area already has relatively high levels of heat pumps. In islands where no properties have gas heating or heat networks, nearly 7% of properties are currently heated by heat pump.

However, the uptake of electric vehicles is slightly behind the UK average. At the end of 2018, 0.43% of vehicles were electric, compared to the UK average of 0.56% of vehicles. Around a third of all EVs in the licence area are based in and around Aberdeen, though there are also 365 registered in Dundee.

Table 7-1 Low carbon technologies take-up by SHEPD households in 2018

Total in SHEPD	Numbers of installations	% of total
Households	702,700	-
Households off-gas	256,300	37%
Domestic cars	688,900	-
Commercial properties	88,900	-

Technology	Number of installations	% of total
Electric vehicles	3,000	0.43%
Heat pumps	7,357	1.05%
Domestic rooftop PV	20,900	2.99%
Commercial rooftop PV	539	

Case study: Electric Vehicles in Dundee
Partners: Dundee City Council, Urban Foresight
Where: Dundee
When: 2011 onwards
What: Dundee leading the way to an Electric Vehicle city

In late 2018, Dundee was named as the most visionary city in Europe for electric vehicles (EV) at the World EV Association in Japan. Dundee City Council has put in place several initiatives including switching the council's vehicle fleet to electric and putting in a charger infrastructure. The Council has the UK's largest public sector electric fleet, with 117 electric cars and vans in use as of 2019[1]. A further 65 electric vehicles will replace the highly polluting diesel bin lorries and road sweepers. The council-owned network of four solar-powered charging hubs is capable of charging 78 cars at a time. The city also has the UK's largest number of electric minicabs (134 as of August 2019). The council estimated that, in 2016/7, using EVs had reduced carbon dioxide emissions by 122 tonnes.

8. New low-carbon technologies

Regen contacted all local authorities to identify the size and locations of strategic domestic and commercial new development sites within the licence area. The study identifies nearly 70,000 new homes to be built by 2032 and 1189 hectares of commercial development and this information helps SSEN to understand where electricity demand may be increasing on their network. These new developments are also likely to see high levels of new demand technologies such as heat pumps and electric vehicles.

There is, however, continuing uncertainty around the speed and level of electrification of heat and transport. As a result, the scenarios have a large range between the highest and lowest projections. Table 8-1 illustrates the proportion of homes in 2032 which may have installed low-carbon technology.

Table 8-1: Percentage and numbers of households with low carbon technologies in 2032 by scenario

Percent by 2032	Electric vehicles (% of all cars)	Heat pumps	Rooftop solar PV
Baseline	0.4%	1.0%	3.0%
Two Degrees	56%	27.3%	7.2%
Community Renewables	57%	33.8%	9.7%
Consumer Evolution	17%	10.5%	5.4%
Steady Progression	17%	7.2%	4.8%

- In Two Degrees and Community Renewables, **56% of the area's 686,000 cars could be electric by 2032**, the year of the ban on the sale of new fossil fuel vehicles. In the higher carbon emission scenarios this figure is 17%.

- Electrification of heat is an important step in energy decarbonisation and the licence area has significant potential to replace existing off-gas technologies, oil and resistive electric heating. The **Community Renewables scenario sees 33% of houses fully or partially electrically heated through a heat pump.**[7] In Steady Progression the total is 7.2%.

Battery storage in the scenarios

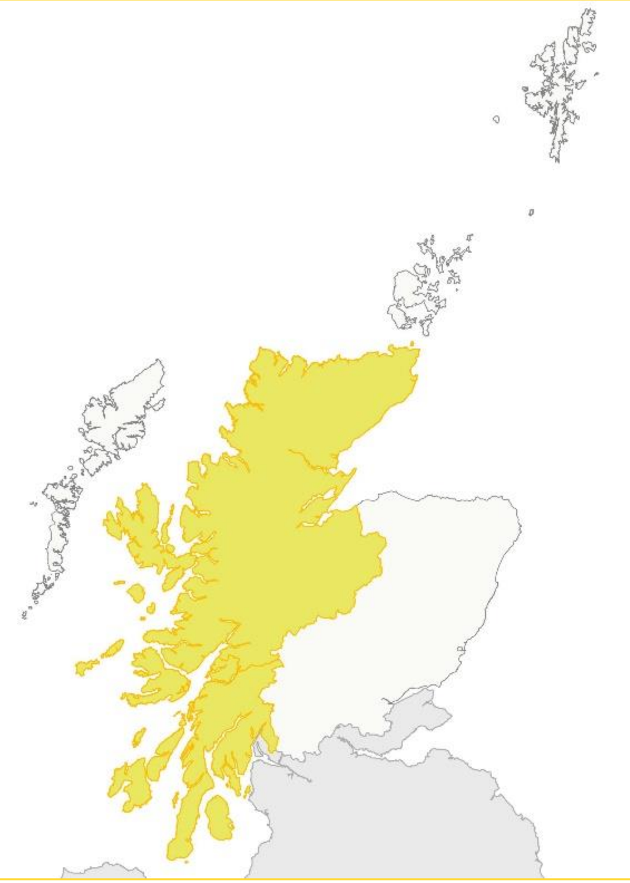
The licence area had no batteries connected to the distribution network at the end of 2018, but as an area of high renewable generation and network constraints, capacity is expected to increase in all scenarios. There is a pipeline of 424 MW and capacity could reach between 300 MW and 1.5 GW by 2032. There are likely to be several value streams for batteries. These include:

- Co-location with renewable energy to store excess generation and sell it at higher cost periods
- Network services where batteries get paid to charge or discharge to help local or national networks
- Commercial batteries located behind-the-meter to reduce peak electricity usage or cost

Regen analysed Capacity Market and local authority planning portals for evidence of activity in developing a business case for the battery projects. Those with activity are considered more likely to go ahead in the shorter term. Of the 23 existing pipeline projects, up to 18 are expected to come online by 2022.

[7] The study does not include scenarios for heat pumps for commercial buildings.

9. West and Highlands



The **West and Highland** region of the licence area has 1.1 GW of distribution connected generation. The vast majority of this is renewable, with 860 MW of onshore wind capacity and 210 MW of hydro generation. Smaller technologies including biomass, rooftop photovoltaic, along with 9 MW of diesel, make up a further 50 MW.

The region has significantly more generation than demand. It has 44% of the distributed generation in the licence area with only 22% of the population.

Despite the large land area, much is protected by national park designations which mean that the areas for new onshore wind generation are mainly located in the East and West coastal regions.

The Highland, Argyll and Bute and North Ayrshire local authorities are planning to build 12,600 new homes in the licence area by 2035. The largest domestic sites are around Inverness and Fort William, with the biggest commercial new developments sited around Inverness, Invergordon/East Ross and Caithness.

Hydropower in the licence area

SHEPD licence area has experienced an extraordinary increase in the installation of small scale hydro over the last three years with capacity more than doubling since 2014. As of 2018 there was 250 MW of distributed hydropower with most of the capacity (210 MW) being within the West and Highlands area. However, there are clear signs that the increase is slowing down as very few projects have connected, according to SSEN data, in 2018 and 2019.

There is a pipeline of 40 hydropower projects that could deliver a further 50 MW of capacity. However not all of these are expected to go ahead, and those that do, are expected to do so before March 2021, which is the deadline for pre-accredited hydro projects to receive the Feed-In-Tariff subsidy.

Future increases in the capacity of hydropower varies by scenario, but none expect the next decade to match the expansion experienced in the last few years. This is because many of the best sites are already developed and further subsidies needed to make more marginal sites viable are not expected past 2021. The Community Renewables scenario sees a further 100 MW of capacity by 2032. Steady Progression has a further 30 MW connecting over the next decade.

Onshore wind in the licence area

1.9 GW of distributed onshore wind capacity was connected in SHEPD from a total of 432 projects at the end of 2018. 70% of the capacity comes from 41 sites over 10 MW. Capacity has been increasing year on year with c. 150 MW connected over the last two years. Of this 860 MW is connected in the West and Highlands with 960 MW connected in the Lowlands and East.

There are 69 onshore wind projects in SSEN's pipeline with a total capacity of 842 MW. Despite a strong pipeline, it currently remains difficult to finance new onshore generation and so few projects are expected to connect imminently.

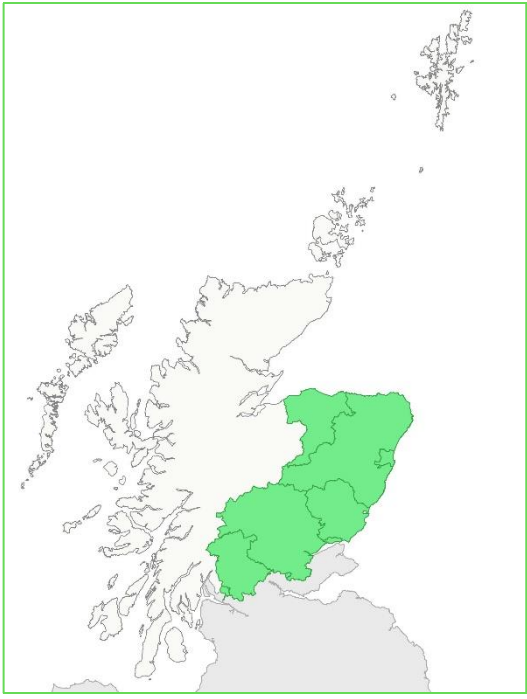
However, with the licence areas significant remaining onshore wind resource, coupled with the Scottish Government's support for renewables and stretching Scottish and UK carbon targets, significant levels of new onshore wind capacity are likely to be installed within the scenario period. Community Renewables sees distributed onshore wind capacity in the licence area more than doubling by 2032.

Coigach community wind turbine

Partners: Coigach Community Development Company, Locogen Ltd
Where: Coigach, Highland
When: 2017 onwards
What: Single 500kW Vestas turbine, the first large community-owned turbine in mainland Highlands.
https://coigach.com/coigach-community-wind-turbine/

Coigach Wind Power is a community energy company founded in 2011 which set up the first large community-owned turbine in mainland Highland. Revenue from the wind turbine has generated funds for the community, supporting local young people, education, and training. Commissioned in March 2017, the turbine is expected to generate more that £4.4 million over its 20 year lifetime, with 100% of profits being used to fund community projects in Coigach including re-developing the local harbour. Initially funded with a high interest peer-to-peer construction loan[1], the project was refinanced after construction, crowd funding £1.75 million through a bond issue with Triodos bank.

10. East and Lowlands



The **East and Lowlands** region contains 468,000 households and around 73% of the licence areas population. Nearly half of the households are in and around Aberdeen.

Distributed generation in the region is dominated by onshore wind which provides nearly 960 MW of the 1.2 GW currently connected. 71 MW of solar, including ground-mounted, and 42 MW of hydropower are the largest technologies after onshore wind. The area also has opportunities for offshore technologies which may connect at the distribution level, particularly wave and floating wind.

55,670 new build houses and 442 commercial new development sites have been identified within the nine local authorities, either partly or wholly, within the distribution network. The largest new domestic sites are in Aberdeen and Perth.

Electric vehicles in the licence area

The licence area currently has slightly lower than GB average electric vehicle (EV) uptake with around 3,000 EV cars registered. Two thirds of the EVs are registered within the Lowlands and East region and 1,000 in Aberdeen City or Aberdeenshire. In the last year there has been a shift away from hybrid electric towards fully electric vehicles reflecting the subsidy shift to supporting only pure electric vehicles.

The scenarios reflect the Scottish Government's ambition for electric vehicles and fossil fuel phase out by 2032 which means the rate of EV uptake catches up and exceeds the GB average over the scenario period. This leads to between 15% and 50% of cars being electric by 2032.

However, the uptake of EVs remains very uncertain and the market depends on the alignment of a number of factors. For very high levels of EV take up in 2020s there needs to be reduced cost, increased mileage range, wider availability and choice of new and second-hand models.

Numbers of cars and electric cars	Total cars 2018	Electric vehicles 2018	Community Renewables 2032	% total cars	Steady Progression 2032	% of total cars
East and Lowlands	499,715	2,106	250,195	50%	83,429	17%
West and Highlands	151,234	681	90,201	60%	27,533	18%
Islands	35,770	169	22,284	62%	6,797	19%

Solar photovoltaics in the licence area

The North of Scotland has around 15% less irradiance than SSEN's Southern licence area, however there is still a significant capacity of solar PV in the licence area, particularly domestic and community roof-mounted.

Over 21,000 rooftop projects have been installed with nearly 100 MW capacity. Around 3% of households have solar rooftop systems. This is a similar percentage of properties to SSEN's Southern licence area. Around 10% of new properties in Scotland built between 2016 and 2017 have photovoltaic systems fitted. This has been driven predominately by new build regulation.

Continuing support from the Scottish Government for renewables and solar generation in a Community Renewables scenario could lead to a tripling of rooftop capacity to nearly 300 MW by 2032. In Steady Progression this is a significantly smaller increase of 75 MW.

The ground-mounted solar baseline consists of six sites with a total capacity of 42 MW. The largest site, connected in 2015, is a 13 MW project on the Errol Estate. There is also a pipeline of 16 projects totalling 272 MW predominantly located on the east coast where solar irradiance is highest.

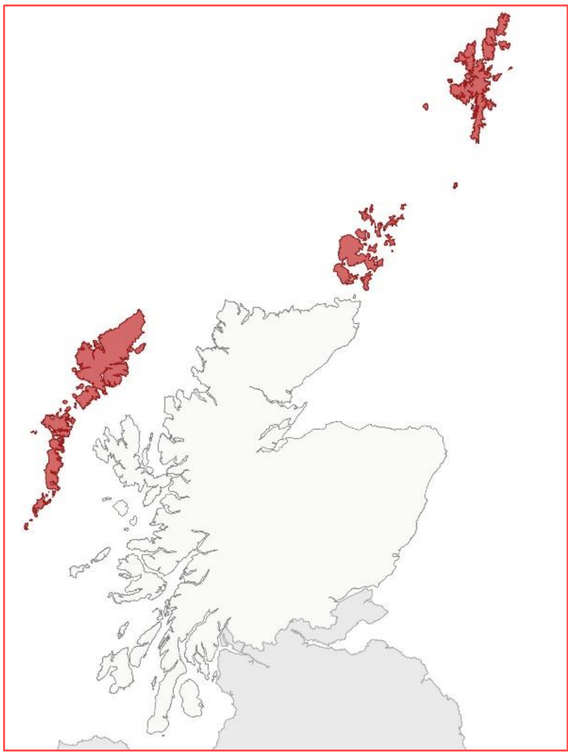
As a result of the low baseline, the licence area is expected to see high percentage capacity increases in all scenarios, reaching between 200 - 400 MW of capacity by 2032. Once the business case for solar starts of be viable without subsidy, the level of capacity increase is expected to be relatively explosive.

Errol solar farm

Partners: Elgin Energy, Savills estate agent, Canadian Solar
Where: Errol Estate, Perth
When: 2016 onwards
What: A 13 MW solar farm on Scotland's east coast
https://www.elgin-energy.com/projects/

Scotland's largest operational solar farm, consisting of 55,000 solar panels and spanning 70 acres on Errol Estate was commissioned in June 2016. Elgin Energy was responsible for the scheme and grid connection, and Canadian Solar now operates the project. The 13 MW project generates energy all year round and provides power to more than 3,500 homes. The site was sourced as a potential for a large-scale solar development back in 2011, showcasing Scotland's east coast as a good candidate for solar PV systems.

11. The Islands



One of the unique characteristics of the SSEN SHEPD area is the number of inhabited islands such as **Na h-Eileanan Siar, the Orkneys and Shetland.** Shetland currently has no network connection to the mainland and thus has local generation to meet the variable local demand.

Most of the power generation on the islands is either from fossil fuel or wind. Of the 257 MW installed capacity, 119 MW is from diesel and a further 18 MW of gas. These provide baseload and top-up power for the islands. The islands also have renewables of which onshore wind has 97 MW.

The islands have around 33,600 households which account for 5% of the population in the licence area. The households are predominately off-gas and subsequently have high rates of heat pump installations.

Analysis shows around 1,600 new homes are planned by 2035, the largest single site comprises 320 houses in Lerwick.

Heat pumps in the licence area

Heat remains a key challenge for decarbonisation and with 37% of domestic dwellings in the licence area not connected to the gas grid. This rises to 95% of households in the Islands. In these off-gas properties there is very high potential for decarbonisation and particularly for heat pumps.

The licence area has seen consistent heat pump deployment with around 1,000 installed under the RHI every year. Installations are highest in areas with the most off-gas grid houses as Table 11-1 illustrates. In addition, 15% of new build homes in 2016/7 had heat pumps installed

Oil is also used in 10% of new properties and 13% of existing properties. The area also has significant levels of direct electric heating including in new properties. District and community heating is also a key trend. 3.6% of new homes in the licence area currently have community heating.

Table 11-1: Numbers of heat pump installations and households

Analysis area	Off-gas houses (% of total)	Domestic heat pumps (%)	Two Degrees by 2032	% of households	Consumer Evolution by 2032	% of households
Lowlands and East	25%	0.5%	137,549	29%	53,894	12%
West and Highlands	55%	2.2%	57,742	41%	21,528	15%
Islands	95%	5.6%*	16,255	48%	6,285	19%

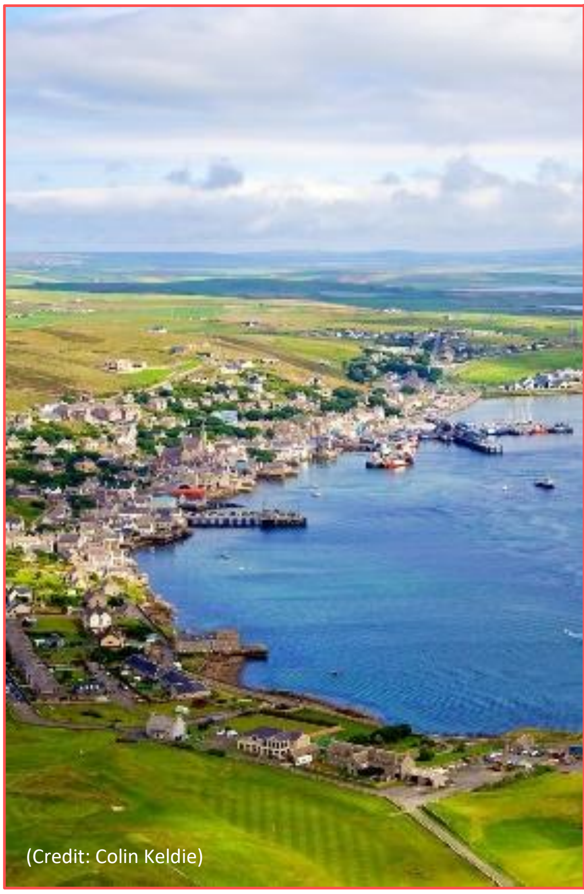
* The baseline for heat pumps and district heat is 8.9% if including Lerwick EfW heat network which serves 1,100 households on Shetland

Interconnectors and diesel generation on the Islands

There are several proposals for new electrical connections between the islands and the mainland. Specifically, this study has considered new interconnectors to the Orkney Islands, Na h-Eileanan Siar, and Shetland. Although these would be transmission interconnectors, they will have an indirect impact on the distribution network and are likely to unlock the potential for new generation capacity and influence when the fossil fuel generators in the islands are expected to decommission.

Whether the interconnectors go ahead is partially dependent on several large wind farms securing price support before being built. In this study only in Two Degrees do all three interconnectors go ahead. None of them go ahead under Steady Progression.

	New interconnector development by scenario		
	Shetland	Orkney	Na h-Eileanan Siar
Two Degrees	Connected in 2024	Connected in 2024	Connected in 2024
Community Renewables	Connected in 2025	Connected in 2025	Not developed
Consumer Evolution	Connected in 2026	Not developed	Not developed
Steady Progression	Not developed	Not developed	Not developed


(Credit: Colin Keldie)

ReFLEX Orkney

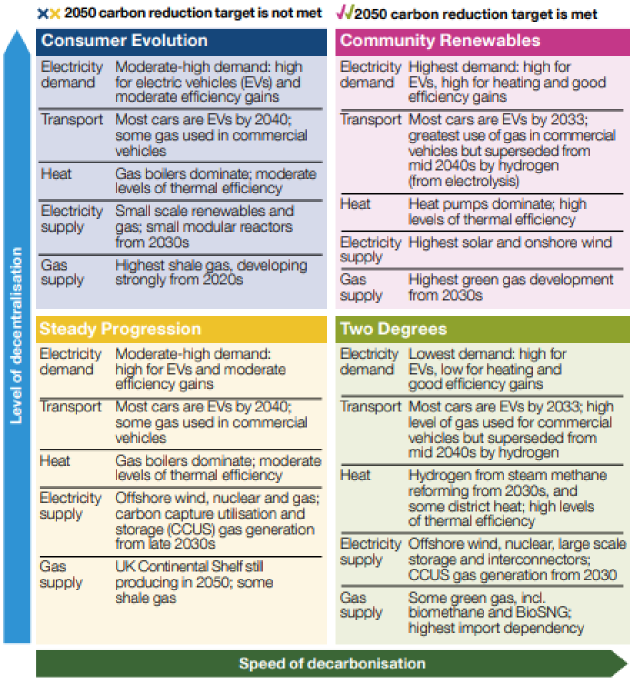
Partners: European Marine Energy Centre, Solo Energy, Aquatera, Community Energy Scotland, Heriot-Watt University, Orkney Island Council, Doosan Babcock
Where: Orkney Island
When: 2019 onwards
What: First of its kind Virtual Energy System (VES)

The first phase of the £28.5m project to create a Virtual Energy System (VES) has been launched in Orkney. The scheme, which will digitally link distributed and intermittent generation to flexible demand, could maximise the potential for renewable energy development on the island. The ReFLEX Orkney project will combine up to 500 domestic batteries, 100 business and large-scale batteries, up to 600 new electric vehicles, 200 vehicle-to-grid chargers, 100 flexible heating systems and an industrial hydrogen cell. Funded through the Industrial Strategy Challenge Fund, the scheme intends to create a 'smart energy island', demonstrating the energy systems of the future, reducing and eventually eliminating the need for fossil fuels.

12. Methodology

Regen's analysis uses the Future Energy Scenarios[8] developed by the National Grid as a starting point. This study uses mostly FES 2018 but also reflects key technology changes in FES 2019 which was released towards the end of the project.

The current FES framework aligns future scenarios to two key axes: speed of decarbonisation and level of decentralisation. Two of the four scenario pathways meet the UK's 2050 emissions' reduction target of 80% by 2050. None of them meet the new 'net-zero' emissions target, however the next annual release of the National Grid study is expected to incorporate this.



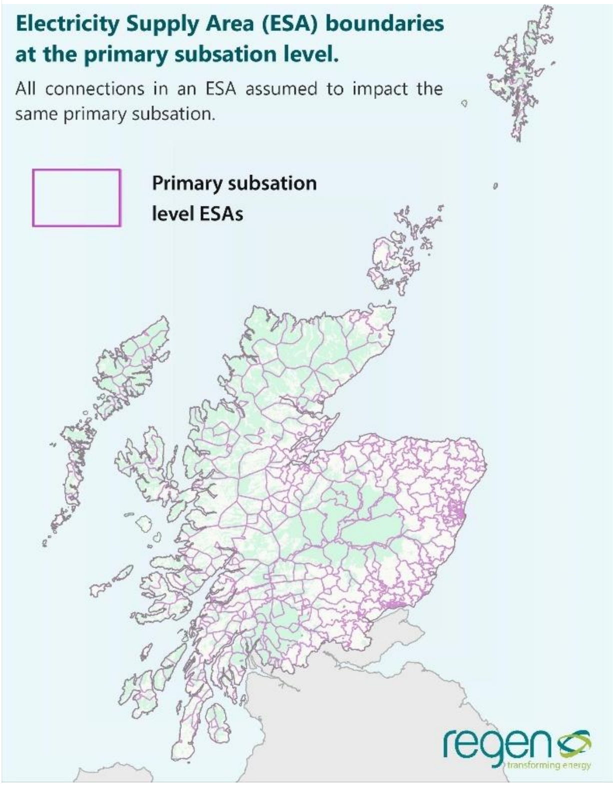
Augmenting the FES 2018 pathways, the Regen analysis uses specific regional and local demographic attributes, geographical characteristics and natural resources to determine projected growth for each scenario. This means that each licence area will differ in specific ways from the rest of GB. For example, there may be particularly good resource for a certain technology which means installed capacity increase may be higher than the FES projection, or perhaps existing regional policy and targets point to faster-than-average deployment. For some technology types, there may already be high levels of deployment, which may limit the potential for future growth in cases where for example the feedstock is limited or where there are cumulative impact issues.

Electricity Supply Areas

The analysis for this study has been framed around Electricity Supply Areas (ESAs) which have been defined through SSEN's network infrastructure and hierarchy.

ESAs are defined as geographic areas served by the same upstream network infrastructure, and can be aggregated at different voltage levels.[9] For this study, primary voltage ESAs were used, meaning the SHEPD licence area was also subdivided further by incorporating local authority boundaries, as shown in Figure 12-1.

Figure 12-1 SHEPD area ESA map



[8] http://fes.nationalgrid.com/fes-document/ assumptions underpinning the scenarios are published in a workbook.
[9] These were created by mapping data on individual substations and the upstream network points using Geographic Information System (GIS) software.

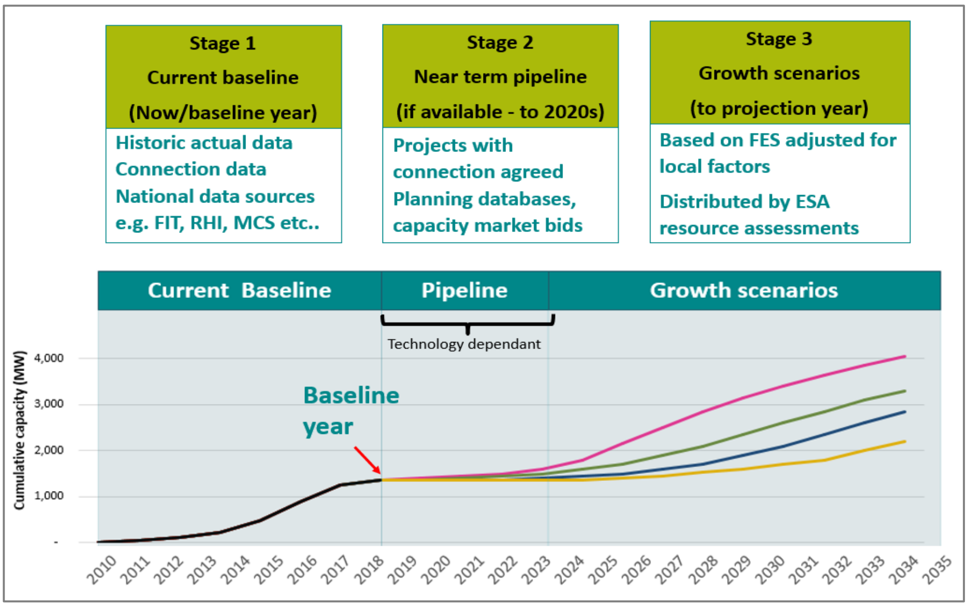
Scenario process

As illustrated in Figure 12-2, the following three stage analysis, is undertaken for generation, demand, and storage technologies:

Stage 1 - A baseline and resource assessment. Baselines and historic growth rates are calculated from SSEN network connection data taken midway through 2019. This information is then reconciled with Regen's project database and desktop research is undertaken to address any gaps or inconsistencies.

Stage 2 - A pipeline assessment. SSEN network connection agreement data is reconciled with local authority planning applications, along with further desktop research and an understanding of the current market conditions. This allows a scenario-specific assessment of which projects may go ahead and in what timescale.

Figure 12-2: Illustration of scenario process



Stage 3 - A scenario projection to 2032. These scenarios use information from National Grid's Future Energy Scenarios FES 2018 and FES 2019. These are then interpreted for specific local resources, constraints and market conditions. The scenario projections are applied to the 507 ESAs in the SHEPD area, taking into account baseline and pipeline distribution, GIS analysis of the resource distribution, and local or regional attributes, for each technology.

When projecting where new projects are likely to connect, consideration is also given to existing constraints on network capacity which may reduce growth in generation in the short term; however, as this analysis is to help SSEN understand where network investment is likely to be needed, existing network constraints are not considered as a factor in the medium- and longer-term projections.

Scenarios are also created for new domestic and commercial development using local authority plans and supporting documents. These are analysed to identify sites, numbers and build rates for new build in the licence area.

Stakeholder consultation. Regen use stakeholder information to help develop the scenarios. Key to the process is a local consultation event where initial outcomes were presented for feedback from local stakeholders. A stakeholder consultation was held in Glasgow in July 2019.

13. Local authority data

The dataset of scenarios by technology was produced by both electricity supply area and by Local Authority. A summary of the local authority data is presented below for Community Renewables and Steady Progression.

In order to access data or to see more detailed information about the assumptions and methodology used to build these scenarios, please contact: futurenetworks@sse.com.

	Community Renewables											
	Distributed generation capacity (MW)			Battery storage (MW)			Electric vehicles (numbers of)			Heat pumps (numbers of)		
	2018	2025	2032	2018	2025	2032	2018	2025	2032	2018	2025	2032
Aberdeen City	27	101	128	-	35	72	434	10,421	59,327	98	8,919	38,422
Aberdeenshire	555	796	1,056	-	107	225	567	12,009	81,885	967	12,501	47,296
Angus	81	154	245	-	98	151	242	5,381	34,072	173	4,574	17,961
Argyll and Bute (73%)	305	475	855	-	71	157	151	3,331	19,690	645	4,488	15,301
Dundee City	22	32	44	-	47	70	266	6,311	36,305	73	5,224	21,003
Highland	821	1,160	1,967	-	148	361	513	10,961	68,609	2,428	13,830	49,737
Moray	286	430	560	-	45	115	200	4,282	27,113	337	4,066	15,302
Na h-Eileanan Siar	83	54	96	-	4	14	62	1,338	8,224	818	2,263	6,727
North Ayrshire (5%)	2	2	10	-	1	2	17	360	1,902	76	641	2,468
Orkney Islands	71	143	133	-	5	17	52	1,079	6,970	771	2,056	5,773
Perth and Kinross	125	215	444	-	201	303	319	6,944	44,121	482	7,457	30,582
Shetland Islands	103	21	225	-	2	7	55	1,082	7,090	307	1,557	5,723
Stirling (35%)	119	143	212	-	17	42	76	1,602	11,076	200	1,475	5,529
Total	**2,599**	**3,727**	**5,974**	**-**	**782**	**1,536**	**2,954**	**65,101**	**406,384**	**7,375**	**69,051**	**261,824**

	Steady Progression											
	Distributed generation capacity (MW)			Battery storage (MW)			Electric vehicles (numbers of)			Heat pumps (numbers of)		
	2018	2025	2032	2018	2025	2032	2018	2025	2032	2018	2025	2032
Aberdeen City	27	43	51	-	8	14	434	2,877	18,140	98	2,748	7,478
Aberdeenshire	555	562	632	-	57	72	567	3,365	24,305	967	4,825	10,265
Angus	81	84	141	-	31	38	242	1,503	10,256	173	1,432	3,055
Argyll and Bute (73%)	305	345	397	-	29	39	151	938	6,061	645	2,019	3,585
Dundee City	22	26	30	-	10	13	266	1,765	11,244	73	1,442	3,058
Highland	821	869	978	-	40	61	513	3,097	20,861	2,428	6,335	11,529
Moray	286	288	329	-	15	24	200	1,211	8,215	337	1,547	3,064
Na h-Eileanan Siar	83	83	85	-	2	3	62	383	2,538	818	1,287	1,811
North Ayrshire (5%)	2	2	3	-	0	0	17	104	611	76	277	492
Orkney Islands	71	72	72	-	2	3	52	311	2,117	771	1,260	1,731
Perth and Kinross	125	175	217	-	21	32	319	1,953	13,297	482	2,856	7,406
Shetland Islands	103	103	106	-	1	1	55	304	2,142	307	756	1,379
Stirling (35%)	119	120	134	-	6	9	76	445	3,270	200	546	934
Total	**2,599**	**2,772**	**3,175**	**-**	**222**	**309**	**2,954**	**18,256**	**123,057**	**7,375**	**27,330**	**55,787**

Slight variations in total figures may result from rounding