LEO Local Energy Oxfordshire

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Spatial analysis of a Smart and Fair Neighbourhood in Oxfordshire

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Context

The UK Government has legislated to reduce its carbon emissions to net zero by 2050. Meeting this target will require significant decarbonisation and an increased demand upon the electricity network. Traditionally an increase in demand on the network would require network reinforcement. However, technology and the ability to balance demand on the system at different periods provides opportunities for new markets to be created, and new demand to be accommodated through a smarter, secure and more flexible network.

The future energy market offers the opportunity to create a decentralised energy system, supporting local renewable energy sources, and new markets that everyone can benefit from through providing flexibility services. To accommodate this change, Distribution Network Operators (DNOs) are changing to become Distribution System Operators (DSOs).

Project Local Energy Oxfordshire (LEO) is an important step in understanding how new markets can work and improving customer engagement. Project LEO is part funded via the Industrial Strategy Challenge Fund (ISCF) who set up a fund in 2020 of £102.5m for UK industry and research to develop systems that can support the global move to renewable energy called: Prospering from the Energy Revolution (PFER).

Project LEO is one of the most ambitious, wide-ranging, innovative, and holistic smart grid trials ever conducted in the UK. LEO will improve our understanding of how opportunities can be maximised and unlocked from the transition to a smarter, flexible electricity system and how households, businesses and communities can realise the benefits. The increase in small-scale renewables and low-carbon technologies is creating opportunities for consumers to generate and sell electricity, store electricity using batteries, and even for electric vehicles (EVs) to alleviate demand on the electricity system. To ensure the benefits of this are realised, Distribution Network Operators (DNO) like Scottish and Southern Electricity Networks (SSEN) are becoming Distribution System Operators (DSO).

Project LEO seeks to create the conditions that replicate the electricity system of the future to better understand these relationships and grow an evidence base that can inform how we manage the transition to a smarter electricity system. It will inform how DSOs function in the future, show how markets can be unlocked and supported, create new investment models for community engagement, and support the development of a skilled community positioned to thrive and benefit from a smarter, responsive and flexible electricity network.

Project LEO brings together an exceptional group of stakeholders as Partners to deliver a common goal of creating a sustainable local energy system. This partnership represents the entire energy value chain in a compact and focused consortium and is further enhanced through global leading energy systems research brought by the University of Oxford and Oxford Brookes University consolidating multiple data sources and analysis tools to deliver a model for future local energy system mapping across all energy vectors.

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Executive Summary

This report uses a local area energy mapping approach to derive spatial intelligence at postcode and property level of a local area - Rose Hill in Oxford city - to provide a deeper understanding of its baseline energy use, energy resources and potential for take-up of low carbon technologies to bring local energy flexibility at property, postcode and LSOA levels. This will help stakeholders such as community energy project developers, local authorities and local community groups to plan for local smart and fair energy initiatives in the neighbourhood of Rose Hill. The findings of the study are also useful for the district network operator in energy system planning.

A detailed spatial analysis was conducted using the LEMAP tool and 69 datasets as described below:

1. Context-boundary dataset (n: 5 layers), such as administrative and census boundary.
2. Land use dataset (n: 26 layers), such as greenspaces, topography and water network.
3. Buildings dataset (n: 5 layers), such as EPC, buildings fabric, built form, etc.
4. Socio-economic dataset (n: 2 layers), such as fuel poverty and census information.
5. Network dataset (n: 9 layers), such as the existing energy geography, substations, etc.
6. Electricity dataset (n: 11 layers), such as LSOA electricity consumption, meter types, etc.
7. Heat dataset (n: 7 layers), such as MSOA, LSOA and postcode gas consumption, etc.
8. Transport dataset (n: 4 layers), such as EV registrations, EV chargers' locations, etc.

The key findings of the report are described below:

- Rose Hill SFN is a 0.74km^2 area located in Oxford City (Oxfordshire) containing 4 LSOA, 79 postcodes and approximately 3,400 people living and working in 1,846 domestic properties (majority from interwar period) and 69 non-domestic buildings. There are 2,623 greenspaces in the case study area of which 86% are private gardens. This predominance of private gardens indicates the potential for (ground source) heat pumps.
- Historically (2015-2019), the LSOAs of Rose Hill have experienced medium-high annual electricity consumption (Ofgem classification) which is between 2,900 kWh and 4,300 kWh per property. LSOAs have experienced a reduction in electricity consumption over the past five years (2015-2019).
- Rose Hill SFN contains 1,589 standard meters in 74 out of 79 postcodes with a mean domestic standard metered electricity consumption of 3,288 kWh. The annual mean domestic electricity consumption at postcode level ranges from medium-low to high, with the highest consumption observed in OX4 4GN with 5,483kWh. Historically this postcode has had the highest consumption of the area; however, since 2015, it has seen 31% reduction in consumption.
- Historically (2015-2019), the SFN LSOAs have had a medium-low to medium-high Ofgem classification based on their domestic gas consumption, which is and has been between 8,000 and 17,000kWh. Also, the LSOAs have experience an increase in consumption in the past five years (n: 0.3%-7%). With LSOA Oxford 015E leading with a 7% increase.
- Rose Hill SFN was found to have 1,643 domestic gas meters with an annual metered domestic gas consumption of approximately 11,878kWh. It is important to note that the postcode OX4 4SH had the highest annual mean domestic gas consumption of 19,894kWh. Interestingly, this postcode has historically (2015-2019) been the highest annual mean gas consumption of the

delimitated area. Besides, the majority (n: 55) of the postcodes of the SFN show an increase in their annual mean gas consumption of 0.29-852%. OX4 4GN is of special interest as this postcode alone has seen an 852% increase in annual mean domestic gas consumption from 2015 (862kWh) to 2019 (8,249kWh), with only seven more meters registered from 2015 (n: 13) to 2019 (n: 20). Highlighting these 55 postcodes as areas of research interest and possible implementation of LCTs for reducing annual gas use.

- An area of interest is the LSOA Oxford 016F with the highest annual metered domestic electricity consumption, the third-highest annual metered domestic gas consumption and the highest aggregation of the People's Power Station and ERIC project PV installation and home batteries. This LSOA also had the highest concentration of (n: 77) of fuel poor households.
- The uptake of LCT in the Rose Hill SFN is mostly centred in the LSOA 016F and specifically in eight postcodes and four neighbourhoods (Nowell road, Mortimer Rd, Dresborough Crescent and Rivermead Rd). These neighbourhoods also represent an aggregation of off-gas postcodes.
- The 2020 EPC rating indicates that 53% of the properties had a domestic EPC rating of D or bellow, while 47% had a rating of C or above, highlighting the low energy efficiency of the SFN for domestic properties. From a property type, the D rating is present in houses from the interwar age due to the thermal performance of the building fabric.
- SSEN DFES has projections for EV chargers, heat pumps and PVs for Rose Hill area:
    - The different scenarios project that 13/14 OA (output areas) areas of the SFN are estimated to have an installed PV capacity of 13,000-17,270kW. With the consumer transformation scenario having most of the installations with 17,270kW.
    - The different scenarios project that 13/14 OA areas of the SFN are estimated to have approximately 530-5,130 heat pump installed by 2050. With leading the way scenario having most of the heat pump installations.
    - The different scenarios project that the 14 OA areas of the SFN are estimated to have approximately 3,700-5,828 EV chargers installed by 2050. With leading the way scenario having the majority (n: 6,100) of the EV charger installations.
    - It is interesting to note that all three LCT DFES projections showed that the OA E00145589 will be an area of high LCT implementation.
- Based on the LEMAP filters and targeting approach, it was found that:
    - *Solar PV installations:* 790 properties were identified located in 75 postcodes of the SFN, 55% of the dwellings in the area. However, another 60 dwelling, counting for 4% of properties, could be suitable for PV installations if the EPC is improved to D rating. From the 790 targeted properties, 420 dwellings were identified as suitable for home battery installation.
    - *Ground source heat pump systems*: 300 properties (21%) in 64 postcodes were identified as suitable with 15 properties highlighted as urgent due to having electric heating systems and basements.
    - *Air source heat pump systems*: 320 properties (22%) in 64 postcodes were identified as suitable for this technology with 27 highlighted as urgent due to having electric heating systems.
    - *EV chargers*: the properties identified for PV and battery can be potentially targeted for EV chargers.

The analysis demonstrates the need for implementing energy flexibility measures in the Rose Hill neighbourhood to achieve local net-zero and improve the quality of life of local residents.

1 Introduction

This report describes the spatial mapping analysis of disparate datasets (housing, energy, electricity networks) to extract insights about energy use, energy generation and energy storage of properties in the Rose Hill neighbourhood in Oxford city. The report is designed to help deliver smart and fair neighbourhoods (SFN) as part of the LEO project. The smart and fair neighbourhood provides a holistic place-based approach to achieving net-zero locally as shown in Figure 1.

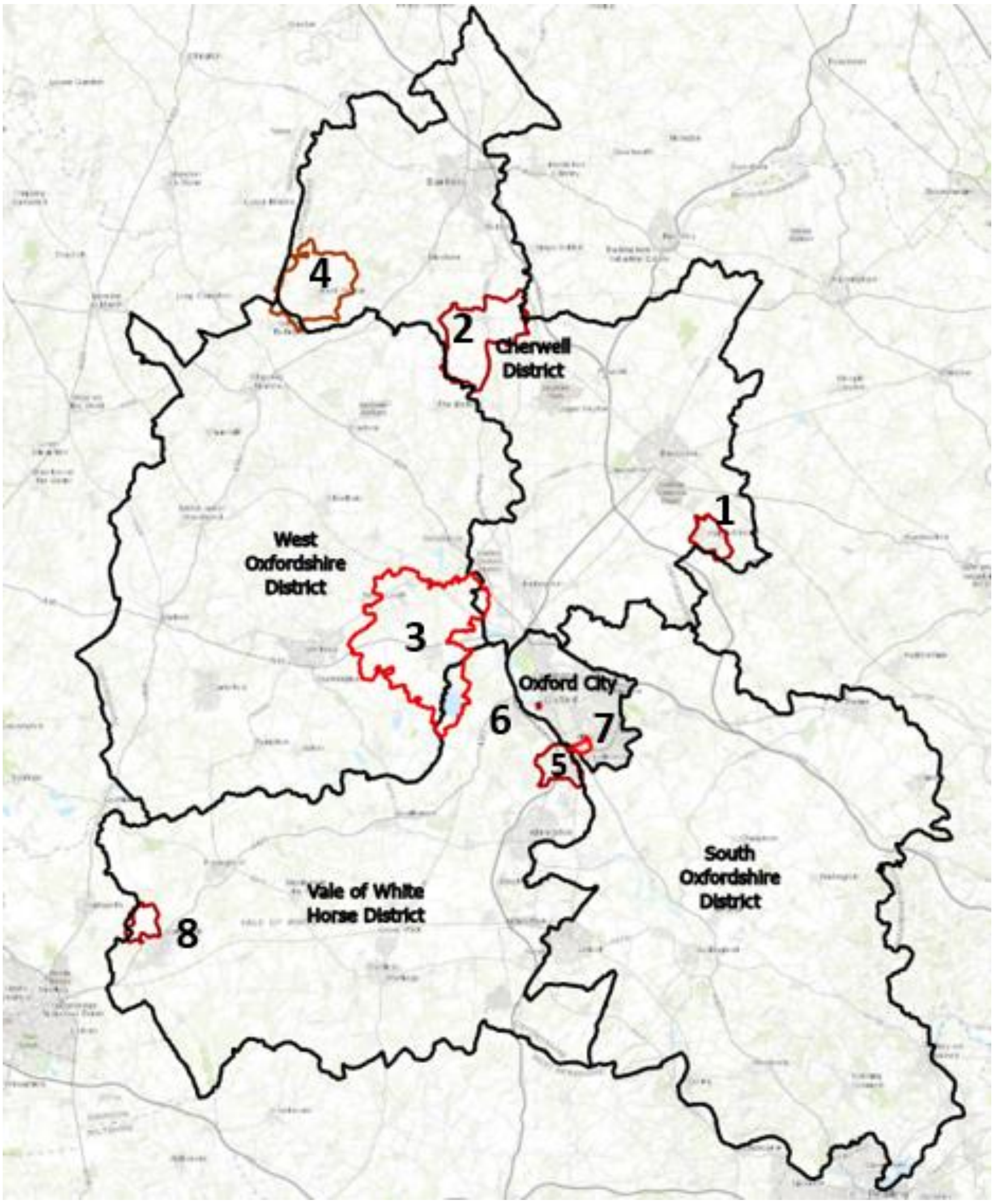


Figure 1. Smart and fair neighbourhood areas of the LEO project

The focus of this report is on the Rose Hill SFN, which is in the Cowley bulk supply point and the Rose Hill Primary substation area (Figure 2).

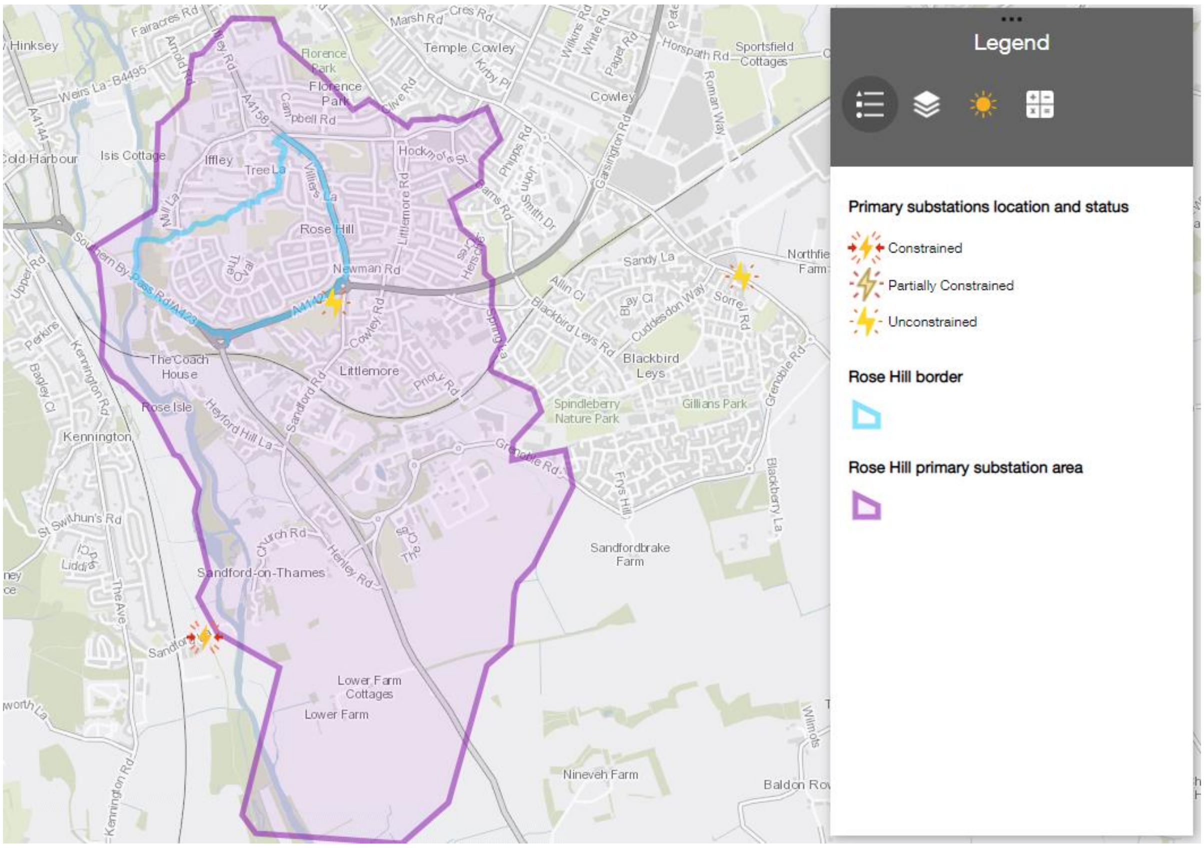


Figure 2. Rose Hill's substation cover area (image from LEMAP).

As the SFN fulfils several of the LEO research areas, it is a prime example of the capabilities of the integrated land use map to provide spatial information to aid in developing the LEO project; specifically, to aid the Rose Hill SFN with the objectives to:

1. Identify how to include tenants in the zero-carbon local energy market
2. Identify areas for PV mini/micro grids on new housing
3. PV and battery at Rose Hill Primary school and community centre
4. Identify the areas of previous project ERIC trial of PV and batteries
5. Identify areas of multiple deprivation

The Rose Hill SFN is in the southwest of the Oxford district in Oxfordshire County. Because the SFN lacked established spatial boundaries, a boundary was defined based on the postcode areas within the SFN (Figure 3). The report focused on highlighting the energy use, generation and storage of the three energy vectors under analysis in the LEO project.

Figure 3. Rose Hill SFN border

A detailed spatial analysis was conducted of the SFN once the boundary had been created. The analyses cover 69/79 identified datasets that correspond to energy and non-energy categories, which underpin LEO mapping land use tool and local energy mapping tool (LEMAP):

1. Context-boundary dataset— administrative and census boundary.
2. Land use dataset— greenspaces, topography and water network.
3. Buildings dataset— EPC, buildings fabric, built form, etc.
4. Socio-economic dataset— fuel poverty and census information.
5. Lifestyle dataset— property value, household income, etc.
6. Network dataset— existing energy geography, substations, etc.
7. Electricity dataset— LSOA and postcode electricity consumption, meter types, etc.
8. Heat dataset— MSOA, LSOA and postcode gas consumption, etc.
9. Transport dataset— EV registrations, EV chargers' locations, etc.

2 Spatial Datasets

We identified nine categories of spatial data that comprise 79 data layers. The nine categories are grouped as non-energy and energy data.

- **Spatial non-energy data**
  1. **Context – boundary layers**
     Geographical boundaries of the County of Oxfordshire.
  2. **Land Use**
     Represents the characteristics attributed to an area of land such as topography, water networks or greenspaces.
  3. **Buildings**
     Provides characteristics of buildings such as property age, use, property type, built form, insulation etc.
  4. **Socio-economic**
     Oxford consultants for social inclusion (OCSI) provide the electoral ward's socio-economic profile based upon age groups, tenure, household occupancy, health, ethnic group, language, religion, poor and deprivation.
  5. **Lifestyle**
     Mosaic consumer classification is based on the shopping preferences, property type and location, preferred communication method (mail, email, phone), and travel patterns.
- **Spatial energy data**
  6. **Network**
     Existing electricity and gas energy assets (substations, storage facilities) and network layout (towers, overhead cables and gas pipes) in the county.
  7. **Electricity**
     LSOA electricity consumption, type of meters (standard, prepayment and smart), large renewable electricity generation and feed-in tariff installation locations.
  8. **Heat**
     LSOA gas consumption, number of meters, off-gas postcodes, domestic and non-domestic properties (postcode scale) under the Renewable Heat Incentive scheme.
  9. **Transport**
     EV registration and EV charging points in the county.

The spatial data are represented at different spatial scales, as explained below:

- **District authority:** an administrative boundary of a county containing between 174,000- 1 million inhabitant.
- **Parish or civil Parish:** administrative division of a county can contain up to 95,000 inhabitants.
- **Electoral Ward:** an administrative boundary of a district regularly containing up to 5,500 inhabitants. However, this will depend on the population of the area. According to the Office for National Statistics, electoral wards and census wards possess exact boundaries except for 25 of the smallest wards (containing less than 100 inhabitants or less than 40 households) merged into seven census wards to avoid confidentiality risks.

- **MSOA:** boundary inside a district containing between 5,000 to 15,000 inhabitants or 2,000-6,000 households
- **LSOA:** boundary inside a ward containing between 1,000 and 3,000 inhabitants or 400-1200 households
- **Census output area (OA):** Smallest unit for which census data is published and can contain up to 125 households.
- **Postcode:** Created and used by the Royal Mail. There are approximately 1.8 million-unit postcodes, and each postcode covers between 1-100 properties in the UK.
- **Dwelling (property):** specific location of a domestic or non-domestic building.
- **Site:** specific location of a large energy facility (generation or storage) or EV charging point.
- **SSEN area:** Delimitation of the area that an electricity substation provides service.

There were 69 datasets acquired and used for this report.
Table *1* lists these datasets and divides them into the categories of land use, building, socioeconomic, lifestyle, network, electricity, heat and transport.

Table 1. Spatial datasets acquired and used for analysis

Layers identified by Oxfordshire County Council (OCC)
Layers Identified by Oxford Brookes University (OBU)

No	Data layer	Description	Spatial resolution	Source	Energy Vector
1	District and City Council boundaries	Oxfordshire County is a 2-tier authority area. This layer provides the boundaries for the district areas.	District and City Council boundaries	OCC / OS Mastermap	N/A
2	Parish Boundaries	Boundaries of 280 civil parishes within Oxfordshire County.	Parish Boundaries	OCC/OS Mastermap	N/A
3	Ward Boundaries	Boundaries of 112 wards in the county.	Ward Boundaries	OCC/OS Mastermap	N/A
4	LSOAs	Boundaries of 404 LSOA in Oxfordshire.	LSOAs	OCC/OS Mastermap	N/A
5	MSOAs	Lower Layer Super Output Area (LSOA) is a geospatial statistical unit created by the Office for National Statistics (ONS). Each LSOA has a minimum population of 1000, and the mean is 1500.	MSOAs	OCC/OS Mastermap	N/A
Land use					
6	Oxfordshire adopted housing and mixed-use allocations	These are sites that have been allocated for housing and/or employment in Local Plans.	County	OCC	N/A
7	Oxfordshire commitments and completions, May 2019	Development sites that have secured planning permission and are currently being built or already completed by May 2019 (latest data).	County	OCC	N/A
8	Oxfordshire emerging allocations	Areas being proposed for inclusion in future revisions of the Local Plans (those not adopted by May 2019).	County	OCC	N/A
9	Adopted allocations Aug 2020	Areas included in the local plans and that welcome planning permissions (August 2020)	County	OCC	N/A
10	Areas of Outstanding Natural Beauty (AONBs)	Areas designated by Natural England to protect and manage the areas for conservation, visitors, and residents.	County	OCC/OS Mastermap	N/A

11	Green Belt 2018	Area of open countryside maintained through National Planning Policy to prevent urban sprawl	County	OCC/OS Mastermap	N/A
12	Ancient Woodland	Areas of woodland that have persisted since 1600 in England and Wales. They are unique and complex communities of plants, fungi, insects and other microorganisms.	County	OCC/OS Mastermap	N/A
13	Special Areas of Conservation (SAC)	Conservation areas of international importance and defined in the EU Habitats Directive (92/43/EEC), also known as the Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora.	County	OCC	N/A
14	Sites of Special Scientific Interest (SSSI)	A formal conservation designation used by Natural England for the finest sites for wildlife and natural features in England, supporting many characteristically rare and endangered species, habitats and natural features.	County	OCC/OS Mastermap	N/A
15	SSSI Impact Risk Zones (IRZ)	A GIS tool developed by Natural England to make rapid initial assessment of the potential risks posed by development proposals to SSSIs.	County	OCC/OS Mastermap	N/A
16	Conservation Target Areas, Oxfordshire (CTA Oxon)	Some of the most important areas for wildlife conservation in Oxfordshire, where targeted conservation action will have the greatest benefit.	County	OCC/OS Mastermap	N/A
17	CTA (Conservation Target Areas) Key link zones	The key link zones of CTA include surrounding land which can buffer and link areas thereby creating important larger and better-connected landscapes.	County	OCC	N/A
18	District Wildlife sites	Sites of importance within each district for wildlife which include important and rare habitats and species.	County	OCC/OS Mastermap	N/A
19	County Wildlife sites	Sites of importance at the county level for wildlife which include important and rare habitats and species.	County	OCC/OS Mastermap	N/A
20	National Nature Reserves	Sites designated by Natural England as key places for wildlife and natural features in England.	County	OCC/OS Mastermap	N/A
21	RSPB reserves England	The Royal Society for the Protection of Birds (RSPB) reserves serve to promote conservation and protection of birds and the wider environment through public awareness campaigns, petitions and through the operation of nature reserves throughout the United Kingdom.	County	OCC/OS Mastermap	N/A
22	Environment Agency (EA) layers	a. EA admin boundaries: Water Companies b. EA Admin boundaries: Water Management Companies c. EA detailed river network d. EA flood map defenses e. EA Flood map areas benefit f. EA flood zones g. EA ground water vulnerability 100K h. EA ground water vulnerability drift 100K i. EA areas susceptible to groundwater flooding	County	OCC/OS Mastermap	N/A
23	Landscape Types	This data is an investigation of landscape character and biodiversity across the county.	County	OCC	N/A
24	Common Land	Land owned by a person (or persons) over which another person has certain rights, e.g. the ‘right to roam’.	County	OCC/OS Mastermap	N/A
25	National Trust Land	Land owned and/or looked after by the National Trust including countryside and heritage landscapes.	County	OCC/OS Mastermap	N/A
26	Parks and gardens	Boundaries of parks and gardens within the county as registered on the Historic England list.	County	OCC/OS Mastermap	N/A
27	Public Rights of Way	Public rights of way allow the public to walk, or sometimes ride, cycle or drive, along specific routes over land which belongs to someone else – the land itself is often privately owned.	County	OCC/OS Mastermap	N/A

28	National Trails	Long distance footpaths and bridleways administered by Natural England.	County	OCC/OS Mastermap	N/A
29	Listed buildings	Buildings with special historical or architectural importance and are of national interest.	County	OCC	N/A
30	Scheduled Monuments	The most important archaeological remains are designated as Scheduled Monuments by Historic England.	County	OCC	N/A
31	Aerial Photography	This layer includes the 25cm resolution aerial imagery captured by Blue Sky	County	OCC	N/A
		Building			
32	UK buildings	Built age and building use.	County	OS MasterMap Geomni	N/A
33	Domestic EPC's	Energy rating, property type and form, glazing type, wall insulation and type, main heating, renewable energy system for domestic property.	Postcode, property	Ministry of housing, communities and local government	Electricity, Heat
34	Non-domestic EPC's	Energy rating, property type and form, glazing type, wall insulation and type, main heating, renewable energy system for non-domestic property.	Postcode, property	Ministry of housing, communities and local government	Electricity, Heat
35	Type of central heating (gas/electric/oil)	Households using gas, electricity, oil etc. as the main central heating fuel.	LSOA	CSE, Census 2011	Heat
37	Rural/Urban split	Areas and population density classified ad either urban or rural by the 2011 census	District, OA	ONS	N/A
38	Property Value	Properties price for the purpose of Council Tax and for non-domestic rates in England and Wales.	Property	Valuation office agency, OCC	N/A
		Socioeconomic			
39	Fuel poor	Number of households cannot afford to warm their homes adequately given their income	LSOA	BEIS and CSE	Electricity, Heat
40	Population profile from Census	Population and household information regarding age, tenure, qualifications, social grade, population density, car availability, employment, etc. from 2011 for the County. Individual datasets can be pulled together to provide socio-economic profile for specific areas.	LSOA, Ward	ONS, OCC Oxford Consultants for Social Inclusion	N/A
		Lifestyle			
42	Mosaic	Consumer classification based on the shopping preferences, property type and location, preferred method of communication (mail, email, phone), travel patterns etc.	Postcode and property	Experian	N/A
		Network			
44	LEO Site Selection Primary Substations	12 primary substation areas selected for LEO flexibility trials.	SSEN area	SSEN	Electricity
45	Primary substations site	Location of SSEN primary substations in Oxfordshire	Site	SSEN	Electricity
46	Substation site	Location of electricity substations	National	OCC/National Grid	Electricity
47	Electricity pylons	Location of electricity pylons	National	OCC/National Grid	Electricity
48	Electricity Lines	Location of electricity lines	National	OCC/National Grid	Electricity
49	Energy storage sites	Existing large energy storage facilities in the county that are connected to the grid.	Site	OCC/BEIS	Electricity
50	Secondary substation	Location, quantity and capacity of the secondary electricity substation	Site	SSEN	Electricity
52	Existing SSEN subscribers in the LEO site selection	Number of SSEN subscribers connected to an LV feeder located in one of the LEO site selection primary substations	Postcode	SSEN	Electricity

	primary substation				
53	Gas Transmission Network	Layout of the transmission network (gas pipes and gas facilities) in the county	National	National Grid	Heat
		Electricity			
54	Existing renewable energy sites from REPD	Location and capacity of large renewable energy facilities connected to the grid in the county based on REPD.	Site	OCC/BEIS	Electricity
55	LSOA metered domestic electricity consumption	LSOA metered domestic electricity consumption, number of meters and mean consumption for the county	LSOA	BEIS	Electricity
56	MSOA metered non-domestic electricity consumption	MSOA metered non-domestic electricity consumption, number of meters and mean consumption for the county	MSOA	BEIS	Electricity
57	Postcode Standard meter electricity consumption	Existing quantities of meters, and mean metered electricity consumption	Postcode	BEIS	Electricity
58	Postcode Economy 7 meter electricity consumption	Existing quantities of meters, and mean metered electricity consumption	Postcode	BEIS	Electricity
59	Feed-in tariff installations	Small-scale (2KW to 50kW) installations of renewable electricity generation.	Postcode	Ofgem	Electricity
60	Energeo - Potential for ground source heat pump	Possible locations of ground source heat pumps using the garden area of properties.	Property	OCC	Electricity
61	Forecasted heat pumps	SSEN and Regen forecasted heat pumps for the county of Oxfordshire, based on four scenarios (Leading the way, consumer transformation, system transformation and steady progress) for the period of 2019-2050	Postcode	SSEN	Electricity
62	Energeo solar renewable energy potential	Possible location of PVs based on the rooftop area of the properties.	Property	OCC	Electricity
63	Energeo wind renewable energy potential	Land parcels where ground mounted solar and wind turbines can be installed.	Land parcel	OCC	Electricity
65	Forecasted rooftop PV	Number of properties that based on four scenarios will be installing rooftop PV connected to the SSEN network form 2019-2050	Postcode	SSEN	Electricity
		Heat			
66	LSOA metered domestic gas consumption	LSOA domestic gas consumption, number of meters, mean and median consumption for the county.	LSOA	BEIS	Heat
67	Postcode metered domestic gas consumption	Metered domestic gas consumption by postcode	Postcode	BEIS	Heat
68	MSOA metered non-domestic gas consumption	MSOA non-domestic metered gas consumption, number of meters, mean and median consumption for the county.	MSOA	BEIS	Heat
69	LSOA Off-gas properties	Number of off-gas properties per LSOA	LSOA	BEIS	Heat
70	Off-gas Postcodes	Postcodes not on the gas grid.	Postcode	CSE	Heat
71	Renewable Heat Incentive (RHI) domestic and non-domestic	Domestic and non-domestic properties having renewable heat using the RHI scheme.	District, Postcode District	BEIS	Heat

	installations' locations				
73	Existing heat Pumps	Properties with heat pump installation connected to the SSEN network	Property	SSEN- High granularity projections for low carbon technology uptake - electric vehicle, heat pumps and solar PV, page 8 paragraph 1	Heat
Transport					
74	EV car charging points	List of EV charging points, type and capacity.	Site, Postcode	National charge point registry; OCC (based on above + Open Charge Map + Oxford City Council), Zapmap, SSEN	Electricity, Transport
75	EV registration in Oxfordshire	Quantity and possible location of EVs in the county.	District	OCC, Department for transport (DfT)Office for Low Emission Vehicles (OLEV)	Electricity, Transport
77	Traffic Flow	Road traffic statistics (Possible locations for EV chargers)	Road	Department for transport (DfT), OCC	Electricity, Transport

3 Local area energy mapping tool

3.1 Development and structure

The analysis was conducted using the local area energy mapping tool (LEMAP) which brought together the public, private and crowd-sourced data on energy demand, energy resources, building attributes, socio-demographics, fuel poverty and electricity networks within the ESRI ArcGIS[1] platform. Postcode and dwelling level energy demand profiles were generated using the CREST energy demand model (Richardson et al., 2010, McKenna and Thomson, 2016). The tool has been organised around three technical and three engagement elements. The technical elements include:

1. 'baselining' local area energy flows in relation to socio-economic characteristics;
2. 'targeting' suitable properties for low carbon technologies (LCT) such as rooftop solar, heat pumps, EV chargers; and
3. 'forecasting' energy demand profiles at postcode level for different LCT scenarios.

The engagement elements include:

1. 'Participatory mapping' to allow residents to visualise modelled energy demand profiles showing energy demand patterns during a typical day in heating and non-heating seasons;
2. 'Storymap' for creating blogs on local energy flows; and
3. 'Forum' to enable chats amongst users of LEMAP and project stakeholders.

LEMAP has been recently updated with two additional elements:

1. 'Capability profile' that shows the social and technical propensity of the household to take up low carbon technologies that can bring energy flexibility, such as solar PVs, batteries, heat pumps and EV chargers; and the
2. 'Dashboard' that provides a summary of all the data in LEMAP by postcode.

LEMAP was designed for community energy project developers, local authorities, district network operators, community groups and residents. The tool's different elements have been designed to address the needs of each of the target users. On one hand, the technical elements present detailed maps showing current and forecasted energy flows in the area, which were designed for social enterprises, local authorities and other SLES project managers. On the other hand, the engagement elements present interactive tools to understand energy flows, including a home energy profile generator, which were designed for community groups and residents.

LEMAP was created to spatially and temporally visualise local energy flows and energy profiles in an intuitive manner to help with the planning of the SFNs. The tool development processes consisted of (Figure 4):

1. gathering relevant energy, buildings and socio-economic data;
2. generating maps and energy profiles using the collected data;
3. creating a website to display maps and energy profiles technically;
4. developing the engagement elements;
5. enabling two-way communication and interaction with users; and

[1] About ArcGIS | Mapping & Analytics Software and Services (esri.com)

6. improving the tool based on feedback from the trial.

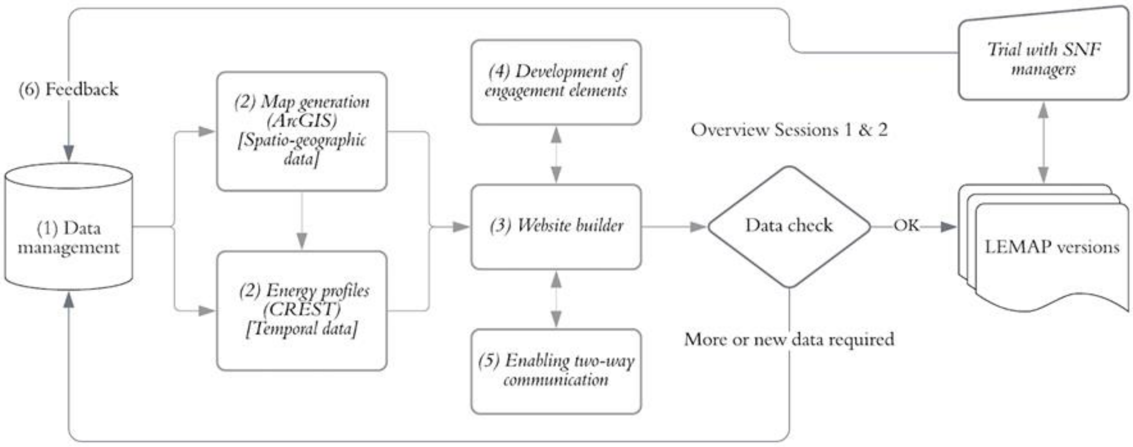


Figure 4 LEMAP development flowchart.

3.2 Navigation of LEMAP

The collected data, described in the preceding section, are presented in a website where maps can be actively explored by the user. As outlined above, the header tabs on the website (Figure 5) lead the user to the technical elements (dark grey tabs): Baselining, Targeting, Forecasting and Capability profile and to the engagement elements (blue tabs): Participatory mapping, Storymap and forum under 'More'. The 'More' section also includes the user dashboard and user guides for the site.

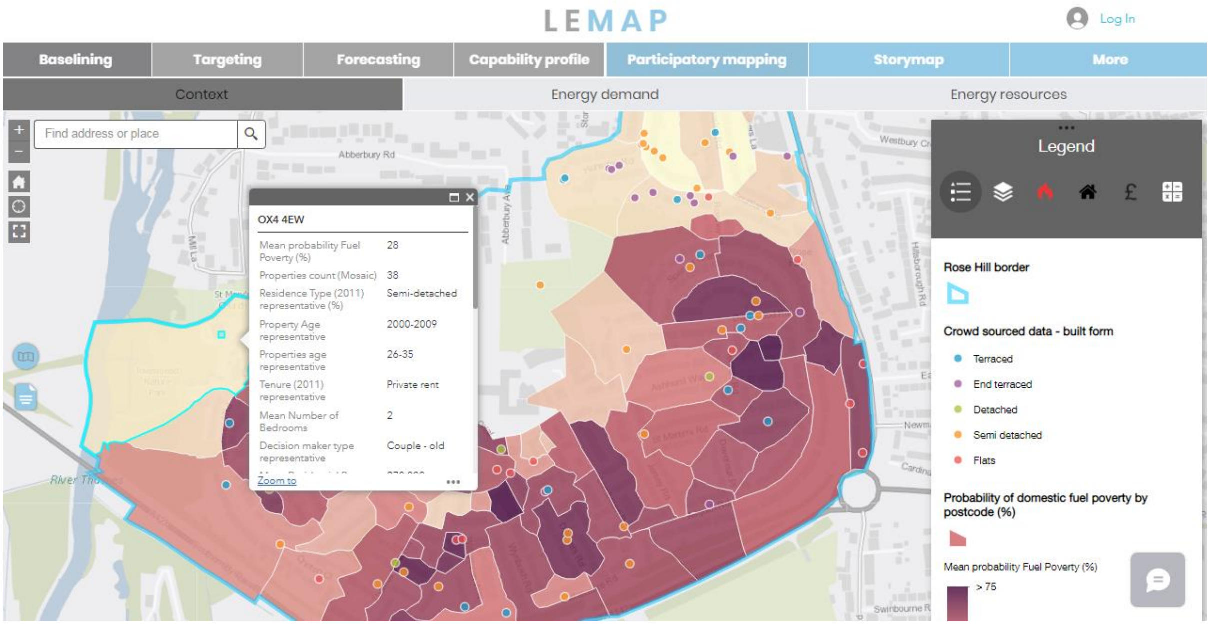


Figure 5 LEMAP website

The website structure shown in Figure 6 shows how it is organised and the various entry points. That is, the user can enter the site from the home page to explore maps and data or via the survey which leads the user to the dashboard.

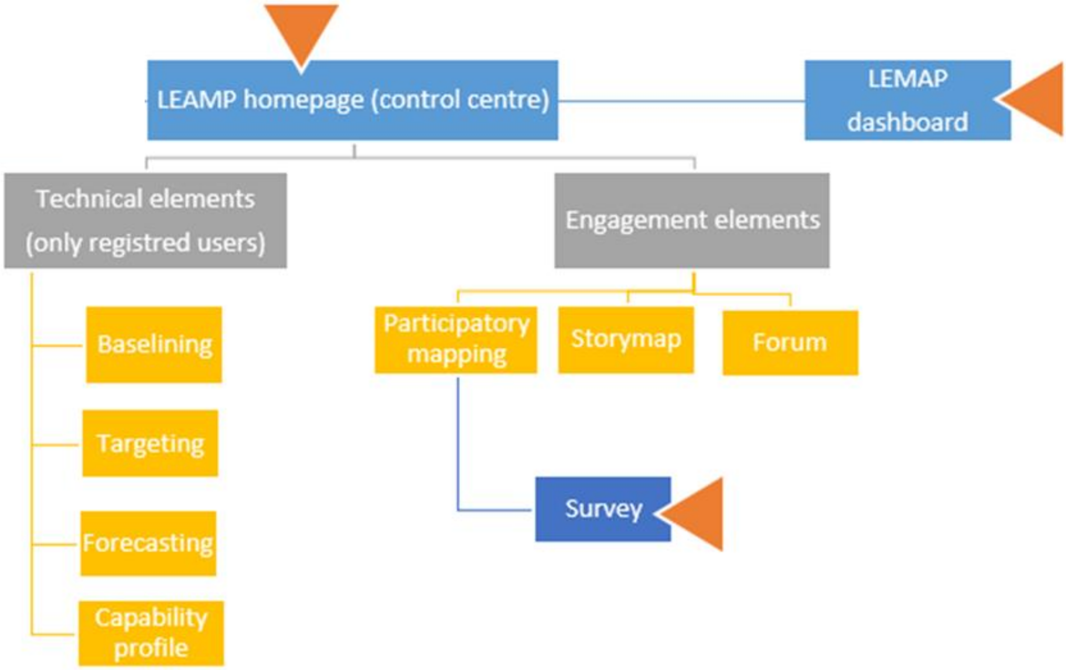


Figure 6 LEMAP website structure

LEMAP V2 trials proved that target users' skills of gathering useful information from maps varies from user to user, while some users find temporal and spatial representation informative, some others find it confusing and prefer data arranged in tables. In order to be inclusive, the dashboard was developed to represent the technical data in a numeric manner. The dashboard was not only intended to provide an alternative view of data, but to show all data condensed in a single display. It also displays information that is not available in the technical or engagement elements, such as the consumption energy change of postcodes over the last five years. The LEMAP dashboard shows socio-economic and baselining data, such as annual energy demand, existing renewables and targeted dwellings for LCTs; grouped by postcode.

The LEMAP dashboard (Figure 7) consist of an interactive informative table that changes depending on the postcode selected. It shows grouped data for each postcode in the SFN area. The dashboard includes a dropdown menu with all the postcodes in the area, which are in a guide map once one of the postcodes is selected.

Literature review indicated LEMAP dashboard to be novel amongst the different tools available for local energy mapping.

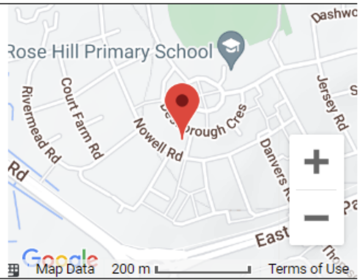
LEMAP Dashboard

Local energy dashboard - Rose Hill

LEMAP **dashboard** shows information about your postcode; including socio-economic and baselining data, such as annual energy demand; existing renewables and targeted dwellings for particular low carbon technologies.

Select a postcode

OX4 4UA



OX4 4UA

Context | Energy demand | Capability for low carbon technologies

Built form	Number of dwellings
Detached	3
Semi-detached	0
Terraced	1

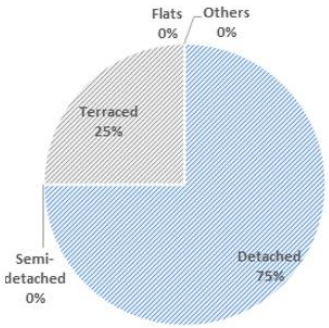
Dwelling age	Number of dwellings
Previous to 1870	0
1870-1919	0
1920-1945	0
1946-1954	0

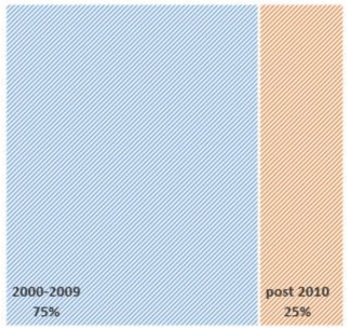
Home tenure	Number of dwellings
Owner occupied	1
Private renter	1

Flats	0
Domestic outbuilding	0

1955-1977	0
1980-1999	0
2000-2009	3
2010-present	1

Social renter	1





Percentage households in fuel poverty	0% / Under average
Average annual household income	£35,000 - £39,999
Average bedrooms per property	3
Average length of residency	7 years
Percentage households with children	50%

Figure 7 LEMAP dashboard

4 Contextual characteristics of Rose Hill area

4.1 Geographical context (Boundaries)

The Rose Hill SFN is in the south-west of the Oxford City District in Oxfordshire County. Covering an area of 0.74sqKM and accounting approximately for 40% of the Rose Hill and Iffley electoral Ward. As the SFN does not possess pre-determined spatial boundaries, these had to be defined based on the postcode areas of the SFN, as can be seen in Figure 8. The SFN contains approximately 3,400 people living and working in about 2,282 properties within 1,551 dwellings (domestic and non-domestic).

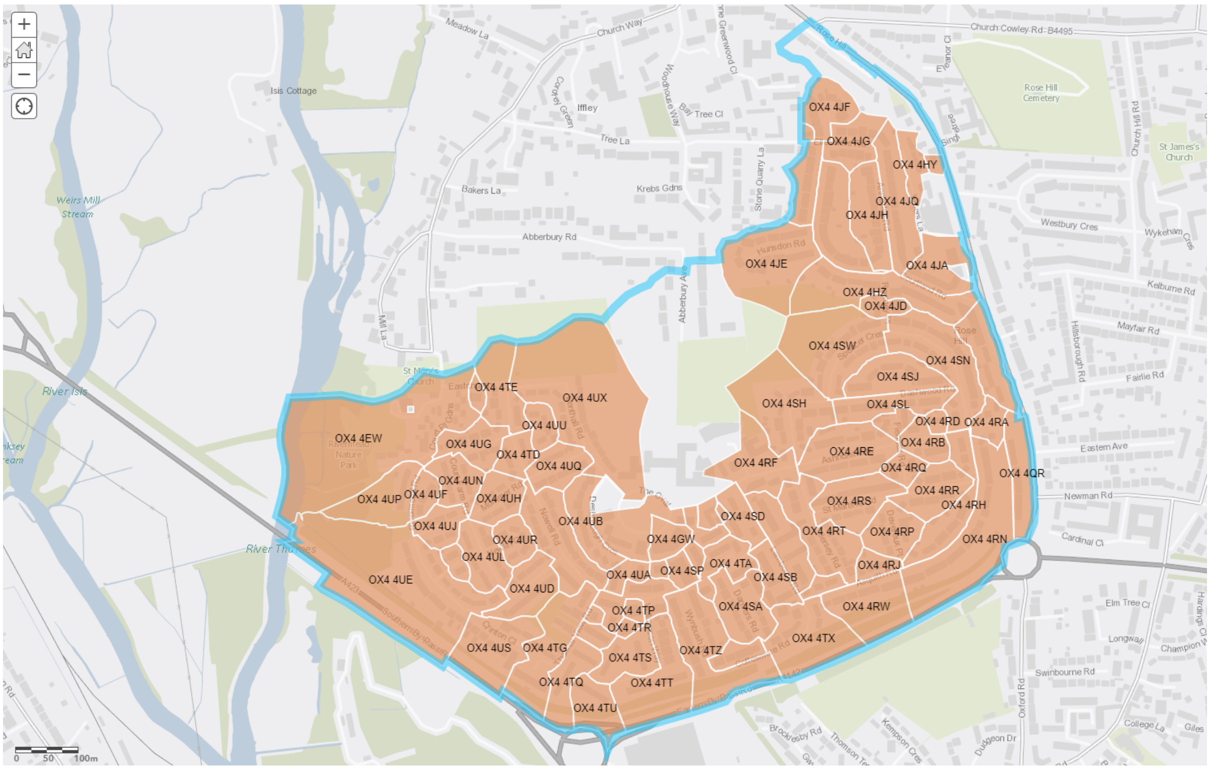


Figure 8. Rose Hill SFN Postcodes and border.

The SFN falls within the Rose Hill & Iffley Ward and the Rose Hill & Littlemore Division administrative boundaries. The SFN overlays two MSOA (Oxford 15 and Oxford 16) four LSOA areas (Oxford 015E, Oxford 015F, Oxford 016E, Oxford 016F) (Figure 9), 14 OAs and 79 postcodes belonging to the postcode sector of OX4 4. From these, the whole or parts of four postcodes were excluded (open section in the centre of the map) as they comprised areas of public buildings or dwellings not considered to be connected to the core infrastructure of the neighbourhood as determined by the local community group.

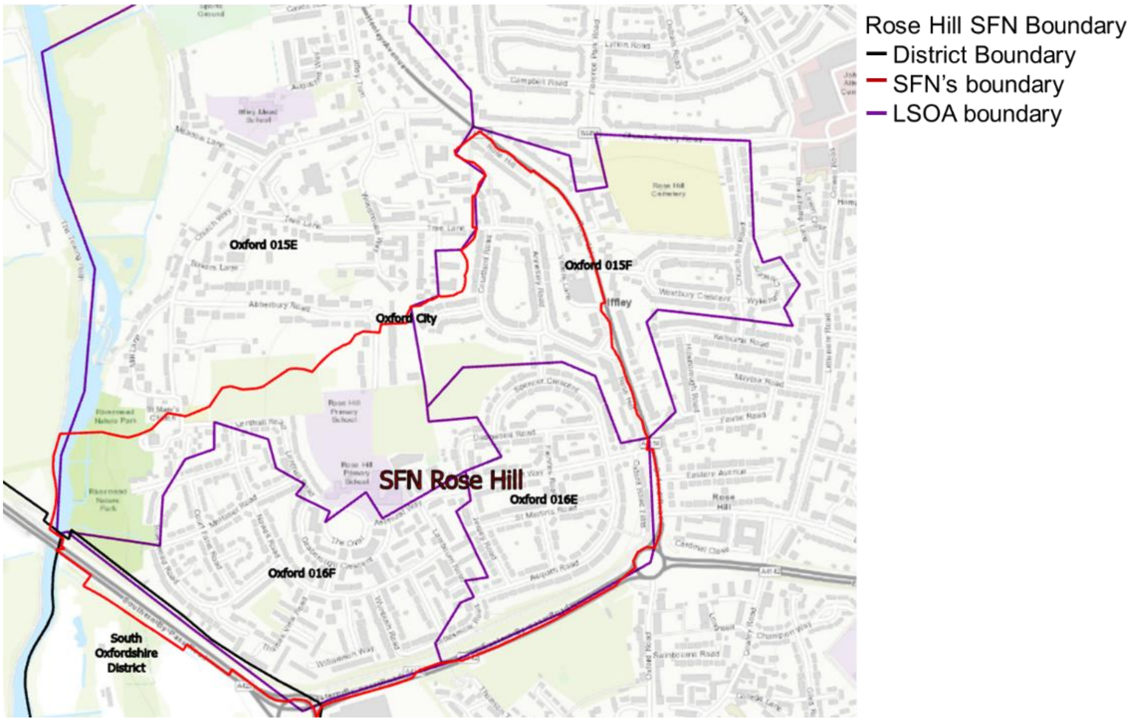


Figure 9. Rose Hill SFN LSOAs boundaries

4.2 Land use

The SFN of Rose Hill possesses 2,623 green spaces with a variety of uses, from private gardens to institutional grounds, natural areas, playing fields and public parks or gardens. Private gardens account for 86% of the green spaces indicating a highly urbanised area. A detailed description and localisation of the green spaces can be seen in Figure 10 and Table 2.

Figure 10. Rose Hill SFN Green Spaces

Table 2. Rose Hill SFN Green Spaces

Rose Hill SFN Green Spaces	No of green spaces
Allotments or Community Growing Spaces	5
Amenity - Residential or Business	75
Amenity - Transport	105
Cemetery	3
Institutional Grounds	29
Natural	7
Play Space	3
Playing Field	11
Private Garden	2,370
Public Park or Garden	21
Religious Grounds	7
School Grounds	57
Total	2,693

4.3 Socio-economic characteristics

A Socio-Economic Profile (SEP) provides an understanding of the social and economic context within a community, region or nation. Which will inform and aid the planning and decision making of the objectives of a project. The SEP also assists in creating a baseline for assessing how the measurement to be implemented will affect an area's social and economic components.

For this report, two SEP analyses will be conducted:

1. A Social Impact Assessment (SIA) and
2. a community adaptive capacity or resiliency analysis.

The SIA was first conducted, with the 2011 census dataset, which is on an LSOA scale, to establish the baseline of the primary substation area inhabitants as to be able to answer question such as:

- What are the social and economic characteristics of the area?
- Do the inhabitants have the socio-economic means to implement energy flexibility measures?

After the postcode lifestyle datasets have been acquired, the community adaptive capacity or resiliency analysis can be conducted, as to be able to establish the response and adaptability to the energy flexibility measures of the inhabitants and be able to answer questions such as:

- What are the socio-economic characteristics of the inhabitants that already have domestic energy flexibility measures implemented?
- How will the implementation of energy flexibility measures affect the inhabitants' social or economic status?

4.3.1 Fuel poverty

Tenure and transport enhance the portrait of the area by providing ownership, rent-ability and mobility information. The Rose Hill SFN possesses a predominance (50%) of socially rented houses. This type of rent, sometimes referred to as council housing, is linked to the local income and provides affordable housing bellow the private rent-pricing scheme. This indicates, along with the high unemployment of the area, a low economic income of the area's inhabitants. This is further aggravated by the fact that the SFN possesses 306 fuel poor households across all four LSOA representing 12% of the households in the LSOAs of the SFN in 2019. Overall, the SFN fuel poverty is above the national average of 10%. Similarly, on an LSOA scale of the fuel poverty (Table 3) half of the LSOA have above average fuel poor households, as the LSOA Oxford 016E that contains the most fuel poor households (n: 104) has a 20% rate and LSOA Oxford 016F has 12% rate (n: 99 households). In comparison, LSOA Oxford 015E has 50 households, and Oxford 015F has 53 households, with an 8-7% rate respectably (Figure 11).

Figure 11. Rose Hill SFN fuel poor LSOA (image from LEMAP)

Table 3. Rose Hill SFN fuel poor households

LSOA	Number of Households	# of fuel poor households	Proportion (%)
Oxford 015E	726	50	7
Oxford 015F	689	53	8
Oxford 016E	531	104	20
Oxford 016F	803	99	12
Total	2,749	306	12

In terms of postcode scale, there is no database providing the exact number of dwellings experiencing fuel poverty; therefore, data representing the probability of dwellings experiencing fuel poverty

(Figure 12) were analysed from lifestyle databases, i.e. Experian's Mosaic dataset[2] providing data on property values and affluence (expected income and spending power).

The postcode with the highest number of households with probability of having fuel poverty is OX4 4SP with 93%, which are predominately flats built between 1955-1979 habited by public renters (social housing); while the lowest is OX4 4JG with 20%, which are mainly semi-detached houses built between 1920-1945 and occupied by the owners.

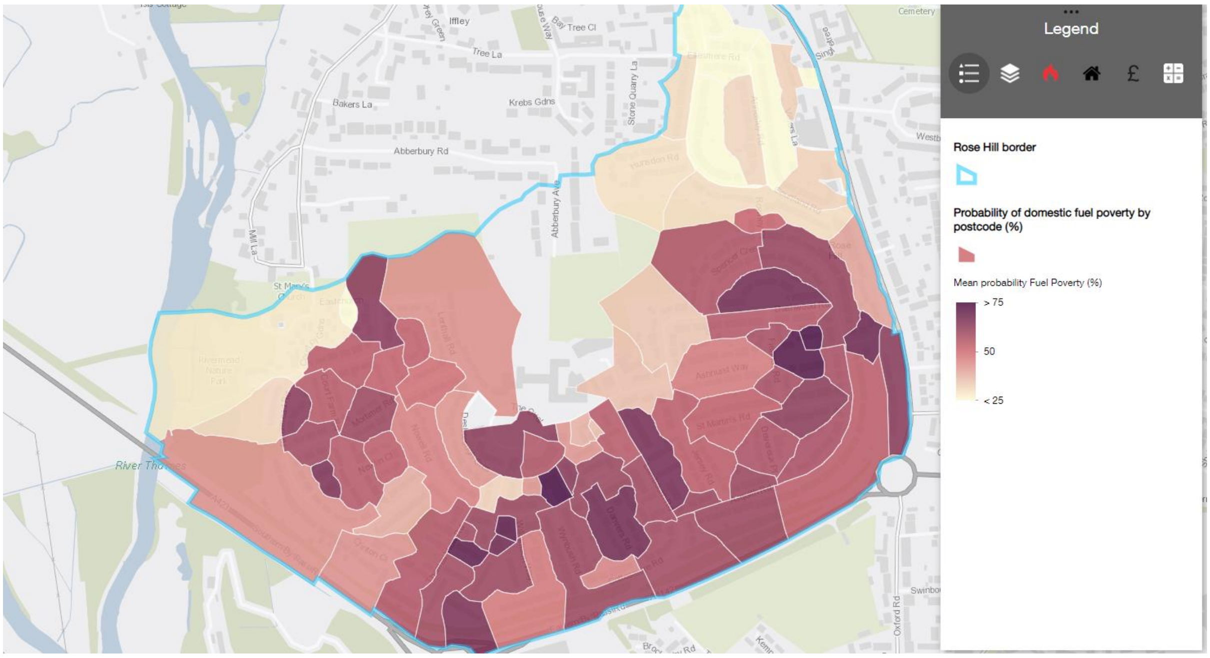


Figure 12. Rose Hill probability of fuel poverty by postcode (from LEMAP*).*

4.3.2 Census Data

SIA or baseline socio-economic profile of the area

The socio-economic analysis captures and analyses the inhabitant of Rose Hill SFN characterisation and provides a brief profile of the area's demographics. The critical socio-economic characteristic extracted from the 2011 census of the LSOA areas are presented in Table 4. This socio-economic profile provides a view of the Rose Hill SFN residents and indicates that, overall, the area is deprived socially and economically, with small pockets of the average socio-economic population. However, the area requires aid.

Table 4. Rose Hill SFN Socio-economic Profile

Rose Hill socio-economic Profile				
No of residents	3,422			
Age group	0-15 age (%)	16-34 age (%)	35-64 age (%)	65+ age (%)
	28	30	33	9

[2] https://www.experian.co.uk/business/platforms/mosaic

Economic Activity	% Employed	% unemployed	% retired	%Students	% other	
	56	7	9	9	19	
Tenure	% owned	% social rent	% private rent	% rent other		
	33	50	14	3		
Car availability	% no car	% 1 car	% 2 car	% 3+ car		
	40	41	15	4		
Qualifications	% no qualification	% level 1	% level 2	% level 3	% level 4	% apprenticeship / % other
	34	15	13	7	19	3 / 9
Social Grade	% AB	% C1	% C2	% DE		
	13	20	21	46		

There is a total of 3,422 inhabitants in the LSOAs that overlap the SFN area. Average occupancy of the properties is evenly split between under-occupied at 28% and 'recommended' occupancy at 28%[3]. The age composition indicates that the average age of the area's inhabitants is 35-64 years (33%), commonly referred to as the working-age group. The second-highest age group were young adults: 16-34 age group (30%). The working-age group's predominance was validated by the area's employability, with 56% of the population employed in either part-time or full-time work activities. However, the unemployment percentage of the area (7%) population is 2.2 times higher than the UK's national average, which according to the ONS (2020), is 4%. This factor indicates large pockets of unemployment population clustering in the area.

Education and social grade play an essential role in the adoption of innovations/new technologies. Also, the population's social grade provides insight into what type of work and at what level. The predominant social grade in the SFN is DE, with 46% of the population. This DE social grade, as BEIS defines, indicates that the population is a semi-skilled or unskilled manual worker, unemployed or work in the lowest grade occupations. This clustering of DE social grade is relatively high, as only 26% of the UK population is under this social grade. This unskilled employment is confirmed by the SFN population's qualifications, as 34% have no qualifications.

[3] That is 28% of the properties containing two or more rooms and 28% containing zero rooms per property. According to the ONS definition, two or more rooms indicate that the property has more unoccupied rooms than recommended for the number and composition of people living in the property and is considered under-occupied. However, the 0 room indicates that the property has the precise number of bedrooms recommended by the 'bedroom standard' for the number and composition of people living in the property.

5 Energy Demand

5.1 Energy Network Geography

The National Grid and SSEN layers provide information on the area's energy (Electricity and gas) network. The following sections will describe in detail the electricity and gas network geography of the SFN.

5.1.1 Electricity Network

The electricity network inside the Rose Hill SFN was not available for this report. However, the county's electricity distribution network provides some information regarding the SFN (Figure 13). Per the National Grid layer, the Rose Hill SFN is located 1.3Km away from the overhead line (OHL) and 4TE route electricity tower that feeds the Cowley-Walham and the Cowley-Minety circuit as well as, located 3.3Km southeast from the substation South Hinksey (SHSK4), that possesses a capacity of 400kV and 5.39Km southeast of the Cowley (COW4) substation with a capacity of 400kV.

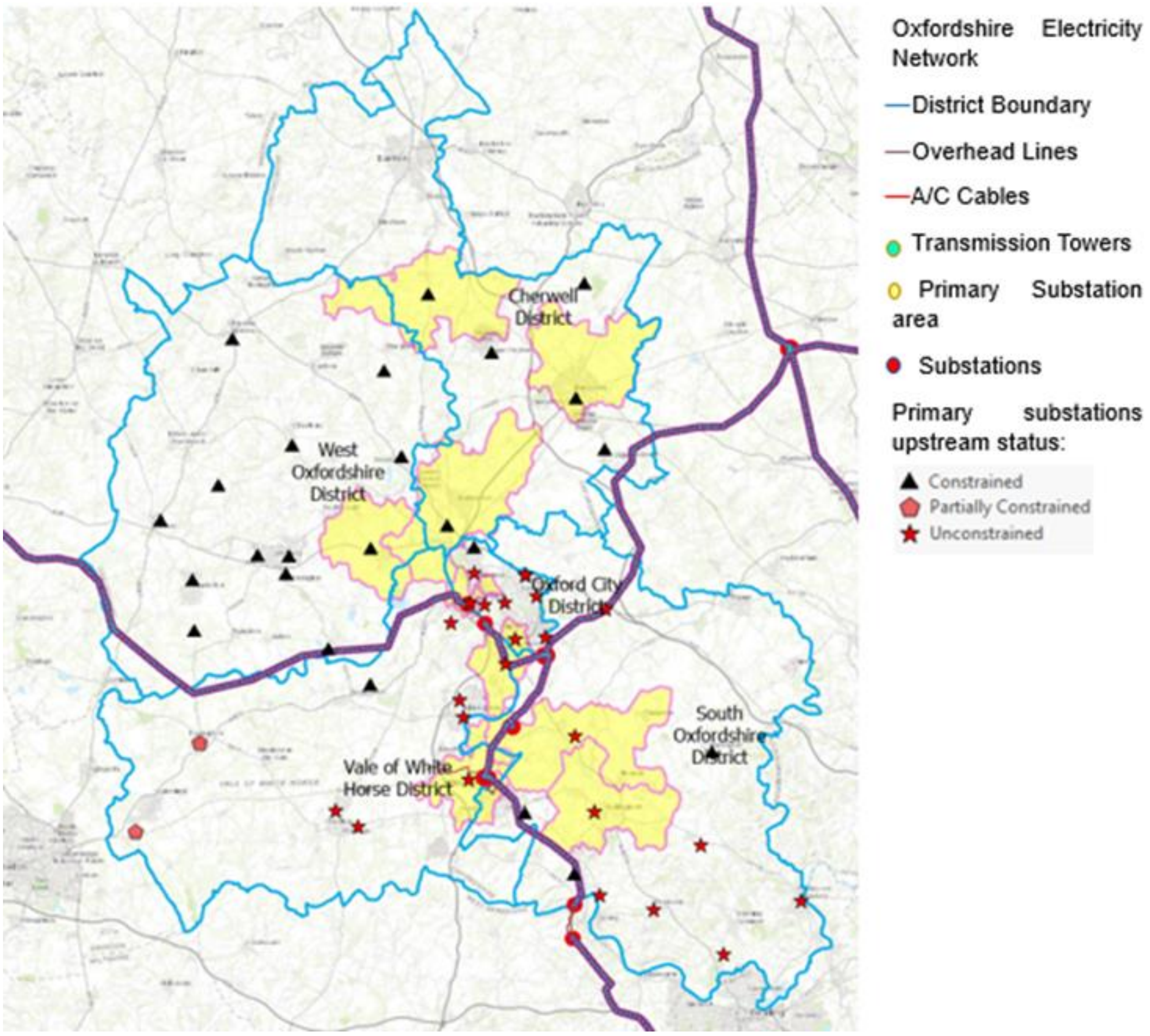


Figure 13. Oxfordshire Electricity network

The SSEN layer provided the location of the primary substation and the substation area nearest the SFN. The Rose Hill Substation is located approximately 78m from the Rose hill SFN; it has an unconstraint status both for upstream and downstream energy flow, with a maximum capacity of 17.68MW. The primary electricity substation area of Rose Hill covers 99% of the SFN area (Figure 14). The SFN has approximately 872 households connected to the SSEN network, specifically to the Rose Hill Primary substation. Indicating a coverage of about 32% of the households in the area.

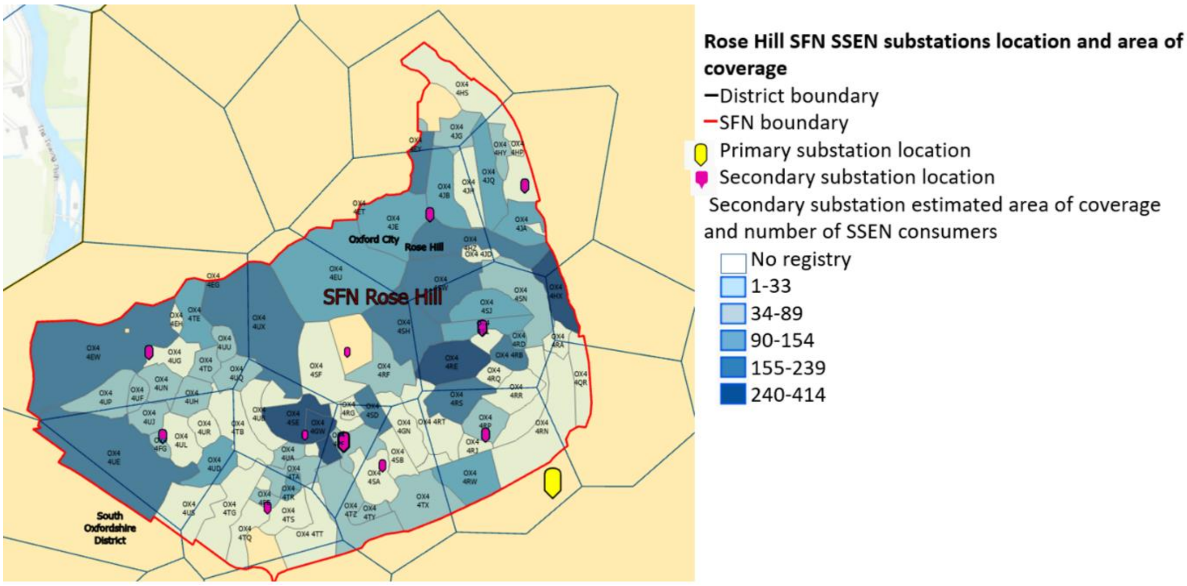


Figure 14. Primary Substation encompass of Rose Hill SFN

The SSEN network dataset also provided information regarding the secondary substations in the SFN. The Rose Hill SFN has 11 secondary substations within its boundary, precisely 10 ground-mounted distribution and one site only distribution site.

5.1.2 Gas Network

Concerning the gas network, the SFN is located 22.46 km north-west from the main gas pipeline, the Old Warden to Chalgrove and 25.81Km south-west from the gas site distribution Long Crendon 2031, an above-ground heat installation (ABI), as can be seen in Figure 15 and Figure 16. The local gas pipe network is not available for this report.

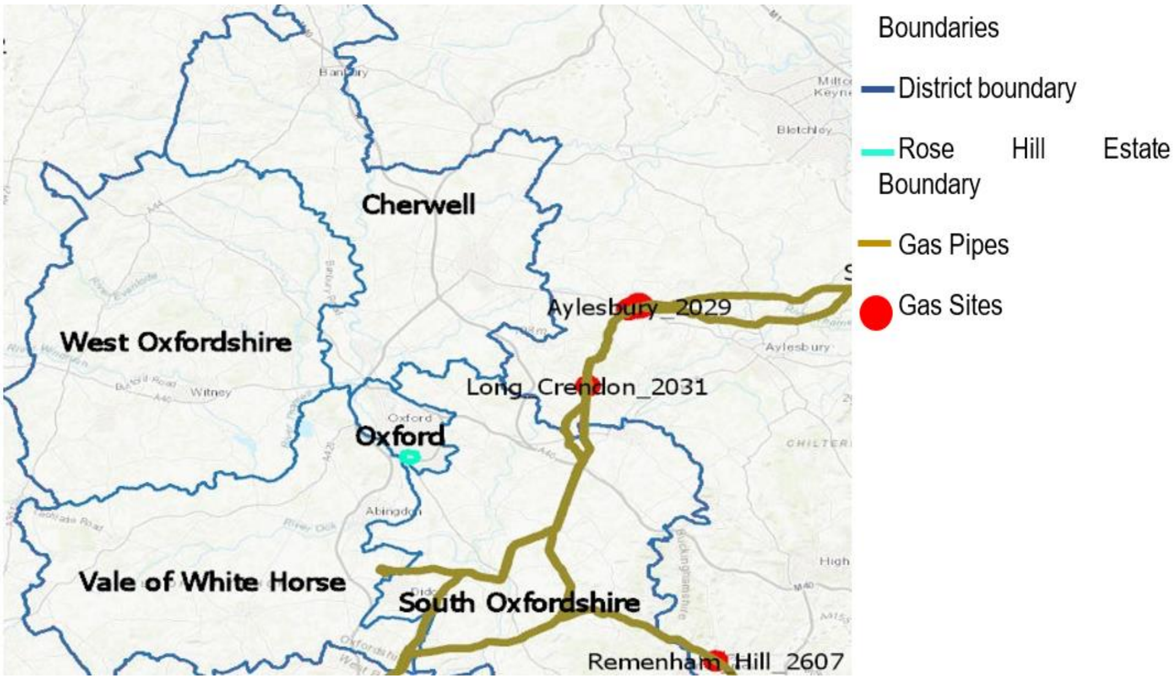


Figure 15. Oxfordshire Gas Network

Figure 16. Rose Hill SFN Gas Network

5.2 Electricity Consumption

5.2.1 Historic LSOA domestic electricity consumption

The LSOA domestic electricity consumption dataset provides current and historic domestic electricity consumption information at an LSOA scale. The Rose Hill SFN contains four LSOA; two (Oxford 016E and F) which are entirely contained within the SFN boundary. Oxford 015E and F are only partially contained within the SFN boundary. Therefore, the LSOA database will provide a generalised overview of the area.

These LSOAs have historically (2015-2019) had a medium-high Ofgem classification based on their consumption, which is and has been between 2,900 and 4,300kWh. Figure 17 shows the annual mean domestic consumption of electricity by LSOA from 2015 to 2019. It also shows that the LSOA has experienced a decrease in consumption in the past five years, with LSOA Oxford 016E leading with a 15% decrease. At the same time, Oxford 016F has a decrease in consumption of 14%. By comparison, the two LSOA's (Oxford 015E and F) not entirely contained by the SFN have a ten per cent decrease in consumption.

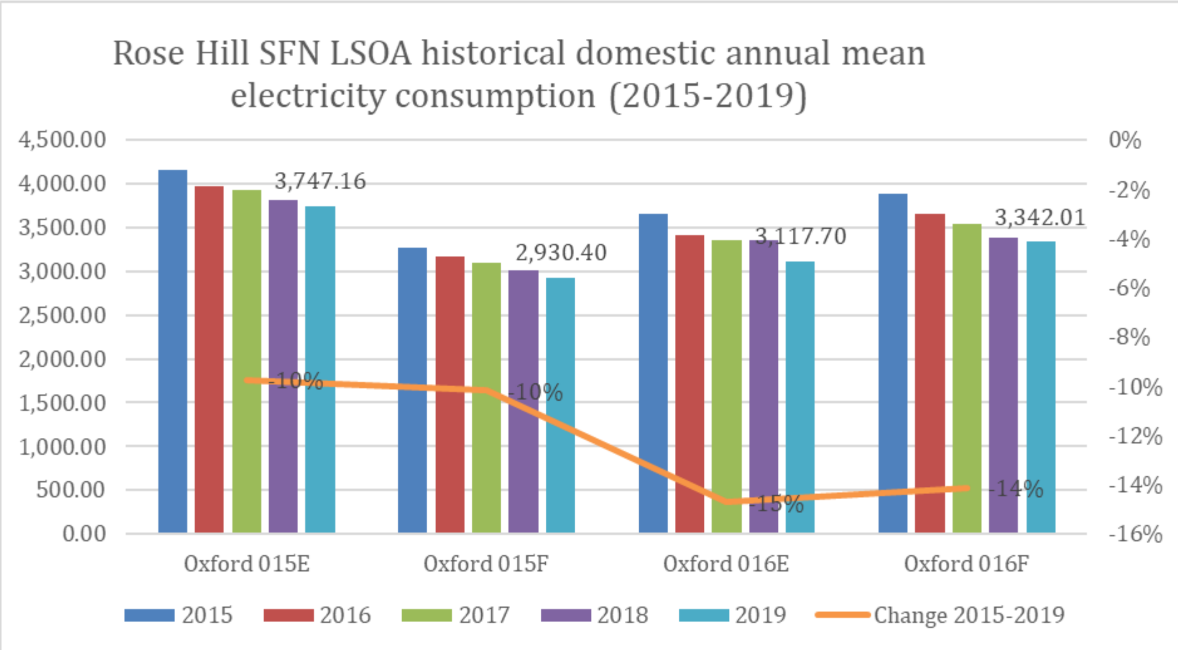


Figure 17. Rose Hill LSOA historical domestic annual mean electricity consumption

However, the overall LSOA annual domestic mean electricity consumption of the area has continuously been lower than the county, region and nation (Figure 18).

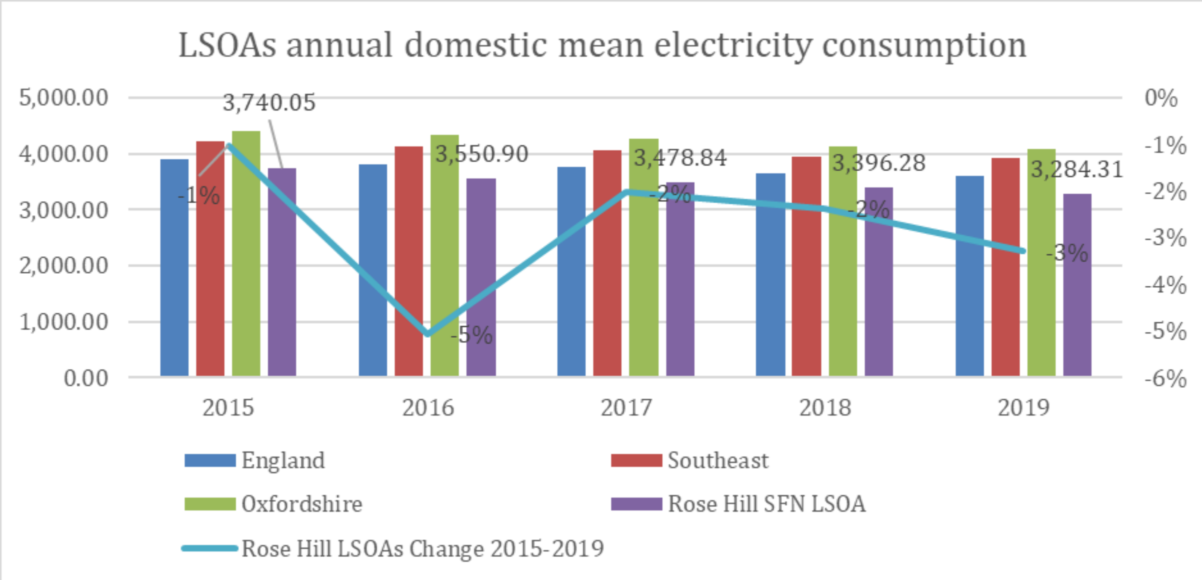


Figure 18. LSOAs annual domestic mean electricity consumption

5.2.2 Current Electricity LSOA Domestic consumption

The 2019 LSOA BEIS dataset provides information on the metered electricity consumption. However, as the SFN does not fully encompass the LSOA, overall consumption cannot be calculated. On an LSOA scale, the highest energy consumption out of the four LSOA covering the area of Rose Hill SFN is registered in Oxford 015E with 2.70GWh of annual metred domestic electricity consumption, followed closely by Oxford 016F with 2.69GWh of electricity consumption. The other two LSOA register the lowest of the four, with Oxford 015F with a consumption of 1.95GWh and Oxford 016E with a consumption of 1.54GWh (Table 5). However, the primary electricity consumption of the Rose Hill area is classified as medium-high. According to Ofgem (2019), mean electricity consumption is based on the electricity profile of the property and the occupancy. The SFN of Rose Hill possess a majority (74%) of property under the electricity profile class 1 and possesses an occupancy of 56% of 1-2 rooms. Based on these factors, the mean electricity consumption of the LSOA's should be around 1,800kWh. However, the different LSOAs all present medium to high consumption as the annual mean metered domestic electricity consumption is between 2,900 and 4,300 kWh. As shown in Figure 19, the LSOA Oxford 015E has the highest annual mean domestic electricity consumption (n: 3,747kWh) of the area. However, this LSOA is not entirely contained by the SFN and can only provide an indication.

Table 5. Rose Hill LSOAs Domestic electricity consumption

LSOAs	Meters	Annual metered domestic electricity consumption GWh	Mean metered domestic electricity consumption kWh
Oxford 015E	710	2.70	3,747
Oxford 015F	666	1.95	2,930
Oxford 016E	497	1.54	3,118
Oxford 016F	805	2.69	3,342

Figure 19. Rose Hill LSOAs annual mean domestic Electricity Consumption

5.2.3 Postcode domestic electricity consumption

5.2.3.1 Postcode domestic electricity consumption economy 7 meters

According to the 2019 BEIS dataset, the Rose Hill SFN possess three postcodes with economy 7 meters. This type of meter present two readings, one for electricity used during the day and one for night. The SFN possesses a total of 52 economy 7 meters with an annual metered consumption of 0.24GWh, and a mean metered domestic consumption of 4,577kWh (Table 6 and Figure 20). Until 2019 the area only had two economy 7 meter postcodes, with OX4 4JQ being a recent inclusion and having the highest annual mean domestic consumption of the economy seven postcodes. Historically, the consumption has had a 5% decrease since 2016. Nevertheless, the economy 7 postcodes have a high electricity consumption based on Ofgem classification, as all have above 4,000kWh.

Table 6. Postcode domestic electricity consumption by economy 7 meters

No	Postcode	Meters	Annual domestic metered electricity consumption (GWh)	Mean domestic metered electricity consumption (kWh)
1	OX4 4GW	42	0.20	4,919
2	OX4 4JQ	5	0.03	7,519
3	OX4 4RD	5	0.006	1,292

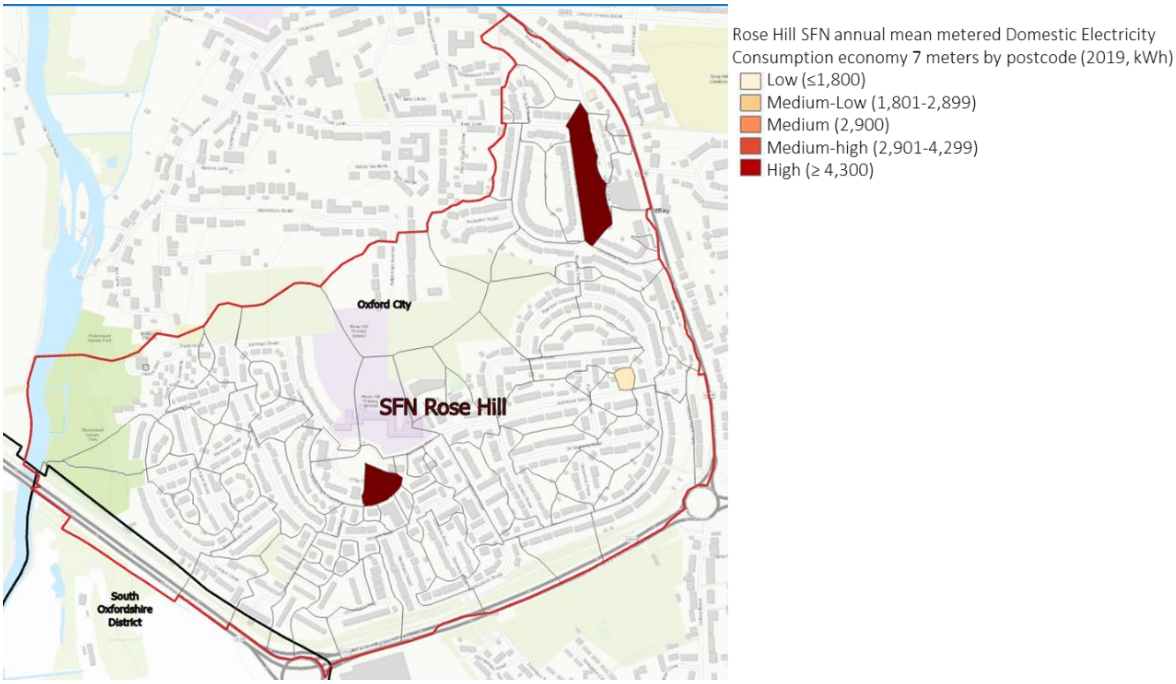


Figure 20. Postcode mean metered domestic electricity consumption (Economy 7 meter)

5.2.3.2 Postcode domestic electricity consumption standard meters

The Rose Hill SFN possesses 1,589 standard meters in 74 out of 79 postcodes (Figure 21). According to BEIS, a standard meter encompasses smart meters, traditional meters and prepayment and credit meters. The Rose Hill SFN possesses an annual domestic standard metered electricity consumption of 5GWh and a mean domestic standard metered electricity consumption of 3,288kWh. Table 9 shows the ten postcodes with the highest annual mean domestic metered electricity consumption registered by BEIS 2019. The annual mean consumption at a postcode level rages from medium-low to high, per Ofgem classification. With the highest consumption at OX4 4GN with 5,483kWh. Historically this postcode has had the highest consumption of the area; however, since 2015, it has seen a 31% reduction in consumption. It is interesting to note that OX4 4TD has not only had a high energy consumption in the last 5 years (Table 7) but the consumption has increased 17% from 2015 to 2019, highlighting this postcode as an area of research interest.

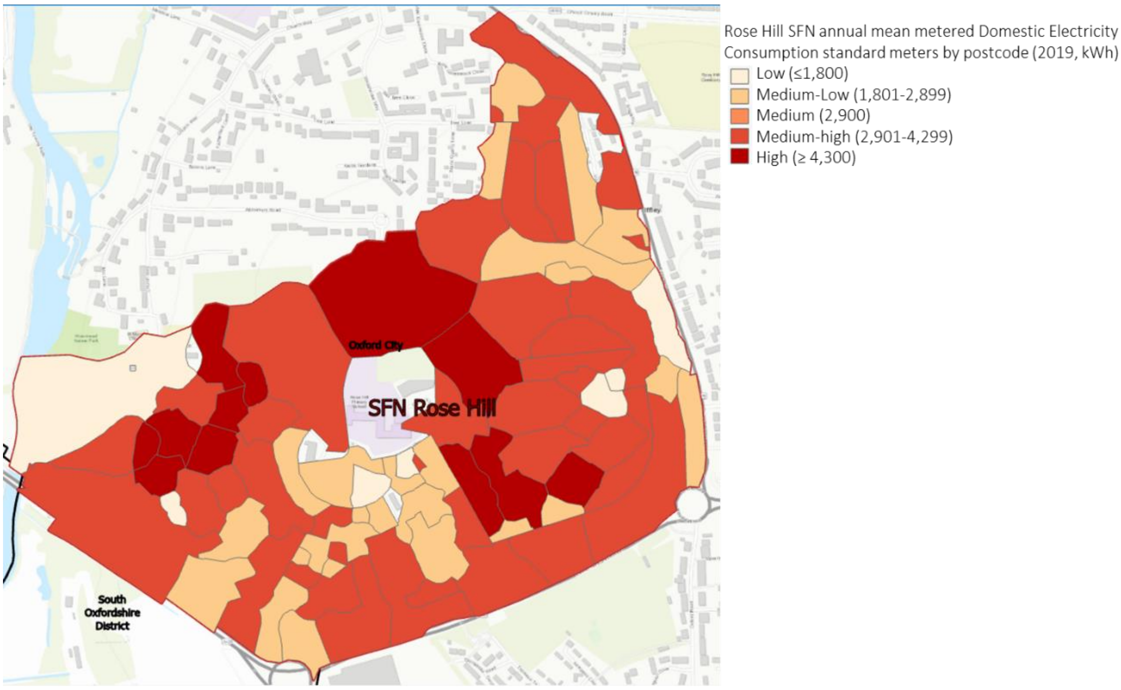


Figure 21. Postcode domestic metered electricity consumption (Standard meters)

Table 7. Postcode domestic electricity consumption by standard meters

No.	Postcode	Meters	Annual domestic metered electricity consumption (GWh)	Mean domestic metered electricity consumption (kWh)	Percentage of change in consumption from 2015-2019
1	OX4 4UR	9	0.04	4,490	-20%
2	OX4 4RT	26	0.12	4,532	-6%
3	OX4 4UH	12	0.05	4,577	-2%
4	OX4 4UJ	11	0.05	4,729	-1%
5	OX4 4UF	6	0.03	4,846	-7%
6	OX4 4TD	9	0.04	4,965	17%
7	OX4 4SH	20	0.10	5,019	-13%
8	OX4 4UU	8	0.04	5,083	-8%
9	OX4 4TE	12	0.06	5,176	1%
10	OX4 4GN	26	0.14	5,483	-31%

Although 55 postcodes in the SNF have seen a reduction in consumption ranging from 1-57%, 19 postcodes have seen an increase in consumption ranging from 1-64% since 2015 (Figure 22). It is important to highlight the postcodes with increased consumption for detailed investigation, particularly ten of those at the highest range of increased consumption as possible areas for LCT implementation to reduce consumption.

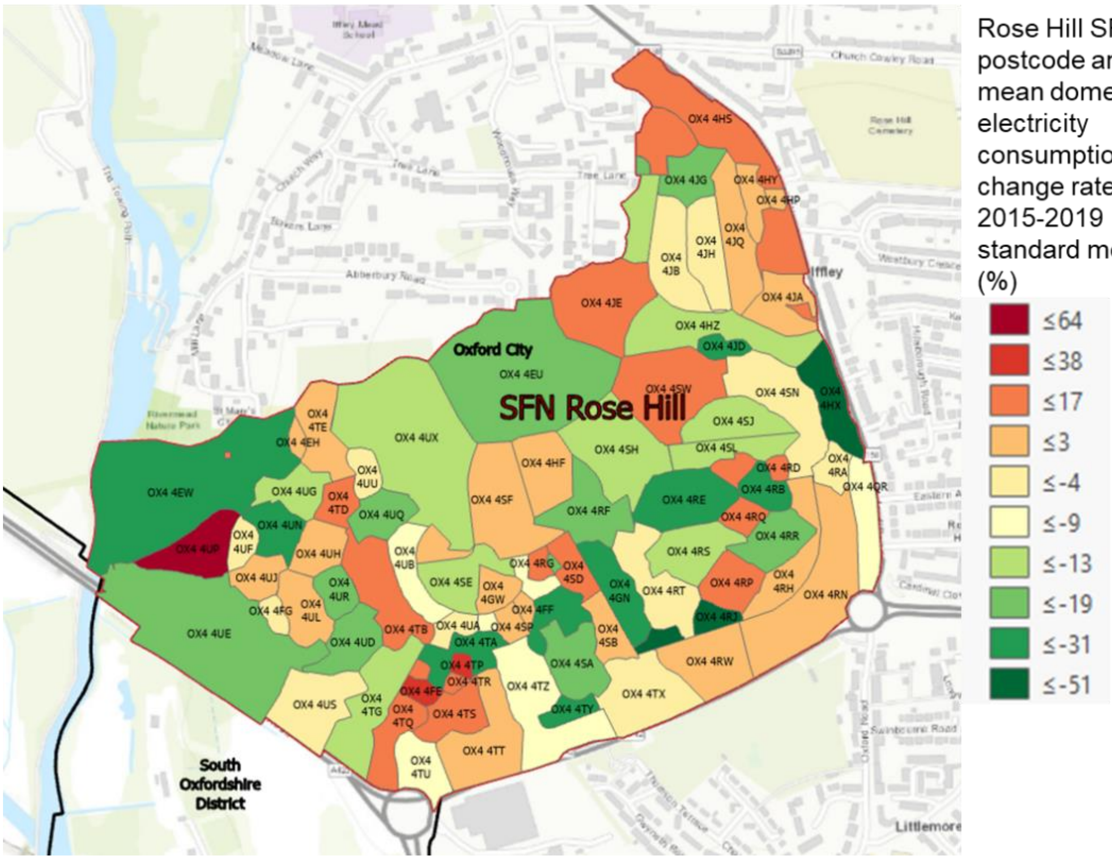


Figure 22. Annual mean domestic electricity change rate 2015-2019 standard meter

5.2.4 Non-domestic MSOA electricity consumption

For the non-domestic consumption, the Rose Hill SFN is located in the MSOA Oxford 015, possessing 287 non-domestic meters with an annual metered electricity consumption of 4.8GWh and an annual mean metered electricity consumption of 16,982.48kWh for 2019. This MSOA has increased by 1.4% the annual mean non-domestic consumption from the previous year. On the contrary, the other MSOA that the SFN is located in, Oxford 016, has seen a decrease in annual mean non-domestic consumption of 12% from the previous year, with a mean consumption 11,524.07kWh and 231 non-domestic meters (Table 8).

Table 8. MSOA non-domestic electricity consumption

No	MSOA	Meters	Annual metered non-domestic electricity consumption (GWh)	Mean metered non-domestic electricity consumption (kWh)	Change 2018-2019
1	Oxford 015	287	4.8	16,982.48	1.4%
2	Oxford 016	231	2.6	11,524.07	-12%

5.3 Gas Consumption

5.3.1 Historical LSOA domestic gas consumption

The LSOA domestic gas consumption dataset provides current and historic domestic gas consumption information in an LSOA scale. (See Section 4.1 on how the LSOAs relate to the SFN boundary.)

Historically the LSOAs that the SFN is located on have had a medium-low to medium-high Ofgem classification based on their consumption, which is and has been between 8,000 and 17,000kWh. Figure 23 shows the annual mean domestic consumption of gas by LSOA from 2015 to 2019. Also, it shows that the LSOAs have experienced an increase in consumption in the past five years, with LSOA Oxford 015E leading with a 7% increase. In comparison, Oxford 015F has an increase in consumption of 4%. By comparison, the two LSOA's (Oxford 016E and F) wholly contained by the SFN have the least amount of increase with 3 and 0.03%, respectably.

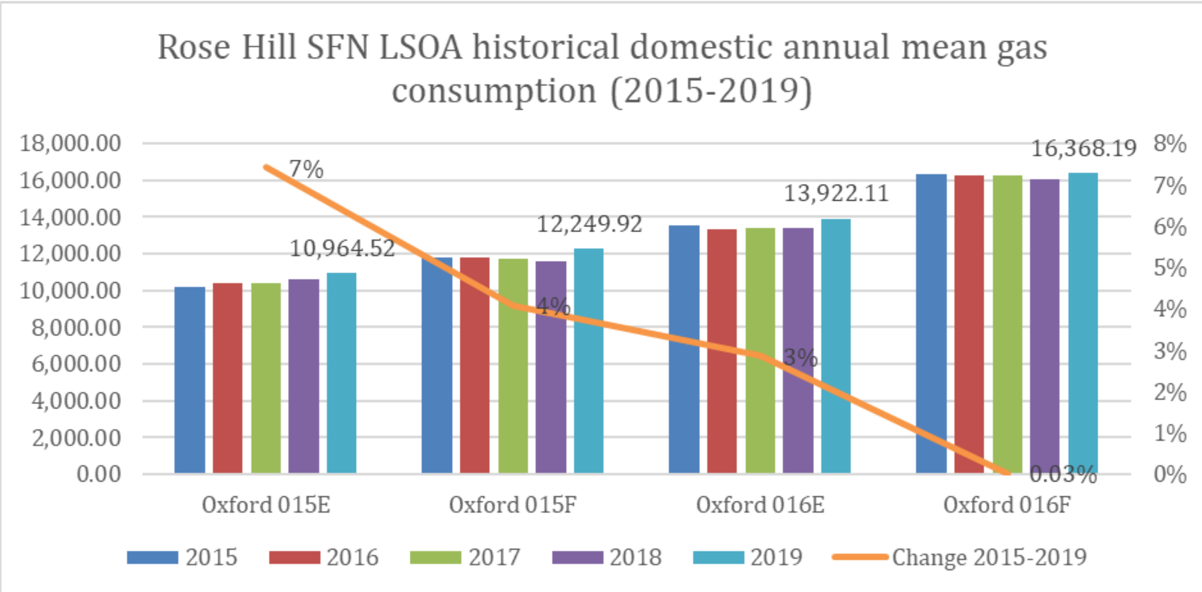


Figure 23. Rose Hill SFN LSOA historical domestic annual mean gas consumption

On the contrary, the overall LSOA annual domestic mean gas consumption of the area has continuously been lower than the county, region and nation (Figure 24). Besides, the area has seen a reduction of consumption from 2015-2018; however, in 2019, the area increased its consumption by 3.68%, undoing the previous years' reduction and having the highest consumption for the area in the last five years. *Note however, these data are not weather corrected.*

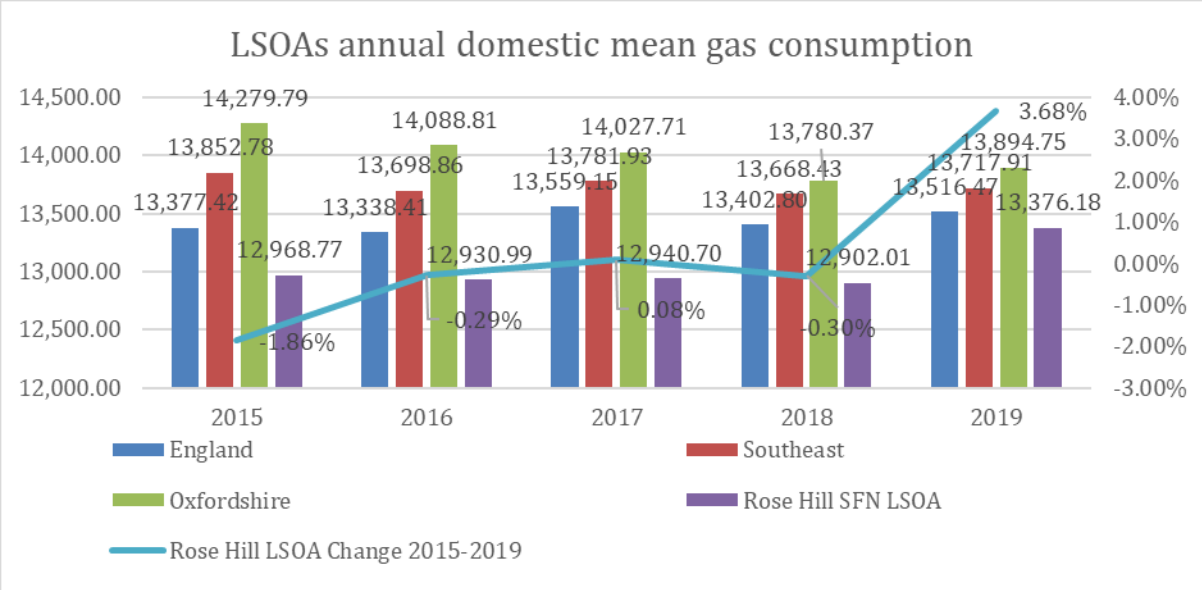


Figure 24. LSOA annual domestic mean gas consumption

5.3.2 Current LSOA Domestic gas consumption

The gas consumption information was analysed from the 2019 BEIS LSOA domestic gas consumption dataset. However, as the SFN does not encompass all of the LSOA, the overall value cannot be calculated. From an LSOA scale, the LSOA Oxford 015E has a high annual metered domestic gas consumption with 10.57GWh. On the contrary, Oxford 015F has 8.43GWh, Oxford 016F has 8.00GWh, and Oxford 016F has the lowest annual metered domestic gas consumption with 6.35GWh (Table 9). The average gas consumption is based on the Property occupancy. The Rose Hill SFN possesses an occupancy of 1-2 rooms in its majority with 56% of the Properties. According to Ofgem (2019), the UK's average gas consumption for a property of this size should be 8,000kWh. However, the properties in the SFN have a mean metered domestic gas consumption of 10,000-16,400kWh, indicating a high consumption of gas (Figure 25). Nevertheless, the LSOA annual mean domestic gas consumption has risen on average 3.84% from the previous year, indicating a possible area of implementation for LCT. The high consumption and the rise could be because 84% of the Rose Hill SFN LSOA uses gas as the primary heating fuel, with only a minority 8% using electric and 1.72% having no central heating.

Table 9. Rose Hill SFN LSOAs gas Consumption

LSOAs	Meters	Annual metered gas consumption GWh	Mean metered gas consumption kWh
Oxford 015E	646	10.57	16,368.19
Oxford 015F	606	8.43	13,922.11
Oxford 016E	519	6.35	12,249.92
Oxford 016F	730	8.00	10,964.52

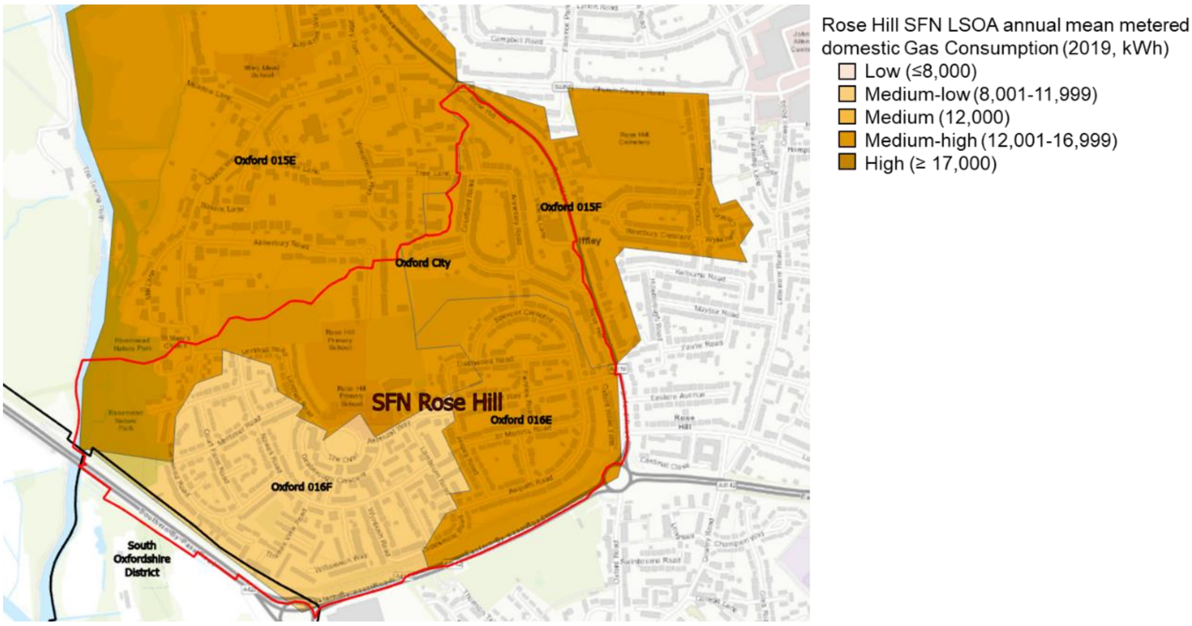


Figure 25. Rose Hill SFN Domestic LSOAs gas consumption

The off-gas postcodes offset the electricity and gas consumption. The Rose Hill SFN possesses two off-gas postcodes OX4 4GW in LSOA Oxford 016F and OX4 4HF in LSOA Oxford 015E. However, this BEIS layer does not provide us with the number of properties not connected. On the other hand, the BEIS 2019 LSOA off-gas layer does provide the number of properties not connected to the gas network, however, as the name implies it is at an LSOA scale which is bigger that the SFN but can provide an idea of the off-gas properties of the SFN. The number of properties not connected to the gas network at an LSOA scale can be seen in Table 10 and Figure 26.

Table 10. Off-gas properties per LSOA

LSOA Name	Number of domestic gas meters	Number of properties	Estimated number of properties not connected to the gas network	Estimated percentage of properties not connected to the gas network (gas meters to number of properties)
Oxford 015E	649	720	71	10%
Oxford 015F	611	660	49	7%
Oxford 016E	522	530	8	2%
Oxford 016F	736	810	74	9%

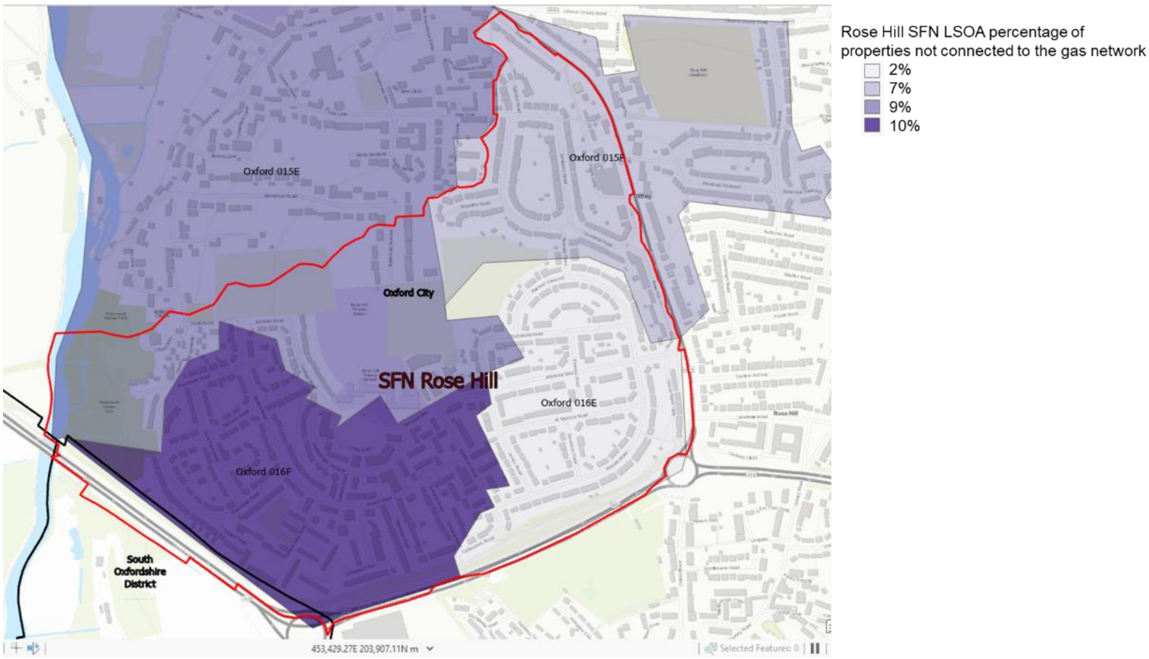


Figure 26. Proportion of off-gas properties per LSOA

5.3.3 Postcode domestic gas consumption

The BEIS experimental gas consumption at postcode scale dataset provides information regarding approximately 95% (n: 75/79) of the postcodes in the SFN (Figure 27). The SFN has 1,643 domestic gas meters with an annual metered domestic consumption of 20GWh and a mean of 11,878kWh. Table 11 shows the top ten annual domestic gas consumption postcodes. It is important to note that the postcode OX4 4HZ has the highest annual domestic gas consumption with 0.8GWh, and the mean metered domestic gas consumption is registered in the OX4 4SH postcode with 19,894kWh. It is interesting to note that these ten postcodes, except for OX4 4TE, have historically (2015-2019) been the highest annual mean gas consumption of the delimitated area. Besides, the majority (n: 55) of the postcodes of the SFN show an increase in their annual mean gas consumption of 0.29-852% (Figure 28). OX4 4GN is of especial interest as this postcode alone has seen an 852% increase in annual mean consumption from 2015 (862kWh) to 2019 (8,249kWh), with only seven more meters registered from 2015 (n: 13) to 2019 (n: 20). Highlighting these 55 postcodes and especially the 11 postcodes as research interest areas and possible LCT implementation for aid in consumption reduction.

Table 11. Rose Hill SFN postcode domestic gas consumption

No.	Postcode	No. of domestic meters	Annual metered domestic gas Consumption (GWh)	Annual mean metered domestic gas consumption (kWh)	Percentage of change in consumption from 2015-2019
1	OX4 4TZ	38	0.60	15,666	28%
2	OX4 4JF	18	0.28	15,709	-2%
3	OX4 4TX	18	0.28	15,809	-4%
4	OX4 4RT	33	0.54	16,282	-15%
5	OX4 4HS	31	0.53	16,982	4%
6	OX4 4JG	18	0.31	17,000	-1%

7	OX4 4UF	6	0.11	17,906	32%
8	OX4 4TE	12	0.22	18,297	12%
9	OX4 4RE	31	0.57	18,539	4%
10	OX4 4SH	23	0.46	19,894	-8%

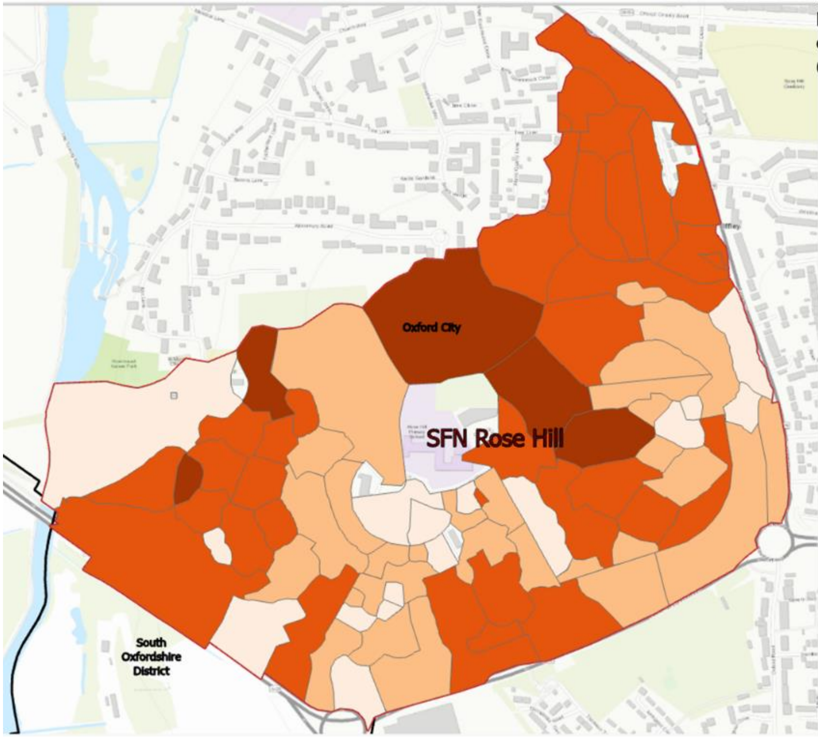


Figure 27. Postcode mean domestic metered gas consumption for Rose Hill SFN

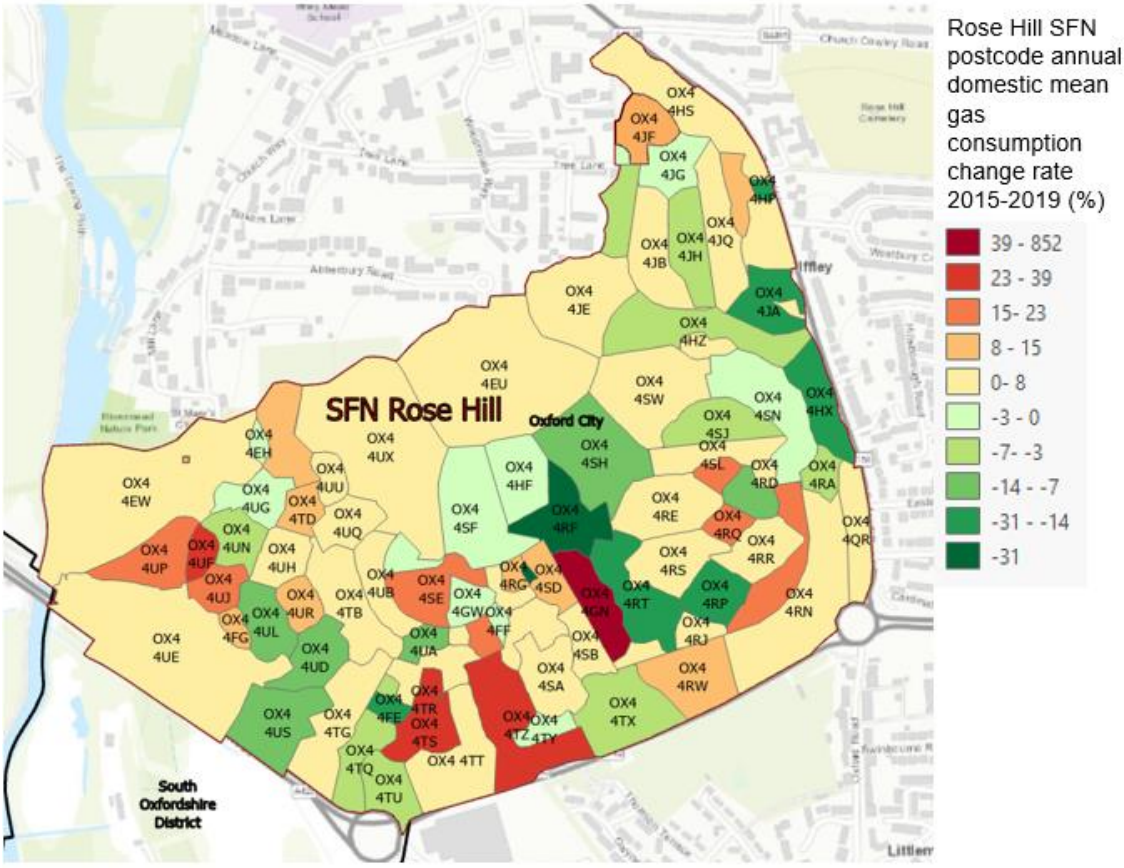


Figure 28. Rose Hill SFN postcode annual domestic mean gas consumption change rate 2015-2019

5.3.4 Non-domestic MSOA gas consumption

Concerning metered gas consumption, the Rose Hill SFN is located in two MSOA, Oxford 015 with 56 meters and an annual non-domestic metered gas consumption of 17.23GWh and an annual mean metered non-domestic gas consumption of 307,754.9kWh. MSOA Oxford 016 possesses 40 non-domestic gas meters with an annual metered gas consumption of 17GWh and a mean metered non-domestic gas consumption of 423,449.5kWh (Table 12). Both MSOAs have experienced a change from 2018 to 2019. However, while Oxford 015 has incremented its annual mean gas consumption by 2%, Oxford 016 has decreased its mean annual consumption by 16% in the same period.

Table 12. MSOA non-domestic gas consumption

No	MSOA	Meters	Annual metered non-domestic gas consumption (GWh)	Mean metered non-domestic gas consumption (kWh)
1	Oxford 015	56	17.23	307,754.9
2	Oxford 016	40	17	423,449.5

5.4 Property analysis

The 2011 census classifies the area as an urban city or town as the area contains a population of approximately 3,400 people living and working in about 1,846 properties in their majority from the interwar period and used for residential purposes only. The analysis highlights that the east side of the state (Postcodes OX4 4HE, OX4 4HZ OX4 4SN, and OX4 4RN) has the highest number of properties.

These 1,846 properties are composed of 1,777 domestic properties and 69 non-domestic properties according to the Geomni UK dataset (Table 13). However, the OS Mastermap only shows 554 properties for this area, with no clear definition of the properties' age, use, or class. This discrepancy between the dataset is due to how each dataset quantifies, classifies, and updates the dataset. The OS MasterMap property layer has not been recently updated. Therefore, it does not possess any of the recent developments of the SFN and quantifies the property's footprint as a whole regardless of the built type.

Table 13. Rose Hill SFN Property age and use.

Premise age	Premise use	No.
Historic to end Georgian 1837	Residential	1
Late Victorian/Edwardian 1870 - 1914	Residential	6
Modern 1980 - current	Educational	2
	Educational, Institutional accommodation	1
	Residential	43
	Retail	3
Post war 1945 - 1980	Educational	2
	Emergency services	5
	Institutional accommodation	4
	Retail below office or residential	8
Post war regeneration 1945-1959	Residential	112
Pre WWI pre 1914	Religious	2
	Retail below office or residential	8
Recent years post 2000	Recreation and leisure	7
	Residential	277
	Transport	1
Sixties/Seventies 1960 - 1979	Residential	310
Unknown	Residential	18
WWI - WWII 1918-1939	Residential	1,010
	Retail below office or residential	26
Total		1,846

5.4.1 EPC data analysis

5.4.1.1 Coverage and distribution of EPCs

According to the 2020 EPC register dataset, only 1,205 properties possess an EPC rating, 1,192 domestic and 13 non-domestic. The Rose Hill SFN possess 1,846 properties indicating that the 2020 EPC registry coverage is approximately 65% of the properties (Table 14). It is important to note that the coverage extends to all four LSOAs and 78/79 of the area's postcodes. The overall SFN EPC rating is C for domestic and non-domestic properties. The rating is predominant in Interwar buildings.

Table 14. Rose Hill SFN 2020 EPC rating

Area	Domestic properties	Non-domestic properties	Coverage	Rating
Rose Hill SFN	1,192	13	65%	C for domestic and non-domestic

For an in-depth understanding of the EPC characteristics of the area, the buildings have been divided into domestic and non-domestic.

5.4.1.2 Domestic properties with EPCs

The 2020 EPC registry has 1,192 domestic properties registered for the SFN with an overall C rating (n: 35%). With a few properties with a D rating (n: 31%), B rating (n: 22%) and only 0.25% have an A rating. On the other hand, 11% of the properties have an E rating, 2% have an F, and 0.25% have a G rating. The predominance of the C rating can be seen in an SFN and postcode scale. However, on an LSOA scale, the rating is predominantly D with 3 out of the 4 LSOA, only Oxford 016F has a B rating (Figure 29 and Figure 30).

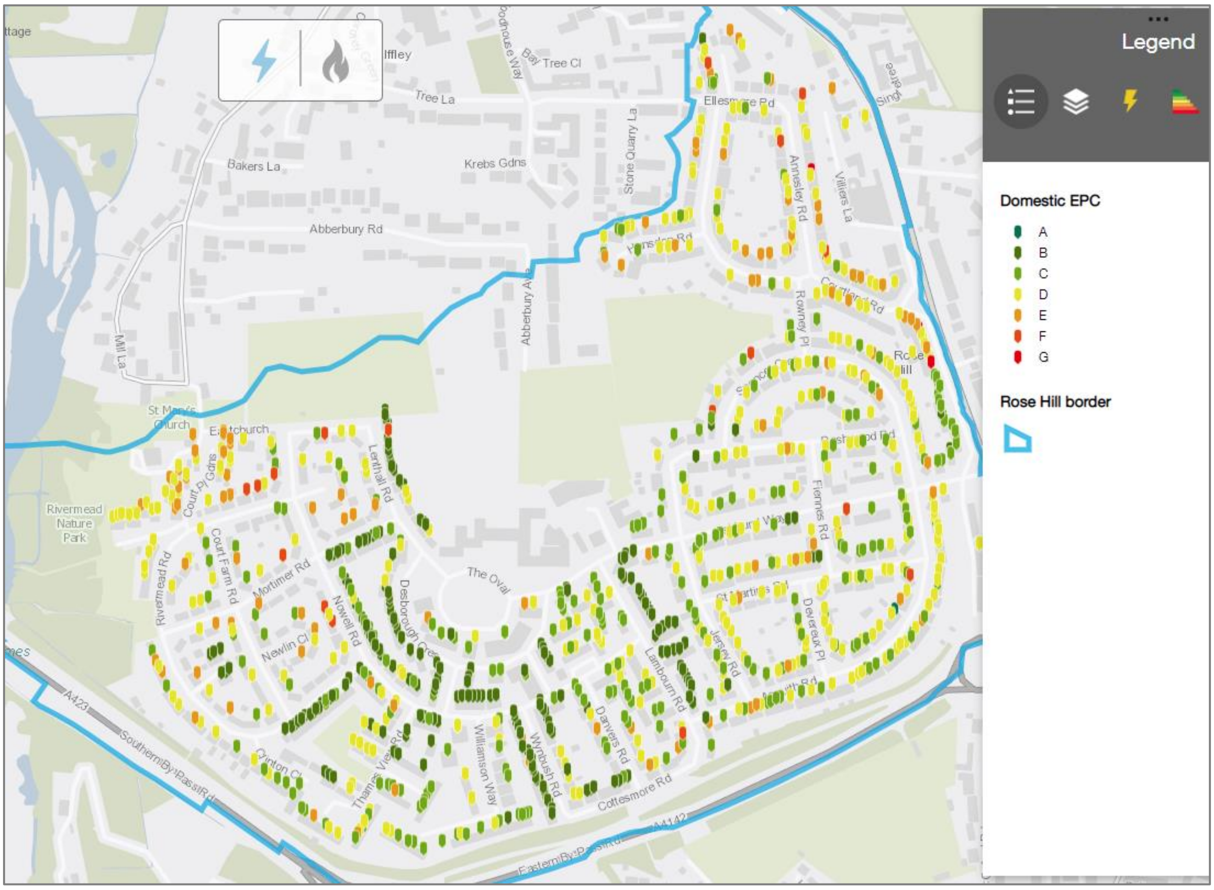


Figure 29. Rose Hill SFN EPC rating by property

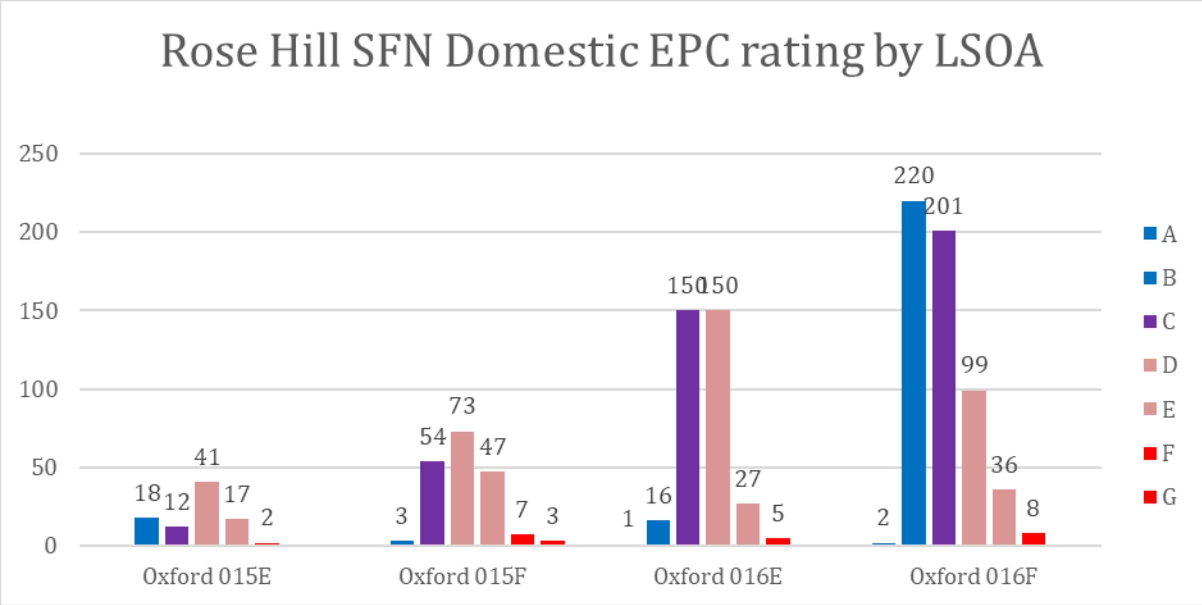


Figure 30. Rose Hill SFN EPC rating by LSOA

5.4.1.3 Non-domestic properties with EPCs

The SFN possesses only 13 non-domestic properties, according to the 2020 EPC registry. The non-domestic properties follow the trend of the SFN, with the majority of the properties possessing a C rating (n: 6) and the second-highest rating being D (n: 4), a few with E (n: 3) and the minority of the non-domestic properties having an A (n: 1) (Figure 31).

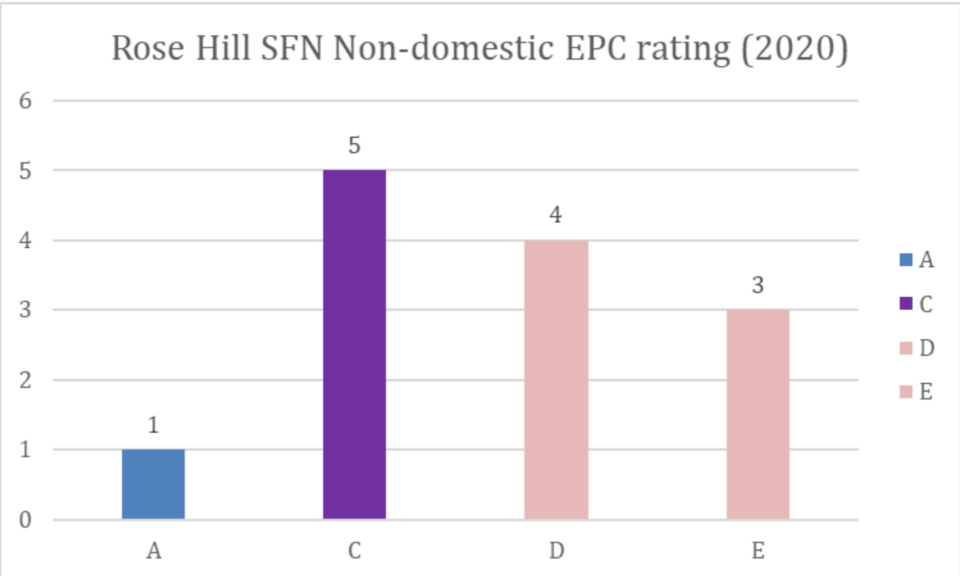


Figure 31. Rose Hill SFN Non-Domestic EPC by LSOAs

5.4.2 Property characteristics using EPCs

The 2020 EPC registry datasets provide property information such as the property type, built form, and property fabric. These characteristics provide insight regarding the energy performance and consumption capabilities of the property. This report will focus on age, property type, built form, glazing, wall insulation, wall type, roof insulation, and ventilation characteristics of the various properties in the SFN. For better understanding, the report will first provide a generalised analysis of the characteristics and, consequently, a breakdown of the properties using (domestic or non-domestic) and by the LSOA within the SFN (Figure 32).

Figure 32. Rose Hill LSOA Boundary

The SFN, according to the 2020 EPC registry datasets, contains 1,205 properties (domestic and non-domestic). Of these, 1,192 are domestic properties, and only 15 are non-domestic. Concerning property type, the SFN follows the county trend with 864 houses, accounting for approximately 73% of the properties of the SFN (Figure 33). Regarding the built form, most of the Rose Hill SFN properties (n: 456) present a semi-detached form.

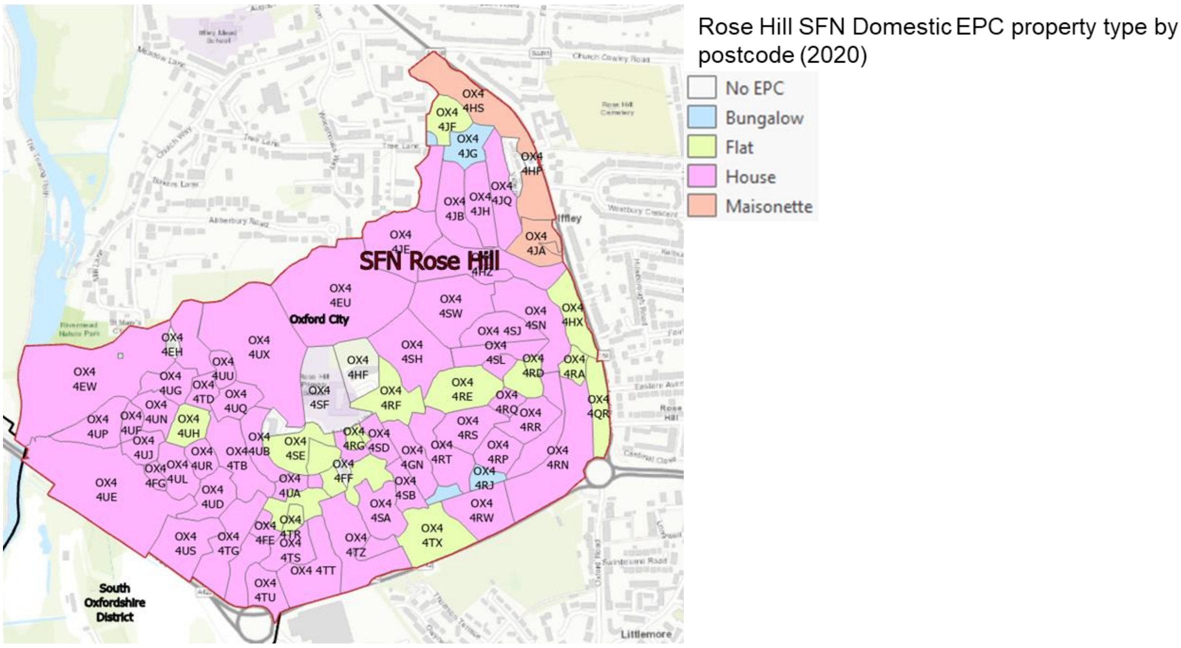


Figure 33. Rose Hill Property type by postcode

Regarding the fabric of the properties, the SFN possesses approximately 69% of the properties with double-glazing. With a few possessing single (n: 1%) or secondary (n: 0.08%) (Figure 34). However, 31% of the properties do not possess a defined glazing in the 2020 EPC registry.

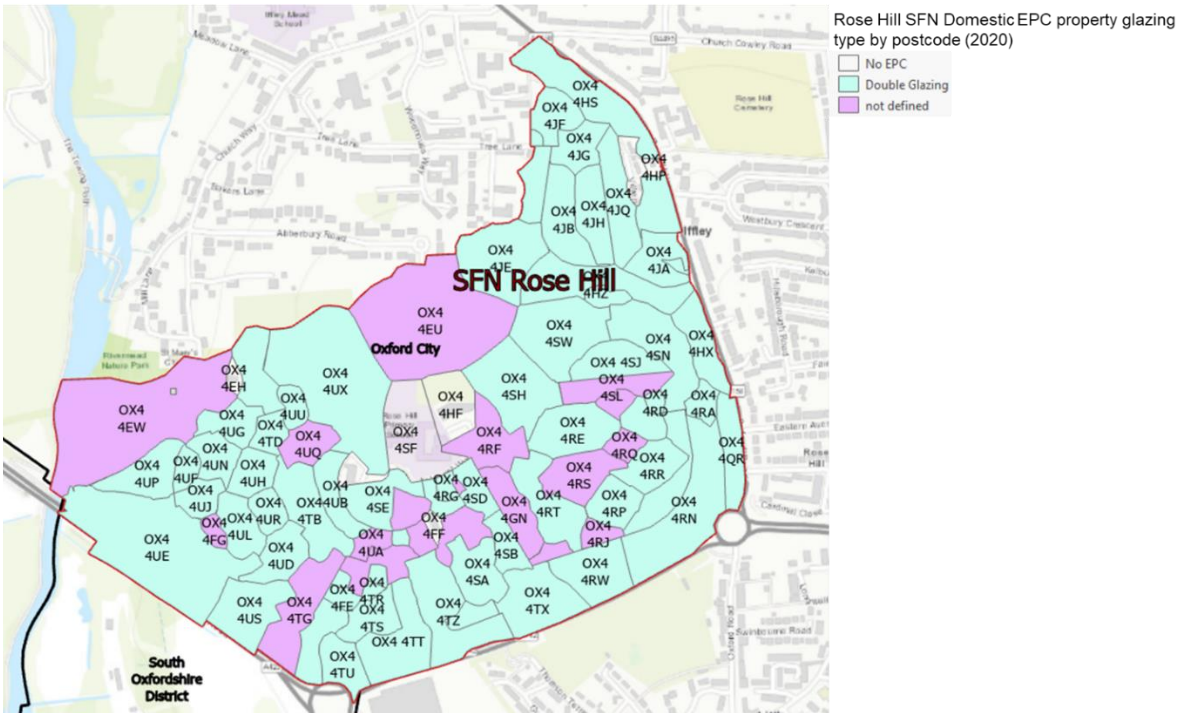


Figure 34. Rose Hill Property Glazing by postcode

The SFN possesses 731 properties insulated, either with internal or external insulation. While 136 properties have partially insulated and 325 have no insulation (Figure 35).

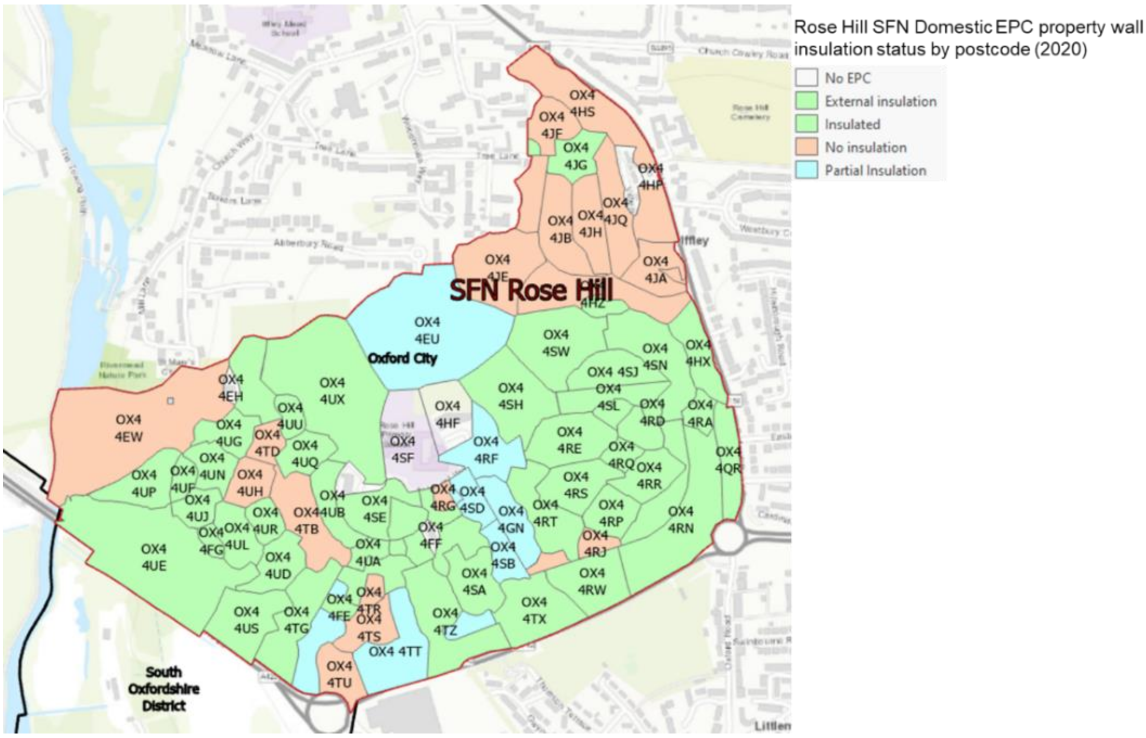


Figure 35. Rose Hill SFN property wall insulation status

The predominant wall construction type (Figure 36) in the SFN is the cavity wall (n: 665). With a few properties with system built (n: 114), timber (n: 81) solid brick walls (n: 51), SAP:05 wall (n: 19), and sandstone (n: 3). However, 259 properties do not have a defined wall type registered.

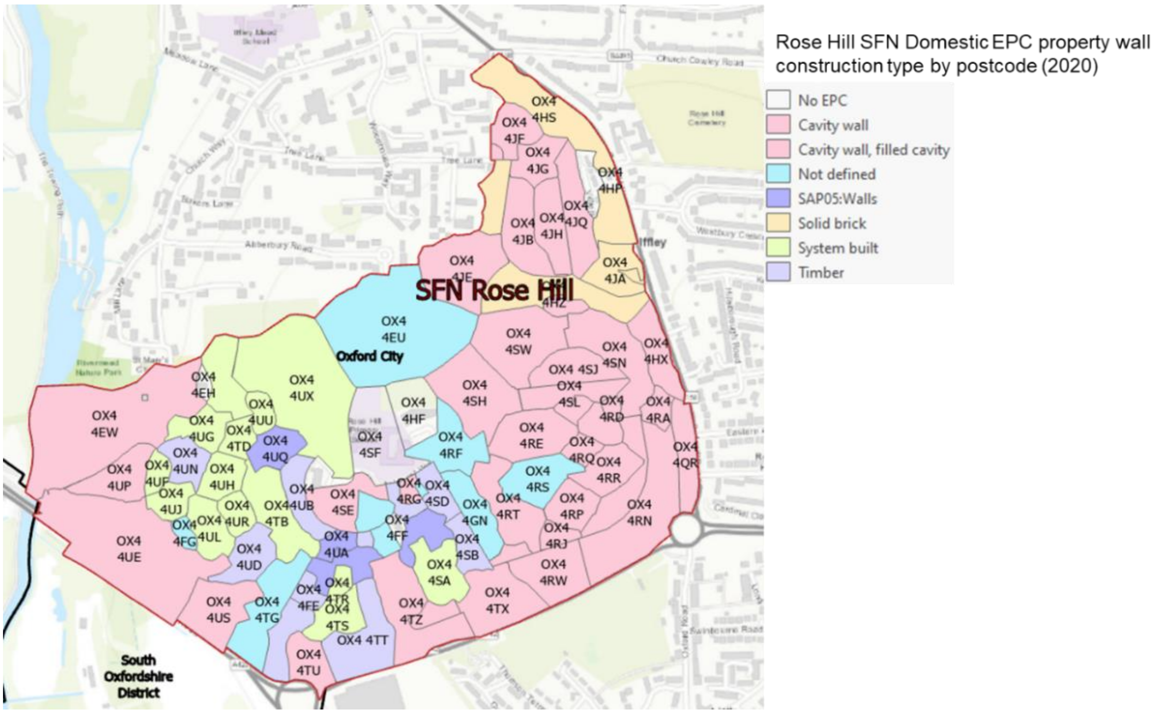


Figure 36. Rose Hill SFN Property wall construction type

The SFN possesses a pitched roof predominantly (n: 784). With a few properties with another dwelling above (n: 173), Sap05: roof (n: 19), roof rooms (n:9) and with the minority being flat roof (n: 1). However, 206 properties do not have this feature defined in the registry. According to the UK 2019 insulation regulations, the recommended roof insulation thickness depends on the type of material used for insulation, whether glass wool, rockwool or cellulose. As the 2020 EPC registry does not specify the material, a thickness minimum of 220mm was taken to evaluate the properties. Based on such assumption, the Rose Hill SFN possesses 110 properties with no roof insulation, and 1,082 properties possess less than the minimum roof insulation (Figure 37).

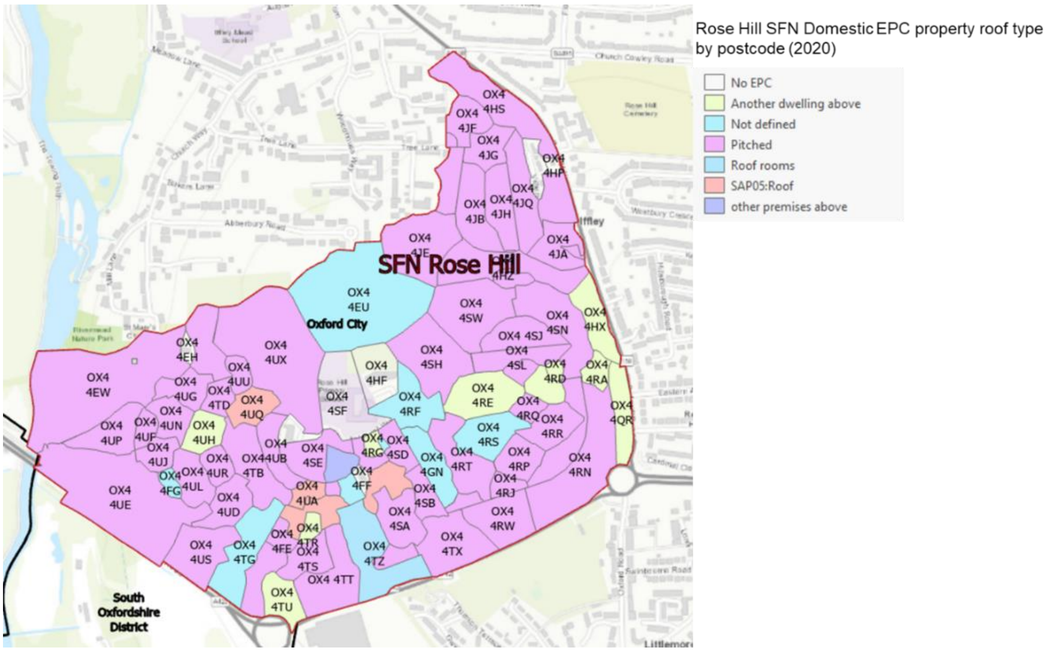


Figure 37. Rose Hill SFN roof type by postcode and LSOA

5.5 Transport

The national charge point registry provides information regarding the EV charging locations. The 2020 BEIS dataset on registered plug-in vehicles provides information on a district scale of the plug-in vehicles (EV) in or around the area of Rose Hill. Rose Hill SFN currently has seven EV charging spots according to the SSEN registry (n: 6), and the National charge point registry (n: 1) (Figure 38).

Figure 38. Rose Hill SFN EV charging spot

6 Energy resources

6.1 Energy generation

This section draws information from the BEIS large embedded renewable generation dataset, the 2020 EPC registry, the Feed-in tariff (FiT) registry, the People's Power Station map, Integrated land use map, and the renewable heat incentive (RHI) government scheme, to provide a complete view of the generation status in Rose Hill. According to the BEIS, the Rose Hill SFN does not possess any large renewable embedded energy generation. However, on a community and individual level, the SFN possess a variety of renewable energy generation. Per the EPC, the area possesses 82 Properties in total with solar PV generation or solar water heater (Figure 39).

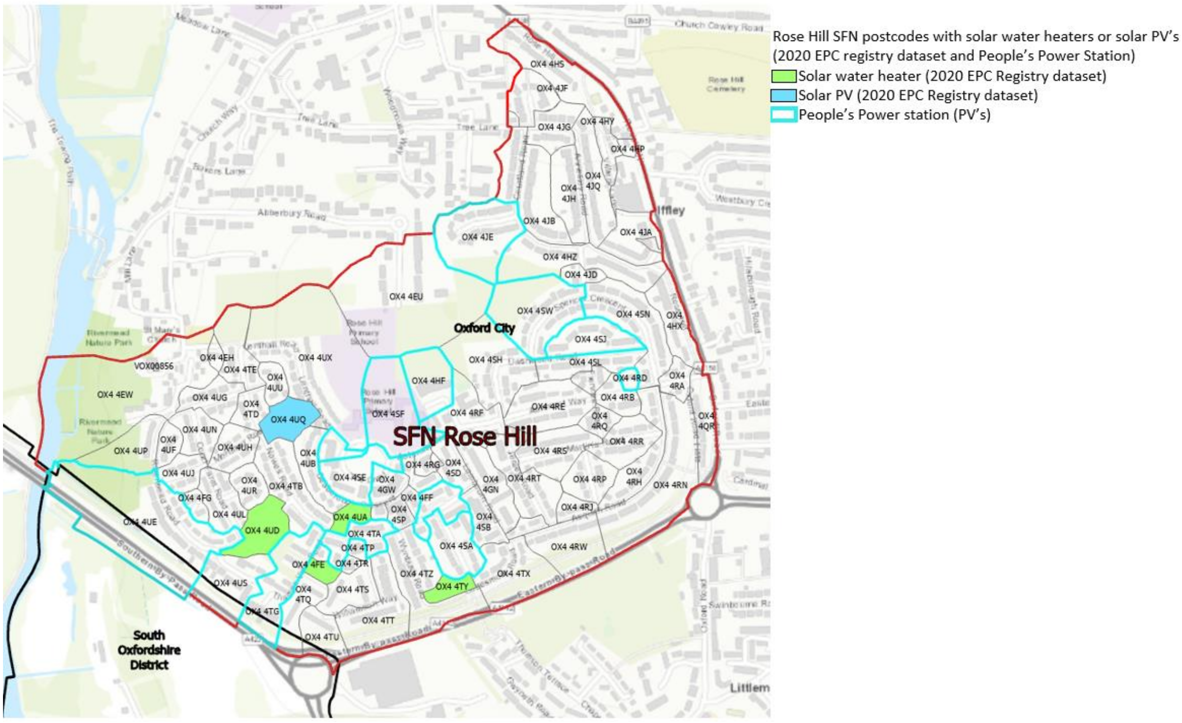


Figure 39. PV and solar water heater installations in Rose Hill SFN

However, the People's Power Station only shows 19 solar PV installations for the Rose Hill SFN (Figure 40, Table 15). The Oxford City Council is registered as the owner of 14/19 PV generation of the area. The rest of the locations are registered either to the house owner or the Low Carbon Hub. The installed capacity registered in the People's Power Station for these 19 locations ranges from 0.5kW to 49kW and from domestic to non-domestic buildings, for a total installed capacity of 222.05kW.

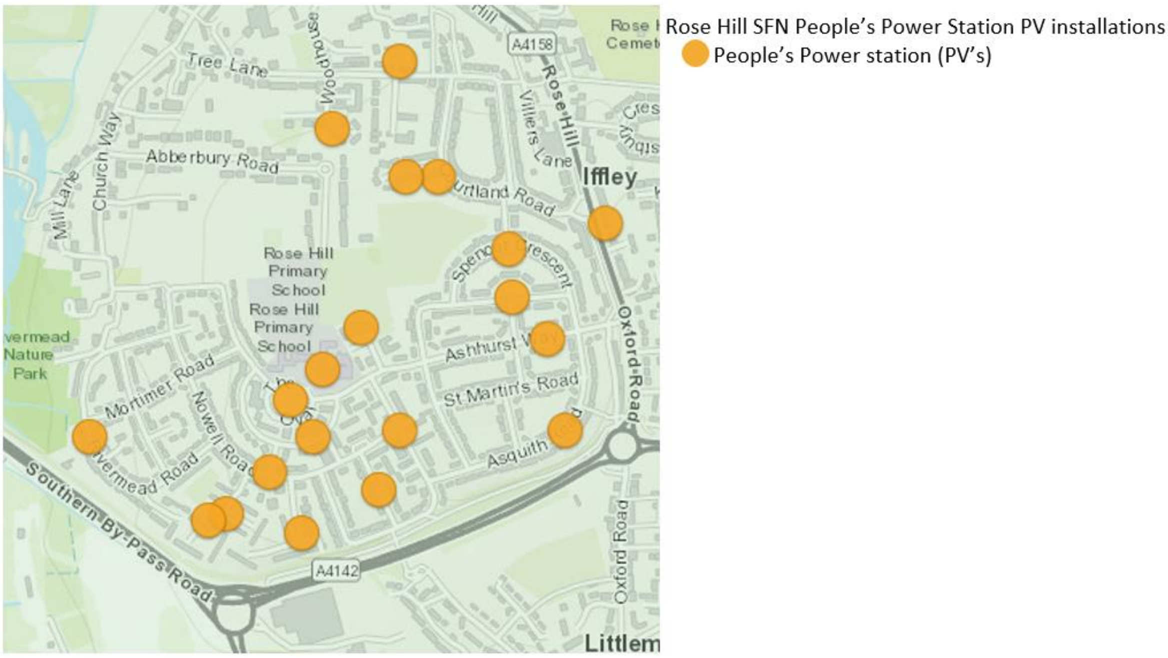


Figure 40. People's Power Station solar PV installations for the Rose Hill SFN

Table 15. People's Power Station RE installations for Rose Hill SFN

No.	Name	Status	Owner	Installed Capacity
1	Rose Hill Community Centre	Non-domestic	Oxford City Council	49kW
2	Rose Hill Primary School	Non-domestic	Low Carbon Hub	28kW
3	Council houses in Rivermead road	Domestic	Oxford City Council	3kW
4	Council houses in Thames View Road	Domestic	Oxford City Council	22kW
5	Council houses in Williamson way	Domestic	Oxford City Council	10kW
6	Council houses in Nowell road	Domestic	Oxford City Council	2.5kW
7	Council houses in Danvers Road	Domestic	Oxford City Council	5kW
8	Council houses in Desborough crescent	Domestic	Oxford City Council	7.5kW
9	Council houses in The Oval	Domestic	Oxford City Council	11kW
10	Council houses in Lambourn Road	Domestic	Oxford City Council	37kW
11	Council houses in Asquith Road	Domestic	Oxford City Council	0.55kW
12	Council houses in Ashhurst way	Domestic	Oxford City Council	16kW
13	Council houses in Dashwood Road	Domestic	Oxford City Council	2.8kW
14	Council houses in Spencer Crescent	Domestic	Oxford City Council	7.6kW
15	Council houses in Azors Court	Domestic	Oxford City Council	8.4kW
16	Terrence Eden	Domestic	Private Owner	4kW
17	105 Rose Hill	Domestic	Private Owner	4kW
18	Rose Hill Domestic	Domestic	Private Owner	1.7kW
19	WillPod	Domestic	Private Owner	2kW
	Total			222.05kW

On the contrary, the Feed-in tariff (Fit) scheme registers for the postal district OX4 (where the SFN is located) 169 properties with PV installations with an installed capacity from 0.55-140.4kW for a total installed capacity of 893.36kW. Of which, the majority are domestic (n: 156), with a few non-domestic commercial (n: 10), non-domestic industrial (n: 1) and two community.

The RHI 2019 registry lists 15 non-domestic properties for an installed capacity of 5.83MW and 31 domestic households in the Oxford district. The registry also has information on a postcode district scale. The SFN is located in the OX4 postcode district, which has five RHI domestic installations (two air source heat pumps and three solar thermal). In contrast, the non-domestic RHI installation in the postcode district has six (one ground source heat pump, one solar thermal and four solid biomass technology). It is possible that one or more of these properties (Domestic and non-domestic) could be located within the SFN.

On the other hand, the 2020 EPC registry shows a low uptake of LCT. As the registry only shows 17 LCT for the SFN. With only two domestic wind turbines, located 172 meters apart in adjacent postcodes OX4 4UQ and OX4 4TB and fifteen solar water heaters cluttered in two LSOA, Oxford 016F and Oxford 015E.The installed capacity of the wind turbines and solar water heaters is unknown, as the 2020 EPC registry does not contain this information.

Eleven of the solar water heater addresses are located in the same postcode as the PVs. These assets together provide an area of study in an LSOA scale of Oxford 016F, on a Postcode level: OX4 4UQ, OX4 4BT, OX4 4UD, OX4 4UB, OX4 4FE and OX4 4TA.

In addtion to the SFN power dataset, it is possible to count low carbon technologies from databases developed in the area. The neighbourhood was also part of a previous ERIC research project which involved a domestic trial of rooftop solar systems (Bruce-Konuah and Gupta, 2017, Gupta et al., 2019). There are 69 of the 82 properties of the ERIC project that lay inside the Rose Hill area. From these properties, there is a total of 504 PV panels installed in the area, which counts for an average of 7.3 panels per home; and an average size system of 2.31 kWp (Figure 41).

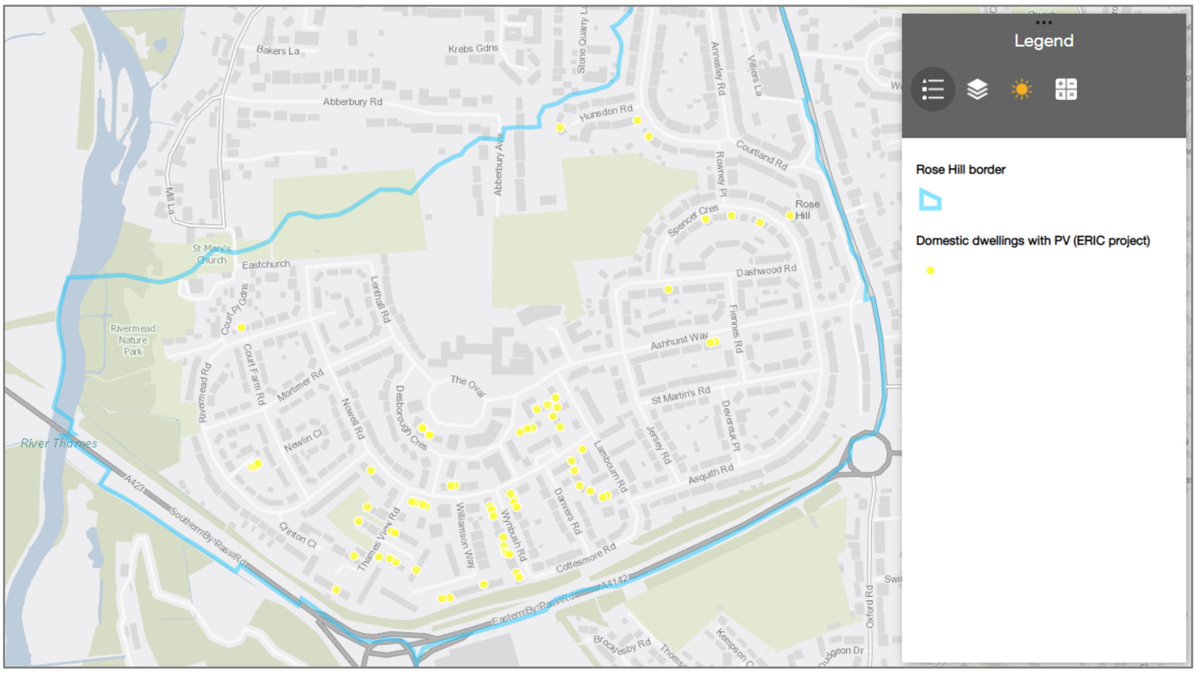


Figure 41 PV systems registered from the ERIC project inside the Rose Hill area.

7 Potential for low carbon technologies

7.1 Potential for solar PV systems

The potential dwellings suitable for solar PV systems was estimated using different databases, including Geomni, Mosaic, EPC and Energeo. For the Rose Hill area it was found that 790 dwellings were suitable for PV systems, which corresponds to 55% of the dwellings analysed (Figure 42). It is important to note that the dwellings identified as suitable for PV systems are those with an EPC rating 'D' or higher. Properties with no EPC rating were considered as suitable if they qualify to the other assumptions specified in Table 16.

Figure 42 Properties targeted as suitable for PV systems in Rose Hill area (image from LEMAP).

The majority of the dwellings suitable for PVs were built between 1918 and 1945. However, dwellings built between 1960-1979 have the highest solar irradiance, as suggested by Energeo data. The dwellings built between 1945-1960 have the most potential area for PV panels; however, only 37 dwellings are suitable for PVs (Figure 43 and Table 16).

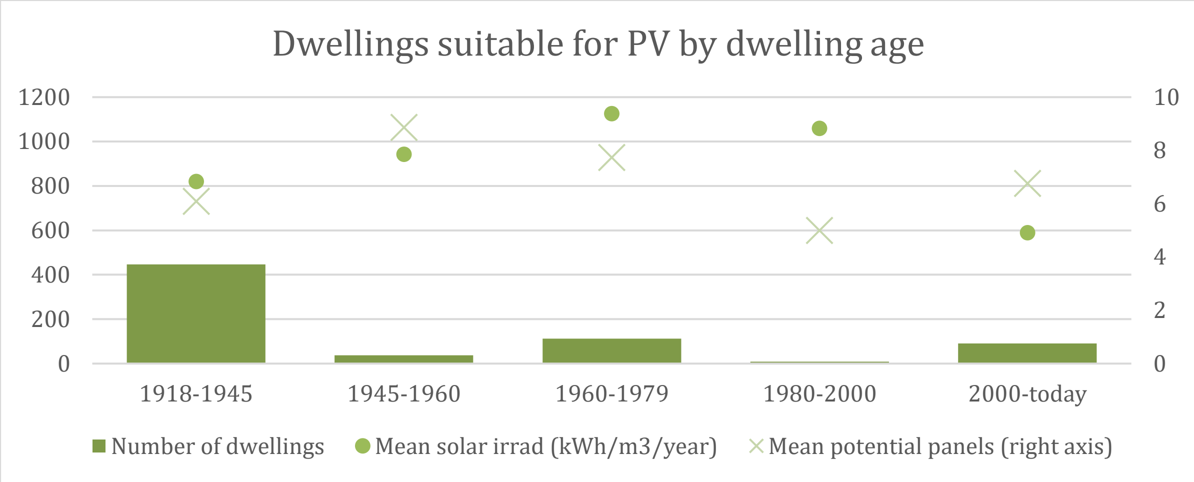


Figure 43 No. of dwellings suitable for PV, mean solar irradiance and mean potential no. of panels by dwelling age.

Table 16 Tabular data supporting Figure 43

Dwelling age	Number of dwellings	Mean solar irrad (kWh/m3/year)	Mean potential panels (right axis)
1918-1945	446	820	6.09
1945-1960	37	943	8.86
1960-1979	112	1126	7.73
1980-2000	8	1059	5
2000-today	90	589	6.76

In the same way, the majority of the dwellings suitable for PVs consist of semi-detached houses, followed by terraced houses. Accordingly, these two-house typologies were estimated to have the higher solar irradiance and potential for solar panels, as established by Energeo data. Only 19 detached houses were identified as suitable for PV systems, which were coincidently identified to have the lowest solar irradiance and potential for PV panels (Figure 44 and Table 17).

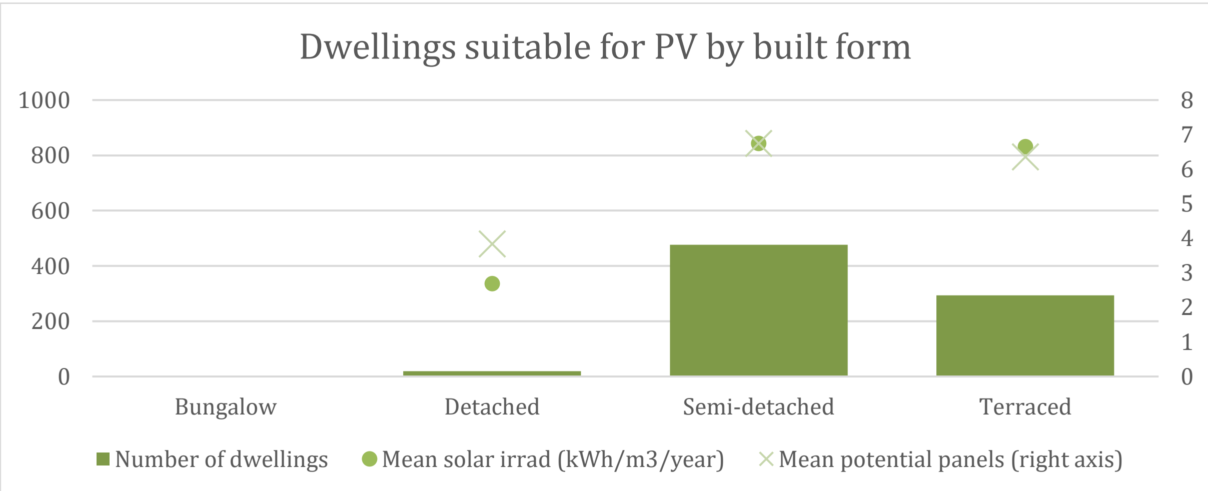


Figure 44 No. of dwellings suitable for PV, mean solar irradiance and mean potential no. of panels by dwelling built form.

Table 17 Tabular data supporting Figure 44

Built form	Number of dwellings	Mean solar irrad (kWh/m3/year)	Mean potential panels (right axis)
Bungalow	1	-	-
Detached	19	336	3.84
Semi-detached	477	844	6.75
Terraced	294	832	6.36

Regarding their EPC, most dwellings suitable for PVs fall into an EPC rating of D. Only properties with EPC rating of D or higher were considered suitable for PVs. Despite having 157 dwellings identified as suitable for PVs, these are estimated to have very low potential for PV panels and low irradiance, as suggested by Energeo data (Figure 45 and Table 18).

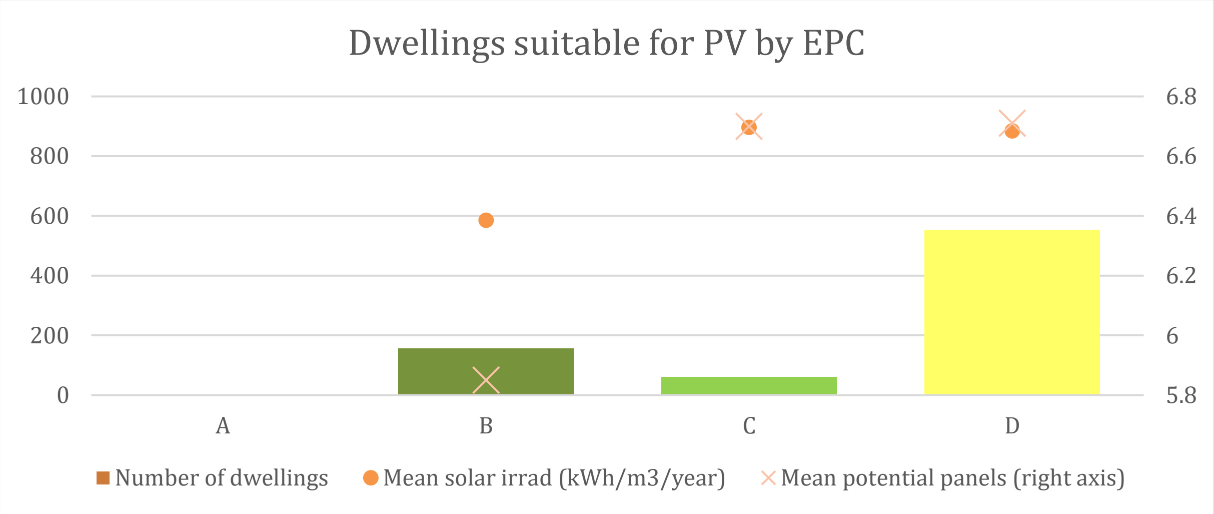


Figure 45 No. of dwellings suitable for PV, mean solar irradiance and mean potential no. of panels by dwelling EPC EER.

Table 18 Tabular data supporting Figure 45

EPC	Number of dwellings	Mean solar irrad (kWh/m3/year)	Mean potential panels (right axis)
A	1	#N/A	#N/A
B	157	586	5.85
C	61	896	6.7
D	554	885	6.71

It was also estimated that 60 additional dwellings could be suitable for PV systems if these improve their EPC, counting for 4% of dwellings in the area in relation to the databases (Figure 46). Dividing the targeting of dwellings regarding their EPC can be used to prioritise the implementation of PV systems as well as identifying the dwellings in need of improving their fabric insulation.

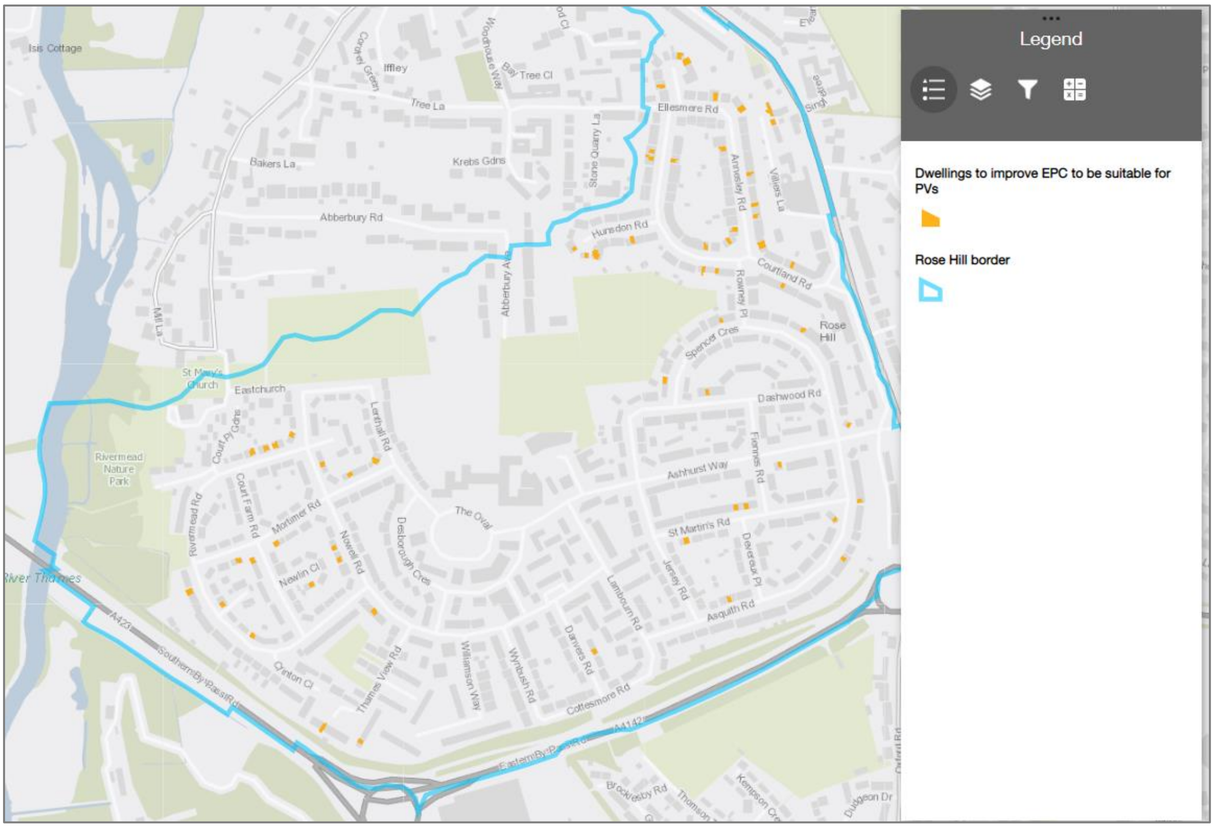


Figure 46. Dwellings targeted as suitable for PVs if EPC is improved (Image from LEMAP).

7.1.1 SSEN DFES projections for PVs

SSEN rooftop solar PV projections are based on the National Grid ESO 2020 distribution future energy scenarios (DFES). That proposed three scenarios in which net-zero is met, two by 2050 (Consumer and system transformation) and one as early as is credibly possible (Leading the way) along with baseline projection called steady progression. Based on these four scenarios, SSEN has created distinct projections for the 13/14 OA's that the SFN is located. The different scenarios project that the OA areas will have an installed PV capacity of 13,000-17,270kW (Figure 47). With the consumer transformation scenario having the majority of the installations with 17,270kW. With the steady progress scenario showing the least amount of installed capacity with 13,024kW. Table 19 shows the five OA's where the scenarios have the highest concentration of PV installations. It is important to note that the DFES scenarios approach was calculated by SSEN at an OA level and may not accurately predict the future installations at a postcode or property level.

Table 19 SSEN DFES projection for the OA's PV size installations in Rose Hill SFN

No	OA	Scenario	PV size (kW) Installations in 2050	PV size (kW) Accumulative by 2050
1	E00145573	Consumer transformation	82	1,403
		System transformation	61	1,384
		Leading the way	50	1,149
		Steady progression	41	1,087
2	E00145589	Consumer transformation	91	2,902
		System transformation	91	2,902
		Leading the way	91	2,902

		Steady progression	91	2,902
3	E00145584	Consumer transformation	97	3,110
		System transformation	97	3,110
		Leading the way	97	3,110
		Steady progression	97	3,110
4	E00145581	Consumer transformation	270	5,141
		System transformation	55	956
		Leading the way	185	3,824
		Steady progression	41	924
5	E00145580	Consumer transformation	338	7,024
		System transformation	99	2,399
		Leading the way	86	2,079
		Steady progression	72	1,986
Overall area (All OAs)		Consumer transformation	690	17,270
		System transformation	516	13,979
		Leading the way	592	15,892
		Steady progression	441	13,024

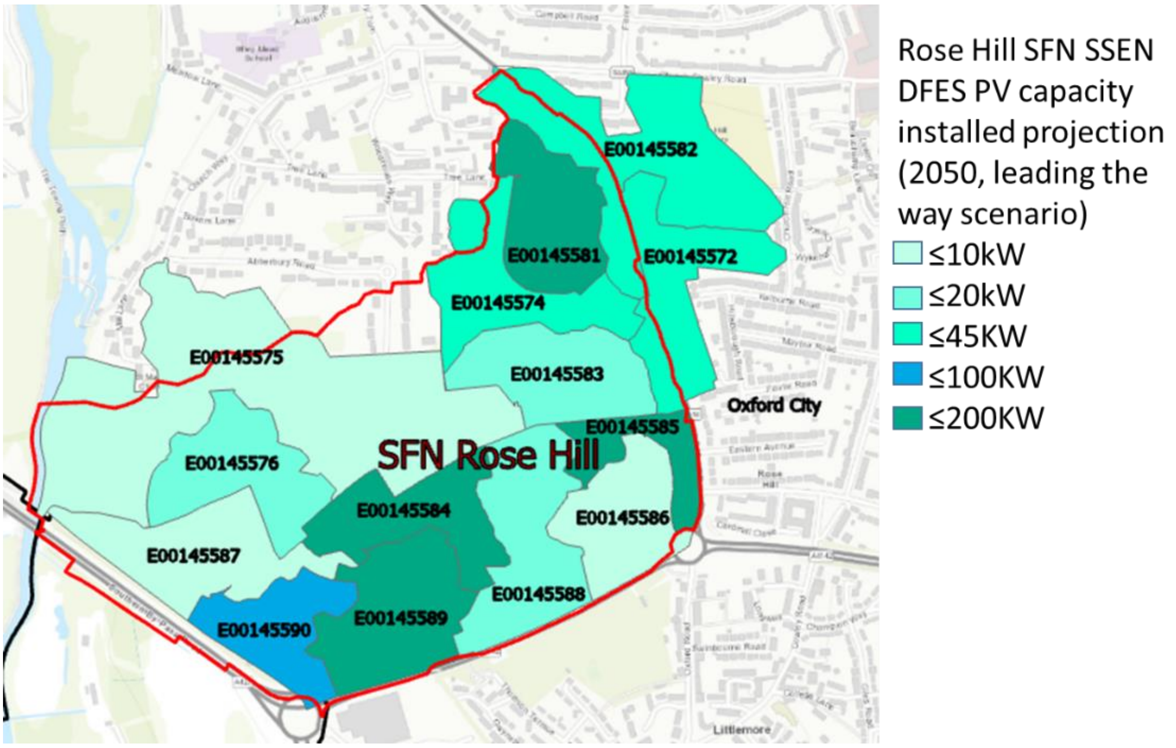


Figure 47. Rose Hill SFN SSEN DFES PV installation size (kW) projections (2050, consumer transformation scenario)

7.2 Potential for heat pumps

The Rose Hill SFN has a high electricity and gas consumption, as can be seen in sections 5.2 and 5.3, ASHP and GSHP can aid in the energy reduction and thermal comfort of the properties. Priority can be given to GSHP in relation to their efficiency; however, fewer properties are suitable for this technology as it requires appropriate garden space area (Figure 48) and works efficiently only on airtight properties with good thermal insulation.

Figure 48. Rose Hill Property (Example of private garden)

7.2.1 Ground source heat pumps

For the Rose Hill area, a total 640 dwellings were identified as suitable for GSHP, which corresponds to 44% of the dwellings analysed. Among the dwellings targeted as suitable for GSHP, 15 were given a priority tag regarding their characteristics, such as being off gas or having a basement for installing the heat pump (Figure 49).

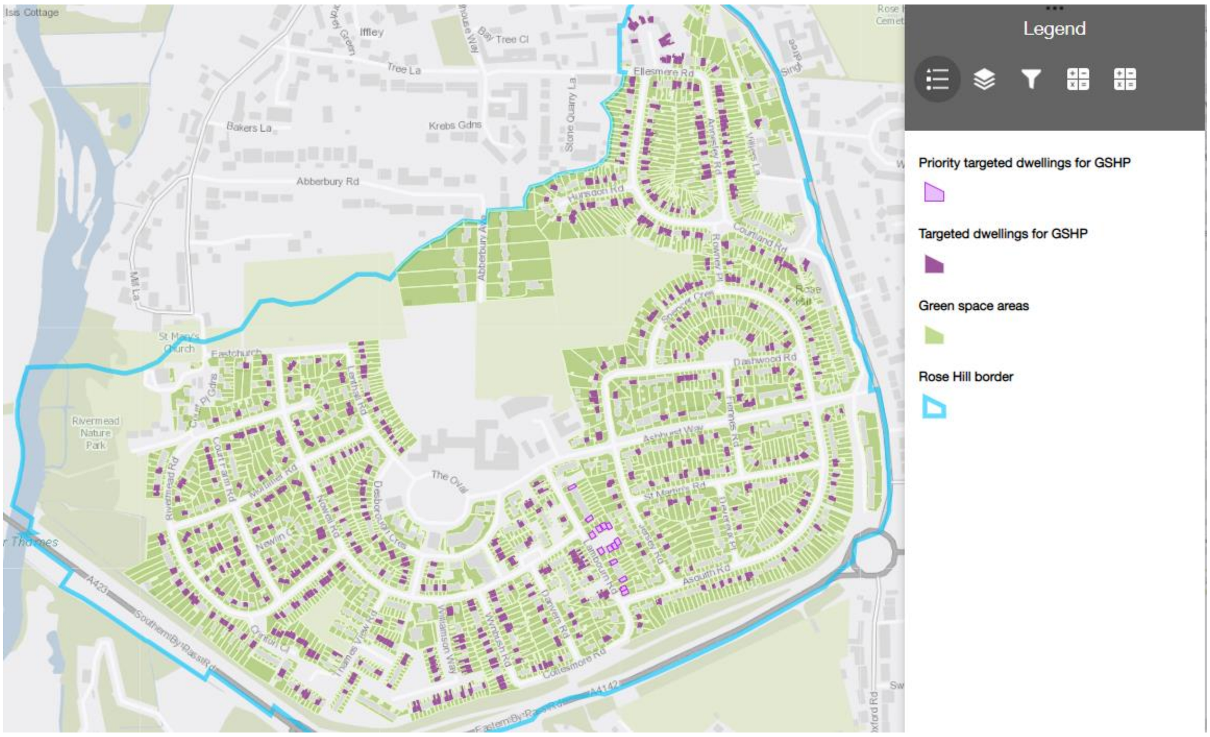


Figure 49. Dwellings targeted as suitable for GSHP and dwellings targeted as priority for GSHP (Image from LEMAP).

Similar to PV, the majority of the dwellings suitable for GSHP were built between 1918 and 1945. It is worth noticing that dwellings built between 1960-1979 have the highest mean dwelling area, as calculated from Geomni data, GSHP is particularly efficient in large dwellings compared to other heating technologies. It might be worth examining if these dwellings have not been subdivided in multiple properties, as recorded by Geomni data almost 100% of them consist of a single household (Figure 50 and Table 20).

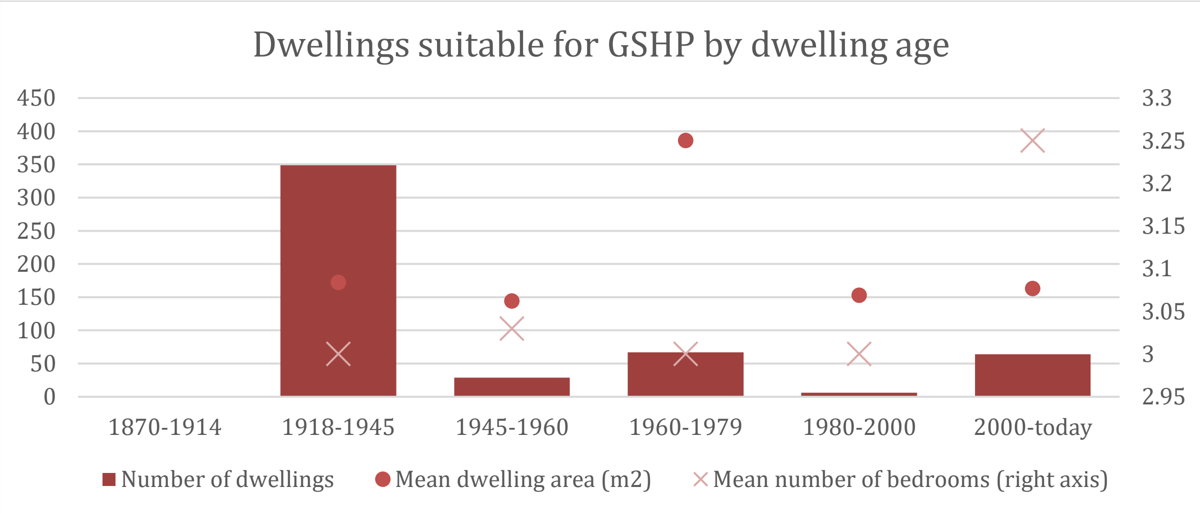


Figure 50 No. of dwellings suitable for GSHP, mean dwelling area and max no. of bedrooms by dwelling age.

Table 20 Tabular data supporting Figure 50

Dwelling age	Number of dwellings	Mean dwelling area (m2)	Mean number of bedrooms (right axis)	Mean properties per dwelling
1870-1914	1	-	-	-
1918-1945	349	172	3	1.02
1945-1960	29	144	3.03	1.03
1960-1979	67	386	3	1
1980-2000	6	153	3	1
2000-today	64	163	3.25	1.39

Also as observed in the analysis of dwellings suitable for PVs, the majority of the dwellings suitable for GSHP consist of semi-detached houses, followed by terraced houses. On paper, detached dwellings look to be the most appropriate for having GSHP, in terms of the amount of garden for installing the equipment; however, in terms of the heating area, detached houses are the lowest in this category (ignoring bungalows), according to Geomni data (Figure 51 and Table 21).

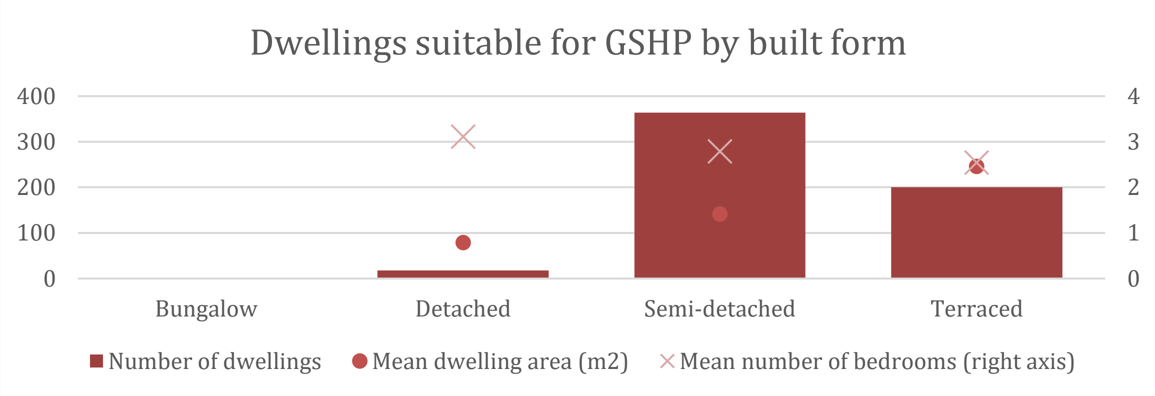


Figure 51 No. of dwellings suitable for GSHP, mean dwelling area and max no. of bedrooms by dwelling built form.

Table 21 Tabular data supporting Figure 51

Built form	Number of dwellings	Mean dwelling area (m2)	Mean number of bedrooms (right axis)	Mean properties per dwelling
Bungalow	1	-	-	-
Detached	18	78.77	3.11	1
Semi-detached	364	141	2.79	1
Terraced	200	246	2.54	1

Regarding EPC, the majority of dwellings suitable for PV fall into an EPC rating of D. This is not a surprise as this is the common EER in the area. Special attention must be given to the properties with an EPC EER of B, as the majority of them have been identified as recently built homes fully sustained by electricity, in which GSHP can be seen as an effective solution. It is observed that these houses do not currently have heat pumps, observing available databases (ERIC project) and the crowd sourced data collected by LEMAP. The five dwellings with EPC ratings of E and F need closer observation. These dwellings have been found to have good insulation materials (including double glazing), however, still fall into low EPC ratings, which might be related to their mechanical systems, including boilers and heating devices. In order to have a wider understanding of the area, the EPC analysis was developed using the derived EPC data from LEMAP, which consists of a calculation based on patterns observed in the area to estimate the EPC rating of dwellings that currently lack EPC data (Figure 52 and Table 22).

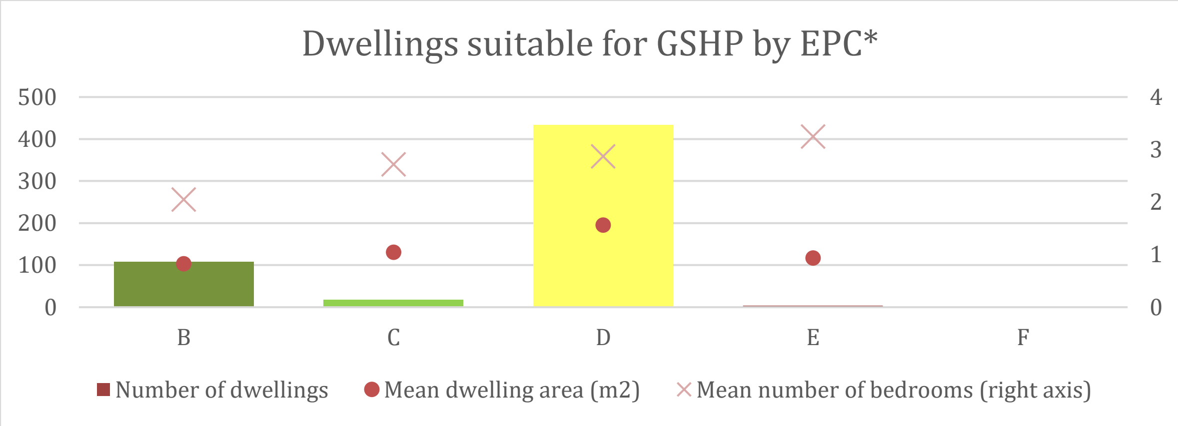


*Figure 52 No. of dwellings suitable for GSHP, mean dwelling area and max no. of bedrooms by dwelling EPC EER. *Derived EPC (LEMAP).*

Table 22 Tabular data supporting Figure 52

Derived EPC	Number of dwellings	Mean dwelling area (m2)	Mean number of bedrooms (right axis)	Mean properties per dwelling
B	108	103	2.05	1
C	18	131	2.72	1
D	434	195	2.87	1
E	4	117	3.25	1
F	1	-	-	-

7.2.2 Air source heat pumps

In the same way, a total 580 dwellings were identified as suitable for ASHP, which corresponds to 40% of the dwellings analysed. Among the dwellings targeted as suitable for ASHP, 27 were given a priority tag regarding their characteristics, such as being off gas or having a basement for installing the heat pump (Figure 53).

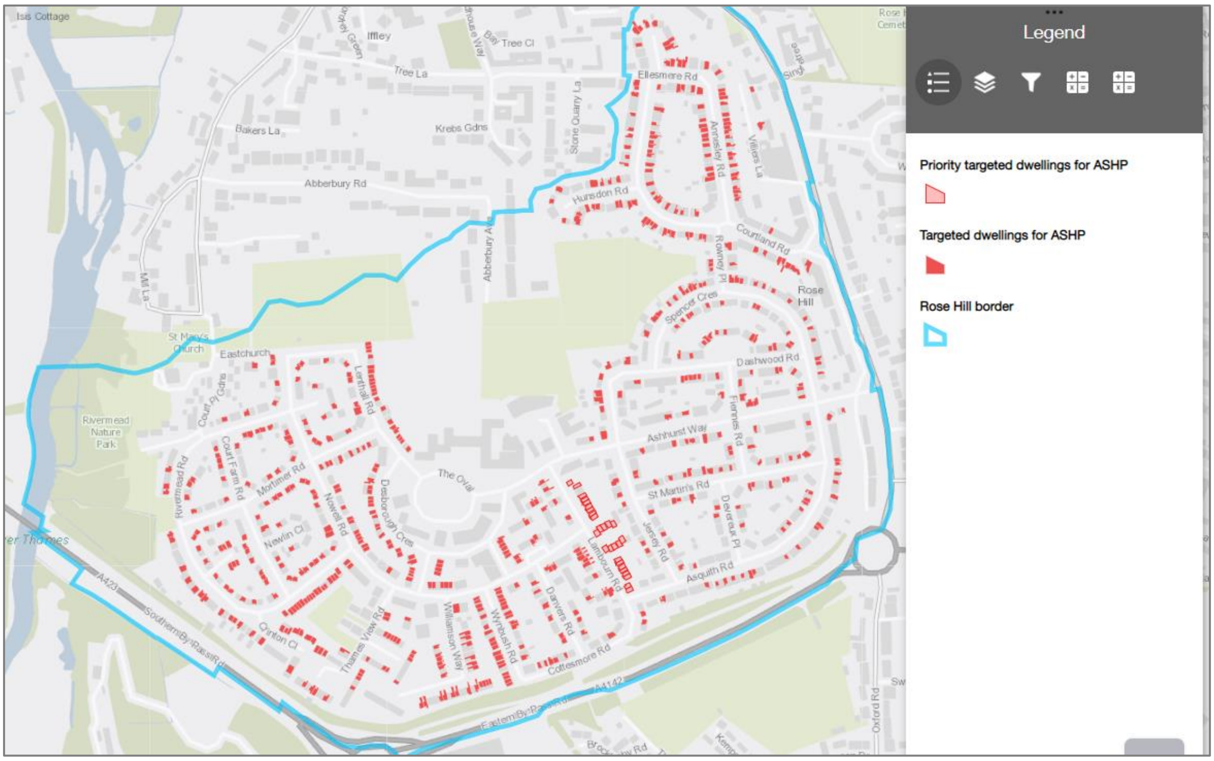


Figure 53. Targeted dwellings suitable for ASHP and priority ASHP (Image from LEMAP).

The targeting of ASHP follows similar assumptions as the GSHP; therefore, the majority of the dwellings suitable for ASHP were also built between 1918 and 1945 and dwellings built between 1960-1979 have the highest mean dwelling area, as calculated from Geomni data (Figure 54 and Table 23).

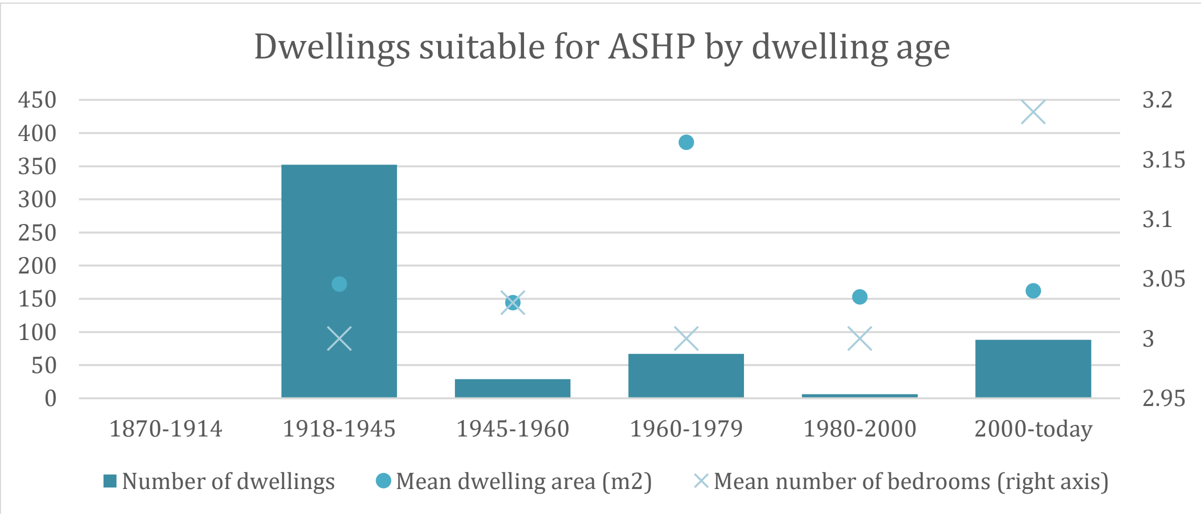


Figure 54 No. of dwellings suitable for ASHP, mean dwelling area and max no. of bedrooms by dwelling age.

Table 23 Tabular data supporting Figure 54

Dwelling age	Number of dwellings	Mean dwelling area (m2)	Mean number of bedrooms (right axis)	Mean properties per dwelling
1870-1914	1	-	-	-
1918-1945	352	172	3	1.02
1945-1960	29	144	3.03	1.03
1960-1979	67	386	3	1

1980-2000	6	153	3	1
2000-today	88	162	3.19	1.48

Also as observed in the analysis of dwellings suitable for GSHP, the majority of the dwellings suitable for ASHP consist of semi-detached houses, followed by terraced houses (Figure 55 and Table 24).

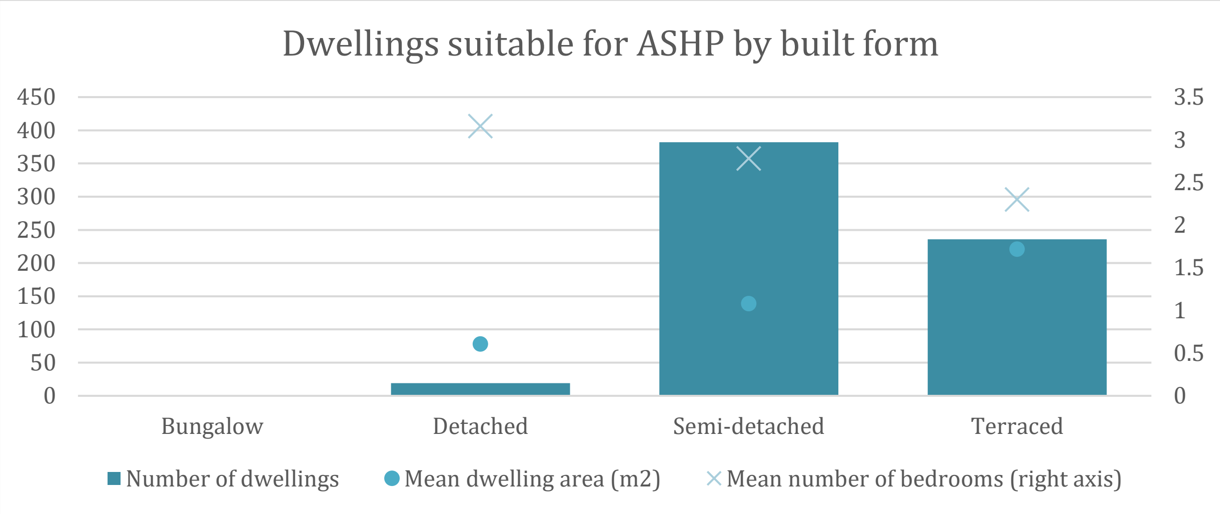


Figure 55 No. of dwellings suitable for ASHP, mean dwelling area and max no. of bedrooms by dwelling built form.

Table 24 Tabular data supporting Figure 55

Built form	Number of dwellings	Mean dwelling area (m2)	Mean number of bedrooms (right axis)	Mean properties per dwelling
Bungalow	1	-	-	-
Detached	19	78.13	3.16	1
Semi-detached	382	139	2.78	1.02
Terraced	236	221	2.3	1

Again, special attention must be given to the properties with an EPC EER of B, as the majority of them have been identified as recently built homes fully sustained by electricity, in which ASHP can be seen as an effective solution. The six dwellings with EPC ratings of E and F need closer observation. These dwellings have been found to have good insulation materials (including double glazing), however, still fall into low EPC ratings, which might be related to their mechanical systems, including boilers and heating devices. In order to have a wider understanding of the area, the EPC analysis was developed using the derived EPC data from LEMAP, which consists of a calculation based on patterns observed in the area to estimate the EPC rating of dwellings that currently lack EPC data (Figure 56 and Table 25).

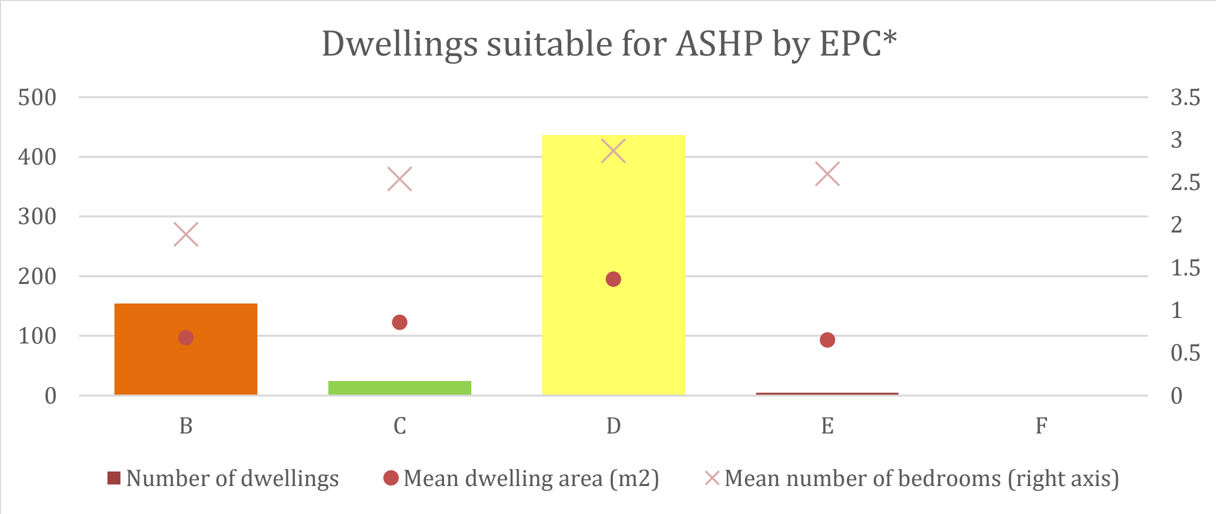


Figure 56 No. of dwellings suitable for ASHP, mean dwelling area and max no. of bedrooms by dwelling EPC derived EER.

Table 25 Tabular data supporting Figure 56

Derived EPC	Number of dwellings	Mean dwelling area (m2)	Mean number of bedrooms (right axis)	Mean properties per dwelling
B	154	96.85	1.89	1
C	24	123	2.54	1
D	436	195	2.87	1
E	5	93.48	2.6	1
F	1	-	-	-

The priority dwellings, for both GSHP and ASHP, concentrate in an area of dwellings built sometime after the year 2000 (Figure 57). These dwellings are built with more recent fabric standards. These dwellings were also designed to rely on electricity as their energy source; therefore, making them ideal for heat pumps. Less of them where targeted for GSHP regarding their size and accessibility to their gardens.

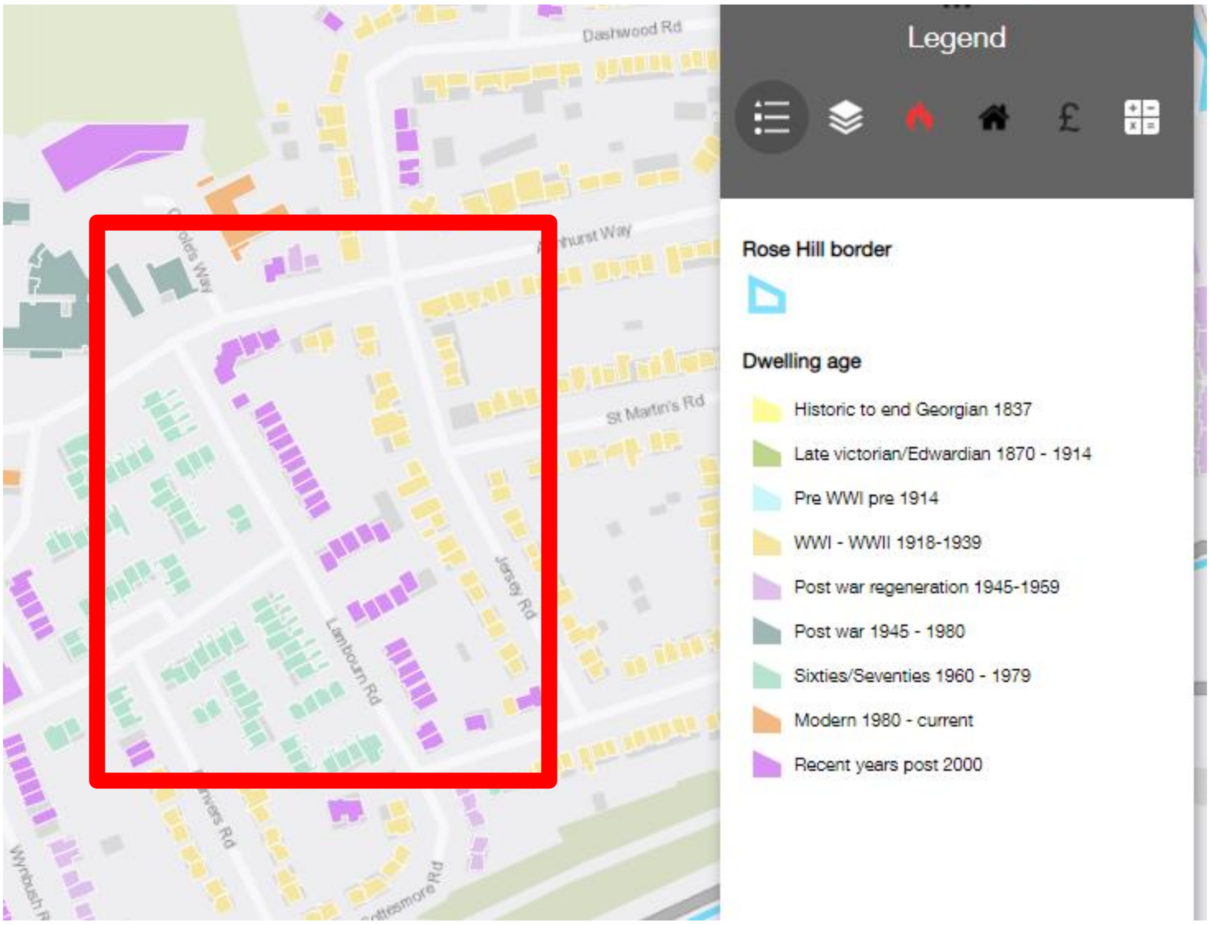


Figure 57. Dwelling age of properties targeted as priority for heat pumps (Image from LEMAP).

7.2.3 SSEN DFES projections for heat pumps

SSEN heat pump projections are based on the National Grid ESO 2020 distribution future energy scenarios (DFES). The different scenarios project that 13/14 OA areas will have approximately 530-5,130 heat pump installed by 2050. With leading the way scenario having the majority (n: 5,130) of the heat pump installations (Figure 58). With the steady progress scenario showing the least amount of heat pumps installed (n: 531). Table 26 shows the five OA's where the scenarios have the highest concentration of heat pump installations. It is important to note that the DFES scenarios approach was calculated by SSEN at an OA level and may not accurately predict the future installations at a postcode or property level.

Table 26. SSEN DFES projection for the OA's quantity of heat pump installations in Rose Hill SFN

No	OA	Scenario	Number of heat pump Installations in 2050	Number of heat pump installations Accumulative by 2050
1	E00145582	Consumer transformation	0	115
		System transformation	0	150
		Leading the way	0	364
		Steady progression	0	38
2	E00145575	Consumer transformation	7	213
		System transformation	4	147
		Leading the way	7	413

		Steady progression	2	42
3	E00145583	Consumer transformation	9	249
		System transformation	4	174
		Leading the way	8	765
		Steady progression	3	58
4	E00145572	Consumer transformation	26	343
		System transformation	13	244
		Leading the way	26	612
		Steady progression	7	55
5	E00145589	Consumer transformation	25	389
		System transformation	15	277
		Leading the way	25	695
		Steady progression	7	94
Overall area (All OAs)		Consumer transformation	67	2,131
		System transformation	35	1,945
		Leading the way	66	5,130
		Steady progression	19	531

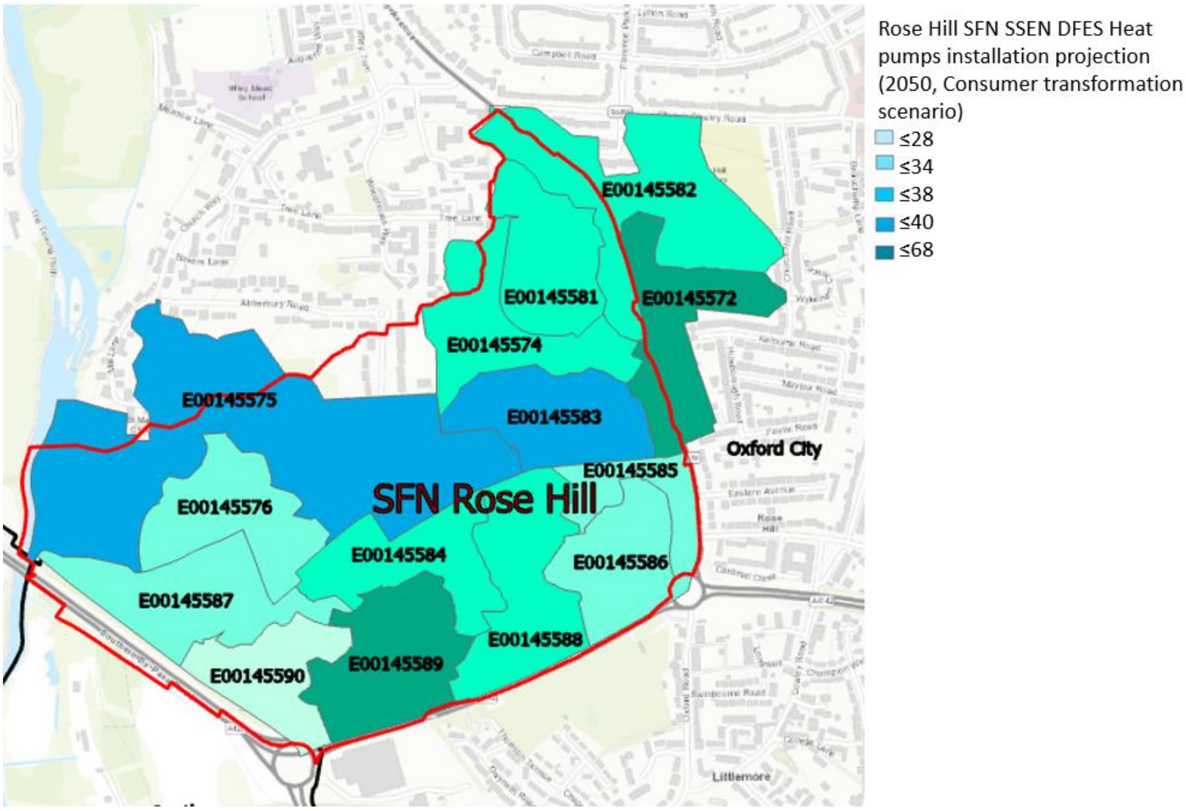


Figure 58. Rose Hill SFN SSEN DFES quantity of heat pumps installations projections (2050, leading the way scenario)

7.3 Potential for EV chargers

Concerning the potential of EV charging spots in the area, the Energeo availability of off-road parking will provide possible areas of EV charger installation. Along with the traffic and EV registry, as the SSEN-Regen report demonstrates, it will provide specific potential spots for either road or property EV charges installations.

For EV charger:

- Off-street parking (Figure 59)
- PV + battery: it is assumed that EV chargers are only suitable for houses with PV and battery

• Tenure: only private rented properties are not suitable for EV charges.

Figure 59. Potential for EV charging spot

Based on the filters applied to the different layers, the analysis identified 52 postcodes with 306 properties suitable for EV chargers (Figure 60). However, this layer and analysis may change once off-street parking layer from OCC is acquired.

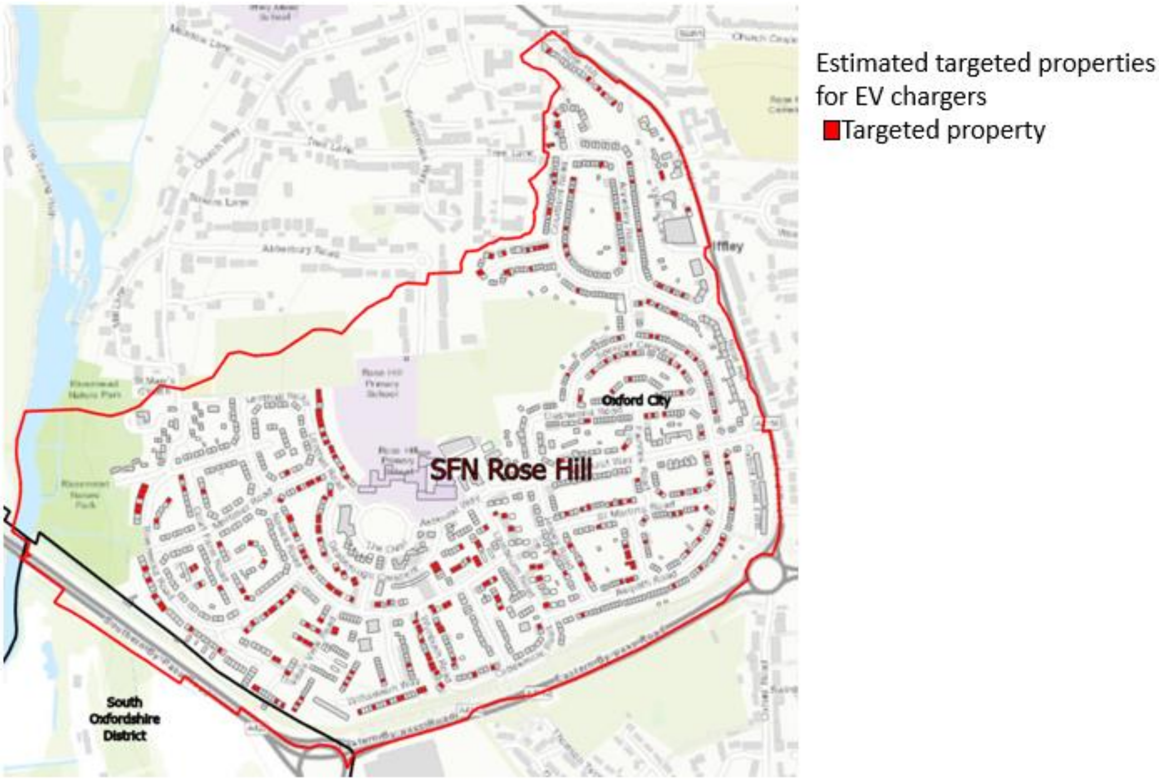


Figure 60. Rose Hill targeted properties for EV charging

7.3.1 SSEN DFES projections for EVs chargers

SSEN EV charger projections are based on the National Grid ESO 2020 distribution future energy scenarios (DFES). The different scenarios project that the 14 OA areas will have approximately 3,700-5,828 EV chargers installed by 2050. With leading the way scenario having the majority (n: 5,828) of the EV charger installations (Figure 61). With the steady progress scenario showing the least amount of EV chargers installed (n: 3,793). Table 27 shows the five OA's where the scenarios have the highest concentration of EV charger installations. It is important to note that the DFES scenarios approach was calculated by SSEN at an OA level and may not accurately predict the future installations at a postcode or property level.

Table 27. SSEN DFES projection for the OA's quantity of EV charger spot installations in Rose Hill SFN

No	OA	Scenario	Number of EV chargers installed in 2050	Number of EV charger installations Accumulative by 2050
1	E00145586	Consumer transformation	62	497
		System transformation	62	414
		Leading the way	62	515
		Steady progression	58	332
2	E00145583	Consumer transformation	77	627
		System transformation	75	517
		Leading the way	78	657
		Steady progression	71	420
3	E00145584	Consumer transformation	58	626
		System transformation	59	534
		Leading the way	60	689
		Steady progression	53	419
4	E00145589	Consumer transformation	83	671
		System transformation	85	591
		Leading the way	88	731
		Steady progression	79	478
5	E00145576	Consumer transformation	80	822
		System transformation	79	665
		Leading the way	82	866
		Steady progression	73	528
Overall area (All OAs)		Consumer transformation	992	5,503
		System transformation	988	4,667
		Leading the way	1,008	5,828
		Steady progression	945	3,793

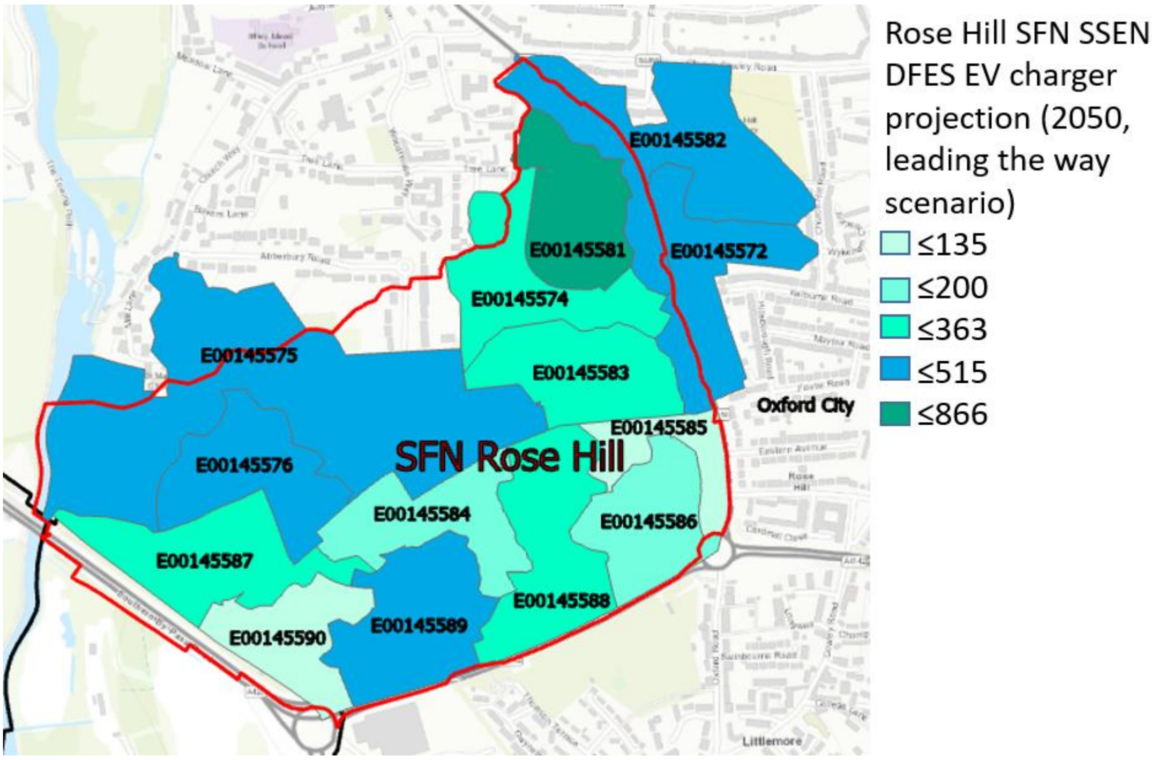


Figure 61. Rose Hill SFN SSEN DFES quantity of EV charging spots installations projections (2050, leading the way scenario)

7.4 Potential for battery storage

500 dwellings were identified as suitable for having batteries, which corresponds to 35% of the dwellings analysed. In order to provide a better understanding of the potential of the dwellings in the area, these can be targeted regarding their suitability to LCTs and batteries.

7.4.1 Potential for PVs and battery

For Rose Hill SFN area, 420 dwellings were identified as suitable for having batteries as well as PV systems, which corresponds to 29% of the dwellings analysed (Figure 62).

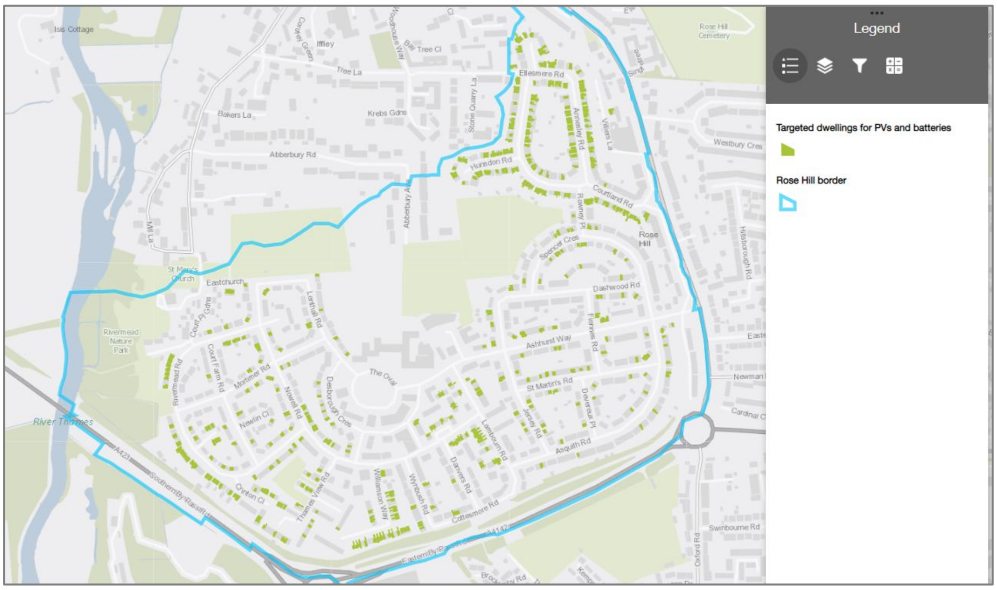


Figure 62. Targeted dwellings suitable for PVs and battery (Image from LEMAP).

7.5 Capability assessment

Capability assessment is based on the capability lens approach developed by the Centre for Sustainable Energy. The assessment helps to find out how likely households are to adopt different LCTs and those who may be left behind based on their socioeconomic characteristics. It can give an idea of the technical, digital, financial as well as social propensity of the households to take up low carbon technologies. The capability assessment in the LEMAP tool for Rose Hill was conducted using data from EPC, Geomni and Mosaic data for Rose Hill. Each capability assessment was assessed in terms of four categories of dwelling potential as shown in Figure 63.

7.5.1 Technical capability

Technical capability refers to the suitability of a dwelling in its location to take up low carbon technologies, rated as follow:

- *Full potential* - capable of adopting all low carbon technologies mentioned above, such as PVs, heat pump, batteries or EV chargers. There were 360 properties identified for having full potential technical capability.
- *Partial potential* - capable of adopting some low carbon technologies. There were 452 properties identified for having partial potential technical capability.
- *Need improvement* – capable of adopting technologies if relevant improvements are made to the dwellings. There were 125 properties identified to require some technical improvements to be technical capable.
- *Unsuitable* - dwellings unsuitable for low carbon technologies, such as listed buildings. There were 759 properties identified for not having technical capability.

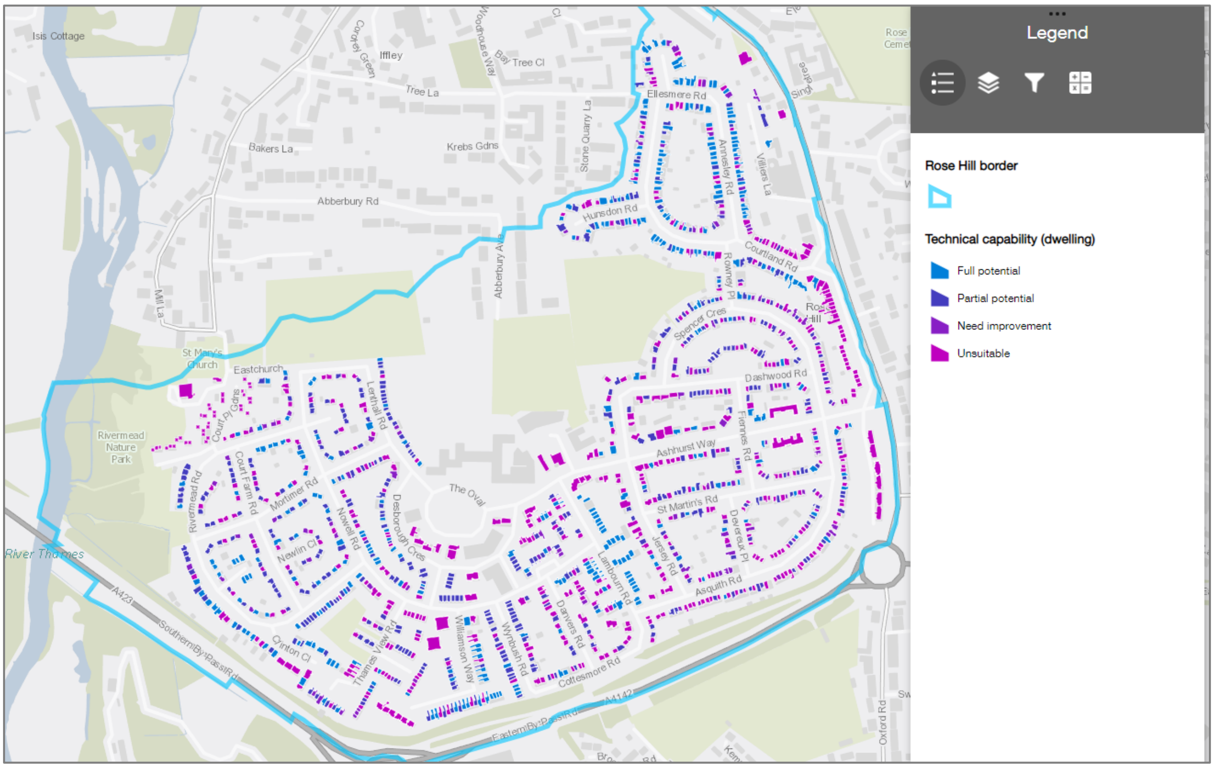


Figure 63. Technical capability targeted dwellings (Image from LEMAP).

7.5.2 Digital capability

Digital capability (Figure 64) defines the engagement of a household in a dwelling with digital technology, including use of smartphones, computers, broadband, and level of digital engagement.

- *Hi-tech users* – households with cutting-edge hardware (smartphones and computers) immersed in digital technology, which play a key role in the way they organise their life. There were 310 properties identified for being highly skilled households.
- *Tech Savvy* – households composed of avid users of social media and smartphones that aspire to obtain cutting-edge hardware. There were 1,093 properties identified for being tech-savvy.
- *Training required* - households that only use digital technology for entertainment, shopping or practical purposes, such as communicating with family and friends. There were 211 households that require some training to be capable of implementing LCTs.
- *Other priorities* - households with limited, little or no interest in digital technology, preference given to non-digital approaches. There were 57 properties identified for having other priorities before implementing LCTs, regarding their digital skills.

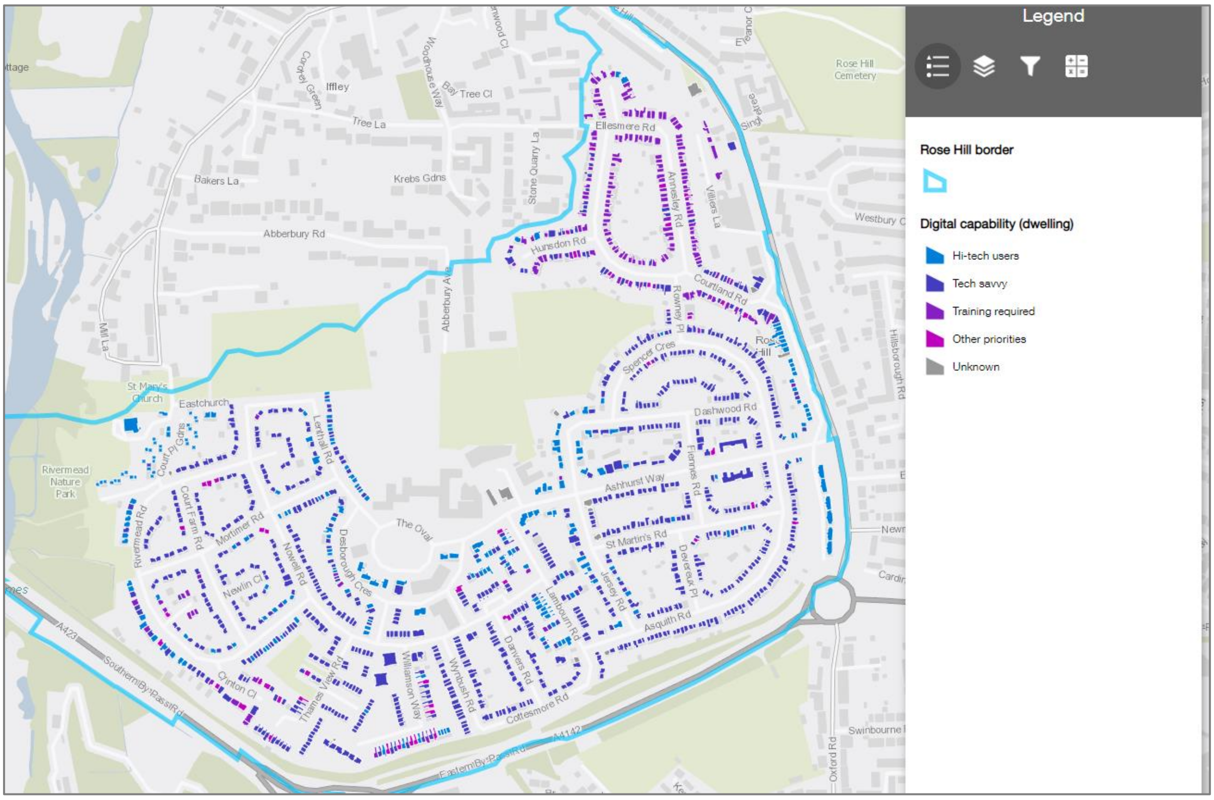


Figure 64. Target dwellings for digital capabilities (Image from LEMAP).

7.5.3 Financial capability

Financial capability (Figure 65) refers to a household's ability to invest, take some level of financial risk or access capital or funding to deploy low carbon technologies or training.

- *Happy investors* - households with ability to invest in low carbon technologies without looking for a financial return. There were 154 households identified for being happy investors.

- *Venturers* - households with access capital or funding to acquire low carbon technologies and expect some economic payback or delay of payments. There were 739 households identified for having the will to venture in investing in LCTs.
- *Penny savers* - households that depend on loans, grants or programmes to implement low carbon technologies or change life patterns towards energy flexibility. There were 732 households identified for depending on financial support to invest in LCTs.
- *Deprived* – socially or economically deprived households with priorities beyond low carbon technologies. There were 70 households identified for being financially unable to adopt any technology.

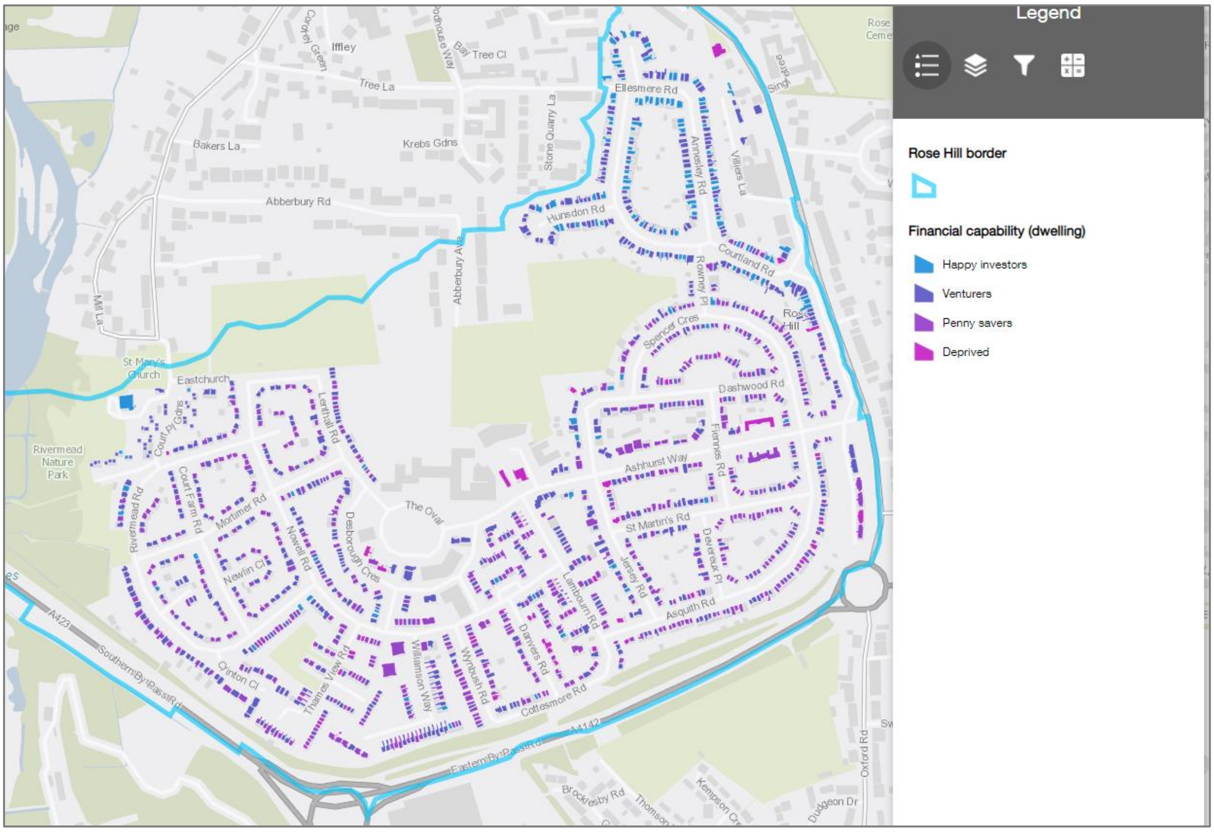


Figure 65. Targeted dwellings regarding their financial capability (Image from LEMAP).

7.5.4 Social capability

Social capability (Figure 66) refers to the household's motivation towards low carbon technologies, including the knowledge base, skills, and awareness to understand and value what these could bring to their lifestyle and the environment.

- *Fully convinced* – households that prioritise activities towards the environment, usually have or are in process of implementing low carbon technologies. There were 152 households identified as entirely convinced about implementing LCTs in their homes.
- *Motivated* - households with some interest and knowledge on the effect of flexible and low carbon technologies on the environment. There were 422 households identified as motivated about implementing LCTs in their homes.
- *Sceptic* - Households that need to be trained or guided to understand the benefits of implementing low carbon technologies or making changes in their lifestyle to flexible

energy patterns. There were 902 households identified to have doubts about implementing LCTs in their homes.

- *Not interested* - households with lifestyles that do not align with using low carbon technologies. There were only 195 households identified to have no interest in implementing LCTs in their homes.

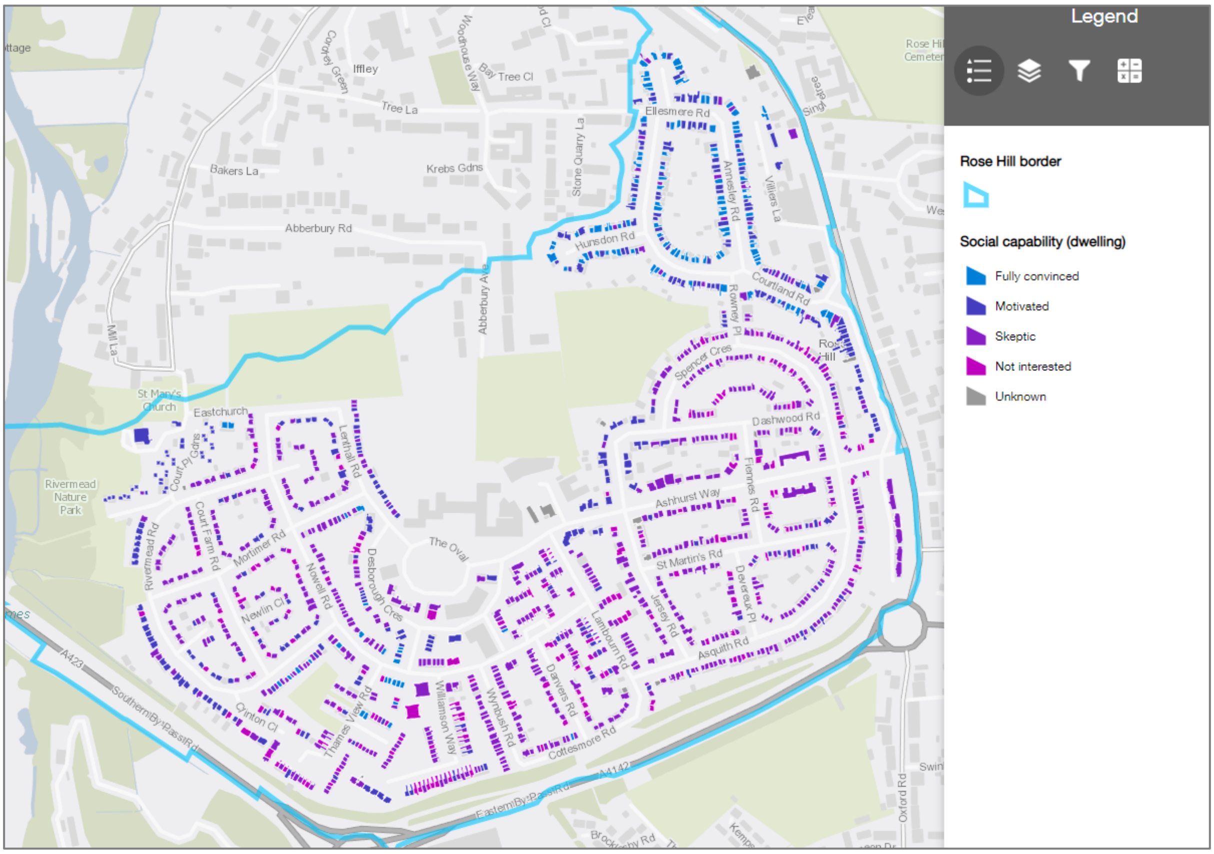


Figure 66. Target properties regarding their social capability (Image from LEMAP).

8 Summary of findings

This report has used a local area energy mapping approach to derive spatial intelligence of a local area (Rose Hill in Oxford) to provide a deeper understanding of its baseline energy use, energy resources and potential for take-up of low carbon technologies to bring local energy flexibility. This will help stakeholders such as community energy project developers, local authorities and local community groups to plan for local smart and fair energy initiatives in the neighbourhood of Rose Hill. The findings of the study are also useful for the district network operator in energy system planning.

The key findings of the study are described below:

- Rose Hill SFN is a 0.74km^2 area located in Oxford City (Oxfordshire) containing 4 LSOA, 79 postcodes and approximately 3,400 people living and working in 1,846 domestic properties (majority from interwar period) and 69 non-domestic buildings. There are 2,623 greenspaces in the case study area of which 86% are private gardens. This predominance of private gardens indicates the potential for (ground source) heat pumps.
- Historically (2015-2019), the LSOAs of Rose Hill have experienced medium-high annual electricity consumption (Ofgem classification) which is between 2,900 kWh and 4,300 kWh per property. LSOAs have experienced a reduction in electricity consumption over the past five years (2015-2019).
- Rose Hill SFN contains 1,589 standard meters in 74 out of 79 postcodes with a mean domestic standard metered electricity consumption of 3,288 kWh. The annual mean domestic electricity consumption at postcode level ranges from medium-low to high, with the highest consumption observed in OX4 4GN with 5,483kWh. Historically this postcode has had the highest consumption of the area; however, since 2015, it has seen 31% reduction in consumption.
- Historically (2015-2019), the SFN LSOAs have had a medium-low to medium-high Ofgem classification based on their domestic gas consumption, which is and has been between 8,000 and 17,000kWh. Also, the LSOAs have experience an increase in consumption in the past five years (n: 0.3%-7%). With LSOA Oxford 015E leading with a 7% increase.
- Rose Hill SFN was found to have 1,643 domestic gas meters with an annual metered domestic gas consumption of approximately 11,878kWh. It is important to note that the postcode OX4 4SH had the highest annual mean domestic gas consumption of 19,894kWh. Interestingly, this postcode has historically (2015-2019) been the highest annual mean gas consumption of the delimitated area. Besides, the majority (n: 55) of the postcodes of the SFN show an increase in their annual mean gas consumption of 0.29-852%. OX4 4GN is of special interest as this postcode alone has seen an 852% increase in annual mean domestic gas consumption from 2015 (862kWh) to 2019 (8,249kWh), with only seven more meters registered from 2015 (n: 13) to 2019 (n: 20). Highlighting these 55 postcodes as areas of research interest and possible implementation of LCTs for reducing annual gas use.
- An area of interest is the LSOA Oxford 016F with the highest annual metered domestic electricity consumption, the third-highest annual metered domestic gas consumption and the highest aggregation of the People's Power Station and ERIC project PV installation and home batteries. This LSOA also had the highest concentration of (n: 77) of fuel poor households.

- The uptake of LCT in the Rose Hill SFN is mostly centred in the LSOA 016F and specifically in eight postcodes and four neighbourhoods (Nowell road, Mortimer Rd, Dresborough Crescent and Rivermead Rd). These neighbourhoods also represent an aggregation of off-gas postcodes.
- The 2020 EPC rating indicates that 53% of the properties had a domestic EPC rating of D or bellow, while 47% had a rating of C or above, highlighting the low energy efficiency of the SFN for domestic properties. From a property type, the D rating is present in houses from the interwar age due to the thermal performance of the building fabric.
- SSEN DFES has projections for EV chargers, heat pumps and PV's for Rose Hill area:
    - The different scenarios project that 13/14 OA (output areas) areas of the SFN are estimated to have an installed PV capacity of 13,000-17,270kW. With the consumer transformation scenario having the majority of the installations with 17,270kW.
    - The different scenarios project that 13/14 OA areas of the SFN are estimated to have approximately 530-5,130 heat pump installed by 2050. With leading the way scenario having the majority of the heat pump installations.
    - The different scenarios project that the 14 OA areas of the SFN are estimated to have approximately 3,700-5,828 EV chargers installed by 2050. With leading the way scenario having the majority (n: 6,100) of the EV charger installations.
    - It is interesting to note that all three LCT DFES projections showed that the OA E00145589 will be an area of high LCT implementation.
- Based on the LEMAP filters and targeting approach, it was found that:
    - *Solar PV installations:* 790 properties were identified located in 75 postcodes of the SFN, 55% of the dwellings in the area. However, another 60 dwelling, counting for 4% of properties, could be suitable for PV installations if the EPC is improved to D rating. From the 790 targeted properties, 420 dwellings were identified as suitable for home battery installation.
    - *Ground source heat pump systems*: 300 properties (21%) in 64 postcodes were identified as suitable with 15 properties highlighted as urgent due to having electric heating systems and basements.
    - *Air source heat pump systems*: 320 properties (22%) in 64 postcodes were identified as suitable for this technology with 27 highlighted as urgent due to having electric heating systems.
    - *EV chargers*: the properties identified for PV and battery can be potentially targeted for EV chargers. However, this quantify may change once the off-street parking dataset has been acquired.

9 References

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