BURO HAPPOLD

SIF - Terraced Street Decarbonisation

PWP6 D5 – Functional specification and requirements for Alpha phase

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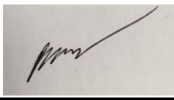
author	**James Robinson**
date	**15 June 2023**
approved	**Phil Proctor**
signature	
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Contents

Table of Tables

Table of Figures

Glossary

Term	Definition
AC	Alternating current
BESS	Battery energy storage system
BUS	Boiler upgrade scheme
CAPEX	Capital expenditure
CEMS	Community energy management system
COP	Coefficient of performance
DB	Distribution board
DC	Direct current
DNO	Distribution network operator
DSO	Distribution system operator
ENWL	Electricity North West Limited
EV	Electric vehicle
EVC	Electric vehicle charger
EVM	Electric vehicle management
GSHP	Ground source heat pump
GSM	Global System for Mobile communication
HDPE	High Density Polyethylene
HEMS	Home energy management system
HV	High voltage
LV	Low voltage
NUAR	National underground asset register
PEX	Cross-linked polyethylene
PV	Photovoltaic
SLES	Smart local energy system
SPV	Special purpose vehicle
TX	Transformer

1 System Design overview

The outline criteria for establishing system options was agreed with the partners to be:

- An affordable, replicable and scalable system approach to decarbonising terrace streets
- A system approach which can be deployed irrespective of tenure and ownership
- A system that encourages fair distribution of energy (and value) across the community
- A system that can be deployed in all urban scenarios including space constrained areas which represents a large portion of terraced communities
- A system which does not require 100% uptake, but which can be extended as required once people come on board
- A system that is able to both reduce network reinforcement requirements (vs the counterfactual of electric boilers) and also operate in areas of constraint
- A system that incentivises uptake

In appraising the potential system options including market evaluation of current solutions and innovation projects seeking to address various aspects identified, the following items were determined as relevant for the approach, many of which are inter-related:

- A package of energy efficiency measures which are affordable and will improve standard of living and reduce energy bills
- A shared heating approach which provides lower cost heating, efficiency, resilience to cold weather and can be deployed in areas of space constraint (i.e. where external heat pump installations are not possible)
- A shared energy (power) system which could fairly distribute energy, reduce tariffs, provide tariff stability and preferably form the basis of local energy economy for reinvestment into the community
- A system that can be promoted by local energy champions and enables a community-based deployment focus
- A system that could be deployed based on current market offerings, whilst accepting there may be some innovation to deliver the solution as a package
- A solution that could be supported by a commercial model that negates the need for significant upfront investment by consumers

In appraising the above further the outcome has been to develop a concept for a Smart Local Energy System (SLES) which will integrate multiple subsystem options as part of a multi-vector system (heat, power and transport) . The approach has been evaluated against current offerings including reviewing examples of similar systems that have been delivered in private wire and social housing contexts. The difference for this scheme being it is on a public network and with private ownership of buildings in most cases. The following key systems and subsystems have been explored further, in comparing against other alternative options:

Shared ambient loop heating

Shared ambient loop ground heating would appear to be the best technical solution for providing community heating in a dense urban environment with space constraints for the following reasons:

Electric boilers as the counterfactual solution are relatively cheap to buy but are significantly higher cost to run risking pushing residents into (or further into) fuel poverty. Typical boiler ratings are around 9-12kW electrical with a coefficient of performance (COP) of 1 as compared to a COP of approximately 3 for heat pumps.

Air Source Heat Pumps (ASHPs) are feasible in some terraced homes but for space constrained areas they are not possible. They are less efficient than ground source heat pumps especially in cold periods. There are limited finance options also available other than the Boiler Upgrade Scheme (BUS) as a contribution the remaining funds would be from traditional lending mechanisms.

Commercial 4th or 5th generation heat networks – may be explored by some town and city authorities in heat zones but require large commercial investment mechanisms and space to put energy centres. They typically require good heat density and anchor loads to be economically viable. They are therefore not a viable option in many cases under our model.

Energy Efficiency Measures with Building Monitoring

Part of the initial evaluation process includes an energy efficiency package with building efficiency monitoring solution. Whilst not part of the system architecture itself, it forms a key enabler to low-cost heat by ensuring the building is efficient enough to operate with a GSHP and the heating system is optimised. The building monitoring system will provide more accurate evaluation of building performance to accurately tailor the efficiency package. The system architecture will then enable operational data to be collected to measure the system performance and evaluate it against predicted performance to better inform following implementations and ensure customer value is met.

Community Energy with peer to peer (P2P) Power Purchase Agreements (PPAs)

Community energy solutions are moving on in leaps and bounds with new commercial models evolving widening the possibility of inclusion. Potential advantages of community energy schemes include:

- Community funding participation allowing local returns on investment
- Ability to raise funding to pay for CAPEX on smaller commercial schemes
- Not for profit organisations supported by volunteers who help lower operational costs and therefore overall systems costs (including lower tariffs for consumers)
- Local energy market structures can be developed recirculated local benefits and setting up community benefit funds
- Stability in energy pricing through long-term contracting mechanisms on local energy sources

These models can work in exclusivity i.e. local energy for energy demand but can also be blended into other tariff structures to meet varying energy needs.

EV local hubs

Due to the lack of off-street parking and concerns on cost of car ownership, the use of local car clubs and/or local charging hub is being explored that would directly integrate into the local energy system. One of the key issues with current market models is that those without off street parking are penalised for not having access to behind the meter rates for charging. Our solution will allow a car club or EV charging stations to access lower cost energy in return for passing lower costs to local residents who will be members of the scheme. Other tariffs can be used for other users.

Home Energy Management System (HEMS)

To optimise home energy consumption and provide flexibility to the grid if needed it is necessary to have a level of control and automation included within the home system. This potentially provides a number of services including:

- Optimise use of energy with the supply of energy to ensure lowest cost for residents
- Work within prescribed constraints of comfort required by residents and capacity on the electrical DNO network to provide flexibility which can be delivered via heat pump control and energy storage (including thermal storage)
- Provide information to consumers and the Community Management System

Community Energy Management System (CEMS)

The CEMS is a system item for managing the overall system which essentially integrates and transfers data between existing systems to permit operations. This includes for example:

- Aggregation of energy resources
- Communication with the HEMS
- Integration with 3rd party systems including Apps for bespoke services
- Communication with the DNO flexibility system
- Integration of billing and management systems

It should be noted the CEMS is not necessarily an individual system itself but is instead a set of functional requirements and governance specification and system architecture which 3rd party providers should comply with to deliver the service offering. They may elect to develop the interfaces between selected parties as part of a market offering.

Energy trading system

A system for billing and management of energy resources is required. This would integrate with the CEMS and be performed by an energy supplier. It will procure local community energy but can mix it with other energy sources as required with a view of offering competitive and stable tariffs. Its systems should be compatible with the system architecture.

Summary of system Outline design

Figure 1-1 shows outline system design for a row of terraced houses and the system is connected as shown in the high-level schematic in Figure 1-2. Section 2 describes the system in more detail.

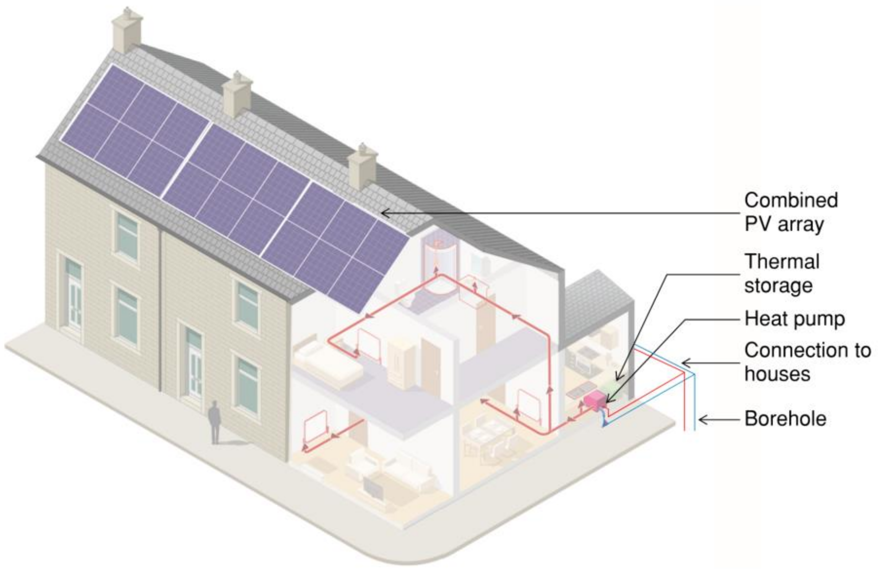

Figure 1-1 Graphic of outline system design

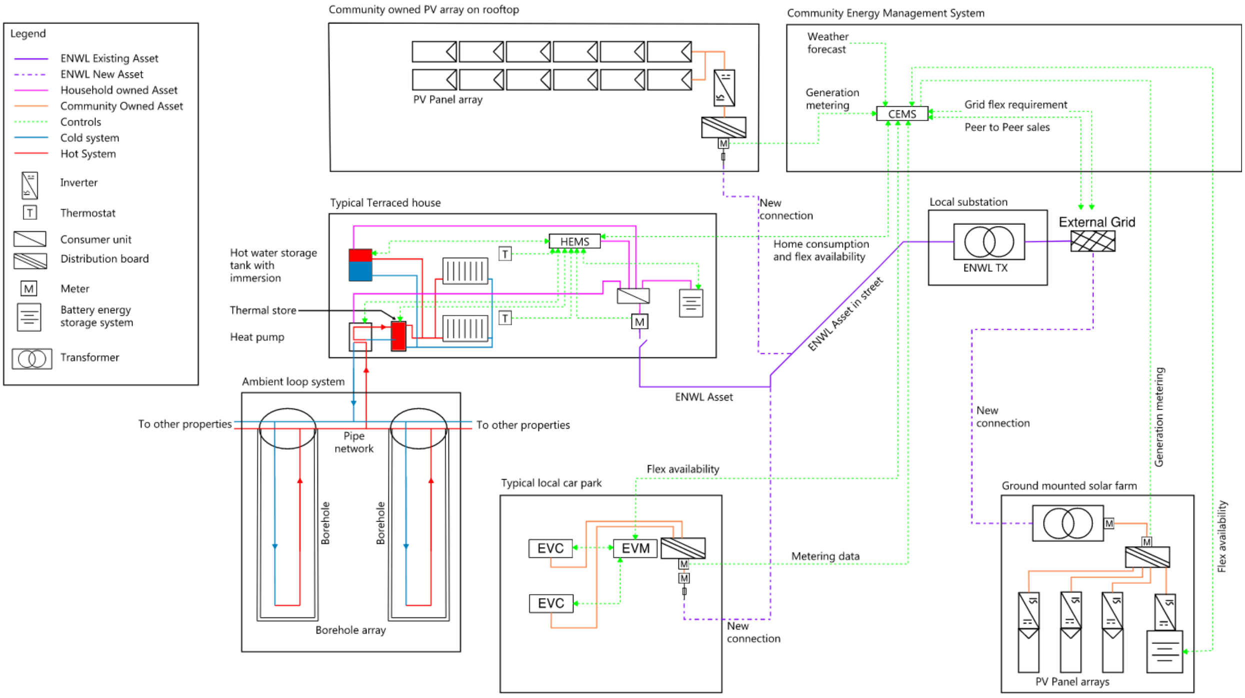

Figure 1-2 High level overall system schematic

2 System elements

The elements of the system as set out in the system design overview section are discussed in detail in the following sections.

Local electrical network

- Renewable energy system
    - Community solar PV system either rooftop mounted or ground mounted
    - Offsite renewable technologies including on/offshore wind or hydro

Domestic heating system

Storage for heat, hot water, or electricity

Electric Vehicle charging

Energy management systems

Each section has contained within it:

Systems description

Breakdown of system components in a table format including:

- Description
- Power connection requirements
- Signal connection requirements

2.1 Local Electrical Network

The electrical transmission and distribution network is used to transport electrical energy from source to consumer. The Distribution Network Operator DNO for the Rossendale area is Electricity North-West ENWL.

The DNO has the responsibility of owning and operating the existing electrical network and when new assets are added to the electrical network such as PV arrays and EV chargers, the DNO should be contacted, and a connection request submitted. The DNO will then complete calculations to ensure the connection request can continue and arrange where required any network reinforcement.

To allow the DNO's to complete their operations and maintenance, all electrical consumers pay a standing charge for network assets and maintenance through their electricity bills.

The electrical elements that make up the network are detailed below in Table 2-1.

Table 2-1 - Electrical network system overview

Item	Description	Power connection	Signal connection
Substation	Substations are the collective term for a HV to LV transformer and switchgear as detailed below	As below	As below
DNO Transformer	Transforms the AC voltage from low voltage to high voltage for distribution around the local network	Connection from grid to Switchgear	- Thermal monitoring - Capacity - Headroom
Switchgear	Includes the fuses and circuit breakers for the LV network	LV power from DNO Transformer to local LV Network	- Breaker status -
Cabling	The cabling connects between the LV switchgear and the consumers. This can be via direct connection or through jointed connections in the road. Cables can be either in ground or overhead and single or three phase	From LV Switchgear to LV consumers.	None
Cut out fuse	The cut-out fuse is designed to protect the supply cabling from overload and to provide fault protection for the installation.	Connected in line with the incoming power supply to the property	None
Smart Meter	Meters the incoming electrical power to the property for billing purposes. This is owned by the electricity supply company and not typically the DNO Communications hubs fitted to smart meters transmit consumption data Typically by GSM network in the south of England and long-range radio in the north of England	Connected in line with the incoming power supply to the property	- Electrical power consumption kWh - Electrical generation kWh

2.1.1 Network upgrades

Network upgrades can be required for a large number of reasons such as planned upgrades, increased resilience, increased load and increased generation on the network. The next couple of sections will focus on the improvements from additional generation and consumption on the network.

2.1.1.1 Generation

When renewable generation is added to the network this can register as a drop in electrical load, which in turn could cause issues of overvoltage on substations and feeders.

When a network reinforcement is triggered on the network, the way in which the costs are covered differs for domestic and non-domestic customers:

Domestic connection: This is largely paid for by the DNO and costs recovered through socialised means from all customers.

Non-domestic connection: A portion of the costs will be required to be paid by the network customer.

2.1.1.2 Consumption

Additional loads can stress the network in several places that may require reinforcement. This could happen in several places such as:

Individual connections

Feeders

Substations

The DNO will complete calculations for the network and where required will initiate network upgrades or rebalancing works which are largely pair for in the following ways:

Domestic connection: This is largely paid for by the DNO and costs recovered through socialised means from all customers.

Non-domestic connection: A portion of the costs will be required to be paid by the customer.

2.2 Solar PV System

Within the case study boundary, solar PV system will be utilised to generate local renewable energy for use throughout the SLES. The PV systems will be focussed on two areas:

Ground mounted PV

Rooftop mounted PV

PV systems use very similar equipment such as PV panels, inverters, and distribution boards however they could be on differing size scales. For example, rooftop PV systems will typically be in the order of 1 – 100kWp and ground mounted will be 100 – 2,000 MWp in size.

2.2.1 Ground mounted PV

Ground mounted PV systems can be located anywhere within the project boundary on suitable land and outside of the boundary in some cases. The large ground mounted systems allow a potential reduction in installation costs due to economies in scale vs rooftop mounted PV systems, however they will require land to mount the systems to, which could entail some land use rent costs.

Figure 2-1 - Example ground mounted solar PV system

Ground mounted systems typically connect to a DNO point of connection via a transformer for direct connection to the local distribution network for use in the local area. The overview schematic of the ground mounted PV system and its connections are shown below in Figure 2-2 and descriptions in Table 2-2.

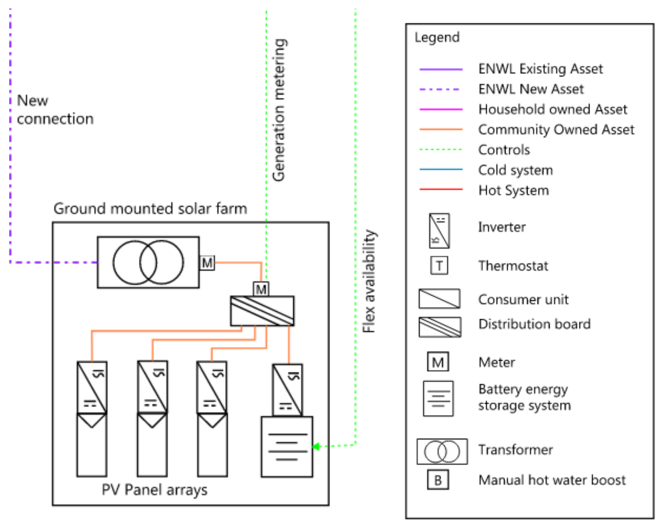

Figure 2-2 - Ground mounted solar PV schematic

Table 2-2 - Ground mounted solar PV system elements

Item	Description	Power connection	Signal connection
PV panels	Panel that converts sunlight into DC electrical energy.	Connected together to form arrays and then connected to the inverters.	None
Battery Energy Storage System BESS	Battery energy storage system that stores excess electrical energy for use at a later time	Connection from BESS to inverter	The BESS will be required to send storage information to the CEMS - Storage capacity kWh - Storage C rating (Charge and Discharge) - Storage state of discharge kWh
Inverter	Equipment to change DC power to AC power via power electronics. Typically sized to below the PV array size in the UK due to the lower volumes of sunlight.	Connected from PV Arrays or BESS to Distribution panel	The inverter will send the status of the inverter system to the CEMS to allow monitoring of the system and to log any system degradation.
Distribution panel	Low Voltage panel that collects all the AC power circuits together to distribute down a larger cable	Connection from Inverters to transformer for distribution	The DB metering system will separately meter generation and consumption and send this data to the CEMS. - Metering of generated PV energy - Metering of power used for Lighting and small power
Smart meter	Records the amount of PV energy generated for the site and sends this information to the community energy management system.	Either direct through connection or via CT's depending on size of connection	Generally GSM connection to transmit usage data to a central platform for storage and access to by approved persons
DNO Transformer	Transforms the AC voltage from low voltage to high voltage for distribution around the local network	Connection from Distribution panel to external grid	Transformer status will be sent to the DNO for monitoring: - Thermal status - Capacity - Headroom

2.2.1.1 Installation requirements

Planning requirements for ground mounted solar PV can vary largely depending on several factors:

Location

DNO network connection or private wire offtake

Type of land parcel

Environmental concerns

Resident approval

When a ground mounted system is being investigated it is important that community and planning engagement is sought to ensure any planning issues are identified early to minimise any potential design costs.

2.2.2 Rooftop mounted PV

Rooftop mounted PV systems are mounted to the rooftops of domestic and commercial buildings utilising what would have previously been unutilised space. An example of this is shown below in Figure 2-3.

Figure 2-3 - Rooftop mounted PV system example

The rooftop mounted PV system proposed would take advantage of the large roof spaces afforded by the terraced houses, to have a single large PV array rather than individual PV systems for each dwelling. The advantage of this type of system is that a combined PV system will have a larger power output from a single connection that could then be used by the residents or exported to the grid for use elsewhere.

The solar PV system could also be used to provide flexibility to the DNO or grid by reducing the requirement for network reinforcement costs by:

- Utilising power at the point of generation to limit overvoltage
- Reducing load on the local substation by shifting demand to times of generation.

The system network schematic for the proposed PV system is shown in Figure 2-4 and the contents of the PV system are outlined and described in Table 2-3.

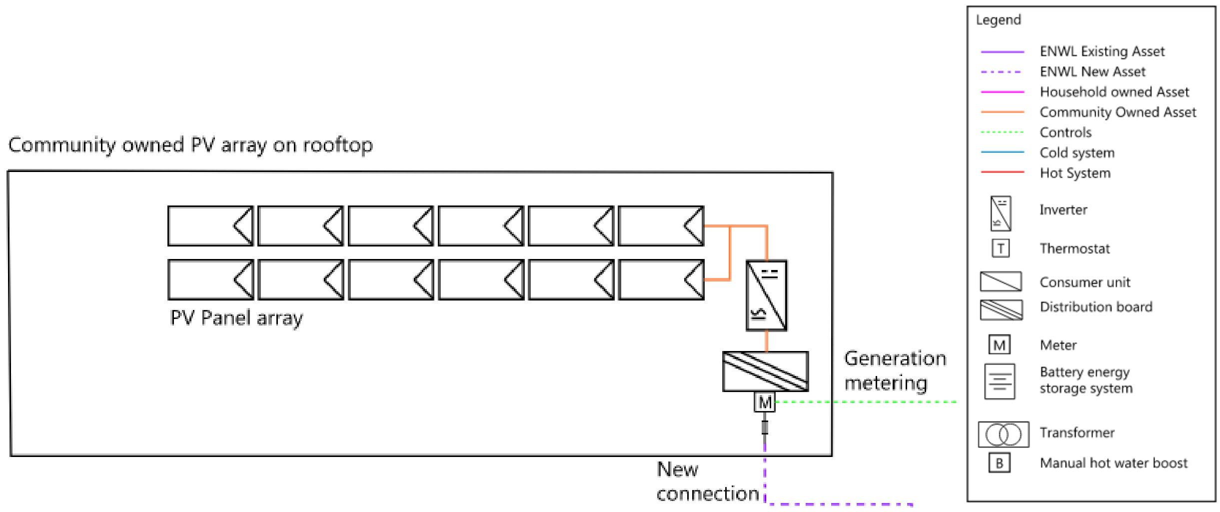

Figure 2-4 - Rooftop mounted PV system schematic

Table 2-3 - Rooftop mounted PV system descriptions

Item	Description	Power connection	Signal connection
PV panels	Panel that converts sunlight into DC electrical energy.	Connected together to form arrays and then connected to the inverters.	None
Inverter	Equipment to change DC power to AC power via power electronics. Typically sized to below the PV array size in the UK due to the lower volumes of sunlight.	Connected from PV Arrays or BESS to Distribution panel	The inverter will send the status of the inverter system to the CEMS to allow monitoring of the system and to log any system degradation.
Distribution panel	Low Voltage panel that collects all the AC power circuits together to distribute down a larger cable	Connection from Inverters to transformer for distribution	The DB metering system will separately meter generation and consumption and send this data to the CEMS. - Metering of generated PV energy - Any consumption
Smart meter	Records the amount of PV energy generated for the site and sends this information to the community energy management system.	Either direct through connection or via CT's depending on size of connection	Generally GSM connection to transmit usage data to a central platform for storage and access to by approved persons
DNO Connection	Connection to the existing DNO network for distribution to the local energy consumers	Connection from distribution panel to external grid	None

2.2.2.1 Installation requirements

Typically planning for rooftop solar PV is straightforward and is almost certainly guaranteed if the size of the array is under 3.6KWp. The exceptions to this are in the event of the application being in a conservation area in which case some specific requirements may be imposed.

Note that it is a possibility that one or more properties within the terraced street may not participate in the scheme. To mitigate this, one of the mitigations below would be required (these mitigations are in order of preference).

1. Encourage uptake through further explanation/education of the benefits
2. Encourage the resident to permit use of their rooftop to run a cable across

3. Loop cable around the property - a more complex and expensive solution which could lead to higher connection costs, should they wish to connect in the future

During conversations with ENWL it was suggested that the combined rooftop PV system would be considered as a commercial system and there could be some complexities around any costs from network reinforcements. In some areas, larger PV systems were triggering reinforcement of the network due to overvoltage presented on the grid. In these instances, it was proposed that maximum system size was investigated to ensure reinforcement costs were kept to a minimum as having to pay these costs would completely remove the financial viability of the schemes.

2.3 Building fabric improvements

To reduce carbon emissions and utility bills, focus on reducing the need for heat in buildings through a fabric-first approach is pivotal. The building fabric improvements should be assessed on a building-by-building basis as there is not a one size fits all procedure for the array of dwellings in the project boundary.

Cost-effective energy efficiency measures include draught-proofing, loft insulation, and cavity wall insulation. Additional measures to consider are interior wall insulation, roof insulation, floor insulation, and upgrading single-glazed windows to double or triple-glazed windows. Figure 2-5 to Figure 2-7 illustrate some of the potential measures.

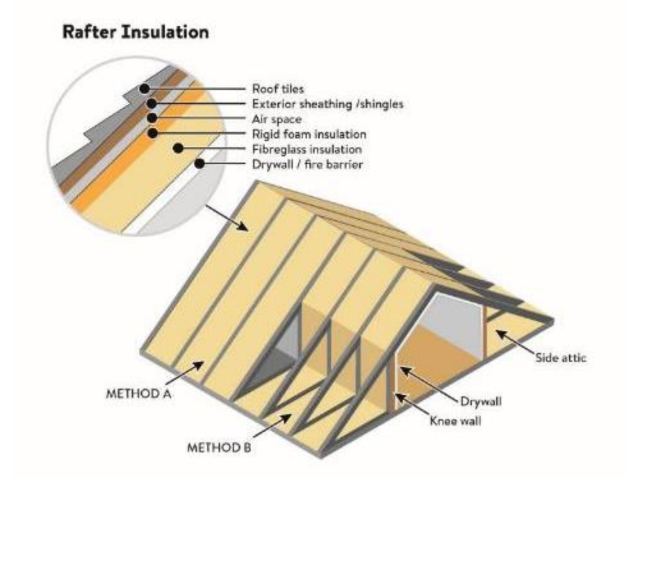

Figure 2-5 Roof insulation

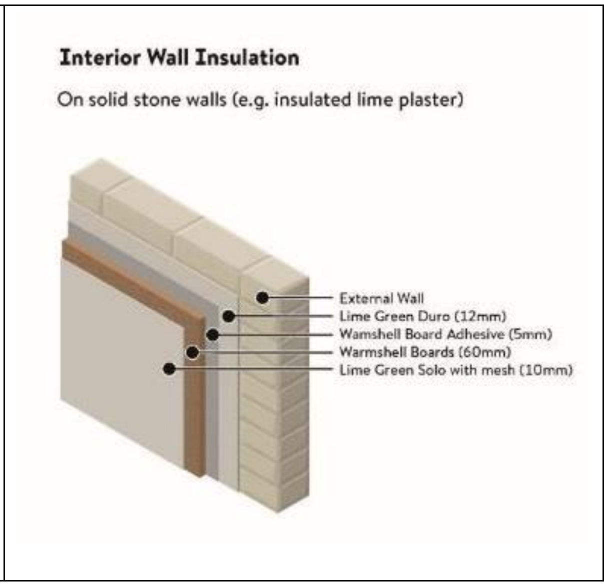

Figure 2-6 Interior wall insulation

Figure 2-7 Double and Triple-glazed windows

2.3.1 Installation requirements

Prior to implementing any building fabric improvements it is recommended that the dwellings are monitored for a period to enable correct building fabric performance to be measured, allowing the most cost-effective improvements to be calculated and rolled out. This monitoring system should be able to complete post installation building performance evaluations to ensure the fabric improvements are working as they should. This performance measurement could be completed by the HEMS when that is installed.

2.4 Heating system

The heating system will be an ambient shared ground loop system that extracts low grade heat from vertical closed loop boreholes drilled into the ground and passes this to a pipe network for distribution to the dwellings. The boreholes can be drilled into the ground where permissible and through conversations with the system installer, these could be placed in either soft ground such as grassy areas or within the road build up.

Each dwelling would accommodate a heat pump unit connected to the shared ground array. The heat pump upgrades the low-grade heat to suitable temperatures for the dwelling. Depths of boreholes are dependent on the underlying geology but typically can range from 100 – 200 m.

Figure 2-8 provides an illustration of the interconnection between the key components.

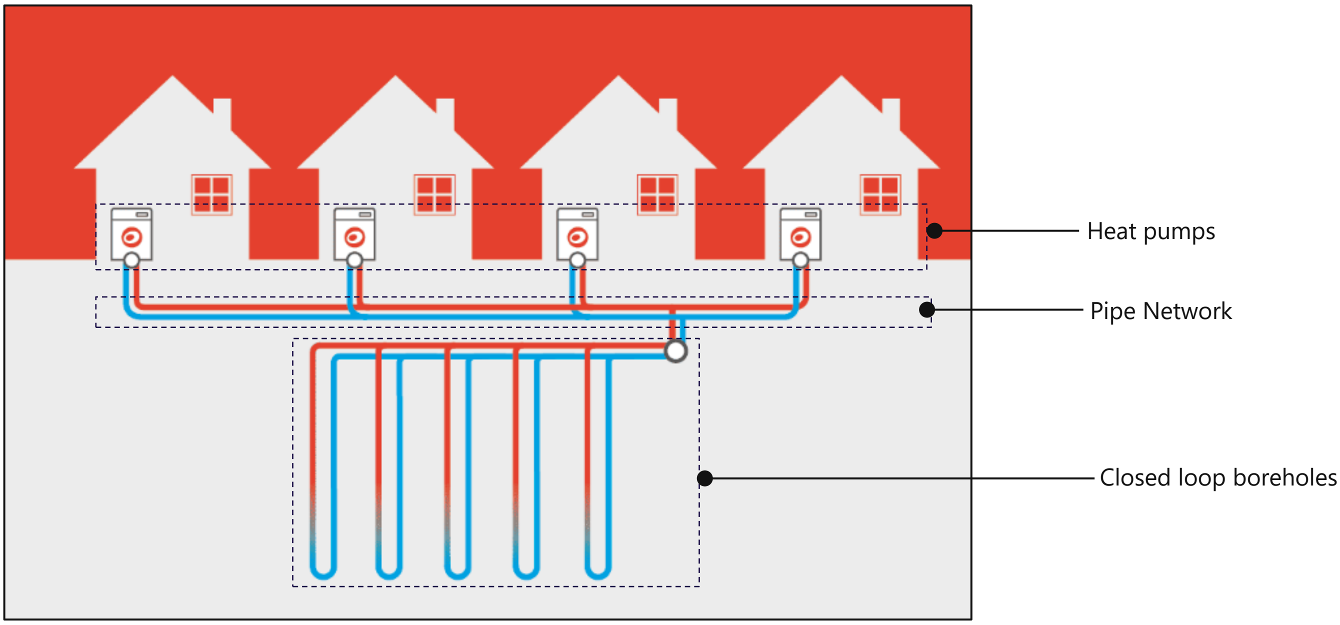

Figure 2-8 Shared ground loop system illustration[1]

Table 2-4 provides a summary of the key components that make up the shared ground loop system.

Table 2-4 Shared ground loop system key components

Item	Description	Power connection	Signal connection
Closed loop Boreholes	A closed loop borehole consists of a 110 – 145mm hole drilled between 100 – 200 m deep. A vertical U tube, made of HDPE or PEX, is inserted into the borehole which serves as a heat exchanger to extract geothermal heat. Each borehole is positioned at 5-10m intervals to allow for sufficient heat extraction all year round. Glycol/water mix is typically used as the heat transfer medium and is pumped around the	None	None

[1] Kensa (kensacontracting.com)

	borehole loops to extract heat at ~8-10°C for distribution.		
Pipe network	Typically made of HDPE or PEX, the subsurface pipe network (~0.5m below ground) is used to distribute low grade heat to individual properties.	None	None
Heat pump	A compact unit that utilises a refrigerant circuit to absorb the low-grade heat from the pipe network and upgrade it to a higher temperature using a compressor. The heat pump can deliver temperatures up to 65°C suitable for dwellings heating systems. A small buffer vessel/thermal store would be required on the delivery side of the heat pump to minimise start and stop cycling.	Single phase domestic electrical connection to power the compression and network pumps.	Connection to the home energy management system to monitor running and to allow remote fault finding and optimisation

Figure 2-9 outlines the heating system schematic.

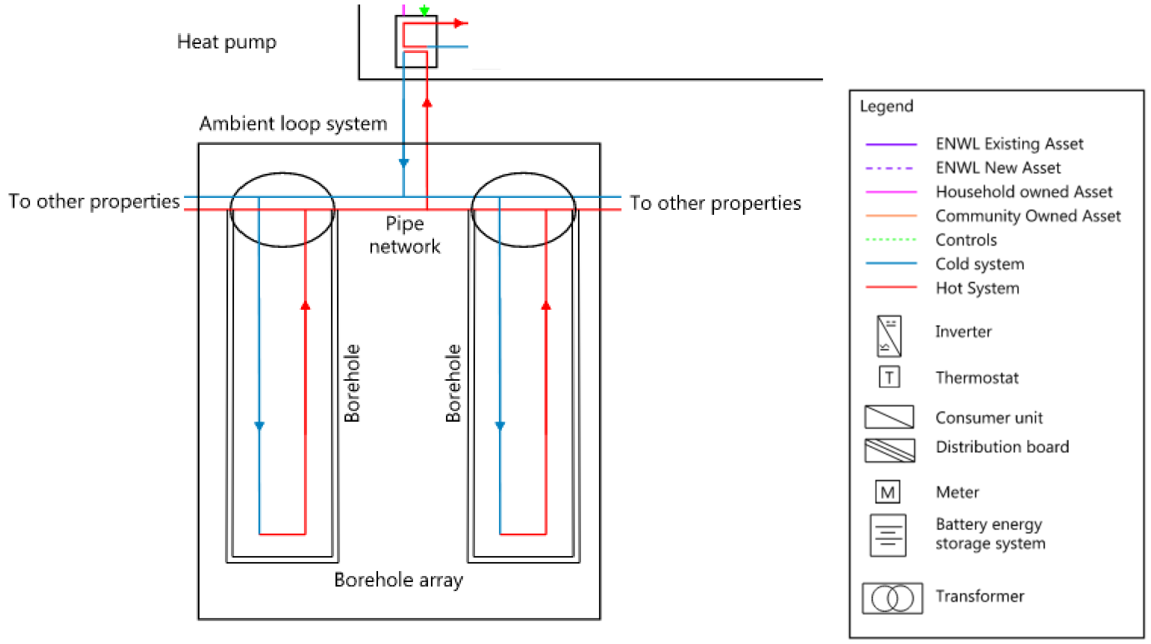

Figure 2-9 Heating system schematic

2.4.1 Installation requirements

Boreholes can be placed either within publicly available land or within the road network close to the dwellings. Planning will be required to enable drilling of the boreholes and installation of the pipe network into the local public domain. To enable the planning process to start, in ground services drawings should be acquired from one of the following sources:

National underground asset register [2] (NUAR) when available

Line search before you dig [3]

External civils contractor that can compile the information for relevant areas.

2.5 Domestic Energy Storage

Storage systems will be utilised in the domestic system to store heat, hot water and electricity. The storage will allow dwellings to:

Store hot water for when it is needed

Reduce peak demands – Thus reducing network demands

Utilise excess generation – Thus reducing network overvoltage issues

Provide flexibility services to the DNO/DSO to reduce consumption or absorb generation as required by the grid

The domestic energy storage schematic is shown in Figure 2-10 with example system images shown in Figure 2-11 to Figure 2-13.

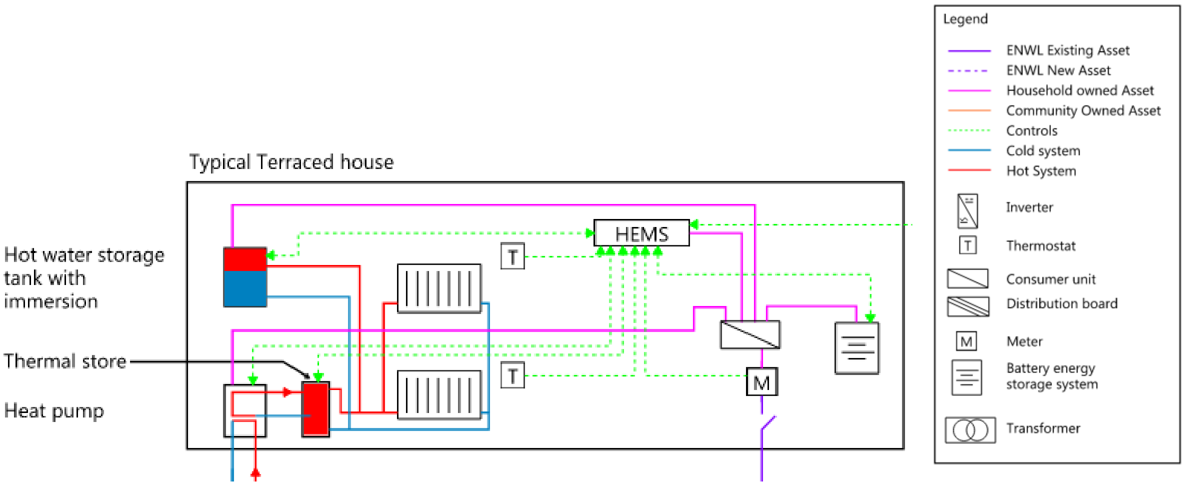

Figure 2-10 Domestic energy storage schematic

[2] https://geospatialcommission.blog.gov.uk/2023/04/05/nuar-available-to-users-in-first-uk-locations/
[3] https://lsbud.co.uk/

Figure 2-11 Example hot water storage

Figure 2-12 Example thermal storage

Figure 2-13 Example battery energy storage

Descriptions and connection details for the storage systems are outlined in Table 2-5.

Table 2-5 - Domestic energy storage

Item	Description	Power connection	Signal connection
Hot water storage	Hot water storage tank design to store the required hot water for a dwelling. This adds resilience to the network as an immersion can be used in case of heat pump failure	Typically 3 kW immersion for resilience connected from the consumer unit through fused spur	The storage tank will update the HEMS the following information: - Storage capacity kWh - Storage state of charge kWh - Target capacity fulfilment time - Immersion availability (Yes/No)
Thermal storage	Thermal store that can absorb heat from the heat pump to be used when ready. This allows highly efficient heat to be generated during the day when PV capacity is available for use when required	None	The thermal store will update the HEMS the following information: - Storage capacity kWh - Storage state of charge - Target capacity fulfilment time
Battery energy storage	Battery energy storage unit that can store electrical energy during times of high generation or cheap purchase for use when low PV generation is not available, or tariffs are at a premium.	Typically 3 kW connection from consumer unit through a fused spur to the battery controller	The battery will update the HEMS the following information: - Storage capacity - Storage C rating (Charge and Discharge) - Storage state of charge

2.5.1 Installation requirements

It is expected that in line with the current use of combi boilers, many properties have converted previously allocated hot water cylinder space into more habitable space within dwellings and thus each dwelling will need to be considered on a case-by-case basis to establish what systems can be installed due to spatial restrictions.

2.6 Electric Vehicle (EV) charging

The largest sector contributing to carbon emissions in the UK is the transport sector[4]. The country is in the process of shifting from the use of internal combustion engines to electric vehicles (EV's) which when using renewable energy will be decarbonised. To assist with the rollout of EV's, and to reduce the risk of range anxiety, better charging infrastructure is required across the country to enable cars to re-charge.

To enable those without dedicated parking bays to access EV charging at rates comparable to having a dedicated charger EV charging will be installed within local car parking areas and connected to the grid via a DNO connection. The charging mechanism should be such that the power from the local PV systems could be utilised at reduced rates.

2.6.1 EV Charger

EV chargers are static infrastructure that act as the connection interface between an EV and the electricity network allowing the batteries to re-charge. The network schematic in Figure 2-14 shows the connection from the DNO connection to the EV chargers via a distribution board. The EV chargers will be monitored and controlled via the EV charge management system detailed in section 2.7.4.

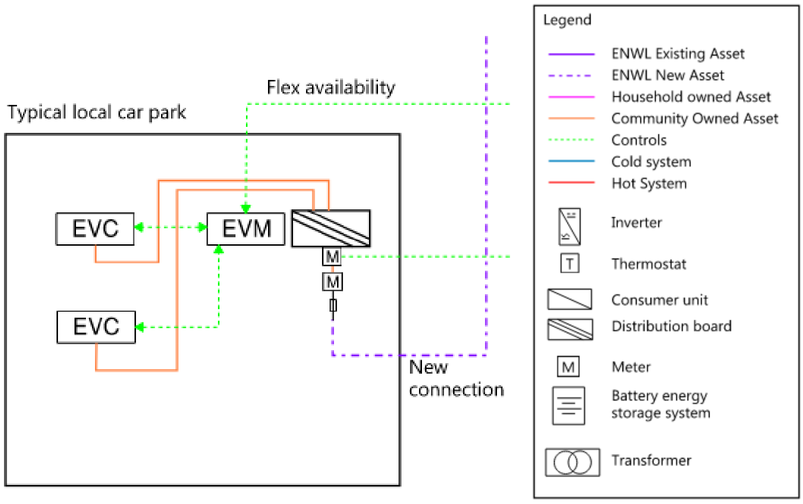

Figure 2-14 EV charging schematic

The chargers come in multiple forms and vary in size, shape, and power ratings and example of these are shown in Figure 2-15 to Figure 2-17.

Figure 2-15 Example public carpark charger

Figure 2-16 Example standard in-street EV charger

Figure 2-17 Example lamppost retrofit in-street EV charger

[4] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1135950/DUKES_2022.pdf

Some of the typologies applicable for terraced housing in Rossendale are shown in Table 2-6. Note that some terraced streets may not be located within a reasonable distance to a public carpark and therefore in-street chargers has also been included.

Table 2-6 EV chargers

Item	Description	Power connection	Signal connection
Public carpark chargers	EV chargers can be installed in public carparks to aim to offer electric vehicle owners a convenient and easily accessible solution for recharging their vehicles. They are typically situated at or between dedicated parking spaces	Typically < 400kW from the local DNO connection via suitably sized switchgear	Connection from the EV charger to the EVM - Charger availability - Charger usage statistics ○ Current power output kW ○ Duration of charge Seconds ○ Charge used kWh ○ Time of day of connection ○ Duration of connection minutes
Chargers in small land parcels	Where suitable, small land parcels could be converted into a small car park with designated charging points	Typically < 400kW from the local DNO connection via suitably sized switchgear	Connection from the EV charger to the EVM - Charger availability - Charger usage statistics ○ Current power output kW ○ Duration of charge Seconds ○ Charge used kWh ○ Time of day of connection Duration of connection minutes
Chargers in private land (with access)	Provided permission is granted and there is sufficient accessibility, private land such as existing supermarket carparks could be allocated EV charging points	Typically < 400kW from the local DNO connection via suitably sized switchgear	Connection from the EV charger to the EVM - Charger availability - Charger usage statistics ○ Current power output kW ○ Duration of charge Seconds ○ Charge used kWh ○ Time of day of connection Duration of connection minutes
In street chargers: standard	Where suitable, new EV charger connection points can be installed within the street	Typically 7kW, 11kW, or 22kW from the local DNO connection via suitably sized switchgear	Connection from the EV charger to the EVM - Charger availability - Charger usage statistics ○ Current power output kW ○ Duration of charge Seconds ○ Charge used kWh ○ Time of day of connection ○ Duration of connection minutes
In-street chargers: lampposts/bollards	Where suitable, new lampposts and bollards can be installed or existing ones can be retrofitted to incorporate an EV charging socket, reducing infrastructure intrusion. Infrastructure intrusion is a significant factor to be considered as many terraced streets have kerb-side parking	Typically <5kW from the local DNO connection via suitably sized switchgear	Connection from the EV charger to the EVM - Charger availability - Charger usage statistics ○ Current power output kW ○ Duration of charge Seconds ○ Charge used kWh ○ Time of day of connection ○ Duration of connection minutes

2.6.2 Installation requirements

Locations should be found to mount the EV chargers where they can be used by the greatest number of residents. EV charging locations outside of residences should be avoided to minimise the potential of the EV charger being blocked out for use by the resident.

Connections to the DNO network should be via a connection request to ensure capacity is available on the network and to ensure any power quality issues are avoided.

2.7 Energy management

To enable the best use of energy within the project boundary, energy management systems will need to be incorporated that can monitor electrical supplies and control storage, generation, and consumption. These energy management systems will be within the home (HEMS), community (HEMS) and EV charging (EVM) boundaries and are discussed in the following sections.

2.7.1 Home energy management system (HEMS)

The home energy management system as the name suggests will collect all the in-home system information and control the required equipment to ensure an efficient house. Figure 2-18 shows an example home energy management system schematic with connections to the monitored and controlled equipment.

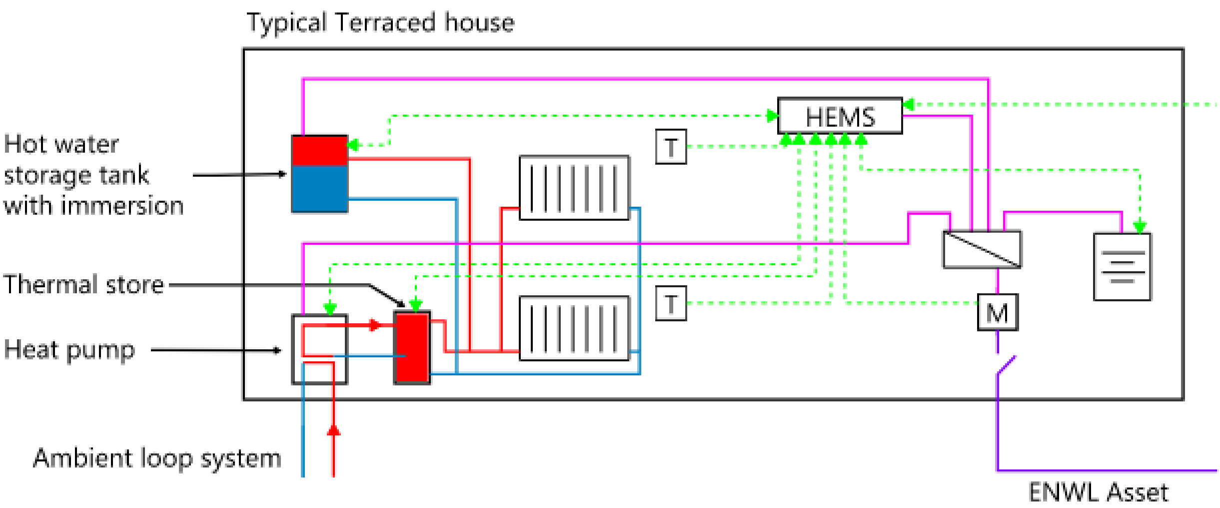

Figure 2-18 - Home energy management system

The elements of the home energy management system are detailed below in Table 2-7.

Table 2-7 - Home energy management system description

Item	Description	Power connection	Signal connection
HEMS	Monitors and controls the dwelling heating, hot water storage, thermal storage and battery storage.	13 A fused spur connection from local consumer unit	- Internal signals from the home for the thermostats, heat pump, thermal storage, hot water storage, and battery storage systems. - App connectivity to allow adjustment of heating and power availability parameters to resident requirements. - Monitoring of the incoming electrical meter to monitor on site power consumption. - Input signals from the CEMS for required flexibility. - Perform post installation energy monitoring to inform building fabric performance
Hot water storage	Hot water storage tank design to store the required hot water for a dwelling. This	Typically 3 kW immersion for resilience connected from the	- Storage capacity - Storage state of charge - Target capacity fulfilment time

	adds resilience to the network as an immersion can be used in case of heat pump failure	consumer unit through fused spur	- Immersion availability
Thermal storage	Thermal store that can absorb heat from the heat pump to be used when ready. This allows highly efficient heat to be generated during the day when PV capacity is available for use when required	None	- Storage capacity - Storage state of charge - Target capacity fulfilment time
Battery energy storage	Battery energy storage unit that can store electrical energy during times of high generation or cheap purchase for use when low PV generation is not available, or tariffs are at a premium.	Typically 3 kW connection from consumer unit through a fused spur to the battery controller	- Storage capacity - Storage C rating (Charge and Discharge) - Storage state of charge

2.7.2 Installation requirements

The home energy management system could be installed in the premises of the controlled equipment or could be a cloud-based system that the controlled devices connect to for monitoring and control.

The physical device would need to have a form of connectivity to allow signals to be sent to and from the device to the internal/external devices.

2.7.3 Community energy management system (CEMS)

The Community Energy Management system is a subsystem which primarily represents a governance and systems interfacing approach to existing systems to permit the optimisation and management of the system as a whole. It is intended to enable the monitoring, control and flexibility services for the asset integration and integration to other third-party systems. Many existing aggregating platforms will have most of this functionality already in place and only limited bespoke interface requirements may be required which shall be identified in further interactions of the system architecture and subsystems identified above.

The schematic connections of the system are shown in Figure 2-19 and the system description in Table 2-8.

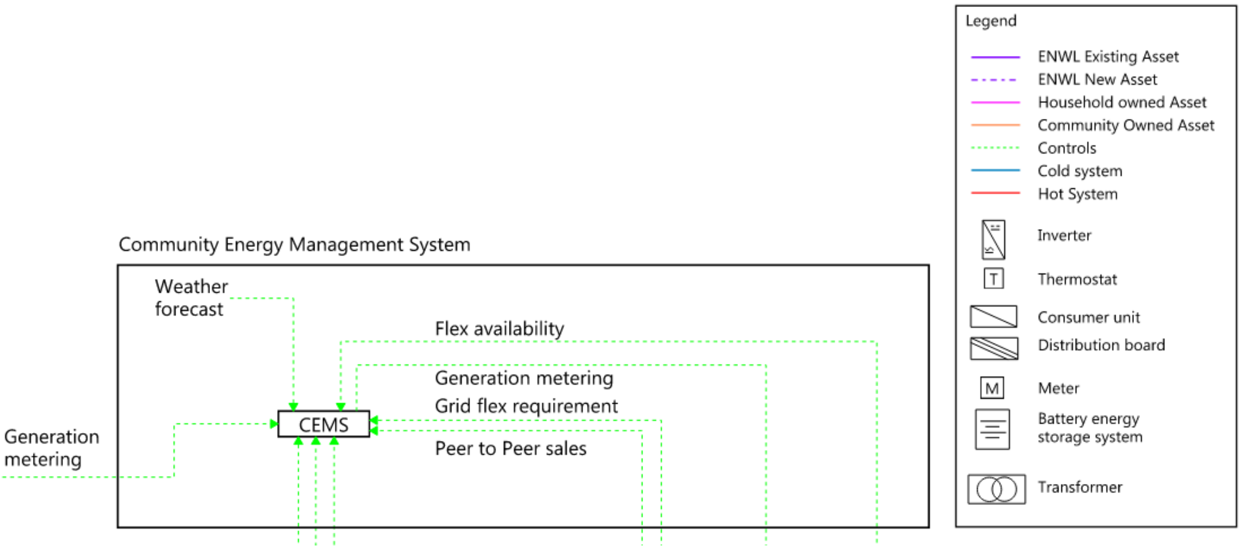

Figure 2-19 - Community Energy Management system schematic

Table 2-8 Community Energy Management System description

Item	Description	Power connection	Signal connection
CEMS	Potentially cloud based or physical system. Monitors and controls the generation, storage and flexibility assets within its project boundary.	Depending on physical location.	The system takes signals from the following entities: - PV monitoring - Weather forecast - Home energy management system - EV charge management system - External grid for flexibility requirements - Peer to peer sales platform to establish the best tariffs The system can issue control signals to the following entities: - Home energy management system to perform flexibility - EV charge management system for flexibility - PV and energy storage for flexibility

2.7.4 EV charge management

Whilst section 2.6.1 discusses the physical system and connection process of EV charging, the following summarises the potential management options for EV charging being explored:

3rd party provided chargers

The system considers the potential options for charging by a 3rd party charger provider which could install systems in available spaces such as lamp posts or leased land and then provide a charging facility. This can include an app specially tailored to local users.

Car club

A local car club could be made available to users who rent cars for short amounts of time. The car club would have its own chargers and would be encouraged to integrate these with the CEMS and utilise locally sourced energy as well as providing preferential tariffs to the local community

Community owned charging

A community SPV can be established which provides charging facility to local consumers e.g. using a community leased land or ownership agreement. The charges can be operated by a third party or the SPV depending on the preferred model with local tariffs for the community.

Public charging

The local authority can provide a charging facility which may be contracted to a third-party provider and would be encouraged to provide local community tariffs and set up an energy supply arrangement via the CEMS.

The schematic connections of the system are shown in Figure 2-20 and the system description in Table 2-9.

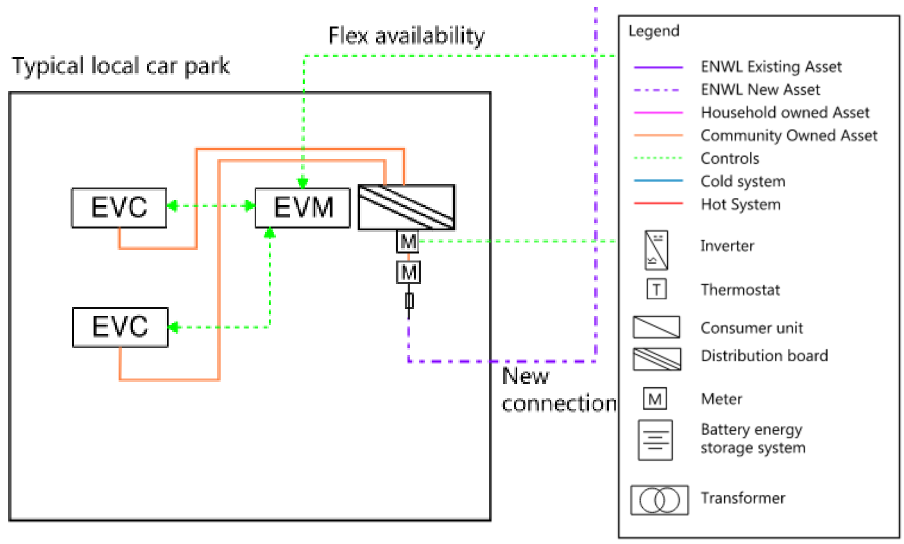

Figure 2-20 EV management system

Table 2-9 EV Charge management system

Item	Description	Power connection	Signal connection
EVM	Physical device or software system to monitor and control the EV chargers	Depending on physical nature of device or cloud-based package	- App connectivity to allow consumer use of charger Connection to CEMS - Available capacity kWh - Available connection size kW - Available duration (Seconds) - Grid flexibility requirement - Available tariff structure Connection to EV charger - Charger availability - Charger usage statistics o Current power output kW o Duration of charge Seconds o Charge used kWh o Time of day of connection - Duration of connection minutes

3 Requirements for Alpha stage

The following steps are recommended for inclusion in the Alpha stage to build on the work done under the Discovery phase:

1. Further develop the reference architecture including developing the outline governance and interface requirements and ensuring alignment with commercial models
2. Set up partnership arrangements with new partners (Kensa, Urban Chain and University of Salford) to further develop their subsystem solutions and obtain learning from existing offerings.
3. Further develop the technical solution based on the reference architecture including interfaces to the DNO(s)
4. Continue to explore potential providers of subsystems and interfaces in the market (e.g. HEMS and aggregating platform providers) as well as learnings from existing projects and product offerings that appear to be applicable
5. Offer the opportunity to selected subsystem providers to participate in testing and evaluation of their systems
6. Develop a secure environment for subsystem testing to ascertain whether proposed systems offerings are valid (with University of Salford) . This will derisk any offerings before going into consumers' homes
7. Explore data utilisation and integration opportunities into the consumer journey e.g., use of the Fairer Warmth App
8. Implement a process of sample home energy performance monitoring to ascertain far more accurately the performance of the terrace homes in the area and better predict the need for efficiency measures vs heat pump sizing (and corresponding number of boreholes)
9. Develop a more accurate energy model that will predict system performance and determine operating parameters and the capability to deliver flexibility to the DNO within established comfort constraints (a comfort constraint being minimum level of comfort assured for residents).

James Robinson
Buro Happold Limited
Camden Mill
Lower Bristol Road
Bath
BA2 3DQ
UK

T: +44 (0)1225 320 600
F: +44 (0)870 787 4148
Email: James.Robinson@Burohappold.com