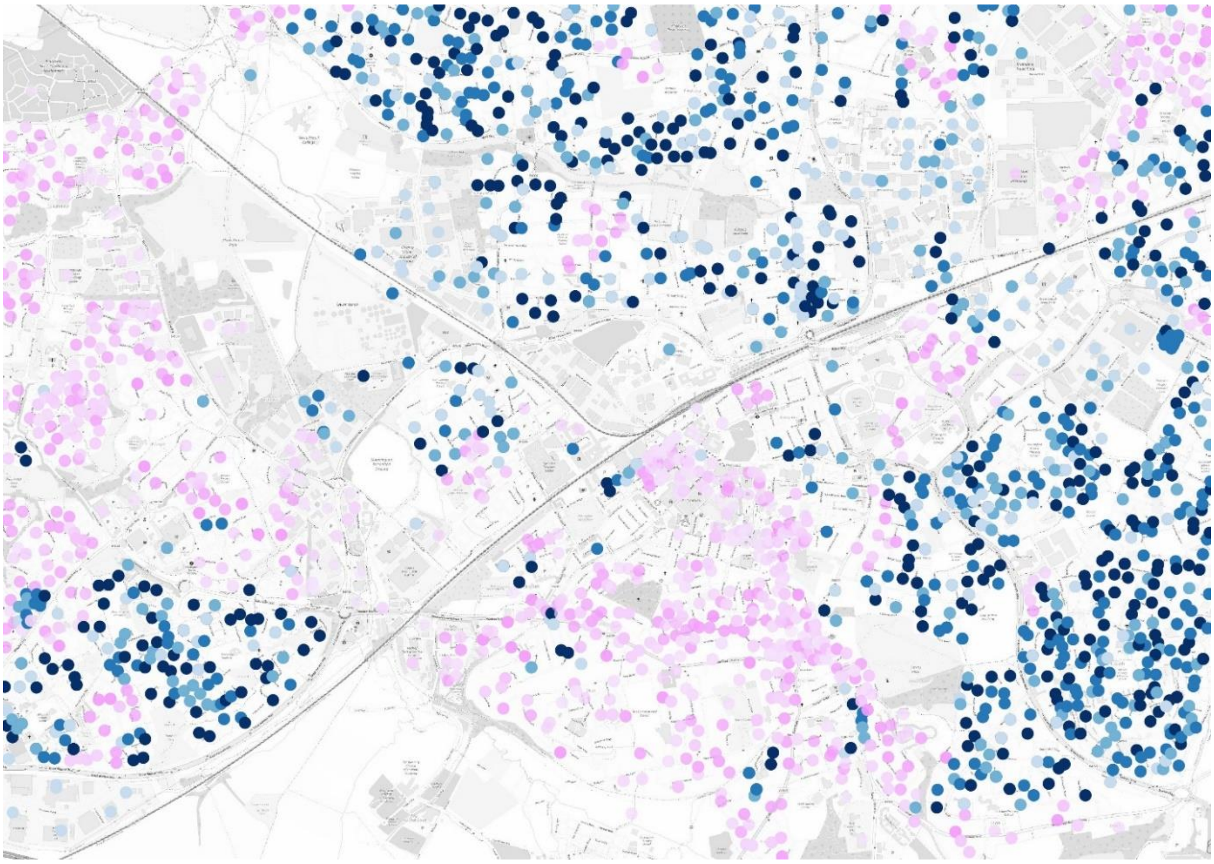
High granularity projections for low carbon technology uptake - electric vehicle, heat pumps and solar PV



Results summary for SSEN Southern and Scottish licence areas

Project: SSEN Electric Vehicle Forecasting - Multisite 0120 Reference: 52330

Version: Final

Licence areas: SEPD and SHEPD distribution networks

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Nomenclature

Nomenclature list	
CCC	Committee for Climate Change
DfT	Department for Transport
EV / EV Charger	Electric Vehicle / Electric Vehicle Charger
Feeder	A low voltage or high voltage network cable that feeds power from an upstream substation to a small collection of domestic or commercial properties. Feeders are typically low voltage, but can supply some large customers directly from primary substations.
Distribution substation	A distribution substation, such as pole mounted transformers or ground mounted transformers, of which there are over 100,000 in SSEN's two licence areas. Distribution substations are typically low voltage.
FES (year)	Future Energy Scenarios. This is an annual publication by National Grid and the (year) references the specific year of publication.
Fleet/Depot charger	A charger archetype. Depot based charging for vehicles that are not home based – mainly LGVs, HGVs and buses/coaches.
HGV	Heavy Goods Vehicle
LGV	Light Goods Vehicle
Two Degrees	A National Grid Future Energy Scenarios scenario. In Two Degrees, large-scale solutions are delivered, and consumers are supported to choose alternative heat and transport options to meet the 2050 target.
Community Renewables	A National Grid Future Energy Scenarios scenario. In Community Renewables, local energy schemes flourish, consumers are engaged and improving energy efficiency is a priority.
Consumer Evolution	A National Grid Future Energy Scenarios scenario that does not achieve the (superseded) 80% decarbonisation target. In Consumer Evolution, there is a shift towards local generation and increased consumer engagement, largely from the 2040s.
Steady Progression	A National Grid Future Energy Scenarios scenario that does not achieve the (superseded) 80% decarbonisation target. In Steady Progression, the pace of the low-carbon transition continues at a similar rate to today but then slows towards 2050.
Net Zero	The bespoke Net Zero high electrification scenario focusses on the electrification of heat and transport to achieve the UK's net zero emissions target as set out in the Climate Change Act 2008 (amended 2019).

About Regen

Regen is an independent, mission-led centre of energy expertise, market insight and analysis, dedicated to transforming the energy system for a zero carbon future. We are a team of energy system and low carbon technology experts, with detailed analysis and evidence-based research underpinning all aspects of our work. As an energy specialist, Regen works with a wide range of industry and public-sector clients. Our mission-led status has enabled us to work more closely with organisations that are at the forefront of the energy system transformation, helping them to shape future policy, develop new markets and business opportunities and to exploit technological innovation.

Our work covers a wide spectrum of energy related capabilities including:

- Policy and market analysis,
- Economic and financial assessment and feasibility studies,
- Energy strategy development and resource assessments,
- Community energy and community stakeholder engagement,
- Customer engagement, including DNO sponsored asset owner and developer forums,
- Communications, including animations, podcasts and our energy art programme,
- Policy and position papers, most recently in areas such as energy storage, local energy markets and electric vehicles,
- Innovation and pilot projects ranging from network innovation to electric vehicles to energy efficiency.

Foreword

As a Distribution Network Operator (DNO), Scottish and Southern Electricity Networks (SSEN) are responsible for maintaining a secure, reliable and cost-effective electricity network for nearly 3.8 million customers. We now need to provide that same level of service whilst simultaneously facilitating the transition to a decarbonised future; one that meets the UK's net zero commitment. That represents such a dramatic change that our role will become one of a Distribution System Operator (DSO). The next 30 years will see unprecedented change in the ways that electricity is used, and our role is clear – to ensure both heat and transport can be decarbonised at the scale and pace our stakeholders demand for all the communities we serve.

These changes generate numerous questions for us as a business. What does this mean for our assets, our priorities and our stakeholders? How and when should we invest? How big a role will flexibility have? How do we ensure the system is fair? How much does this change across our networks?

Data is key to answering these questions. That is why we have asked Regen to provide analysis to a far greater level of detail than ever before. Regen has previously looked at local future electricity growth scenarios for our networks at a high level, but as we move into the next price control period (RIIO-ED2) our forecasts need far greater granularity, especially for Low Carbon Technologies such as electric vehicles, heat pumps and solar PV. This work sees Regen providing forecasts down to individual low voltage networks, which means understanding our network on a street-by-street level. This will allow us to anticipate where and when we need to make necessary investments to provide the smarter, flexible and secure energy system that support our stakeholders as Distribution System Operator (DSO).

This key piece of work is integral to our three strategies: the EV Strategy; the EV Strategy; the Digital Strategy and the DSO Strategy. Improving our understanding of the impact of electric vehicles, heat pumps and solar PV on our network will help support our customers and stakeholders in decarbonising and securing a net zero future for everyone.

Richard Hartshorn

SSEN, EV Readiness Manager

1 Introduction

Regen has been commissioned by Scottish and Southern Electricity Networks (SSEN) to produce high granularity projections for key Low Carbon Technologies (LCT). These projections are analysed down to the level of low voltage network assets, including the 400,000 street level LV feeders and over 100,000 distribution substations that are located in SSEN's Southern and Scottish electricity distribution licence areas.

The aim of this analysis is to enable SSEN to improve its understanding of the impact of electric vehicles, heat pumps and domestic solar on its low voltage network. Regen has previously undertaken scenario analysis for SSEN, projecting changes in demand and generation technologies connecting to Electricity Supply Areas (ESAs) at the 11 kV network and above in both SSEN's Southern and Scottish licence areas. However, for key LCT there is now a need for a more granular forecast, to enable detailed investment planning and risk mitigation strategies, as well as to provide an evidence base to support the development of SSEN's RIIO-ED2 price control period business case.

This report presents the results of that study and summarises the methodology and data sources used.

Scope of this report

- This report presents the scenario-based projections for Electric Vehicles (EVs), EV charger, heat pumps and rooftop PV in SSEN's Scottish and Southern licence areas.
- Highlights from the accompanying detailed dataset and summary analysis that is intended to help SSEN identify possible network issues and identify cost effective solutions for addressing future network constraints.
- Summary projections for the installation of approximately 270,000 non-domestic and 1.6 million domestic EV chargers in the SSEN Southern licence area in a Net Zero scenario in 2050, serving 4.5 million EVs.
- Summary projections for the installation of approximately 50,000 non-domestic and 382,000 domestic EV chargers in the SSEN Scottish licence area in a Net Zero scenario in 2050, serving 600,000 EVs.

Low Carbon Technology projection dataset (which accompanies this report)

The primary output of this study was a database of LCT projections with the following variables:

- Low Carbon Technologies
    - Electric vehicles - Including five vehicle archetypes
    - Electric chargers - Including eight EV charger archetypes
    - Heap Pumps – Electric only and hybrid gas systems
    - Rooftop solar PV
- Units – Numbers and capacity (MWs) of individual installations
- Geography – SSEN Southern and Scottish licence areas
- Granularity – Over 400,000 individual feeders, equivalent to street-level forecasts
- Scenarios – Four 2019 National Grid Future Energy Scenarios, plus a bespoke Net Zero scenario
- Time period - Annually from 2019 (the baseline year and year the study was commissioned) to 2050

In addition to the LCT projections, this study also delivered a collated dataset of LCT load profiles that have been derived from a range of existing sources, including innovation projects such as My Electric Avenue and Electric Nation, in addition to wider market analysis studies such as the National Grid Electric Vehicle Charging Behaviour Study.

2 Methodology

2.1 Study approach

The analysis undertaken for each LCT in the study involved the following three stages:

Stage 1: A baseline assessment. EV baselines for installed capacity are calculated from a range of sources including SSEN's connections data, OLEV data, public data sources and ZapMap data. Heat pump and rooftop PV baselines are estimated from SSEN connections data, Ofgem RHI Freedom of Information Requests and public Ofgem FiT datasets. This information is then reconciled with Regen's project database and further desktop research is undertaken to address inconsistencies.

Stage 2: Resource assessment. Locational data from various data sources and GIS analysis is used to understand the geographical distribution, local attributes, constraints and potential for technologies to develop within the region and each unique LV feeder and distribution substation.

Stage 3: Scenario projections to 2050. Using National Grid's FES 2019 as a framework, a bottom-up assessment of local resources, constraints and market conditions is carried out to develop the scenarios for each technology. Research is undertaken with specific developers active in the licence area.

Disaggregation to feeders

Disaggregating LCT projections to over 400,000 individual LV feeders and over 100,000 distribution substations presented a major challenge, both in terms of data processing and analysis. Once 400,000 individual LV feeders were combined with the other core variables of multiple technologies and sub-technologies, 31 years of annual projections and five scenarios, in the order of one billion individual projection values were successfully calculated for the study.

Furthermore, undertaking LCT projections for feeder and distribution substations required high granularity spatial data. A wide range of high granularity spatial datasets were, therefore, used on this study, including Ordnance Survey Addressbase data, DfT road traffic flow data, Census Output Area data, postcode statistical data, and individual property EPC data.

2.2 Low Carbon Technologies assessed

This study is focussed on assessing the impact of low carbon technologies on the low voltage network, and so focusses on technologies that are likely to be deployed on the low voltage network level such as EVs/ EV chargers, heat pumps and rooftop solar PV. This includes a number of different EV charger vehicle archetypes. The following table summarises the technologies and sub-technologies that have been assessed:

Technology category	Archetype category	Archetype sub-category	Additional detail
EV charger archetypes	Domestic off-street charger		Dedicated home based charger. Chargers associated with off-street parking, usually on private driveways.
	Domestic on-street charger		Residential based charging for on-street parking. Chargers associated with cars without access to off-street parking.
	Workplace charger		Workplace based chargers at places of employment or employee parking.
	Fleet/Depot charger		Depot based charging for vehicles that are not home based – mainly LGVs, HGVs and buses/coaches.
	En-route / local charging stations		Local charging stations, used for the primary purpose of vehicle charging.
	En-route national network charger		National charging stations assumed to be large scale with high capacity chargers.*[1]
	Destination charger		Locations whose primary purpose is not charging, including leisure facilities, supermarkets, attractions and hotels.
	Car parks charger		Public and privately owned car parks that the public have access to.
Road vehicles	Buses & Coaches	Battery Electric	
	Cars	Battery Electric	
	Cars	Plug-in hybrid	
	HGVs	Battery Electric	
	LGVs	Battery Electric	
	LGVs	Plug-in hybrid	
	Motorcycles	Battery Electric	
Heat pumps	Domestic	Electric	
		Hybrid	
	Non-domestic	Electric	
		Hybrid	
Rooftop PV	Domestic		

Table 1: Technology archetype summary

[1] It is known that some existing and future EV chargers, particularly national en-route charging, will not connect to the LV network. However, it has been included to help frame the future investment requirements needed, and feed into the 11kV scenario projection study that SSEN have also commissioned.

2.3 Geographical scope and network hierarchy

This study analysed the uptake of LCTs in both the SSEN Southern and Scottish licence areas, at two different levels within SSEN's electricity network hierarchy.

Firstly, domestic LCTs (off-street EVs and chargers, heat pumps and solar PV) were analysed at a feeder level, of which there are approximately 400,000 in SSEN's licence areas. This is roughly equivalent to sub-street level analysis, with the number of connections averaging at eight customers, though ranging from individual customers to 200 customers.

Secondly, non-domestic LCTs (on-street EVs[2] and chargers, en-route local EV chargers, en-route national EV chargers, destination EV chargers, car park EV chargers, fleet/ depot EV chargers, workplace EV chargers, and commercial and industrial heat pumps and solar PV installations) were analysed to a distribution substation level. There are over 100,000 distribution substations in SSEN's licence areas.

Simplified electricity network hierarchy

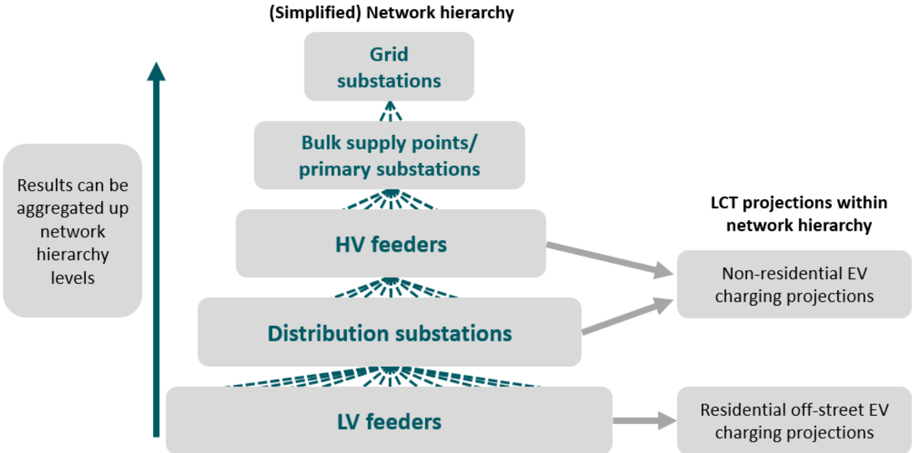


Figure 1: Simplified network hierarchy

Figure 2 shows the feeder locations in Reading town centre, in addition to their parent transformers within the network hierarchy. The transformers are illustrated as an approximate geographical area that their child feeder occupies, known as an Electricity Supply Area (ESA).

Example feeder and distribution substation density in Reading

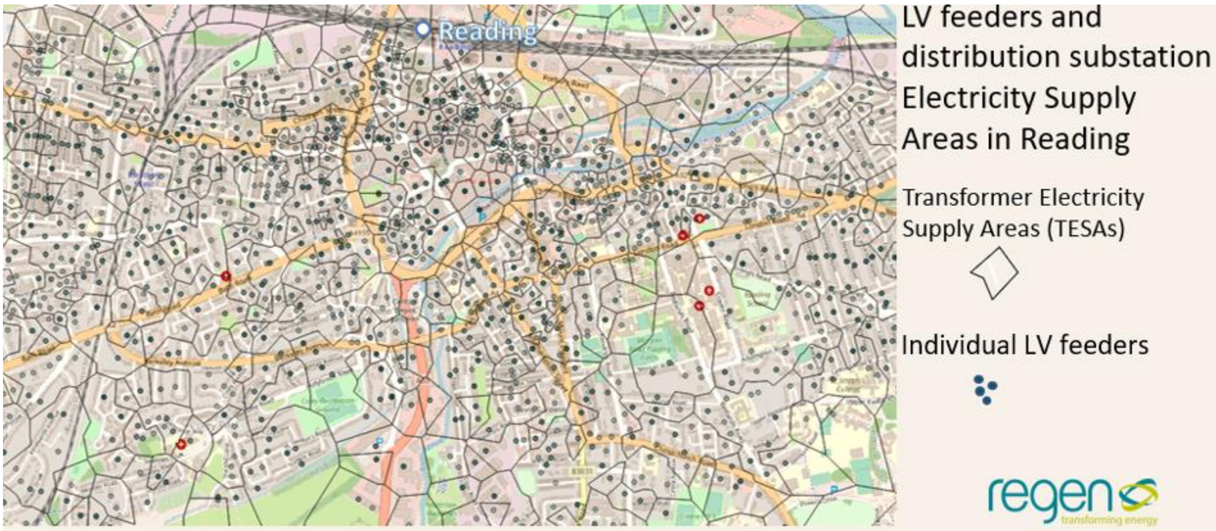


Figure 2: Feeders in Reading town centre

[2] On-street chargers includes on-street charging in the residential setting but is categorised as non-domestic since on-street projections are made at a distribution substation level rather than LV feeder level.

2.4 Scenario framework

In order to analyse a range of future projections, analysis was undertaken for five different scenarios. These included the four scenarios in National Grid's 2019 Future Energy Scenarios study: Two Degrees, Community Renewables, Consumer Evolution and Steady Progression, plus an additional Net Zero scenario. The Net Zero scenario was added to recognise that since the analysis behind National Grid's FES 2019 was undertaken, the UK's climate, energy and transport policy landscape has shifted, with the UK Parliament declaring a climate emergency, a more ambitious 2050 net zero emissions target being passed into law, and a proposal to bring forward to 2035 (or possibly earlier) a national ban on new petrol, diesel and hybrid cars. The Net Zero scenario modelled assumes high degrees of electrification, rather than the widespread adoption of hydrogen boilers for heating.

National Grid FES 2019 framework

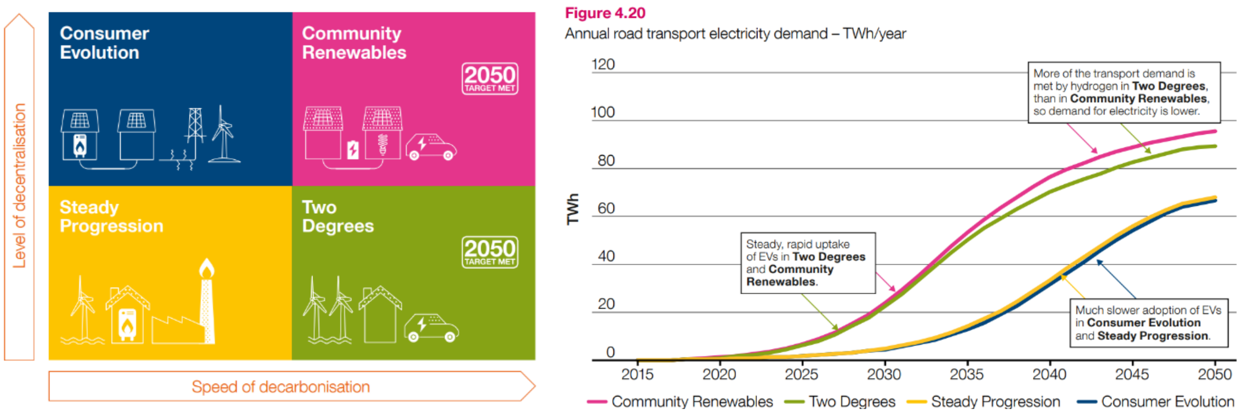


Figure 3: National Grid's 2019 Future Energy Scenario matrix and annual road transport electricity demand as an example of projections can vary by scenario

Key elements of the five scenarios analysed in relation to LCTs are:

- In Two Degrees, most road transport is powered by electricity by 2050. HGVs use more varied fuel sources, particularly hydrogen due to larger scale generation of the fuel.
- In Community Renewables, consumers are highly engaged in smart charging and Vehicle-To-Grid (V2G). Most road transport is powered by electricity by 2050. HGVs use more varied fuel sources. Hybrid gas heat pumps are a key part of decarbonisation in this scenario.
- In Consumer Evolution and Steady Progression, electricity usage for road transport increases, however petroleum-based products are still used out to 2050. Heavy-duty vehicles will continue to use a gaseous fuel, most likely natural gas. Hydrogen remains a niche fuel. Hybrid gas heat pumps are a part of decarbonisation in these scenarios.
- The bespoke Net Zero scenario focusses on the electrification of heat and transport to achieve the UK's net zero emissions target. It includes an even faster take up of electric vehicles in the near-term, and lower total vehicle numbers and miles driven. It is a scaled-up version of Two Degrees and Community Renewables and incorporates the main CCC's recommendations for a 'further ambition' scenario. Hybrid gas heat pumps are considered a transition technology, so while increasing in the near term, they reduce to zero by 2050.

In order to apply the national scenarios for specific SSEN licence areas and below that to local authority areas, ESAs and the low voltage network, the Regen analysis incorporates regional and local demographic and economic attributes, regional policy context, geographical characteristics and natural resources to determine the projected growth for each scenario. This means that each licence area and region will differ in specific ways from the rest of GB. For example, there may be particularly good resource for a certain technology which means the installed capacity increase may be higher than the FES 2019 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. The table below illustrates high level spatial factor variations between SSEN's two licence areas that contribute to regional variation in the results.

SSEN licence area high level spatial factor characteristics

Spatial factor	Southern licence area	Scottish licence area
Fuel poverty (Source: BEIS)	Marginally below average fuel poverty, approximately 10% of homes.	Significantly above average rates of fuel poverty, approximately 40% of homes.
Number of vehicles per household (Source: DfT)	1.4 vehicles per household, approximately average.	Approximately average number of vehicles per household, slightly higher than the Southern licence area.
Rural/ urban split (Source: ONS)	Above average proportion of houses in urban areas. The licence area includes parts of west London, Oxford, Southampton and other cities, as well as the New Forest and parts of Dorset.	Below average proportion of houses in urban areas. The urban population is found mainly on the Eastern coast of North Scotland, including Dundee and Aberdeen. The licence area also includes inhabited islands, such as Orkney and the Shetland Islands.
On-gas properties (Properties connected to the national gas distribution network) (Source: BEIS)	Marginally below average proportion of houses connected to gas network.	Below average proportion of houses connected to gas network.
Local authorities (Source: climateemergency)	54 local authorities, 30 of which have declared a climate emergency.	14 local authorities, seven of which have declared a climate emergency.
Number of homes connected to the electricity network (Source: SSEN)	Approximately 3,034,400	Approximately 692,700

Table 2: Example geospatial licence area characteristics

2.5 Spatial resource assessments

A wide variety of datasets were used to analyse specific regional and local demographic attributes, geographical characteristics and local resources. For example, in order to evaluate the number of commercial and industrial sites connected to a feeder, SSEN connectivity data was used to identify individual sites which were then classified by type of commercial and industrial activity using Ordnance Survey Addressbase data. While not perfect, owing to data limitations, this allowed a much more granular assessment of commercial and industrial activity connected to the network.

The analysis of LCT deployment growth focused on two different types of growth factor.

1. **'Scale factors'** - Knowing the number of different potential load sources or consumers that could be connected to a network asset such as a feeder. For example the number of homes, or commercial and industrial properties, or the number of current vehicles registered in an area or number of petrol stations.

2. **'Uptake factors**'- Applying a growth factor weighting to determine the propensity of those load sources or consumers to adopt low carbon technology. For example, including factors such as affluence, availability of off-street parking, urban and rural settings. Plus other factors such as the local planning and policy "attractiveness" for low carbon technology.

For example, if a feeder has a scale factor of n homes connected to it, how many of those homes have an uptake factor of off-street parking, and so are suitable to host an off-street EV charger? Or if a feeder has a petrol station associated with it, how busy is the petrol station in order to inform how many EV chargers it might host?

Assigning data to individual substations and technology archetypes

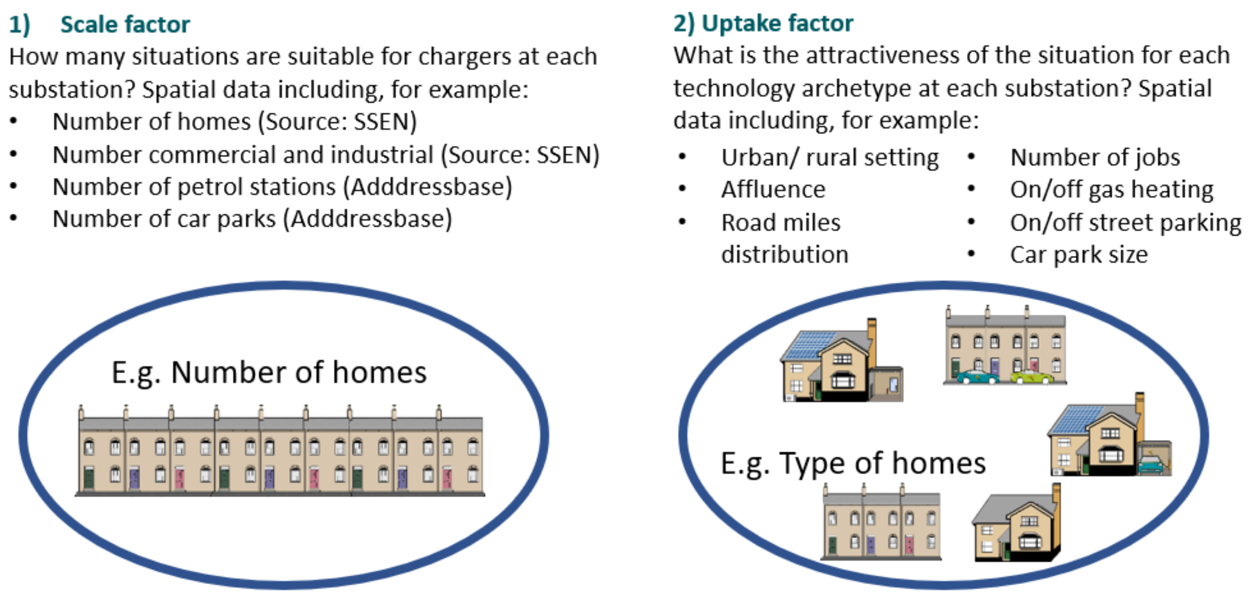


Figure 4: Scale factor and uptake factor illustration

A combination of different uptake factors can be used to evaluate a weighting, or suitability factor for the future uptake of a specific technology archetype at each feeder. These uptake factors usually vary over time and by scenario, and can be used to make use of several varying assumptions and safeguards, for example:

- Ensuring that hybrid gas-back up heat pumps are only deployed in on-gas areas, and subsequently weight electric heat pumps to off-gas areas.
- In some scenarios, rooftop solar PV could be weighted towards affluent neighbourhoods and social housing in the near-term, before being replaced by a more balanced and ubiquitous approach in the longer term.
- Evaluating the availability of a resource (an upper limit), such as how many houses have access to off-street parking at each feeder, or how many public car parks are associated with each feeder.
- Recognising that regions may adopt different policies in regards to planning and positive support for LCT deployment. For example, it is notable that support for public charging networks at destinations, car parks and public workplaces is more apparent in Scotland, whereas private en-route charge stations are more prevalent in the SSEN southern licence area.

2.6 Use of affluence as a key distribution factor and implications for the equitable access to low carbon technology

The distribution analysis uses affluence as one of the key factors driving the uptake of low carbon technologies. This is based on previous new technology deployment trends and empirical evidence that the uptake of low carbon technology has, to date, tended towards more affluent areas. For EVs, it is also based on the very practical consideration that, in the near term at least, the availability of off-road parking is a key driver for EV adoption.

The assumption that affluence will be a key driver for LCT adoption does, however, need to be applied with caution, especially in relation to network investment. There is a risk that, if affluence is given too much significance, network investment will be channelled to more affluent areas which would then create inequitable access to LCT for the future. There is also a risk that networks may underestimate the impacts of other factors which may actively counter balance affluence, for example the actions of local authorities and social housing providers to encourage LCT uptake in less affluent areas, as is already seen in relation to public charge point provision in Scotland. In the case of EVs, there is also a strong argument that the initial cost barrier will be superseded as EV capital costs reduce and EV driving (with lower running costs) becomes the cheaper transport solution.

To provide a degree of balance in the analysis the following approach has been taken.

- Affluence is considered a key distribution factor in the short term for Net Zero, Two Degrees and Community Renewables. For the Steady Progression and Consumer Evolution scenarios, which have lower social interventions, affluence remains a stronger driver in the medium term.
- Over the medium and longer term, for the higher ambition scenarios, the impact of the affluence distribution factor is reduced and an assumption is made that the deployment of LCT technologies will become more ubiquitous and will follow the underlying factors.
- For solar PV and heat pumps, the scenarios specifically include a social housing weighting factor to counter purely affluent areas. This social housing impact has previously been documented in Regen's DFES studies.
- For the more ambitious scenarios, from mid to late 2020s, the underlying assumption is that EVs will become ubiquitous. Therefore, the growth in demand for EVs in both on-street and off-street areas begins to increase at equivalent rates.

The impact of affluence on LCT uptake, and how the networks respond through network investment to ensure equitable access to new technology, is a key area for further research and should be considered as part of each network's stakeholder engagement, local area plans and RIIO-ED2 business planning. There may be a case for higher levels of network provision in less affluent areas which is outside the scope of this study.

3 Electric vehicle results summary

3.1 Electric vehicle baseline analysis

As of Q3 2019, there were nearly 41,000 EVs[3] registered in the SSEN Southern licence area, equivalent to about 0.9% of all vehicles in the area. The licence area, therefore, currently has slightly above average EV uptake compared to the whole of Great Britain, for which approximately 0.7% of all vehicles are electric. In contrast, the SSEN Scottish licence area currently has a slightly below average EV uptake, with about 0.5% of its vehicles being electric.[3]

The baseline analysis included an assessment of the spatial distribution of on and off-street domestic parking per feeder. This is essential to ensure feeders do not receive over estimations of the potential for off-street domestic EV chargers. This confirmed that rural areas have higher levels of off-street parking compared to urban areas. However, there is high granularity variation in this trend, often associated with affluence and detached/semi-detached housing. This assessment identified that 60% of homes have access to off-street parking in the Southern licence area and 70% in the Scottish licence area. Therefore, aside from other contributing variables, the SSEN Scottish licence area would expect to see more off-street domestic EV chargers per household than the Southern licence area.

Vehicle baseline by body type

Region	Category	Cars	Motorcycles	LGVs	HGVs	Buses & coaches	Total
Great Britain	**All vehicles**	31,842,466	1,331,716	4,102,879	505,092	154,296	**37,936,449**
SSEN Southern		3,842,526	164,420	574,500	54,695	19,333	**4,655,474**
SSEN Scotland		688,626	24,494	104,092	11,650	4,064	**832,926**
Great Britain	**EVs**	244,059	2,445	9,628	374	463	**256,969**
SSEN Southern		38,704	464	1,522	56	45	**40,791**
SSEN Scotland		3,633	25	157	3	8	**3,826**

Table 3: Vehicle baseline in SSEN's licence areas and GB. Source: DfT, 2019

Historic uptake of EVs in SSEN's licence areas

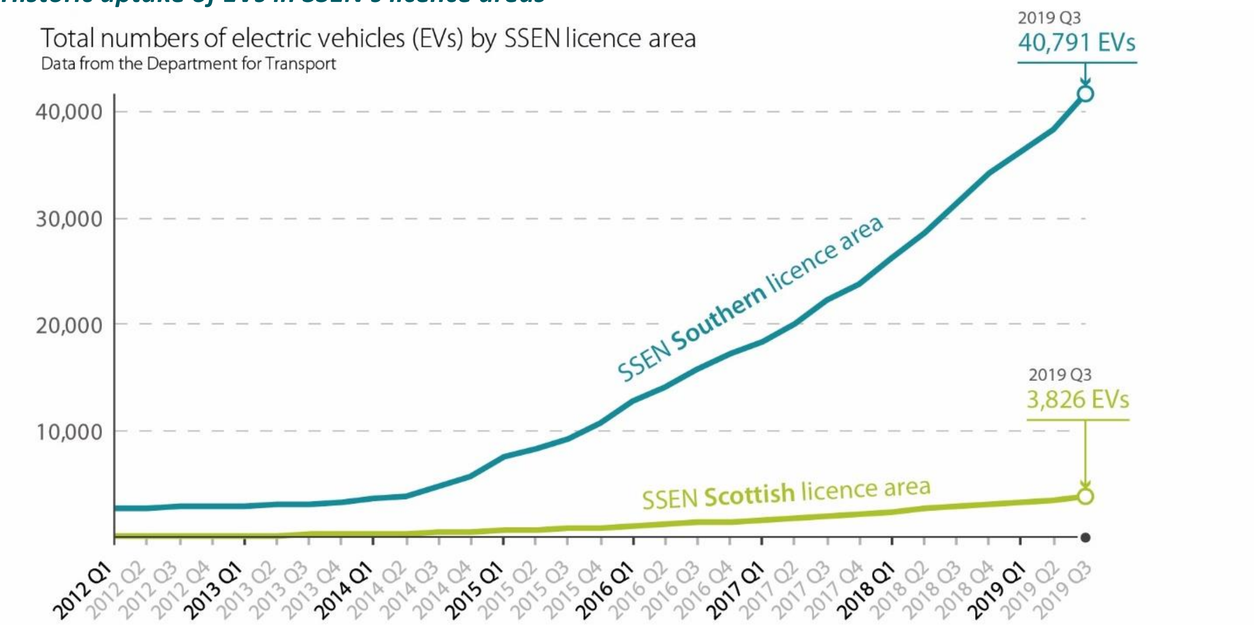


Figure 5: Historic EV uptake. Source: DfT 2019, Regen analysis. SSEN Southern hosts approximately 3.8 million vehicles and Scottish licence area hosts 0.69 million vehicles Note: these statistics may include a very small number of ULEV vehicles.

[3] EV and vehicle statistics source: DfT, Q3 2019. Note: Since the UK has a relatively low number of EVs at present, the baseline should be used with caution as it is not necessarily indicative of future trends.

3.2 Electric vehicle projections to 2050

The increase in EV uptake will be driven by a mix of local and national policies. The UK government has already proposed that the ban on new petrol and diesel vehicle sales will be brought forward from 2040 to 2035, and has continued to offer purchase price support for EV vehicles as well as support for charger deployment. Local and regional policies such as; clean air and low emission zones, funding and support for charger deployment and public engagement will be key factors for future EV uptake within each network licence area.

However, three of the four scenarios modelled in this study go further and assume that the impending ban on petrol and diesel vehicle causes petrol and diesel vehicle sales to fall to near zero sooner than 2035. National Grid's Two Degrees and Community Renewables data on EV numbers suggest that petrol and diesel car sales are close to zero in the early 2030s. In order to differentiate the Net Zero scenario, it is assumed that there are nearly zero petrol and diesel vehicles sales from the late 2020s.

The results summarised in Figure 6 show that in the high-growth scenario, the licence areas are projected to have reached peak EV sales from around 2030, resulting in around 4.5 million EVs in the Southern licence area and around 600,000 EVs in the Scottish licence area by 2040. The vast majority of these would be BEV cars, with other vehicle types making up a small but potentially significant contribution in the less ambitious scenarios.

Regen's EV growth model assumes that EV uptake in the Southern licence area stays ahead of the national average in the short and medium term but will align to national average by the end of the scenario period. In the Scottish licence area, EV uptake is currently behind the national average and is assumed to remain so in the short term, before aligning with the national average in the medium and long term. This assumption reflects the current key uptake factors driving the early adoption of EVs that are considered in our geospatial modelling, such as affluence levels, off-street parking and second car ownership along with clean air zones in and around urban centres. In the Net Zero scenario in particular, these early uptake factors make way for more ubiquitous factors that result in the same relative uptake rates in the Scottish and Southern licence areas.

EV projections in SSEN's Southern and Scottish licence areas (all vehicle types)

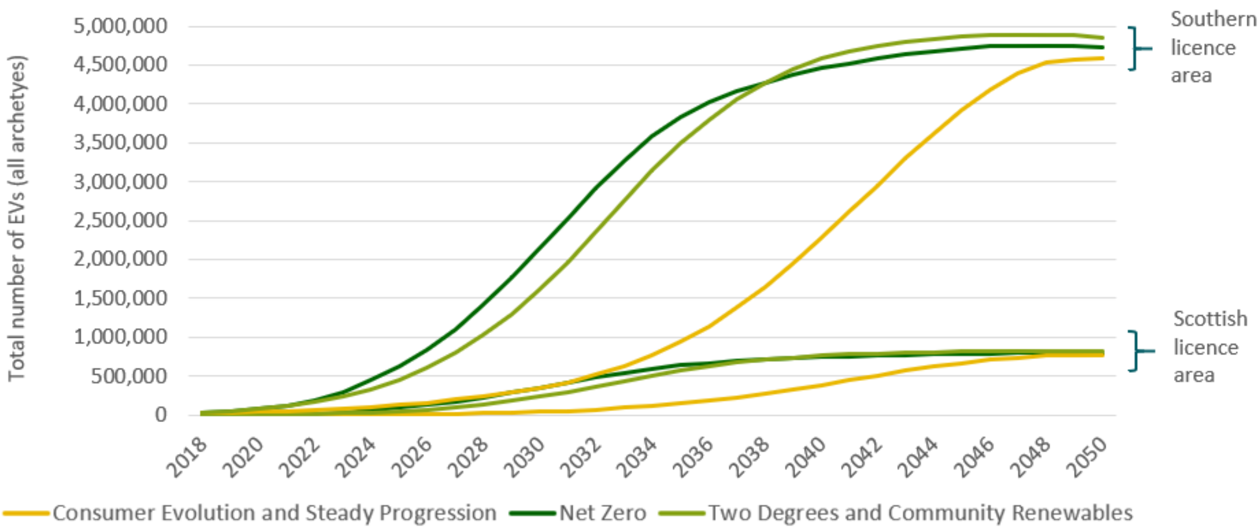


Figure 6: EV projections in SSEN Southern and Scottish Licence Areas. Source: Regen modelling. Scenarios have been grouped where there is a minimal difference between them.

4 Electric vehicle charger results summary

4.1 Electric vehicle charger baseline analysis

According to an analysis of ZapMap data there are a total of 2,018 and 771 public EV chargers in SSEN's Southern and Scottish licence areas respectively.[4] In addition to these public chargers, there are a total of approximately 32,000 domestic EV chargers and a further approximately 2,000 workplace and fleet EV chargers in SSEN's licence areas. This is summarised in the table below by charger archetype.

Number of public EV chargers

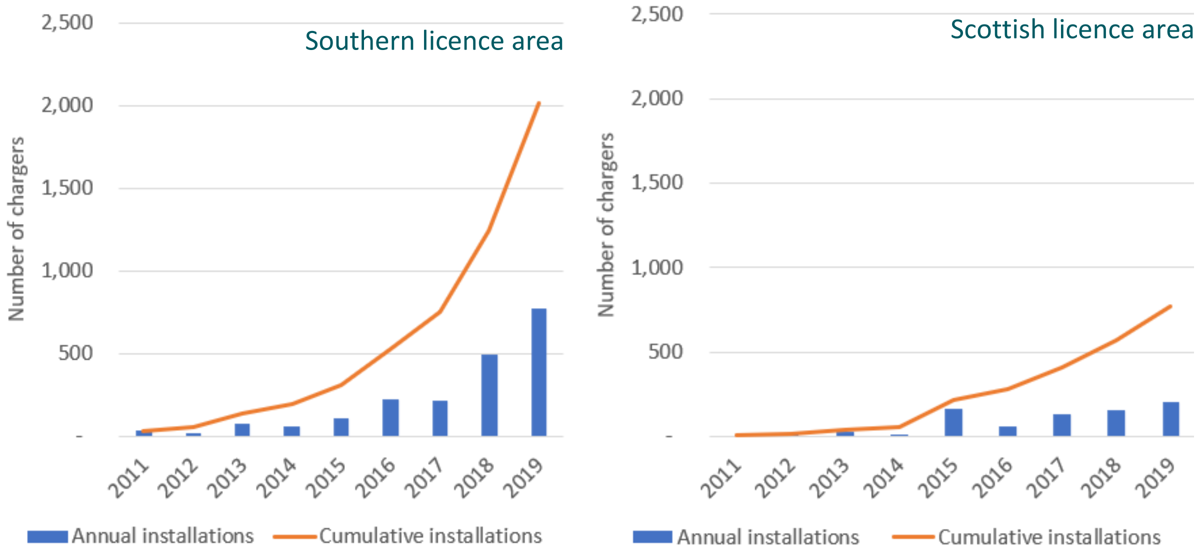


Figure 7: Public EV charger uptake in SSEN's licence areas. Source: ZapMap

There are different spatial trends in the two licence areas for where public EV chargers are installed. In the Southern licence area, there is a relatively high proportion of EV chargers located in on-street settings, while there are relatively few on-street chargers in the Scottish licence area. In the Scottish licence area, 34% of EV chargers are located in car parks, compared to 20% in the Southern licence area.

The ZapMap data shows a marked difference in the current baseline of public charger type and locations in the Southern and Scottish licence areas, with Scotland having a higher proportion of chargers in public car parks, public sector workplaces and other public spaces. The reason for these differences could be partly explained by the different government strategies in each licence area. Approximately 73% of EV chargers in Scotland are operated by ChargePlace Scotland, a national network of chargers developed by the Scottish government through grant funding of Local Authorities and other organisations. This more centralised approach to charging infrastructure has resulted in a greater proportion of EV chargers in centralised public parking locations such as car parks, park and rides, public estates and educational centres.

[4] Source: ZapMap 2020.

Public EV charger locations baseline

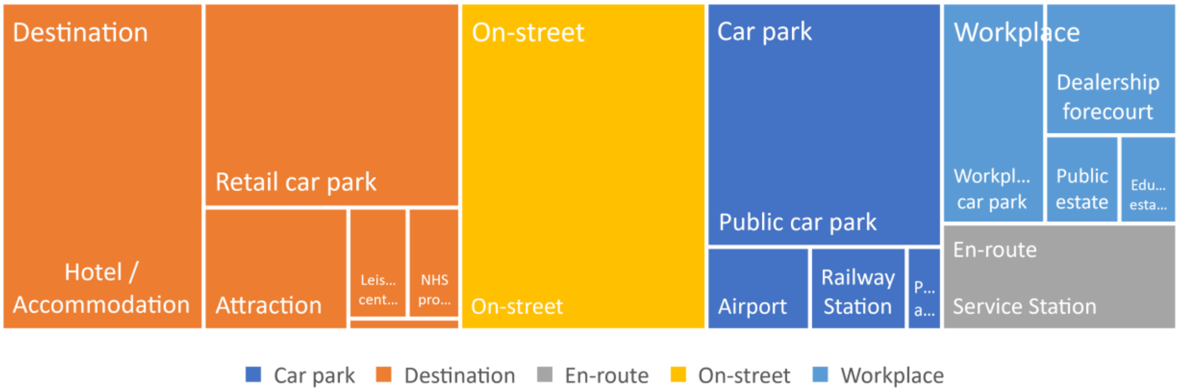


Figure 8: Proportion of EV public charger locations in the Southern SSEN licence area. Source: ZapMap. (Size of areas represent the proportion of the number of EV chargers in each category.)

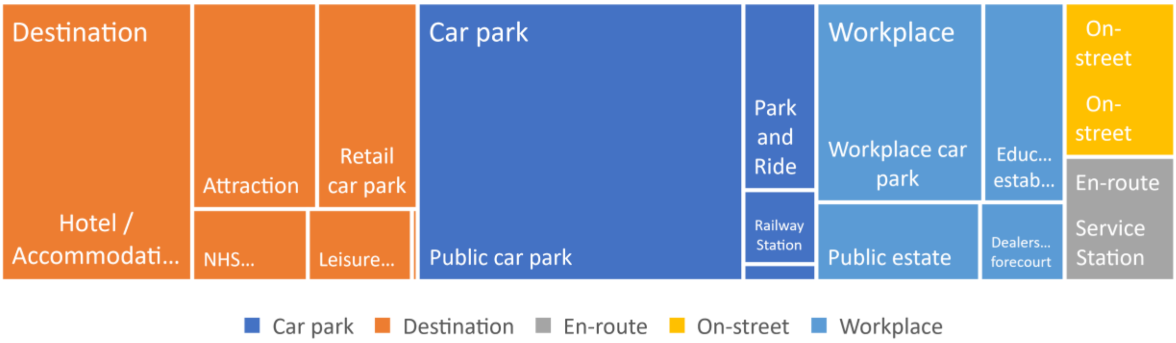
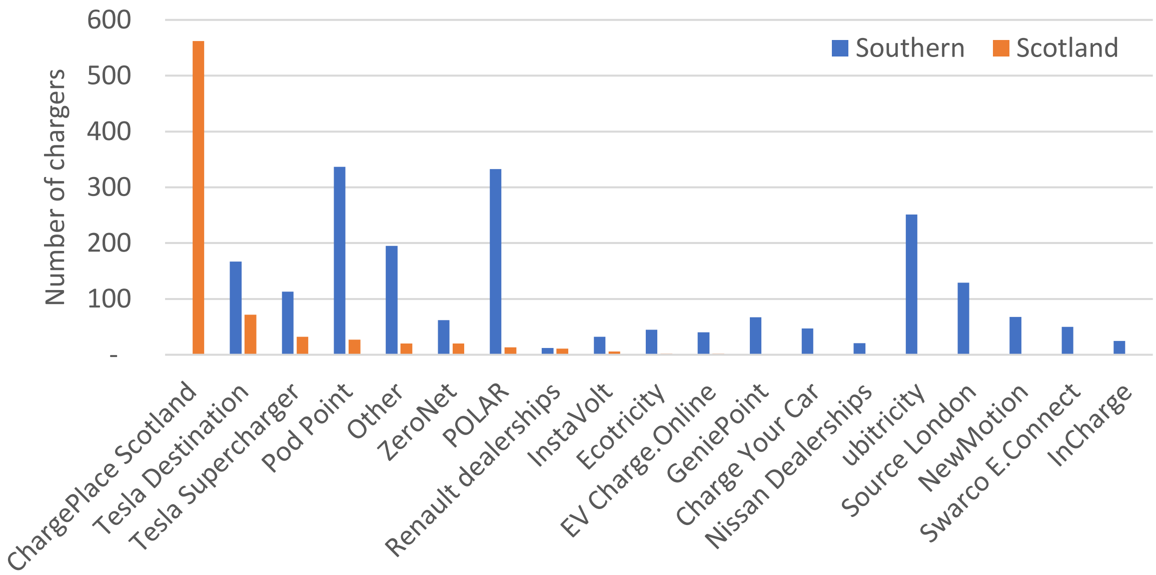


Figure 9: Proportion of EV public charger locations in the Scottish SSEN licence area. Source: ZapMap (Size of areas represent the proportion of the number of EV chargers number of EV chargers in each category.)

However, in the Southern licence area the majority of charging infrastructure is operated by private ventures. Approximately 50% of EV chargers in the Southern licence area are operated by three main private installers: Pod Point, POLAR and Ubitricity. This has resulted in more decentralised EV charging infrastructure, including in settings such as on-street, retail car parks, hotels and other destination locations.

Public EV charger operators in each SSEN licence area



4.2 Electric vehicle charger projections

The EV charger projections were derived in Regen's EV charger model which estimates charger network capacity that is likely to be required to deliver EV electricity demand. In the near and medium term its analysis process comprises of these key steps, which will vary by scenario, region, archetype and year:

1. Analyse what the energy requirement is of EVs in the region;
2. An analysis of where that energy be delivered;
3. Estimate the capacity utilisation that is expected;
4. Evaluate where this charger capacity is likely to be distributed.

The results presented in the graphic below illustrates various aspects of the results. For example, how decentralised a scenario's energy system is projected to be will affect the spatial distribution and number of EV chargers in each EV charger archetype. Community Renewables and Consumer Evolution, as more decentralised scenarios, have greater on-street charging capacity than centralised scenarios. Meanwhile, the more centralised scenarios have more capacity in centralised charging locations, such as en-route charging.

Domestic off-street (home charging) EV charging

There are nearly 2,200 domestic off-street EV chargers in SSEN's Scottish licence area's baseline and over 16,300 in the Southern licence area. The number of domestic off-street chargers is expected to rapidly increase under the three more ambitious scenarios, then level out by 2040 once the existing petrol and diesel vehicle stock are almost entirely replaced by EVs.

Number of domestic off-street EV chargers by scenario and SSEN licence area (thousands)

Licence area	Scenario	Baseline (thousands)	2030 (thousands)	2040 (thousands)	2050 (thousands)
Scottish licence area	Two Degrees	2	134	382	396
	Net Zero	2	146	368	382
	Steady Progression	2	18	202	352
	Consumer Evolution	2	18	200	349
	Community Renewables	2	134	381	395
Southern licence area	Two Degrees	16	902	1,653	1,653
	Net Zero	16	984	1,594	1,594
	Steady Progression	16	147	862	1,319
	Consumer Evolution	16	143	843	1,299
	Community Renewables	16	897	1,644	1,644

Table 4: Off-street domestic EV charger numbers

The uptake of off-street domestic EV chargers are correlated with the uptake of EVs associated with off-street parking. The majority of EV cars are assumed to be associated with off-street parking in the near-term before EVs become more ubiquitous and the rate of uptake of EVs in households without off-street parking increases.

By 2050 in the Net Zero scenario and in the Southern licence area, it is projected that nearly 1.6 million off-street EV chargers serve over 1.6 households and approximately 2.4 million cars, LGVs and motorbike EVs that are associated with off-street domestic charging. In the Scottish licence area, in the Net Zero scenario in 2050, it is projected that 382,000 off-street EV chargers serve nearly 400,000 households and approximately 412,000 cars, LGVs and motorbike EVs that are associated with off-street domestic charging.

Domestic off-street charger distribution analysis focused on the possible uptake of domestic EV chargers per EV at each household. As a result, the distribution of vehicles associated with on and off-street parking was evaluated, with the anticipated result that a feeder is more likely to see domestic off-street EV charging in more rural and more affluent areas where off-street parking exists. This is illustrated in the graphics below.

Electric vehicle home charging availability in the Scottish licence area

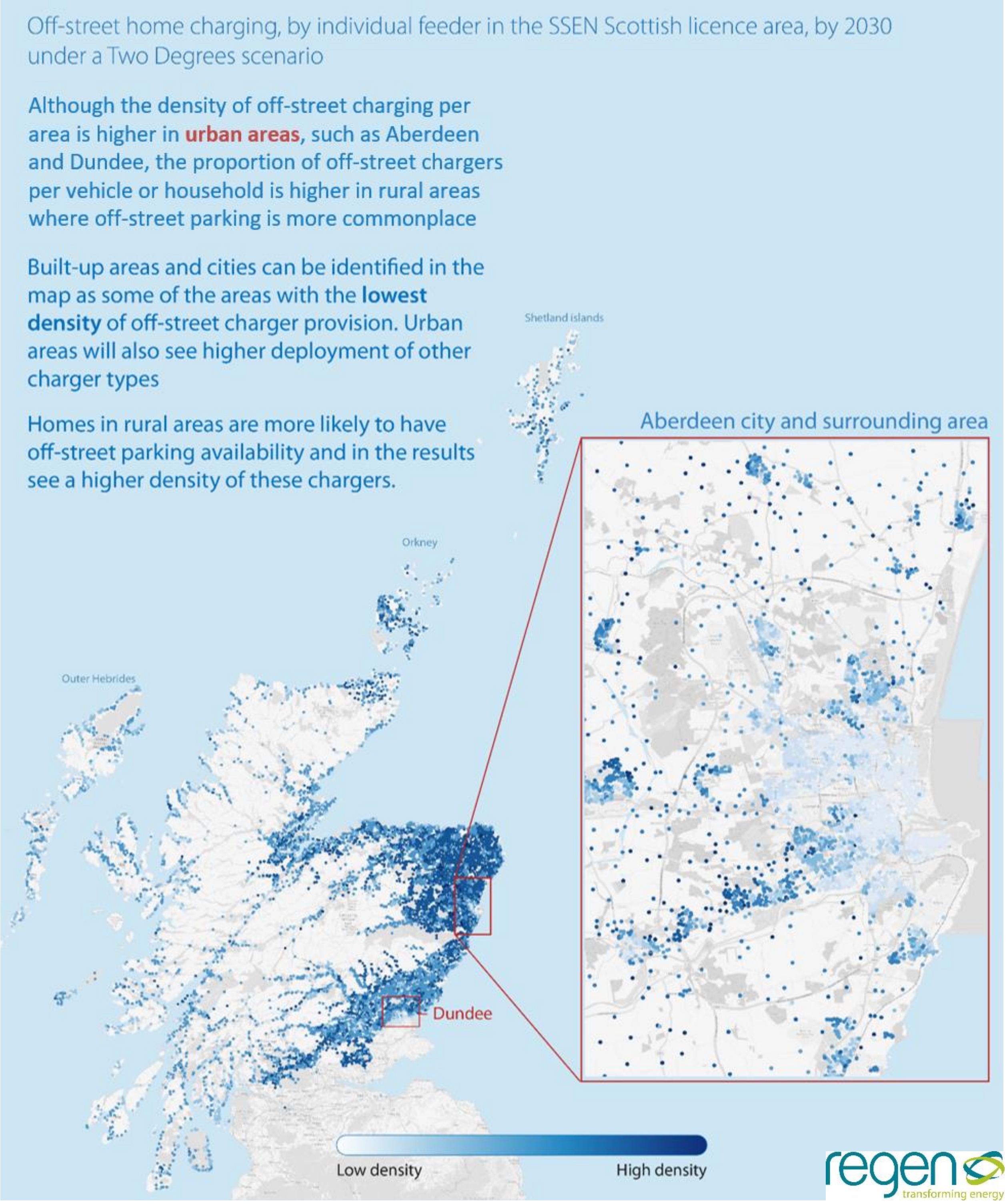


Figure 10: Relative density of home parking availability by feeder distribution areas in SSEN's Scottish licence area

Electric vehicle home charging availability in the Southern licence area

Off-street home charging, by individual feeder in the SSEN Southern licence area, by 2030 under a Two Degrees scenario

Low density — High density

EV chargers in homes with off-street parking are assumed to be 7 kW.

Urban areas have lower off-street parking provision. Built-up areas and cities can be identified in the map as some of the areas with the **lowest density** of off-street charger provision.

Homes in rural areas are more likely to have off-street parking availability and in the results see a higher density of these chargers.

Very rural areas in National Parks such as the New Forest and South Downs can be observed to have high density of off-street home charging

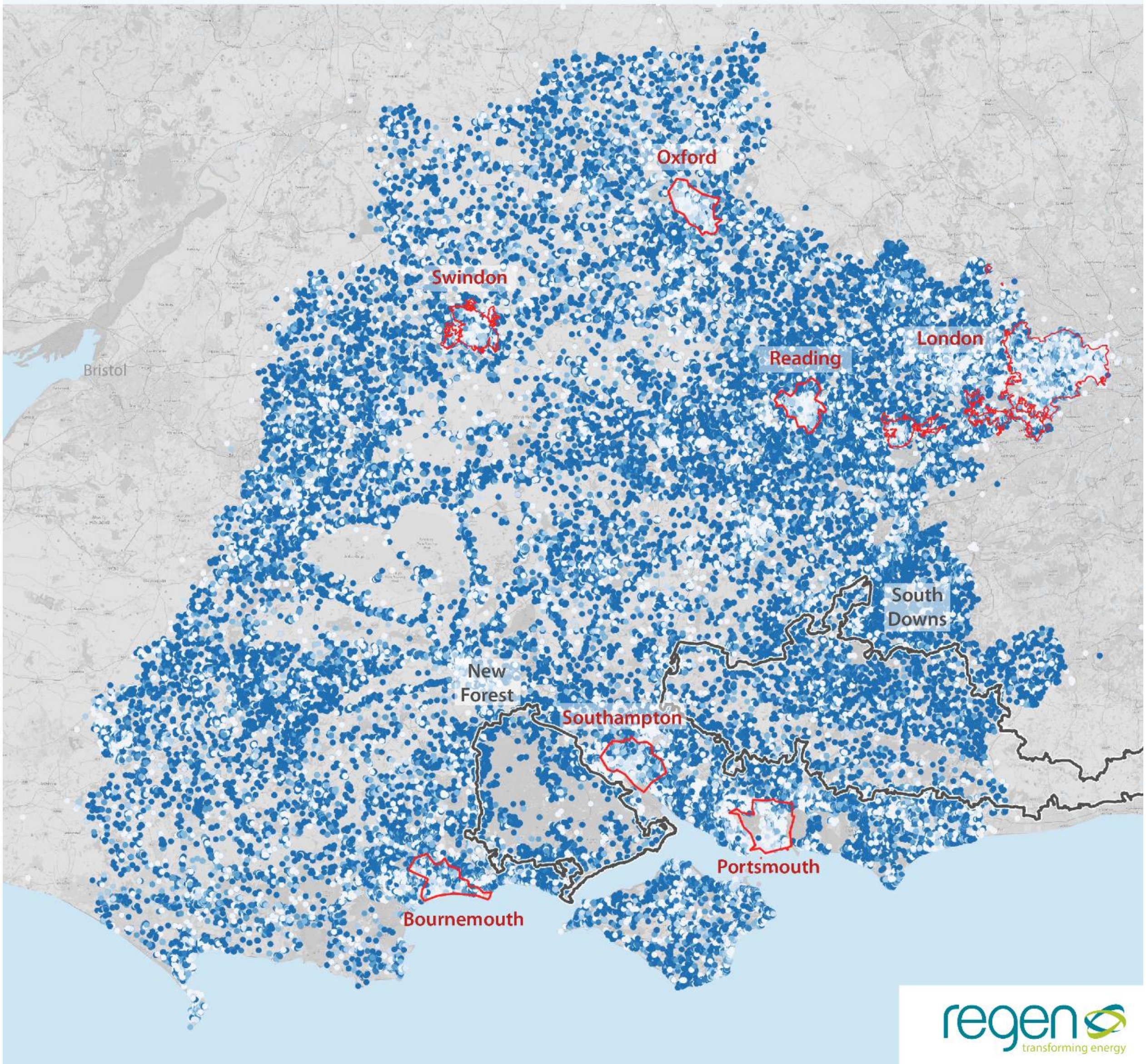


Figure 11: Relative density of home parking availability by feeder distribution areas in SSEN's Southern licence area

Example LV feeder domestic off-street home-charging availability in Swindon and Dundee

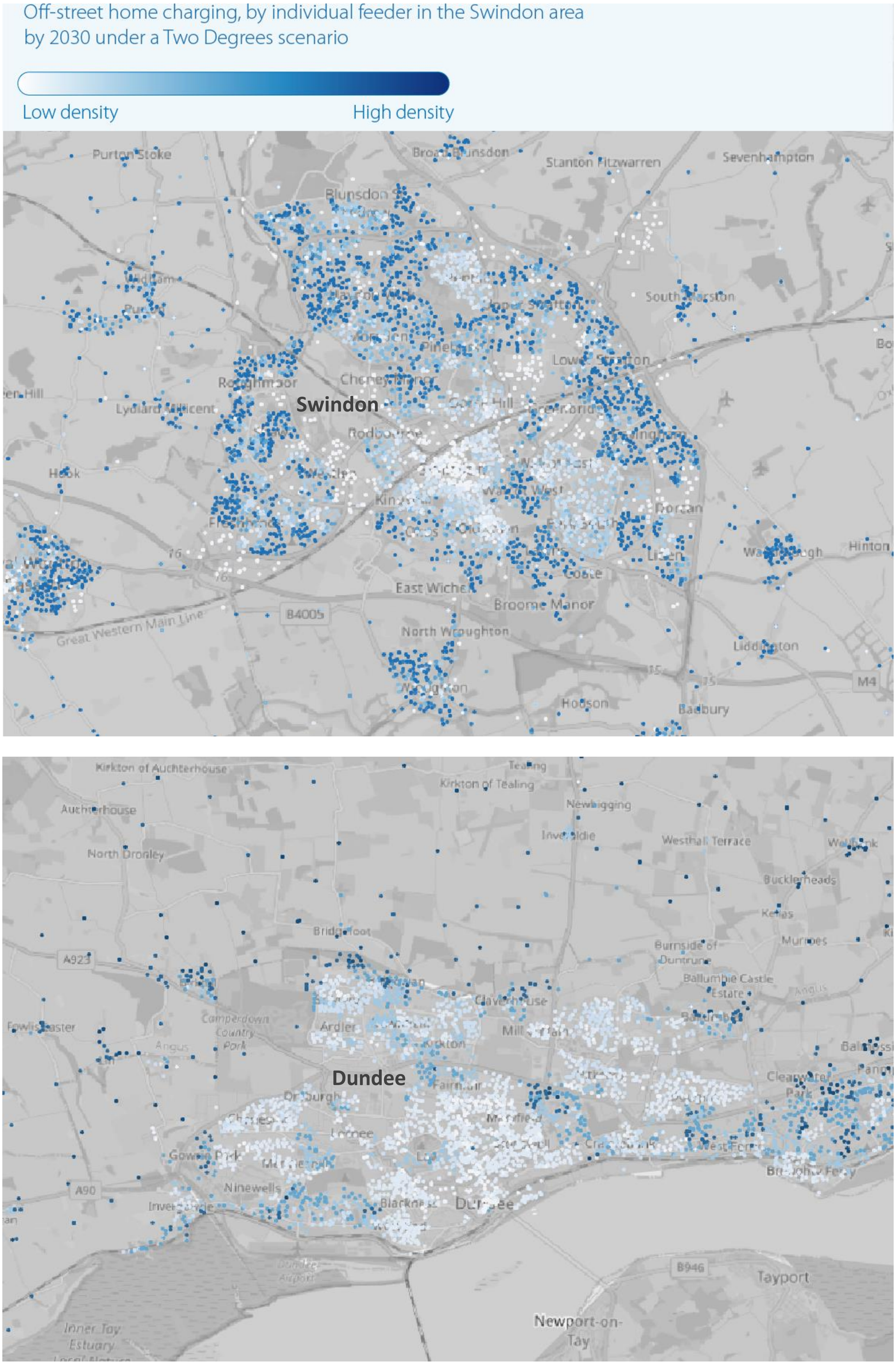


Figure 12: Example off-street parking density

Non-domestic EV charger capacity results arranged by scenario

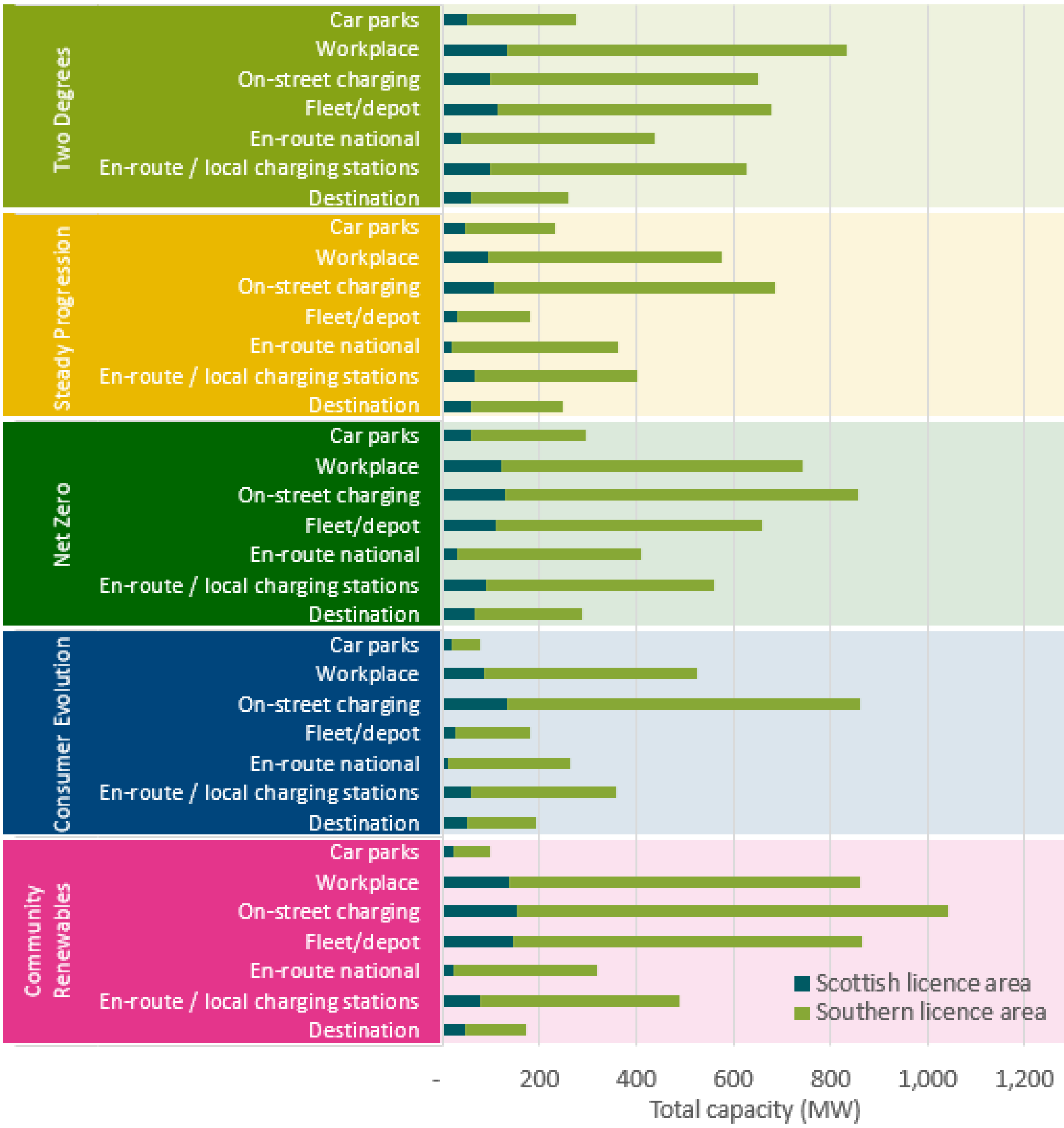


Figure 13: EV charger capacity in 2050 by scenario and charger archetype

The spatial distribution of non-domestic chargers was analysed in a unique manner for each archetype. En-route local and national charging locations were evaluated based on the density of local housing, the volume of local traffic, the distribution of existing petrol stations and the road classification the site is located on. Car parks, workplace and fleet depot locations were analysed from Ordnance Survey Addressbase data and their weighting was evaluated from employment and commuting road traffic statistics. The on-street domestic analysis was undertaken in parallel with the off-street parking analysis to identify vehicles associated with on-street parking. The spatial distribution is illustrated in the graphic below.

Non-domestic charger distribution

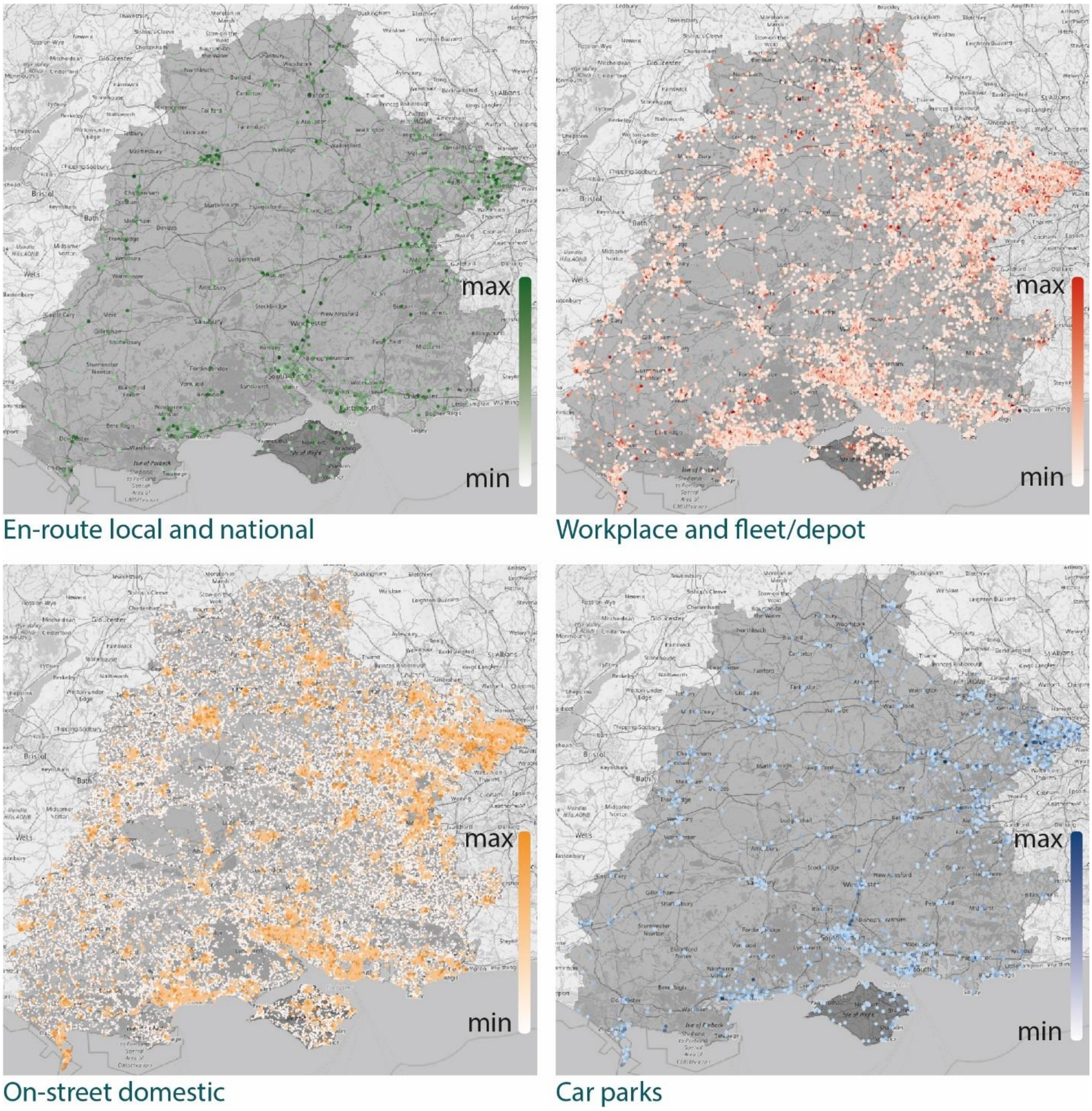


Figure 14: Non-domestic EV charger distribution by grouped archetype

Example of non-domestic charger distribution in Dundee

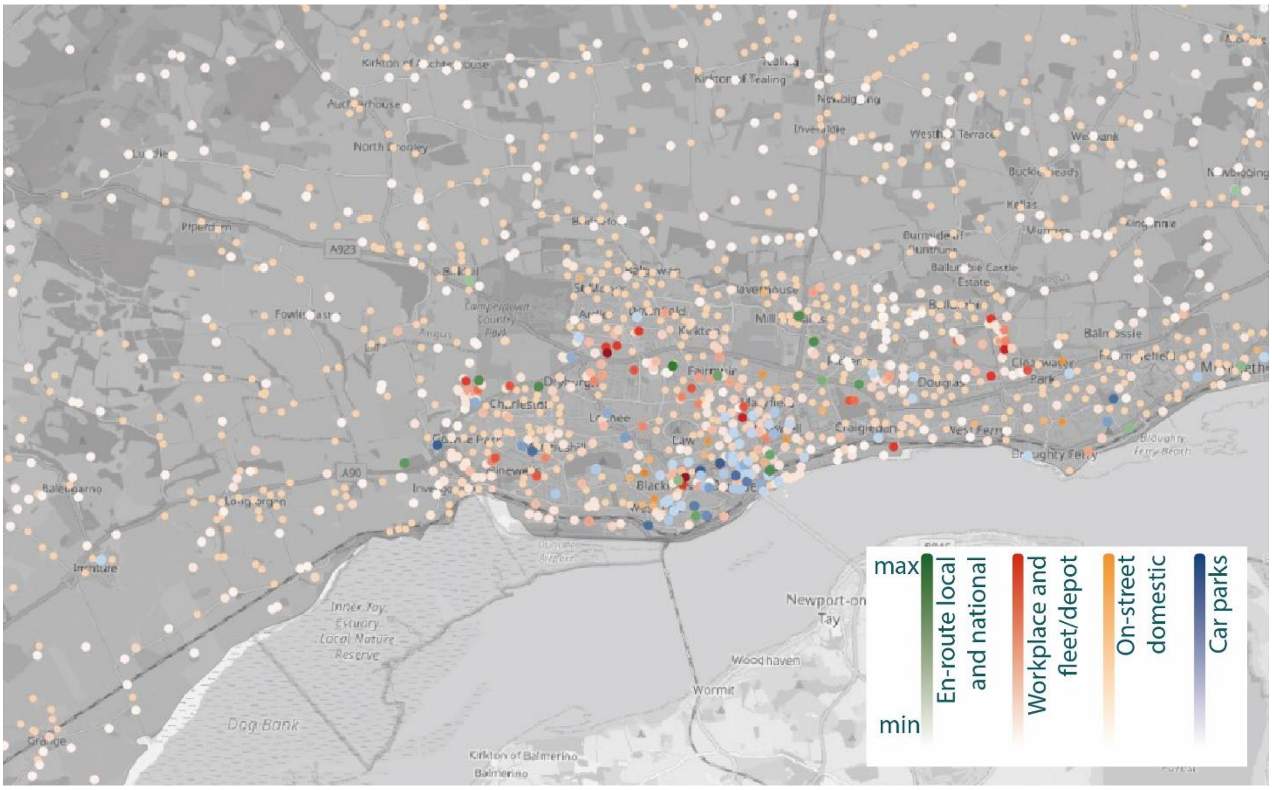


Figure 15: Local non-domestic charger distribution in Dundee, in 2050 in a Two Degrees scenario

Example of non-domestic charger distribution in Southampton

Figure 16: Local non-domestic charger distribution in Southampton, in 2050 in a Two Degrees scenario

Key assumptions

The table below lists some high-level key assumptions and areas of analysis for the development of the EV charging scenario projections.

Variable	Assumption
Domestic off-street charger capacity	It is assumed that each off-street EV charger is 7 kW.
Miles per kWh	EV cars and charging efficiency rises from 2.9 miles per kWh today to ~3.8 miles per kWh in 2030. This is based on an analysis of WhatCar vehicle and charging efficiency and historic efficiency improvement trends. Each vehicle type has its own efficiencies that vary over time.
Home charging	The percentage of energy delivered to EV cars and LGVs at home varies between 40% and 75% depending on scenario.
Scaled EV uptake	Licence areas that are ahead or behind average EV uptake rates merge to equal uptake rates by around 2025 to 2035, depending on scenario.
Number of vehicles and vehicle mileage	The gross total number of vehicles in each licence area remains constant in all scenarios but Net Zero. Ambitious scenarios see a reduction in vehicle miles.
Utilisation rates	The utilisation rates of some EV archetypes remains very low in the near term, particularly for car parks and destination charging. Utilisation rates increase over time, varying by scenario.

Table 5: Example key assumptions

A note on load profile and design demand analysis

In addition to the LCT projections, this study also delivered a collated set of demand load profiles for domestic EV charger use, heat pump demand and solar generation. These have been derived from a range of existing sources, including My Electric Avenue, Electric Nation, and wider market analysis studies such as the National Grid Electric Vehicle Charging Behaviour Study.

To create EV Charging load profiles Regen evaluated mean and standard deviations of energy demand for 7 kW domestic chargers, derived from Electric Nation’s Greenflux and Crowd Charge datasets. The profile design demand calculations were undertaken using the ACE 49 design demand methodology with the addition of a number of factors including smart and non-smart charging, and a mileage factor to assess the potential network load impact of EV charging for concentrations of high and low mileage vehicles.

5 Domestic heat pumps results summary

5.1 Domestic heat pumps baseline

The decarbonisation of heat remains a key challenge to achieve UK government net zero commitments. The deployment of heat pumps is identified by the CCC and the FES 2019 as a clear, no regret and urgent heat decarbonisation option. Heat pumps are an especially important technology to achieve decarbonisation in homes not connected to the gas grid. Approximately 16% of domestic dwellings in the Southern licence area and 37% in the Scottish licence area are not connected to the gas grid, including 95% of households in the Scottish Islands. In these off-gas properties there is very high potential for decarbonisation, particularly from heat pumps.

Both licence areas have seen consistent heat pump deployment with approximately 1,000 installed under the RHI every year in both the Scottish and Southern licence areas. As a result, the Southern licence area currently hosts about 9,000 heat pumps and the Scottish licence area 7,600. Installations are proportionally highest in areas with the most off-gas grid houses.

5.2 Domestic heat pump projections

This assessment makes scenario-based projections for two core technologies: electric heat pumps and gas back-up hybrid heat pumps. Ground, water and air source heat pumps are considered synonymous for the purposes of this study.

Hybrid gas heat pumps are becoming a more important technology for heat decarbonisation in existing harder to treat homes and are a key feature in Community Renewables and Two Degrees. The use of the back-up boiler (usually gas) during low ambient temperatures and peak demand periods can help reduce the impact of heat pumps on the electricity network. Hybrid heat pumps are also important in the near-term for the Net Zero electrification scenario, but are assumed to peak in 2035 and reduce to near zero by 2050, reflecting a possible electrified net zero heat scenario.

Percent of homes in the SSEN licence areas with a heat pump installed

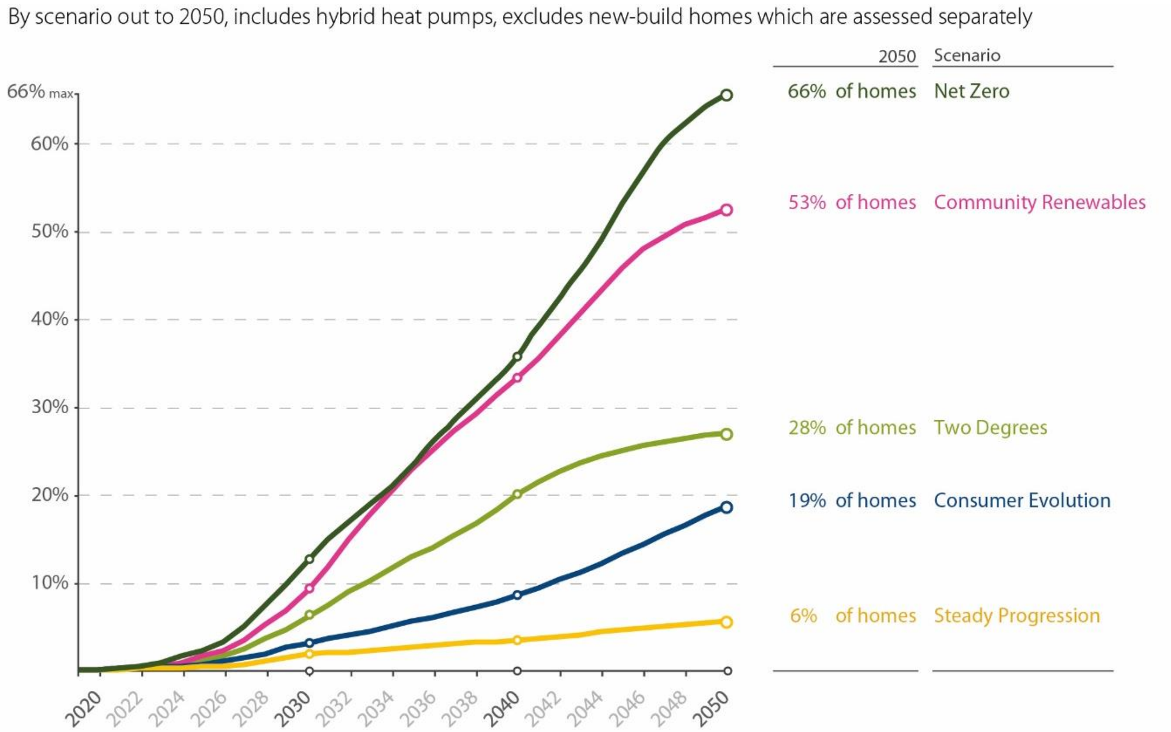


Figure 17: Heat pump projections in the SSEN Scottish licence area

It is assumed that significant increases in the number of heat pumps are facilitated by several key drivers. These include a combination of favourable government policy, regulations and incentives, technology cost reductions, national building regulation changes, local planning policy and the availability of consumer capital. The less ambitious and more centralised scenarios see smaller increases in heat pump numbers as a result of fewer of these key drivers being in place.

SSEN provides network connection to many homes in Scotland which are not connected to the gas grid, including some of the large inhabited islands such as Shetland and the Outer Hebrides. It is these homes which are most suited to early uptake of electric heat pumps in order to reduce the energy bills. In the Scottish licence area, hybrid gas heat pumps are concentrated in the East of the licence where the gas distribution network is more prevalent. These spatial trends are illustrated in the graphic below.

Spatial distribution of heat pumps in the Scottish licence area over time

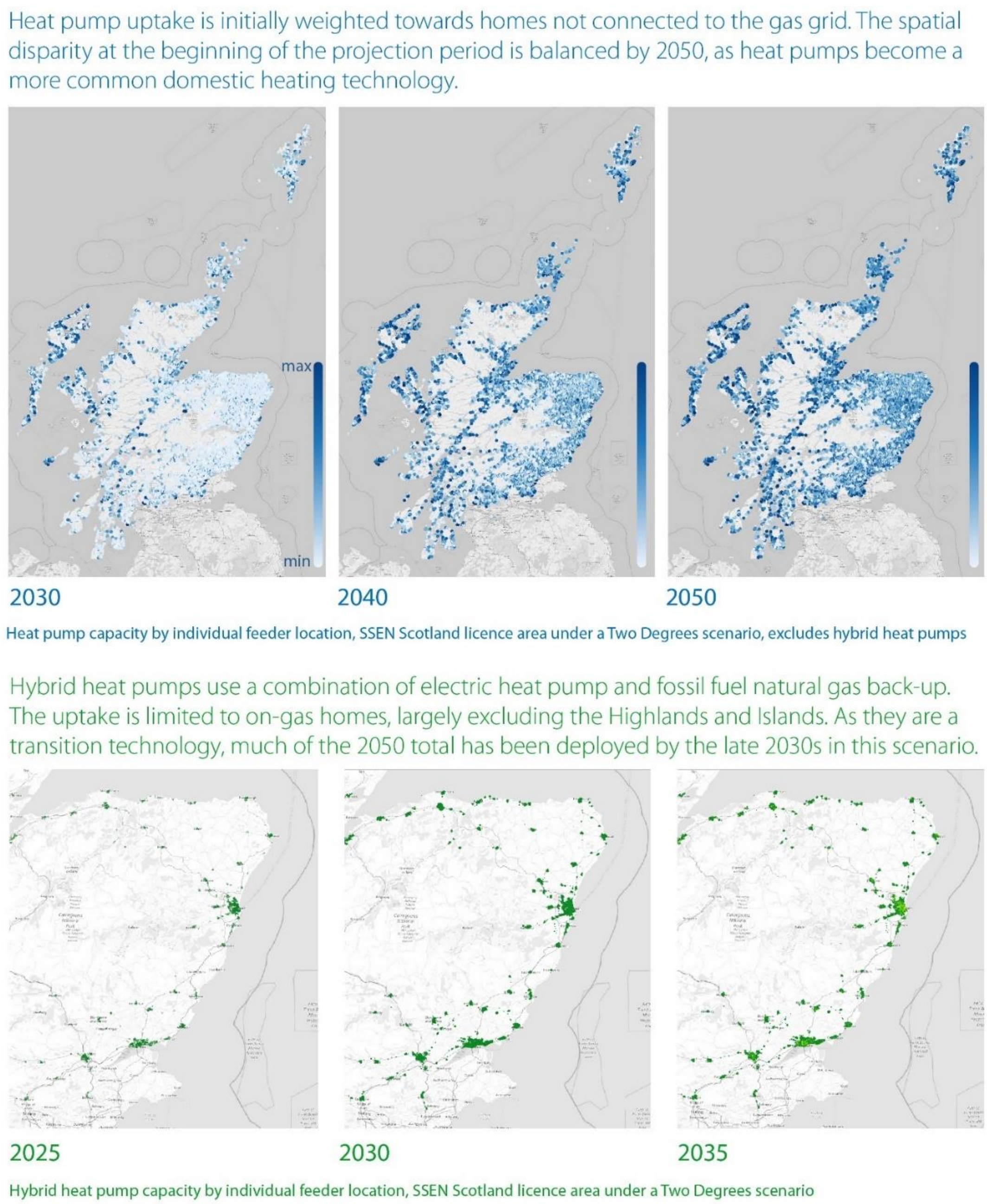


Figure 18: Heat pump distribution in the Scottish licence area. Southern area is not plotted as a licence area scale as the distribution of on and off gas areas is not as informative as the Scottish licence area.

Example spatial divide in hybrid gas and electric heat pump uptake

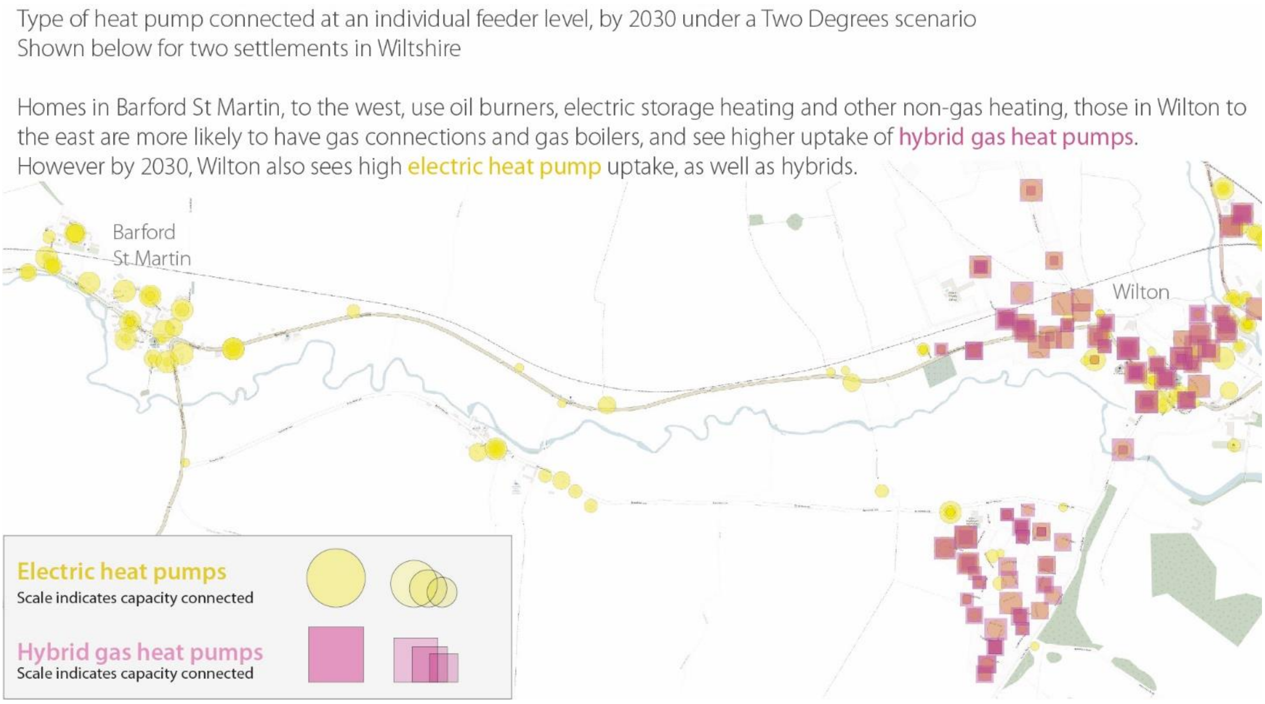


Figure 19: Illustrative spatial distribution of hybrid gas heat pumps and electric heat pumps

Example local hybrid gas and electric heat pump uptake in an on-gas town

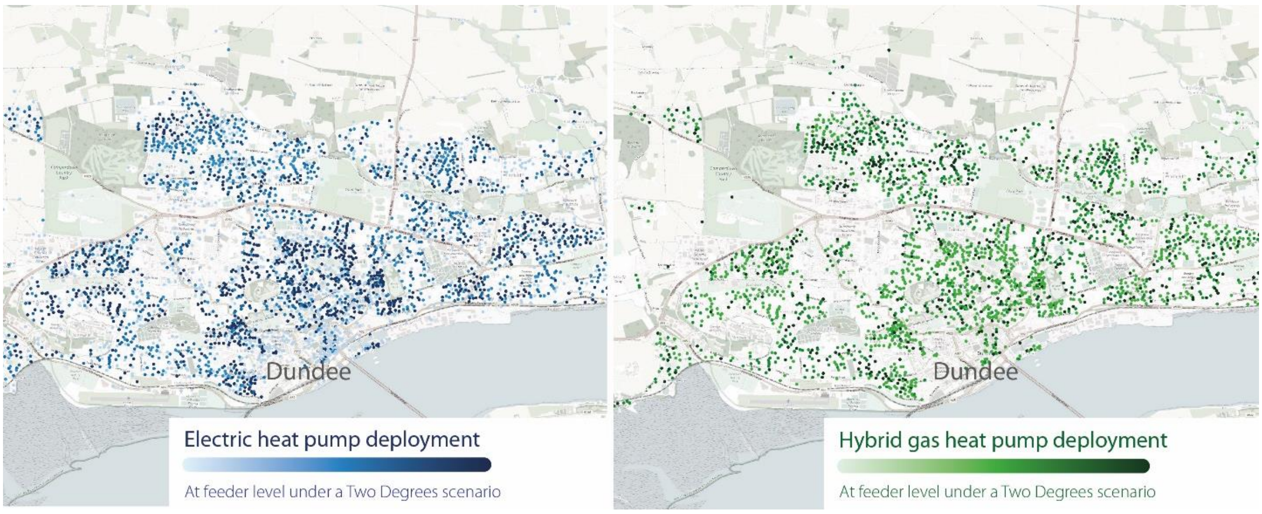


Figure 20: Example feeder level heat pump distribution.

In the scenarios with stronger decarbonisation targets, the deployment of heat pumps increases to include more on-gas homes, with significant numbers of boilers being replaced by heat pumps from the 2030s onwards. From a base of 7,644 heat pumps in the SSEN Scottish licence area, around 215,000 homes are projected to install a heat pump under a Two Degrees scenario by 2050, compared to a low of 28,000 under a Steady Progression scenario. This low increase in the Steady Progression scenario occurs in the context of a lack of financial support and regulations supporting heat pumps in on-gas areas.

The Net Zero scenario in this analysis is a high-electrification scenario and sees hybrid gas back up heat pumps drop to zero, from a peak of around 50,000 homes in the late 2030s. In this Net Zero scenario, domestic emissions are minimised to the extent that hybrid heat pumps are treated as a transition technology and support is withdrawn in favour of electric back up heat pumps and other decarbonised heating solutions. An alternative scenario which sees hybrid heat pumps replaced by hydrogen boilers has not been modelled.

Number of domestic heat pumps results summary

	Heat pump archetype	Scenario	Baseline	2030	2040	2050
Scottish licence area	Electric back up heat pump	Two Degrees	7,644	22,185	98,626	168,026
		Community Renewables		35,653	157,208	256,009
		Steady Progression		17,782	25,952	33,781
		Consumer Evolution		18,580	37,207	60,002
		Net Zero		68,055	251,836	513,784
	Gas back up hybrid heat pump	Two Degrees		16,386	28,041	53,847
		Community Renewables		14,324	68,149	135,918
		Steady Progression		2,969	6,757	15,881
		Consumer Evolution		5,823	17,939	78,618
		Net Zero		14,324	43,928	0
Southern licence area	Electric back up heat pump	Two Degrees	8,966	94,237	421,342	562,302
		Community Renewables		122,950	628,781	963,641
		Steady Progression		45,085	67,302	88,543
		Consumer Evolution		72,495	133,216	190,276
		Net Zero		217,567	1,004,157	1,956,366
	Gas back up hybrid heat pump	Two Degrees		100,900	225,686	252,312
		Community Renewables		177,224	412,881	627,841
		Steady Progression		17,939	46,148	82,789
		Consumer Evolution		35,547	143,903	361,306
		Net Zero		185,470	65,120	0

Table 6: Domestic heat pumps results summary

6 Domestic rooftop solar PV results summary

6.1 Rooftop solar PV baseline

There is currently 252 MW of domestic rooftop solar PV in the Southern licence area, and 60 MW in the Scottish licence area. The rate of growth in rooftop solar PV capacity has reduced considerably since 2015, when the Feed-in Tariff (FIT) support was reduced significantly before being removed in March 2019. This baseline capacity has been installed on 2.7% of homes in the Southern licence area and 2.8% in the Scottish. The average size of all domestic installations is 3.6 kW. Looking ahead the FIT is being replaced by a new Smart Export Guarantee, which could provide the basis for new domestic installations. The new Future Homes Standard may also encourage solar deployment on new buildings.

6.2 Rooftop solar PV projections

It is assumed that in the more ambitious scenarios, significant increases in rooftop solar PV capacity are facilitated by several key drivers. These include a combination of favourable government policy and support, technology cost reductions, flexibility revenue savings and availability of consumer capital. The less ambitious and more centralised scenarios see smaller increases in total rooftop capacity as a result of fewer of these key drivers being in place.

In addition to the key drivers above, social housing is an important factor for future growth in rooftop solar PV deployment. Rooftop solar PV can be used to reduce tenant energy bills, address fuel poverty and help meet carbon reduction commitments. The longer-term investment windows and use of different funding models will help social housing solar PV deployment.

Deployment of domestic rooftop PV in SSEN's licence areas

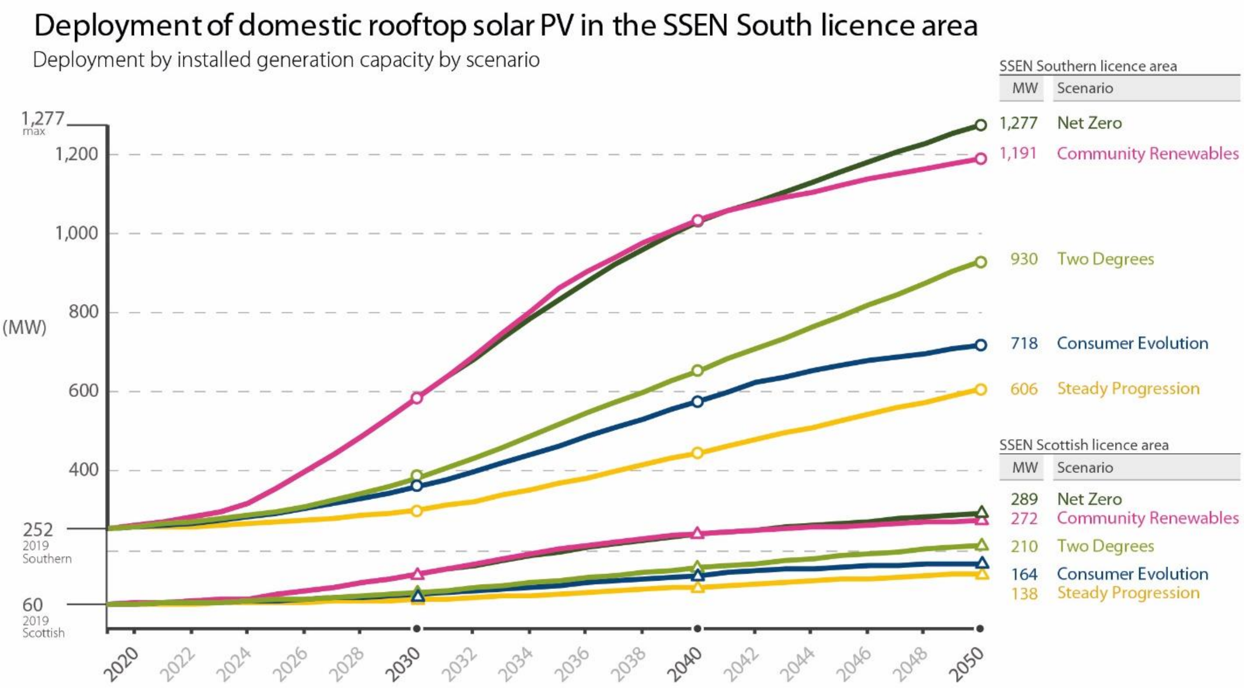


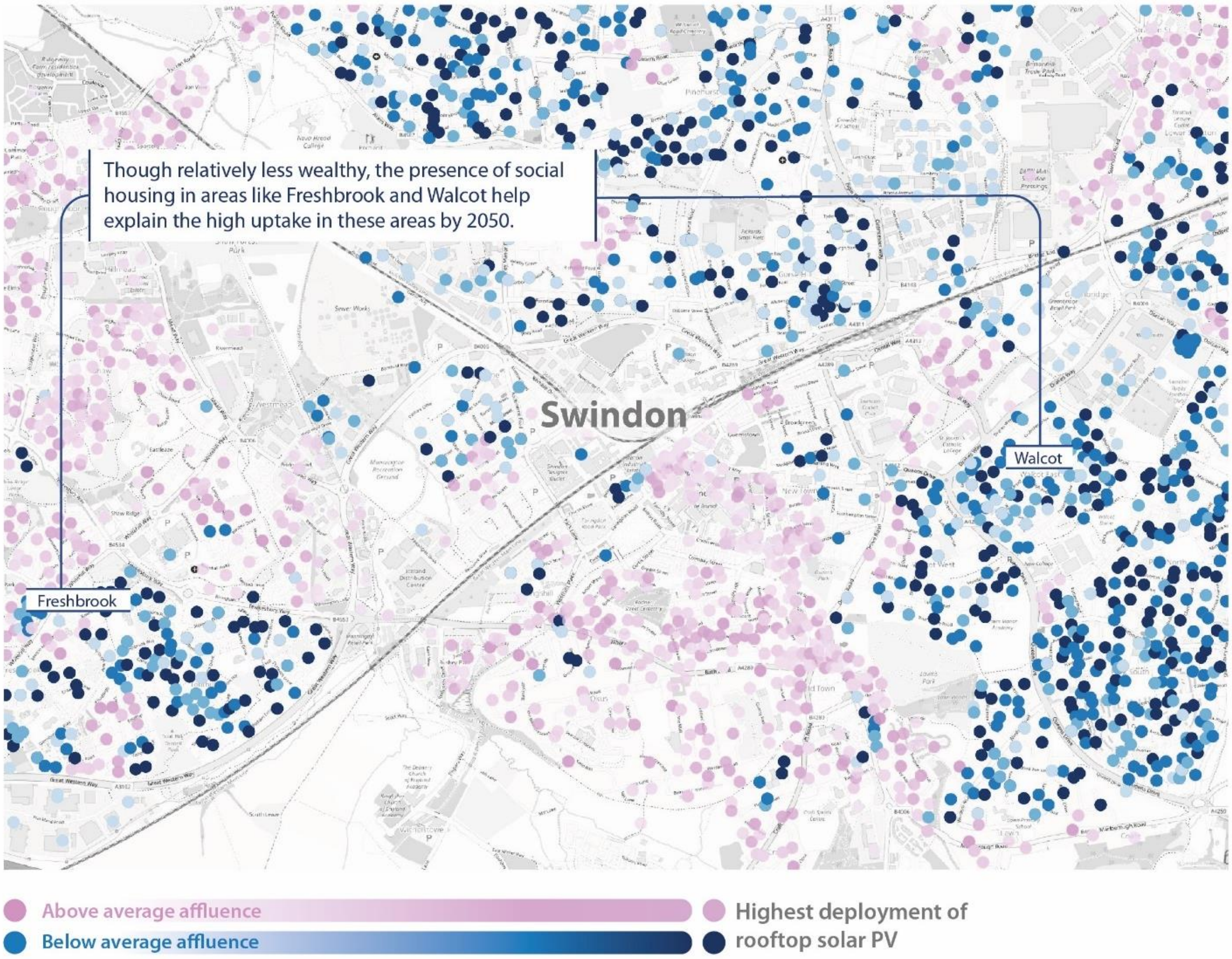
Figure 21: Domestic rooftop PV projections

Community Renewables and Net Zero show significant domestic rooftop PV increases in the late 2020s and 2030s. By 2050 they have quadrupled the currently installed capacity of domestic rooftop solar PV. There is reduced deployment in the more centralised Two Degrees, as renewable energy planning is focussed on larger, utility-scale generators. Though relatively less, this scenario still more than doubles installed capacity by the mid-2030s.

Though both licence areas have historically seen rapid deployment of rooftop PV under the FIT, the current slow capacity increases are expected to continue in early 2020s under most scenarios. As a result of the slow domestic rooftop PV market, in the near-term spatial distribution is weighted towards homes with higher wealth and areas of higher homeownership. Historically, some social housing providers have deployed a large amount of rooftop solar PV, and this acts as a weighting in some of the scenarios, balancing out the weighting towards more affluent areas.

Example feeder level rooftop solar PV distribution in Swindon

Total rooftop solar PV capacity by individual feeders in Swindon, split by relative affluence in the SSEN licence area, by 2050 under a Net Zero scenario.



In a Net Zero scenario, by 2050 the deployment of rooftop solar PV is relatively ubiquitous and affluence plays a less critical role in its deployment. However, in the near and medium term deployment is weighted significantly towards affluence, and social housing drives the deployment in **below average affluence** areas.

Capacity of domestic solar PV results summary

Licence area	Scenario	Baseline (MW)	2030 (MW)	2040 (MW)	2050 (MW)
Scottish licence area	Two Degrees	60	90	152	210
	Community Renewables		137	240	272
	Steady Progression		72	105	138
	Consumer Evolution		85	135	164
	Net Zero		137	238	289
Southern licence area	Two Degrees	252	381	654	931
	Community Renewables		584	1,036	1,192
	Steady Progression		301	446	606
	Consumer Evolution		360	577	718
	Net Zero		584	1,031	1,277

Table 7: Domestic solar PV results summary