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SMILE

Smart Island Energy Systems

Deliverable D2.1

Schematic and technical description of Orkney DSM system architecture

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Terminology and abbreviations

Algorithm: suite of algorithms connected to Smart Charging System (SCS) to determine the need and capability of smart charging and to suggest execution of Charge profiles.
ANM: Active Network Management
API: Application program interface; a set of routines, protocols, and tools for building software applications. An API specifies how software components should interact and for programming graphical user interface (GUI) components.
BESS: Battery Energy Storage System
CES: Community Energy Scotland
Charge profile: profile for Electric Vehicle (EV) charging in terms of time and energy absorbed by the vehicle.
CLC: Connection programmable logic controller
Connector: plug into the Electric Vehicle Supply Equipment (EVSE)/Charge station or point, to which the User plugs in the cable from the EV.
CoP: Coefficient of Performance
CPBO: Charge Point Back Office, the system component controlling the EVSE.
DNO: Distributed Network Operator
DSM: Demand Side Management
EMEC: European Marine Energy Centre
ERE: Eday Renewable Energy
EV: Electric Vehicle
EVSE: Electric Vehicle Supply Equipment, the EV Charge Point or Charge Station.
GUI: General User Interface, mostly referring to Driver App, or Web Portal
HSO ltd: Heat Smart Orkney Limited (Rousay Egilsay, and Wyre Development Trust (REWDT), wholly-owned subsidiary set up to administer and manage the Heat Smart Orkney (HSO) project)
HSO: Heat Smart Orkney (project)
LV: Low voltage. In the context of the Orkney Distribution grid <11kVolts.
MQ: Message Queue used to connect system components and track all communication between system components.
OREF: Orkney Renewable Energy Forum
PDI: Process Data Interface
PLC: programmable logic controller
REWDT: Rousay, Egilsay, and Wyre Development Trust
REWIRED: Rousay, Egilsay and Wyre Islands Renewable Energy Development Ltd (also wholly owned trading subsidiary of REWDT)
RM: RouteMonkey
SCADA: Supervisory control and data acquisition
SCS: Smart Charging System. The key component of the smart charging architecture which directs the CPBO and EVSEs based on inputs from the Algorithm.
SGS: Smarter Grid solutions
SnT: Surf ‘n’ Turf project
SSEN: Scottish Southern Energy Networks (DNO in Orkney)
User: end user of a system, mostly referring to EV driver, but can also be operator, maintenance, etc.
VC: VCharge
VCCC: Vnet Cloud Control Centre
VPN: Virtual Private Network
VScon: VCharge SCADA Connect
WTG: Wind Turbine Generator

1 Introduction

1.1 Disclaimer

This document is an output of what has been developed in the first 7 months of the project, so is subject to revisions, changes and improvements as the partners involved with the delivery of the demonstrator further define project details over the coming months. It is no means a finalised document for the final system installation.

1.2 Scope and Objectives

This document will explain the background to the SMILE Orkney demonstrator project; and look forward to what the demonstrator will set out to achieve in the proposed DSM system. This report, forming D2.1, describes the overall design concept and architecture of the Orkney Demand Side Management (DSM) system. The report will particularly include a technical description of the DSM system architecture along with schematics; to include the basic interaction and interfaces of the system components, with input from all participating partners in WP2, as well as specialist subcontractors.

Within this framework, the main objective of the Orkney pilot project is to demonstrate ways to transform the existing semi-smart grid system (management of generation only) into a fully smart system (management of generation and demand), by using existing grid infrastructure and integrating new communications and control systems, as well as new controllable energy demand for heat and transport.

Accordingly, the regional demonstrator will involve the integration of demand side response and management, energy storage, and low-carbon heating and transport, across two independent but integrating aggregation platforms, with an operational smart grid. By adjusting their individual and combined demand, the actively managed loads will locally react to the existing active management of local grid export of generation. The aim is to prevent generators from having their output restricted due to grid restrictions, at times and in areas where energy could actually be harnessed or stored when needed. The vision is to turn the existing necessary management of grid limitations into an opportunity to intelligently and locally use the abundance of renewable electricity available to meet local heat and transport needs.

1.3 Structure

Section 2 introduces Orkney and the context of where the SMILE demonstrator will be operating inside the ANM scheme already in operation by the DNO.
Section 3 includes the new system architecture, going one-by-one through each of the types of demand (domestic heat, EV's and the industrial load). Each demand type has a description, the architecture overview, the hardware and software requirement as well as partner technologies. The end of each sub-section also includes a summary of key data collection and parameters for technical and operational analysis in the project.
Associated information relating to relevant legislation, grid codes, markets and policy etc. are excluded from this report as they will be covered separately through their own work streams and deliverables under work packages 5-8.
Section 4 includes some information about the participant recruitment process, looking forward to the next step after the technical system architecture set up.

The final section, 5, concludes the report by summarising some of the key outcomes and the next steps.

1.4 Relationship with other deliverables

The system architecture established in D2.1 will feed into the system modelling, as well as development of the VCharge and Route Monkey algorithms and platform set up. This is fundamental to having the 'brains' to be able to control the demand smartly, especially with multiple types of technology and working in response to curtailment signals.
After confirming the architecture, the next tasks in parallel are the participant recruitment and D2.3. As the system and details have been clarified, the details of what information needs to go out to householders and EV owners is better defined.

1.5 Partner contribution

The SMILE partners that have contributed to this document include:

- CES are WP2 package leader and are responsible for the overall project management and delivery of the Orkney demonstrator site. They have created and provided the overall and integrated architecture and diagrams, have been co-ordinating input from the other partners for this deliverable as well as the background information.
- VCharge are a partner supplying DSM tools including the dynamos and an aggregator platform to the project. They will gather signals from the local generation, along with other forecasting, to control local demand via the dynamos connected to sources of heat and EV demand. VCharge have been working in Orkney with CES and the local community generators since early 2014, looking at how local demand can be controlled to facilitate increased renewable energy generation in Orkney. VCharge have provided detailed local system architecture diagrams, based on how they will control each source of demand with their platform.
- Sunamp are a partner supplying equipment (Phase Change Material (PCM) heat batteries for domestic heating and hot water) to the demonstrator site for the domestic heat installs. They have provided technical details of their systems and support in the system architecture diagrams.
- LiBal are a partner supplying batteries and the battery management system to the project, being used for the domestic heat installs. They have provided technical details of their systems and support in the system architecture diagrams.
- Route Monkey are a partner with a focus on optimising the EV charging side of the controllable demand. They have contributed to the architecture diagrams with VCharge by adding knowledge about how their back offices will communicate with each other. The Route Monkey platform will offer the predictive behaviour algorithms to do the smart charging of electric vehicles alongside VCharge's aggregator platform.
- AAU and RINA consulting are not in the core WP2 team but have been included in the deliverable as a reviewer for submission purposes.

2 National and Regional Considerations

This section looks at the background to the situation in Orkney, which helps put into context the significance, aims and rationale about the approach taken in the SMILE project; in particular working within the boundaries of the existing Active Network Management (ANM) scheme in operation in Orkney.

2.1 Overview of the Orkney Grid and ANM

The Orkney distribution network is connected to the Scottish mainland network via two 33kV submarine cables. SSEN (Scottish and Southern Energy Networks) are the DNO for the area, as well as the rest of the north of Scotland, Figure 1. This allows generators in Orkney to export, electricity to the Scottish Mainland as well as importing when there is no generation. Within Orkney, there are smaller 11kV and LV circuits going to the North Isles and the Orkney mainland.

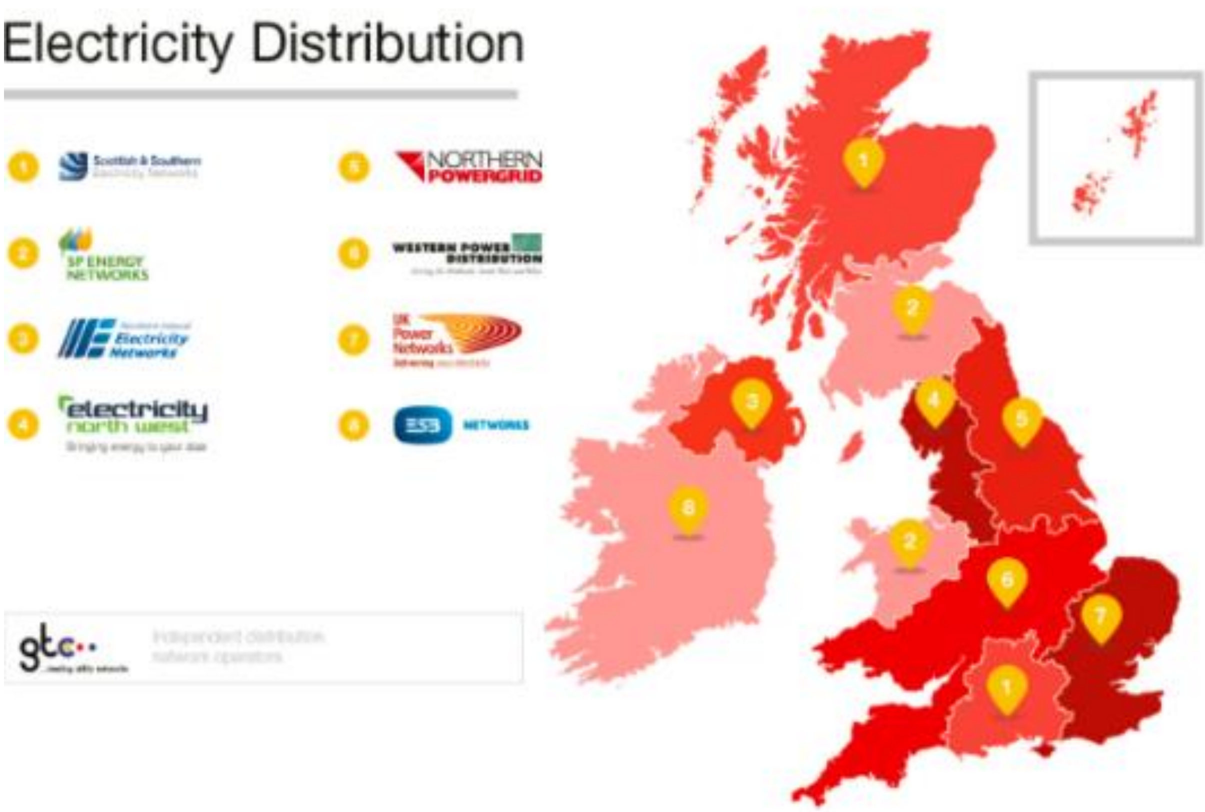

Figure 1: DNO's UK wide[1]

The Sankey type diagram (Figure 2) illustrates the energy sources and main areas of consumption within Orkney. It shows the different fuel sources as bars in the middle of the diagram. The size of each of the bars is proportional to the total amount of energy for either the fuel (green bars in the middle), end use (blue bars on the right) or sector (red bars on the left). The width of the arrows is also proportionally energy flow.

[1] http://www2.nationalgrid.com/UK/Our-company/Electricity/Distribution-Network-Operator-Companies/

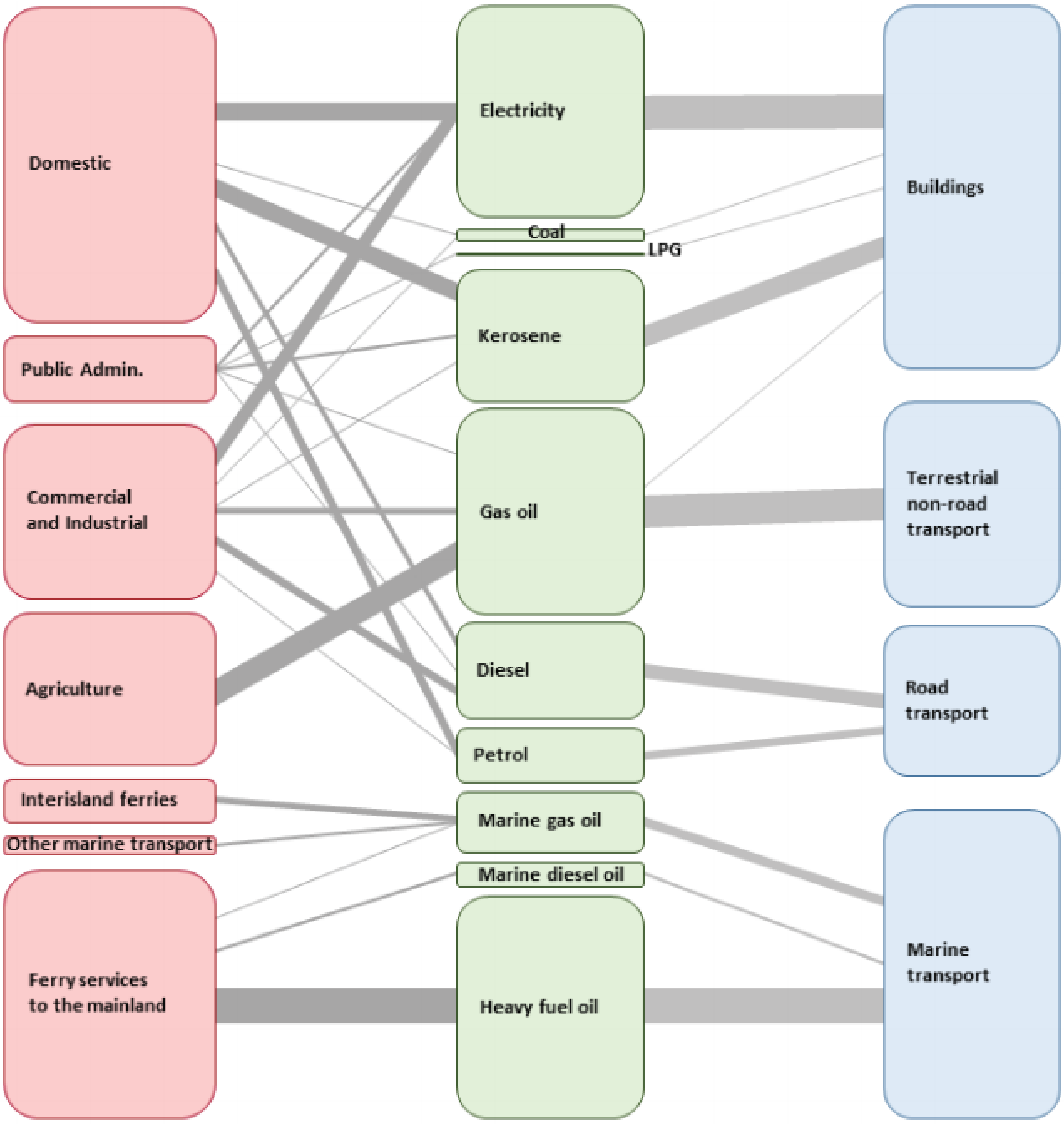

Figure 2: Sankey diagram[2]

The total renewable energy capacity installed is around 57MW. Most of this is from wind energy, as well as some others from solar, biomass, tidal and wave. The winter peak demand is 34MW (Figure 3). Orkney still imports significant amounts of fossil fuels for domestic heating, transport (road, marine, air) and industry.

[2] OREF Orkney Energy Audit 2014 (http://www.oref.co.uk/resources/orkney-energy-audit/)

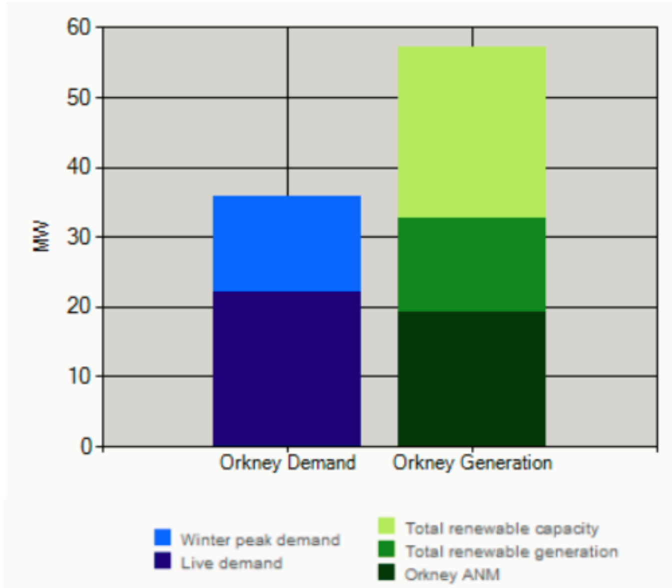

Figure 3: Orkney demand and generation (from live updates, taken on 27/11/2017 15:22:28)[3]

Most of the wind energy was installed in 2005-2014 (Figure 4) while individuals, businesses and communities made the most out of the government incentives at the time: Feed in Tariffs (FiTs) and Renewable Obligation Certificates (ROCs), see section 2.1.1 for more details. April 2015 was the last month where the Islands required a net import of electricity, with 2016 seeing Orkney producing approximately 120% of its electricity needs from wind.

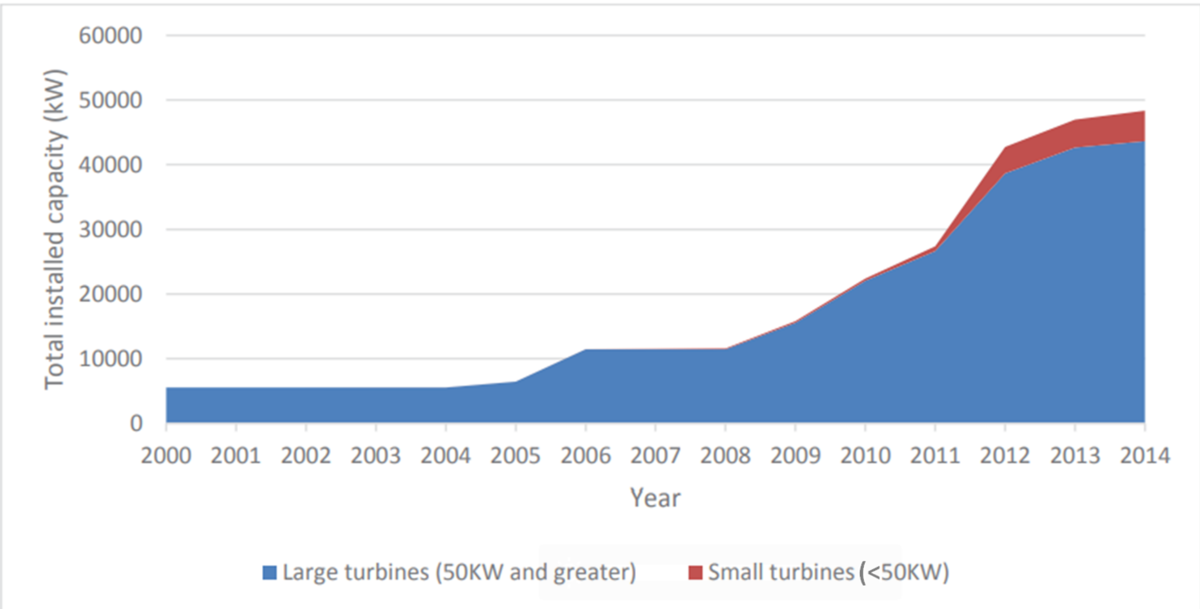

Figure 4: Total installed capacity of all turbines in Orkney

[3] http://anm.ssepd.co.uk/

In 2009 an ANM system was set up which allowed generators to connect to the grid without substantial upgrades. The ANM system operated by the DNO SSEN, and designed by Smarter Grid Solutions (SGS) is frequently referenced to as a successful deployment of ANM in the UK. Before the deployment of ANM, Orkney was restricted in its ability to integrate more renewable generation due to the 33kV cables going to the mainland being at capacity. Against a conventional reinforcement cost of £30 million to install a new submarine cable, the £500,000 ANM scheme uses real-time automated controls to manage generation output while taking into account the export capacity at key bottlenecks within the local distribution grid. For the island generators, operating in the ANM zone brings both opportunities (a grid connection that would not be possible otherwise) and challenges (curtailment; of unpredictable and uncontrollable levels).

The network is divided into zones which reflect local areas of the 33kV grid that are potentially restricted upstream of these key bottleneck points in the network. The key limiting factor (e.g. maximum current flow) is measured at these key points, and the system receives real time information from the measurement points. The zones and their associated measuring points are identified in the map (Figure 5).

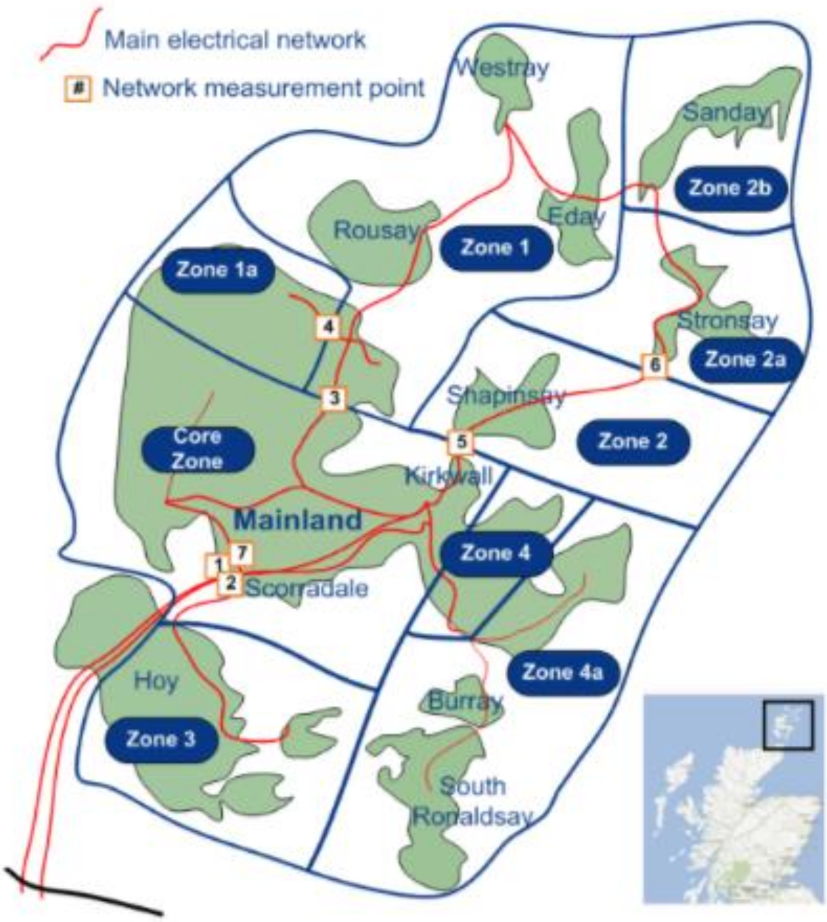

Figure 5: SSEN's diagram of the ANM zones and island grid network[4]

[4] http://anm.ssepd.co.uk/ANMGen.aspx

The ANM system allows conditional and actively managed grid export connections for generators. It uses real time network information to calculate safe levels of generation for managed connections in accordance with their commercial agreements and Principles of Access (PoA). The PoA is the mechanism by which the commercial arrangements are put in place to ensure the fair allocation of limited generation on the network. On Orkney, the Last in First off (LIFO) method has been used. The last generator to accept a connection offer is restricted before the first. This list of generators, ordered by their connection acceptance, is also referred to as the priority stack.[5]

Managed connections were the only option offered to some generators in Orkney by SSEN at the point of application, as the existing grid is not sufficient to offer firm connections. This restricts generators from putting power onto the electrical network at certain times. This is known as curtailment and the generator will have been given a curtailment assessment as part of the connection offer that they have accepted. Unfortunately, some of these estimates were considerably less than has been experienced in reality, and some generators are experiencing 30-80% of curtailment, 5-8 times their initial estimates; hence negatively impacted when their generation is greater than what the grid can support, or what is being used locally.

Since 11th Sep 2012, SSEN have not approved any new generation grid connections above G83 code (approximately maximum of 3.7kW per phase) as the current system is at capacity without major cable upgrades.

There are proposals from SSEN to upgrade the transmission connection to mainland Scotland with a 220kVA subsea connection, although timeline and feasibility for it is dependent on new renewable energy developments of this scale to be in the pipeline, which is not clear in the current market for the UK Government Contract for Difference (CfD) subsidy regime for remote islands.[6] Additionally, it is confirmed that this would only provide new grid connections to new projects on Orkney and not help the existing generation without the further local reinforcement necessary to connect to these new higher voltage circuits.

2.1.1 Background to UK subsidy schemes from renewable energy generation

The Feed in Tariff (FIT) scheme is a government programme designed to promote the uptake of small-scale renewable and low-carbon electricity generation technologies. Introduced in 2010, the scheme requires participating licensed electricity suppliers (FIT Licensees) to make payments on both generation and export from eligible installations[7].

The Renewables Obligation (RO) is one of the main support mechanisms for large-scale renewable electricity projects in the UK. The RO came into effect in 2002 in England and Wales, and Scotland, followed by Northern Ireland in 2005. ROCs are certificates issued to operators of accredited renewable generating stations for the eligible renewable electricity they generate. Operators can trade ROCs with other parties. ROCs are ultimately used by suppliers to demonstrate that they have met their obligation. It places an obligation on UK electricity suppliers to source an increasing proportion of the electricity they supply from renewable sources. The RO closed to all new generating capacity on 31 March 2017.

The latest government subsidy for large-scale renewable energy generation is through the Contract for Difference (CfD) Scheme. This process is different to both the FiT and ROCs as the funds are

[5] http://anm.ssepd.co.uk/ANMGen.aspx
[6] https://www.ssen-transmission.co.uk/projects/orkney/
[7] www.ofgem.gov.uk/environmental-programme

allocated through a competitive auction scheme to eligible technologies. Onshore wind was excluded from the list of eligible technologies after the first auction results in February 2015. The second round results were announced in September 2017, with the majority of the funding going to offshore wind projects. It has been announced that non-mainland onshore wind projects would be eligible to apply in the next round planned for April 2019, as they are assessed as less established technology due to the increased costs for grid connections etc. However, the competitive nature of the process does not guarantee success in the auction. The process has proved to be highly competitive, with offshore wind strike prices being reduced by 50% between the first and second rounds; and well below the costs for mainland onshore wind in the first auction.

2.2 Work done already on the ANM scheme in place

CES has already worked with other local partners before the initiation of SMILE to develop, technologically test and build on basic DSM solutions to mitigate curtailment. This section summarises the equipment installed and the learning that was gained from the various trials.

2.2.1 VScon devices

Community turbines in Orkney (Rousay, Eday, Stronsay, Shapinsay and Hoy) both had VScon's installed and the CLC communications ports upgraded by project partners. They were able to get the existing ANM communication architecture also upgraded inside their substations by SSEN, meaning that the project has the potential to both access signals from the turbine SCADA and the local ANM system when the turbines are being curtailed (partially or fully). CES and VCharge have been involved with interpreting the signals from the VScon's for other demonstrator DSM projects in Orkney before SMILE was initiated.

The VScon is a purpose built embedded device used as a passive data, acquisition platform with no control capabilities or impact on turbine output. It was developed by VCharge with the full co-operation of the DNO, SSEN, and the turbine manufacturer Enercon during the 2014 trials in Orkney using DSM. They were installed in March 2015.

Installed at the wind turbine utilizing Enercon and SSEN provided connection points, the VScon is designed to communicate with the following remote monitoring, control and communication systems already in place at the turbines:

- **SGS Connect** - Forming part of the Active Network Management system (ANM) it interfaces with and instructs the control of the turbine connected to the grid on behalf of the DNO[8]. It enables the ANM to monitor operations, regulate the import or export of power, adjust other operating parameters and ensure autonomous fail-safe operation of the controlled device. This ensures that the grid is always maintained within safe operating limits.
- **ENERCON SCADA PDI** - This provides an interface that enables online access to wind turbine monitoring data without using the ENERCON SCADA remote software[9].

The VScon completes real-time data processing of the SGS Connect and ENERCON SCADA PDI data to determine whether the turbine is marginally curtailed. Marginal curtailment occurs when the turbine is curtailed but is first in the ANM system priority stack to receive extra export capacity. It is vital to know when this is the case, as only when the turbine is marginal will extra local load directly benefit that turbine rather than others in the Orkney grid. The priority stack order was determined when the wind turbines received the acceptance for a grid connection, but is not publicly available.

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[8] http://www.smartergridsolutions.com/media/32195/connect-new-oct.pdf
[9] http://www.enercon.de/fileadmin/Redakteur/Medien-Portal/broschueren/pdf/en/ENERCON_TuS_en_06_2015.pdf

Every second, the VScon forwards raw data and processed marginal curtailment data via a secure Virtual Private Network (VPN) connection to the Vnet Cloud Control Centre (VCCC). Figure 6 below is a graphical representation of such data as received at the VCCC (note that Rousay is coloured green) including the active power from the actual generation, SGS connect signals and the wind speed.

Figure 6: Screenshot of Vnet Cloud Control Centre (VCCC)

2.2.2 Orkney Curtailment Modelling

The generator, REWIRED Ltd, and CES have collated a number of years worth of operational data from the community turbines. This dataset has been used to track available resource, turbine performance, and curtailment events. Combined with measuring point margin data which has been provided by SSEN, they allow informed decisions to be taken on project operational parameters and optimisation (e.g. operational margins, dwell and ride-over times), and assist in economic assessments of the proportion of curtailment relief provided to participating generators during DSM operation.

An example of the summary annual curtailment profile of a generator is shown in Table 1 below, which displays frequency and total duration of curtailment events by length of event, over the course of one year. Figure 7 breaks annual curtailment for this generator down by month, marginal and full event, and length of event.

Table 1: Summary curtailment profile of a typical generator

	Annual curtailment events (marginal and full)		Annual marginal curtailment events	
Duration of event	**Frequency of event**	**Total Duration (hours)**	**Frequency of event**	**Total Duration (hours)**
< 1 min	446	11.2	2956	54.3
2-10 min	2586	229.9	1914	121.7
10-30 min	551	157.4	307	84.2
30-60 min	186	128.7	83	56.6
1-2 hour	118	167.0	34	48.7
2-5 hour	93	278.4	13	40.4
5-12 hour	42	310.8	4	29.1
12-24 hour	13	224.4	4	77.5
>24 hour	4	249.4	0	0.0
Total	**6326194**	**1757.3**	**1845257**	**512.6**

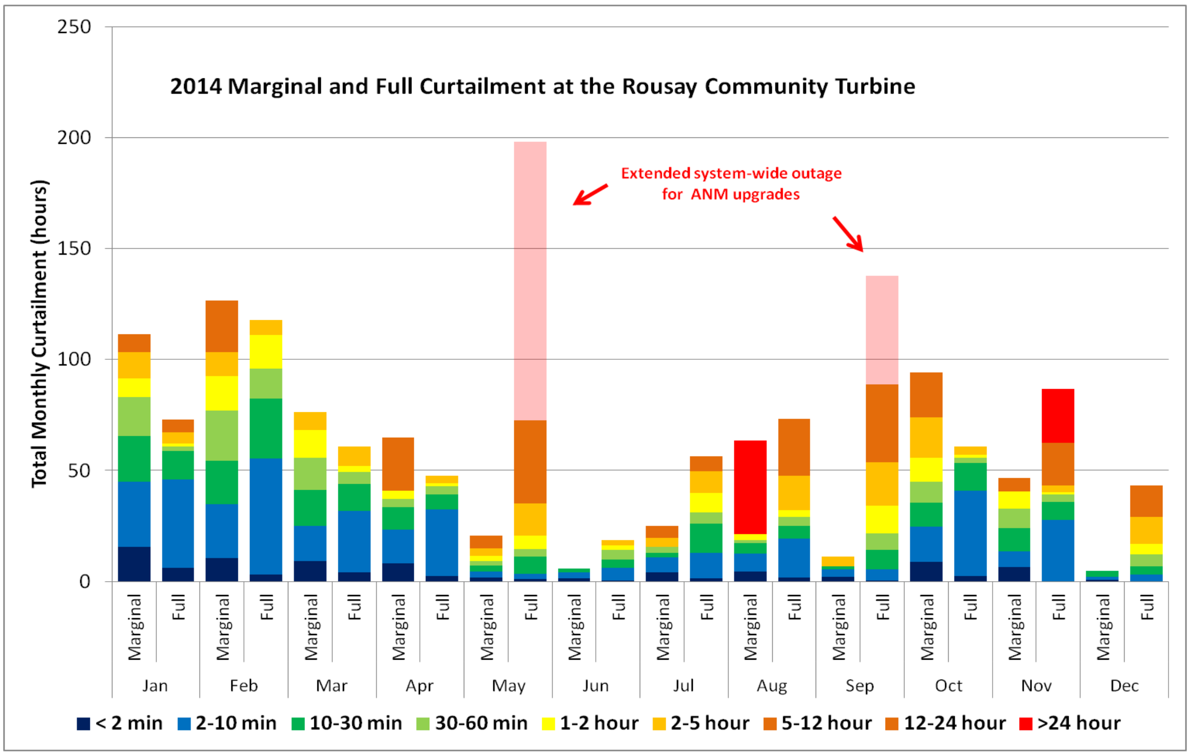

Figure 7: 2014 Marginal and Full Curtailment at the Rousay Community Turbine

2.2.3 Other Demand Side Management projects in Orkney relevant to SMILE

CES are working in partnership with communities in Orkney on other parallel and complementary projects, funded by local partners, the Scottish Government and EU H2020. These are mostly related to the approach of energy storage and demand side management, and SMILE will continue to build on this. See sections 3.3.2 on Heat Smart Orkney[10], and 3.5.1 Eday Electrolyser/ Surf ‘n’ Turf[11].

[10] http://rewdt.org/index.php?link=hsoAbout&name=HSO
[11] http://www.surfnturf.org.uk/

3 Orkney Regional Pilot Overview

This section explains the overall scope, remit and rationale of the Orkney demonstrator proposals, and gives an overview of what the Orkney demonstrator hopes to implement in SMILE. As well as the area of activity and the overall integrated architecture of the proposed communication, control and aggregation systems, the three different types of controllable demand will be described in detail, giving the specification, architecture overview, hardware and software requirements, and partner technologies in turn that will be implemented.

- Domestic heat installs
- EV charging
- Industrial load

3.1 Area in ANM zones for SMILE Demand Side Management

The demonstrator will focus on installing the controllable demand within zone 1 of the ANM scheme, in order to maximise the impact on curtailed generation. The community owned wind turbines within zone 1 affected by curtailment are on Rousay (REWIRED ltd) and Eday (ERE ltd), marked by the blue circles in Figure 8 below. Deploying DSM installations in this project is expected to have the most benefit on the curtailment of the Rousay turbine because of their position in the priority stack in the zone, so work is focussing on this generator although it is hoped to include the Eday turbine as part of the project and in the eventual benefit of curtailment abatement.

The domestic heat installs, EV smart charging and large industrial load will support in increasing the electricity demand to reduce levels of curtailment in the right place at the right times. There are other community wind turbines in Orkney that are curtailed; on Stronsay and Shapinsay which could be included to the project; although to start with only turbines within zone 1 will be included to maximise the impact of the controllable demand. The other wind turbines could recruited at a later stage depending on the results and impact of the turbines on Rousay and Eday and further recruitment of linked controllable load within the zone, hence noted as 'option 2'/ green circles. Likewise there are a number other privately owned generators within Zone 1 experiencing similar, or worse, levels of curtailment, however it is envisaged that they would only be included in a wider "business as usual" phase after this project, to both better optimise the opportunity of the controllable demand systems in place and provide further reduction in consumer electricity costs.

Figure 8: Geographical representation of zone 1 within the Orkney archipelago, including location of the community wind turbines

The extent and structure of the grid in Zone 1 has been mapped out beyond 33kV, to the 11kV and LV levels in Figure 9 below. This helps to define where demand can be added usefully, and so where the participant recruitment needs to take place, with respect to keeping within the relevant measuring points and feeders. Increasing the electricity demand locally, within the zone will help to improve the amount of curtailment that occurs to the wind turbine currently marginal in the 'stack' of generators. Hence, all installs will be focussed in this area, where possible. The solid "boundary" line in Figure 8 defines the same area on a geographical representation of zone 1 within the Orkney archipelago, and in relation to the location of the Rousay community turbine.

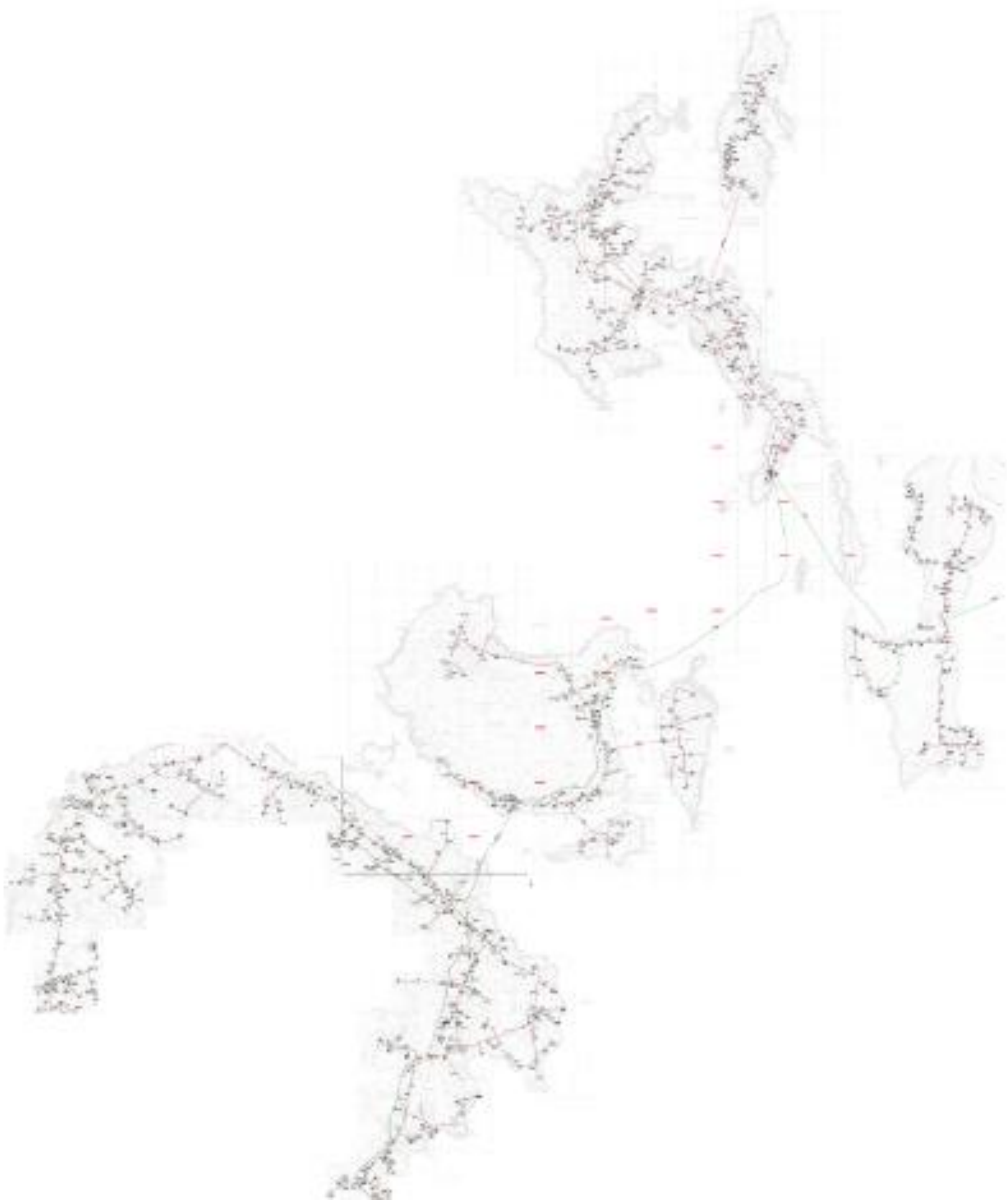

Figure 9: Detail of grid circuitry for ANM zone 1 at 33kV, 11kV and LV levels

3.2 Overall architecture

The overall architecture is presented in Figure 10. Dotted lines represent communications and solid lines represent electricity flows. This will be explained in further detail in the following sections.

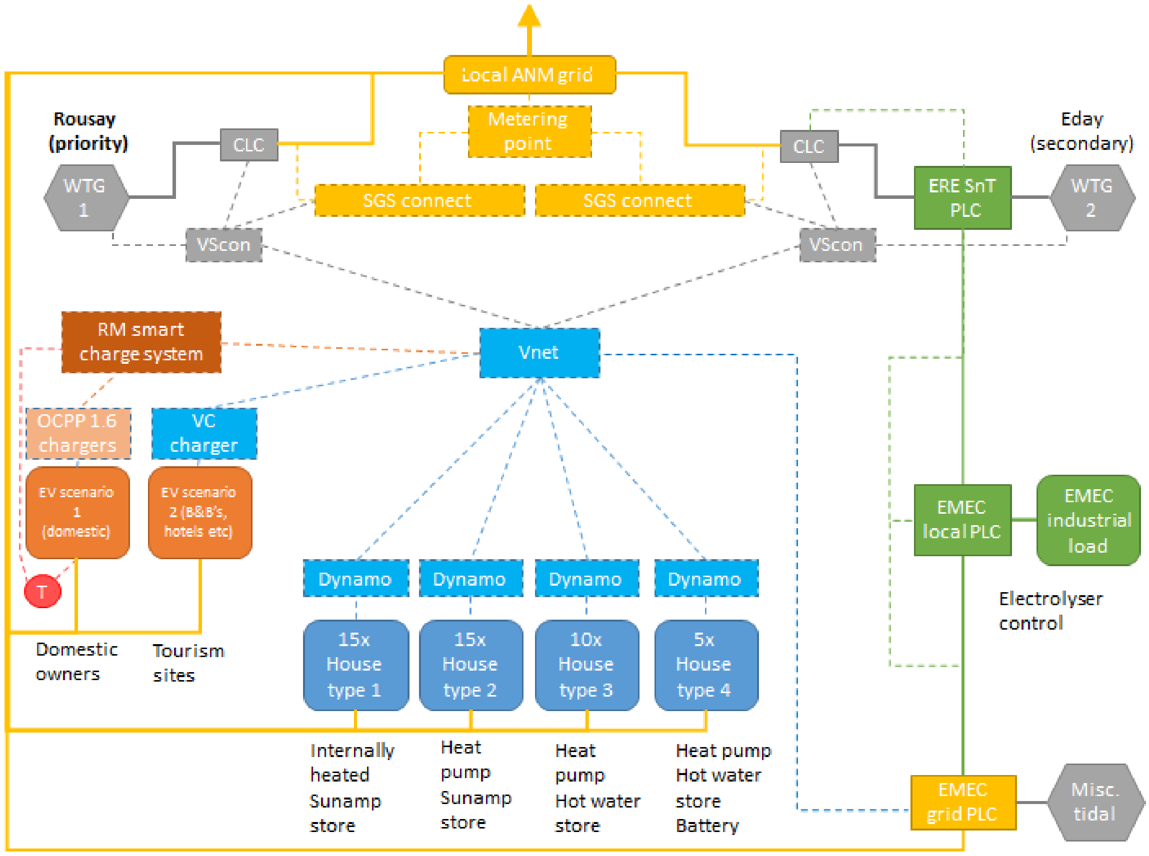

Figure 10: Overall architecture

3.2.1 Domestic heat installs

The domestic heat installs will consist of approximately 45 properties with a variety of different types of technologies to be implemented, including flow boilers, heat pumps, Sunamp PCM heat battery thermal store, hot water tanks, and batteries combined with VCharge dynamos (or similar) as below:

- 15 x 5.6kW Internally heated Sunamp PCM heat battery thermal store , VCharge controls
- 15 x 5kW Air to water heat pump, Sunamp PCM heat battery thermal store , VCharge controls
- 10 x 5kW Air to water heat pump, hot water thermal store, VCharge controls
- 5 x 5kW Air to water heat pump, hot water thermal store, Battery Energy Storage System (BESS) VCharge controls

The types of houses and final quantities recruited will largely depend on the uptake of participants (household energy use, size, existing heating system) and their existing or preferred way of providing heat and hot water to their homes.

The heat pumps mentioned above have an 11kW output but due to the Coefficient of Performance (CoP) the load only equates to about a 5kW load.

3.2.2 EV charging

The EV charge points will comprise of domestic households (scenario 1) and local tourism sites and accommodation (scenario 2) within Zone 1, that either have an EV that they currently charge at home, or a business/ facility that would benefit from being able to offer EV charging to customers/ visitors.

Some of the advantages of this dual approach are that it allows two independent but interlinked DSM systems to be demonstrated interacting and being coordinated to the same generation ANM system. With scenario 1, where considerable intelligence can be gathered on the patterns of charging and vehicle use, DSM curtailment response can be refined with predictive knowledge and learning algorithms in this situation. Whilst in parallel, DSM installations in scenario 2 can be best tested and shown to be robust, compatible and effective whilst being agnostic to the connected vehicle technologies and use patterns.

The specific detail of types of vehicles and quantities recruited in each scenario will depend to some degree on the uptake of participants (car type, charger type) and their existing or preferred charging methods. Where existing chargers are not able to be adapted to make smart connections, these could be upgraded under the scope of the SMILE project if budget allows and new controlled charge points will be installed in places where no charging is currently in place.

3.2.3 Large industrial load

The industrial load is proposed to be the smart control of the 11kV on-site switching and storage system, including the existing electrolyser (operational November 2017), on Eday which is owned by EMEC (The European Marine Energy Centre). It is currently a part of the Surf 'n' Turf project funded by the Scottish government CARES Local Energy Challenge Fund and also a FCH JU funded project called BIG HIT. The electrolyser (and potential other on site storage) uses electricity from tidal energy at the test site and wind energy from the ERE turbine 600m away; SMILE will help implement the smart control of switching between the two generators and the local grid to maximise generation and hydrogen production from both of the sites (wind and tide).

3.3 Domestic heat installs

This section describes in greater detail the domestic heat installs, including background information; followed by each of the types of heating systems to be installed in different properties.

3.3.1 Background to heating in Orkney

The mix of heating in Orkney mainly consists of oil central heating or old electric storage heaters. Some properties still have no central heating and only use open fires (wood, peat or coal), see Figure 11. The project will consider which particular properties to complete the installs in once more information about the specific household situations and systems is known through the participant recruitment.

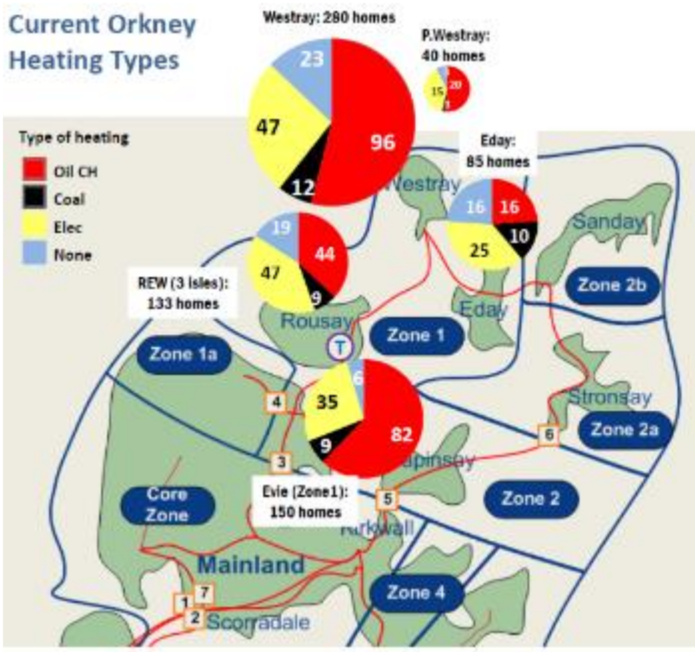

Figure 11: Indicative current heating types in the target area in Orkney*

*This figure does not show the additional ~700 homes in zone 1 that are on Orkney mainland and on the same 11kV feeder, but it does give an accurate indication of heating types.

3.3.2 LECF project: Heat Smart Orkney

SMILE builds on the Heat Smart Orkney project, funded by the Scottish Government/ Local Energy Scotland Challenge Fund. This is led by REWDT and delivered by their specially set up and wholly owned subsidiary, Heat Smart Orkney ltd, with project partners REWIRED, Community Energy Scotland, VCharge and Catalyst. DSM enabled storage heaters, flow boilers, hot water cylinders and immersion heaters, will be installed into participating homes as secondary heating devices and these will be switched on only when a signal is sent from the grid, via the turbine and then the VCharge platform to control equipment (switches) attached to each device. This project looked at only simple single heating sources and resistive forms of heat and not into other types of electric heating (heat pumps) or PCM heat battery thermal store (Sunamp) and integrated, whole house, heating systems.

The main technical differences between the two projects are highlighted in Table 2 below.

Table 2: Basic description of HSO and SMILE installations

Item	HSO	SMILE
Technology	Basic resistive heat devices	Innovative household heat systems, EV smart charging, industrial load
Heating devices	Quantum storage heaters, flow boilers, hot water cylinders and immersion heaters. Single point devices	Heat pumps, Sunamp PCM heat battery thermal stores, hot water cylinders, batteries. Whole house systems.
Heating devices switched on	Only as secondary heating, turned on devices during marginal curtailment only	Primary heating, turned on during curtailment and at other times, as required by user or when electricity prices are favourable.
Payment mechanism	Private/3rd party rebate system based on comparison to existing heating system costs (calculated on historic billing) and identification of electricity metered through specific devices when used for curtailment mitigation. System should be agnostic to/utilise existing licensed supplier arrangements.	Likely to be a combination of rebating system, technological cost reduction and potential value through grid services. Still agnostic to/using existing licenced energy supplier. To be confirmed after modelling and analysis
Wind turbine generators curtailment signals	REWIRED (Rousay community wind turbine) only	To be confirmed – Mainly Rousay and Eday
DSM controls used for	On every individual space and water heating device	On integrated space and domestic hot water heating systems and each EV charger
Participant recruitment	HSO ltd	Subcontracted to HSO ltd
Customer Relationship Management (CRM)	Using CES's in-house developed tool (CRM), used by HSO ltd	To be confirmed

The system architecture for HSO is represented in Figure 12, showing only the domestic installs with dynamos. The same principles will apply for SMILE, but will be adapted and built on to reflect the expanded project and changed parameters.

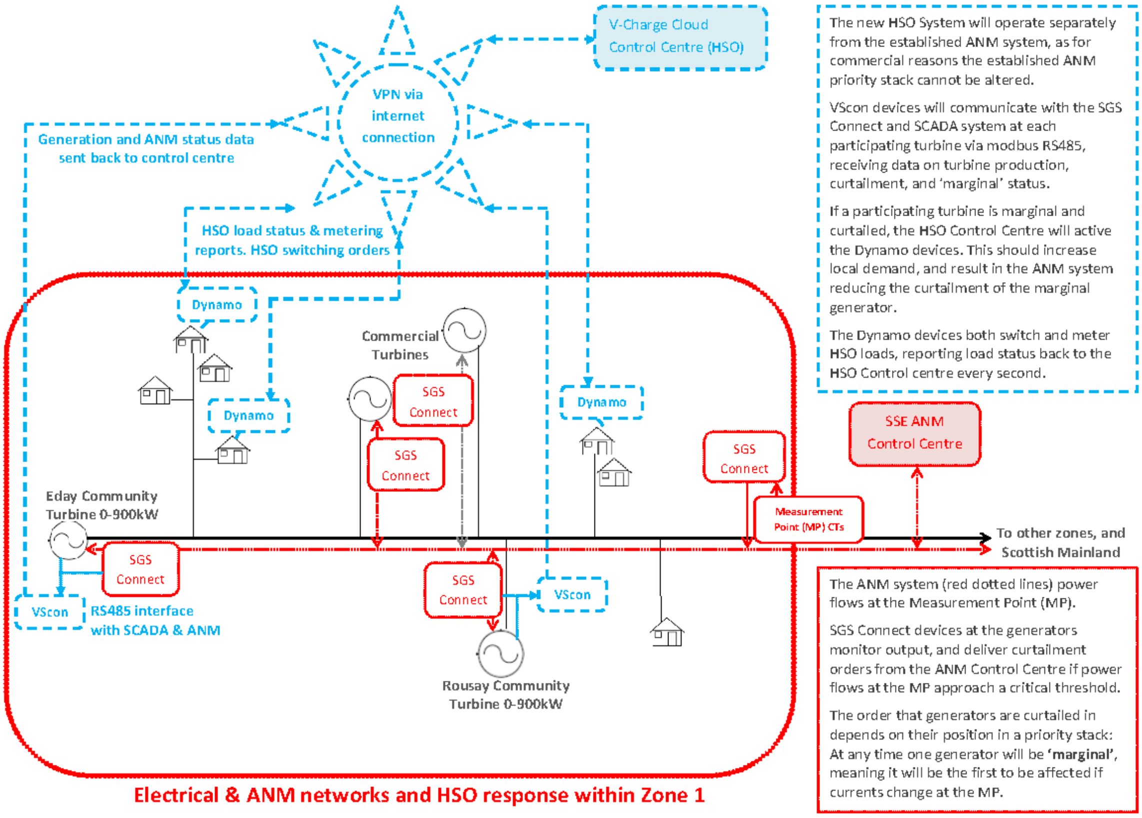

Figure 12: HSO system architecture

3.3.3 Detail of House Type 1: Sunamp internally heated PCM heat battery thermal store

3.3.3.1 Description

House type 1 will use a Sunamp internally heated PCM heat battery thermal store to generate and store heat for central heating and hot water, as in Figure 13. The advantages to this are:

- Fast response to curtailment signal
- No additional heat generating hardware required (i.e. heat pumps or flow boilers)
- Compact heat store.

Potential disadvantages to this approach are:

- Product is new from Sunamp and could have risks in deployment as it is not as tried and tested as other products
- Coefficient of performance of 1 maximum, which is lower than the option with an ASHP (which has a value of 3) but may be better at responding to curtailment events

The electricity demand of the install is to be confirmed, however they can be designed with multiples of 2.8kW elements i.e. 2 elements combined would give a 5.6kW rating.

The capacity of energy that can be stored in the current proposal is for a SunampCube of approx 65kWh storage, with dimensions of 120cm x 100cm x 150cm high to be sited outside. Otherwise smaller internal units could be used. This will be determined by the household property recruitment survey of suitability and final install specifications.

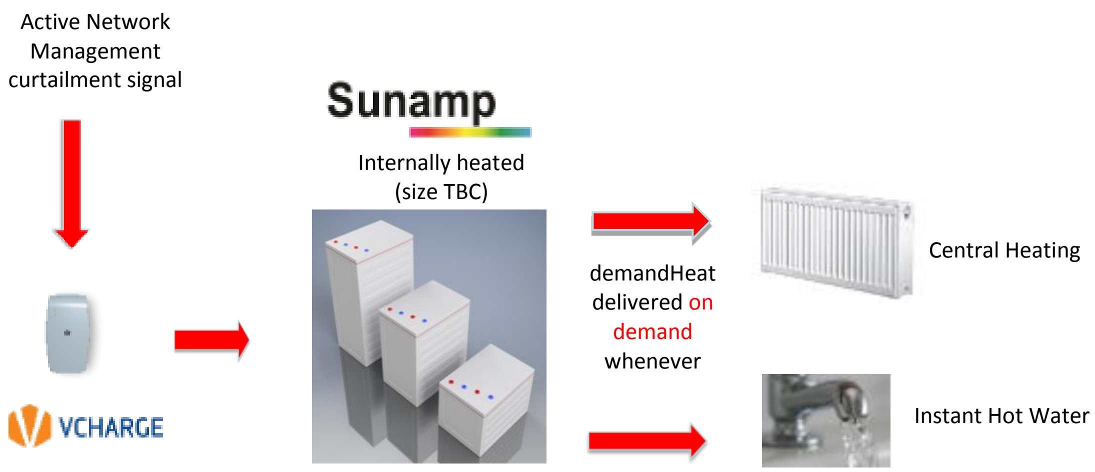

Figure 13: Domestic install House type 1 description

3.3.3.2 Architecture Overview

The diagram below illustrates the architecture of the system.

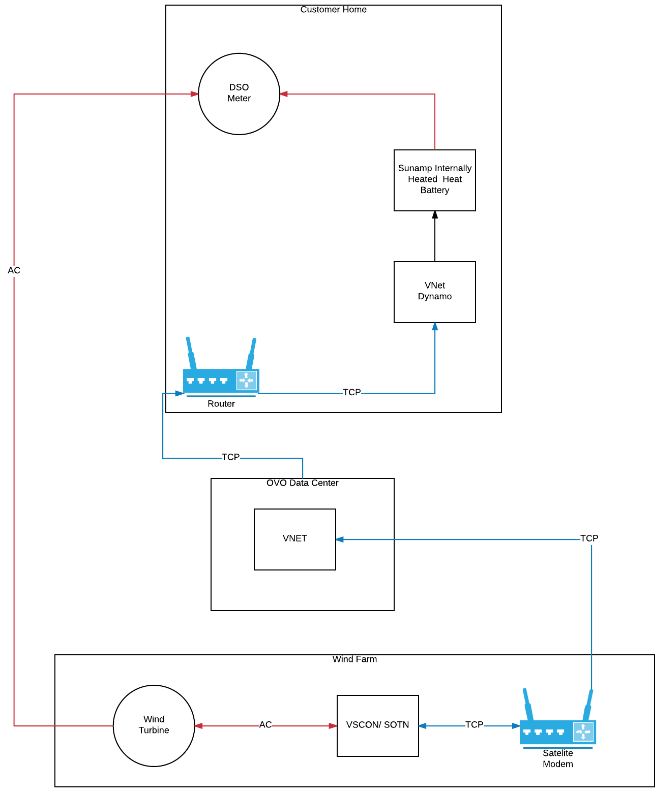

Figure 14: Domestic install House type 1 architecture

3.3.3.3 Hardware and Software Requirements

The hardware necessary includes:

- Wet heating system (either existing or to be installed)
- Monitoring equipment (data logger)
- New electrical circuits
- New consumer unit
- Sunamp internally heated PCM heat battery thermal store
- VCharge dynamo (1 per household) and comms hub

The software necessary includes:

- IOT Hub
- Device management API

3.3.3.4 Partner Technologies

Sunamp will be providing the internally heated PCM heat battery thermal store to the project. VCharge will be providing the dynamo devices (or similar), as well as the control platform for these devices.

3.3.4 House Type 2: Heat pump and Sunamp PCM heat battery thermal store

3.3.4.1 Description

House type 2 will use a heat pump and a Sunamp PCM heat battery thermal store to generate and store heat for central heating and hot water, as in Figure 15. The advantages to this are:

- Well proven combination of hardware
- Coefficient of performance of up to 3
- Compact heat store

Potential disadvantages to this approach are:

- Heat pump response to curtailment (how often they can be turned on and off; when first started they have to run for a certain time, and also when turned off they have to wait for some time before they can be turned on again)

The electricity demand of the install will be determined by the size of the heat pump: typically up to 11kW heat output with a demand of 5kW.

The capacity of energy that can be stored in the current proposal is for a SunampCube of approx 65kWh storage, with dimensions of 120cm x 100cm x 150cm high to be sited outside. Otherwise smaller internal units could be used. This will be determined by the household property suitability and specification.

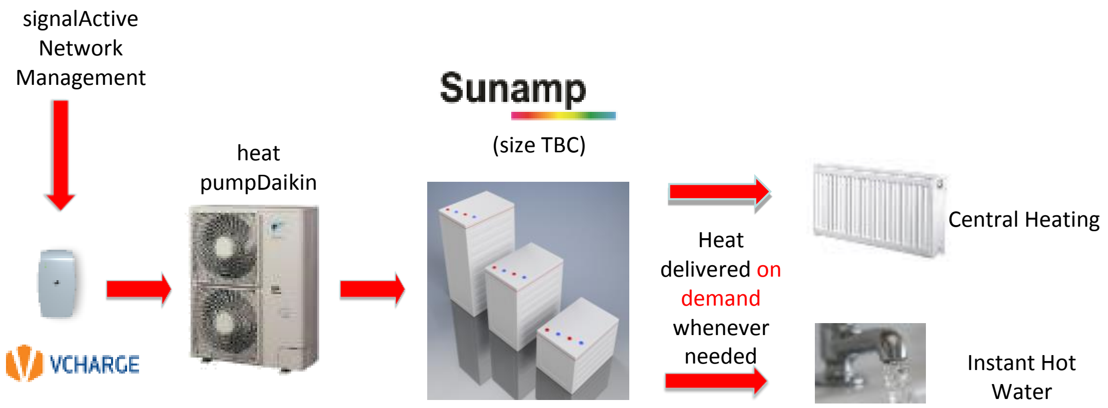

Figure 15: Domestic install House type 2 description

3.3.4.2 Architecture Overview

The diagram below illustrates the architecture of the system.

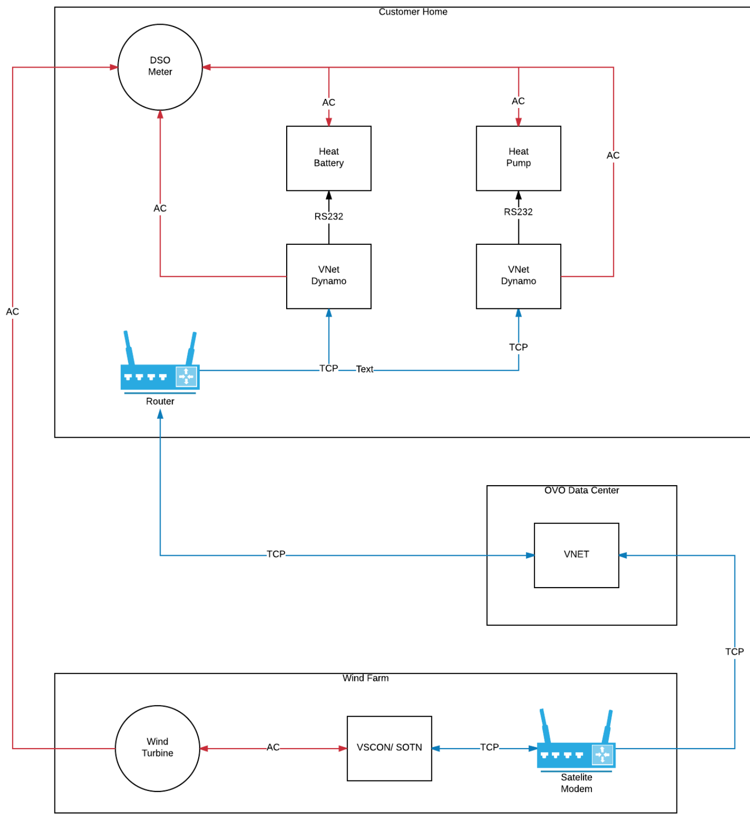

Figure 16: Domestic install house type 2 architecture

3.3.4.3 Hardware and Software Requirements

The hardware necessary includes:

- Wet heating system (either existing or to be installed)
- Monitoring equipment (data logger)
- New electrical circuits
- New consumer unit
- Sunamp PCM heat battery thermal store (size tbc)
- Air-to-water heat pump (e.g. Daikin Altherma HT 11kW)
- VCharge dynamo (1 per household) and comms hub

The software necessary includes:

- IOT Hub
- Device management API

3.3.4.4 Partner Technologies

Sunamp will be providing the PCM heat battery thermal store to the project.
VCharge will be providing the dynamo devices (or similar) as well as the control platform for these devices.

3.3.5 House Type 3: Heat pump and hot water store

3.3.5.1 Description

House type 3 will use a heat pump and a hot water store to generate and store heat for central heating and hot water, as in Figure 17. The advantages to this are:

- Well proven combination of hardware

Potential disadvantages to this approach are:

- Heat pump response to curtailment (how often they can be turned on and off; when first started they have to run for a certain time, and also when turned off they have to wait for some time before they can be turned on again)
- Potentially high heat losses and higher costs to run
- Large space required in property for hot water store

The electricity demand of the install will be determined by the size of the heat pump: typically up to 11kW heat output with a demand of 5kW.

The capacity of energy that can be stored in this configuration will determined by the household property suitability and specification of the hot water store. It is hoped that it would be storage in the same ballpark as the Sunamp PCM heat battery thermal store (65kWh).

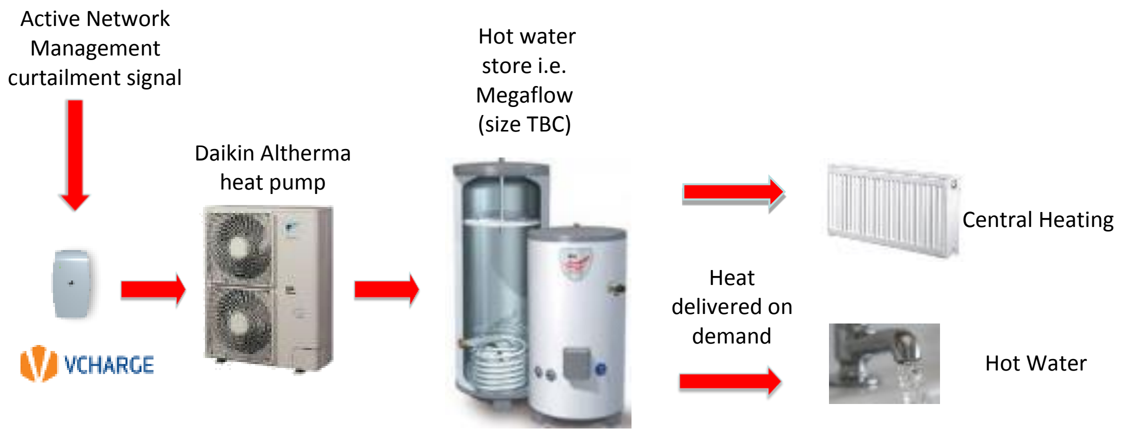

Figure 17: Domestic install House type 3 description

3.3.5.2 Architecture Overview

The diagram below illustrates the architecture of the system.

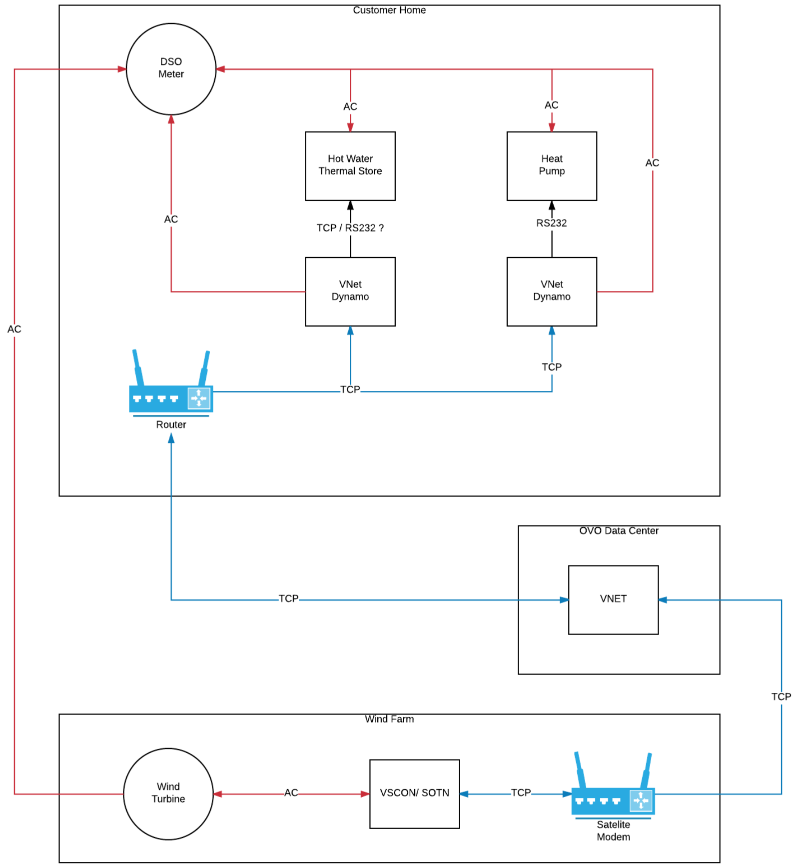

Figure 18: Domestic install House type 3 architecture

3.3.5.3 Hardware and Software Requirements

The hardware necessary includes:

- Wet heating system (either existing or to be installed)
- Monitoring equipment (data logger)
- New electrical circuits
- New consumer unit
- Hot water tanks and immersion (size tbc)
- Air-to-water heat pump (e.g. Daikin Altherma HT 11kW)
- VCharge dynamo (1 per household) and comms hub

The software necessary includes:

- IOT Hub
- Device management API

3.3.5.4 Partner Technologies

VCharge will be providing the dynamo devices (or similar), as well as the control platform for these devices.

3.3.6 House Type 4: Battery, heat pump, hot water store

3.3.6.1 Description

House type 4 will use a heat pump and a hot water store to generate and store heat for central heating and hot water, as in Figure 19. A battery will be included in the system to provide electricity to the heat pump. The advantages to this are:

- The battery can be charge quickly on curtailment events and make maximum efficiency of the heat pumps
- Coefficient of performance of up to 3

Potential disadvantages to this approach are:

- Additional system complexity
- Large space required in property for hot water store and battery
- Potentially high heat losses and higher costs to run

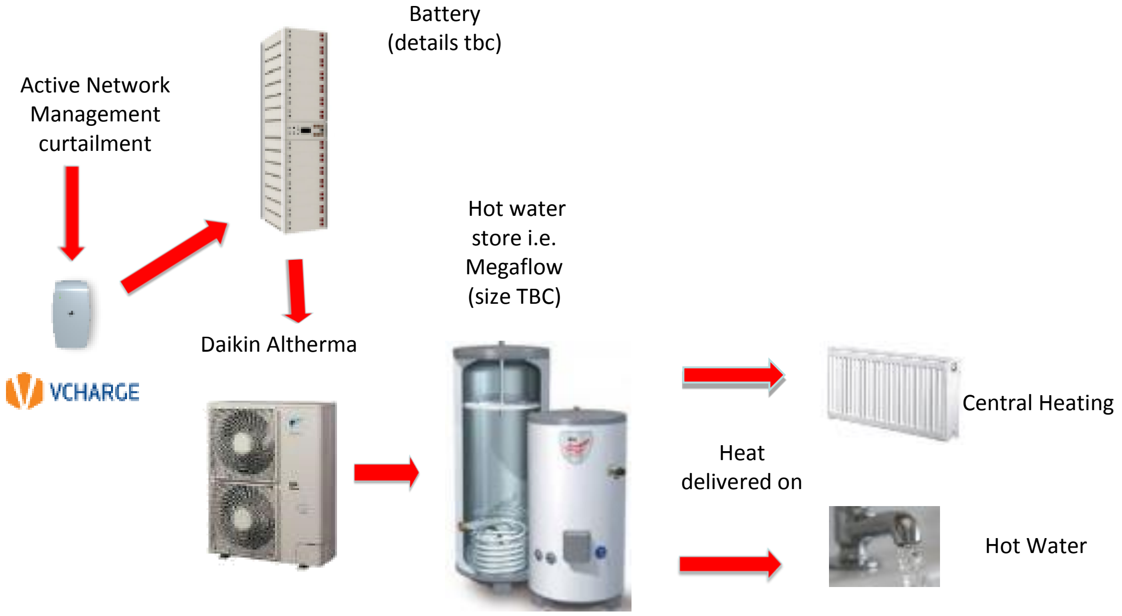

Figure 19: Domestic install House type 4 description

3.3.6.2 Architecture Overview

The diagram below illustrates the architecture of the system.

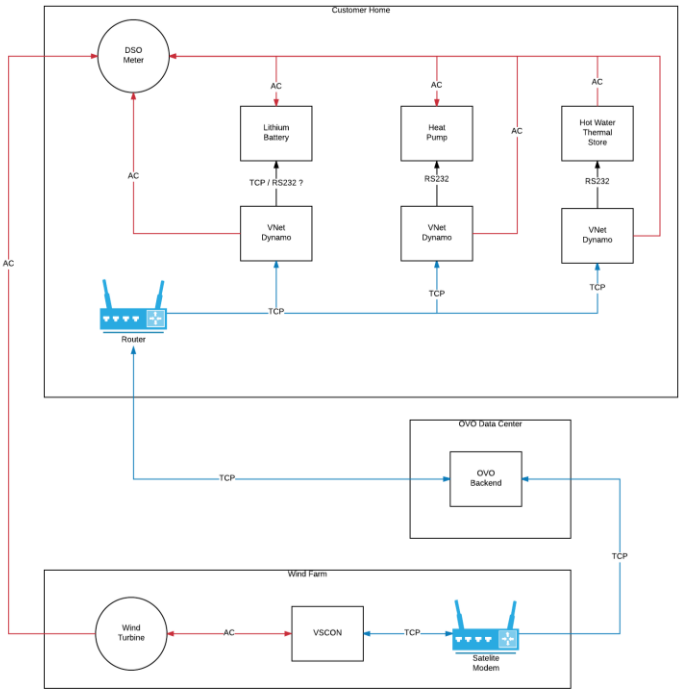

Figure 20: Domestic install House type 4 architecture

3.3.6.3 Hardware and Software Requirements

The hardware necessary includes:

- Wet heating system (either existing or to be installed)
- Monitoring equipment (data logger)
- New electrical circuits
- New consumer unit
- Hot water tanks and immersion (size tbc)
- Air-to-water heat pump (e.g. Daikin Altherma HT 11kW)
- LiBal battery
  - 7.5 kWh. Consisting of 1 pack and 16A inverter 240V. Single phase.
- VCharge dynamo (1 per household) and comms hub

The software necessary includes:

- IOT Hub
- Device management API

3.3.6.4 Partner Technologies

VCharge will be providing the dynamo devices (or similar), as well as the control platform for these devices.
LiBal will be providing the batteries for the households.

3.3.7 Data collection and parameters for analysis

The partners are considering the technology for data collection and the various parameters to be analysed. Parameters for analysis pre/post installs so far include:

- Cost of heating home
- Comfort levels for heat delivered
- Average temperature of house (or per room)
- Carbon footprint of heating house
- Electricity used from otherwise curtailed electricity, off peak rates or standard tariff
- Energy used from electricity (grid), micro generation, fossil fuels or other (wood fires/ peat) etc
- System efficiency

Suitable data logging technology will need to be installed to gather this information.

3.4 EV charging

3.4.1 Background to EV's in Orkney

Orkney presently has the highest proportion of EV's of any other county in Scotland, Figure 21. There are over 150 EVs in Orkney (September 2017), out of a population of around 17,000 people. The number of EV's continues to grow[12], Figure 22.

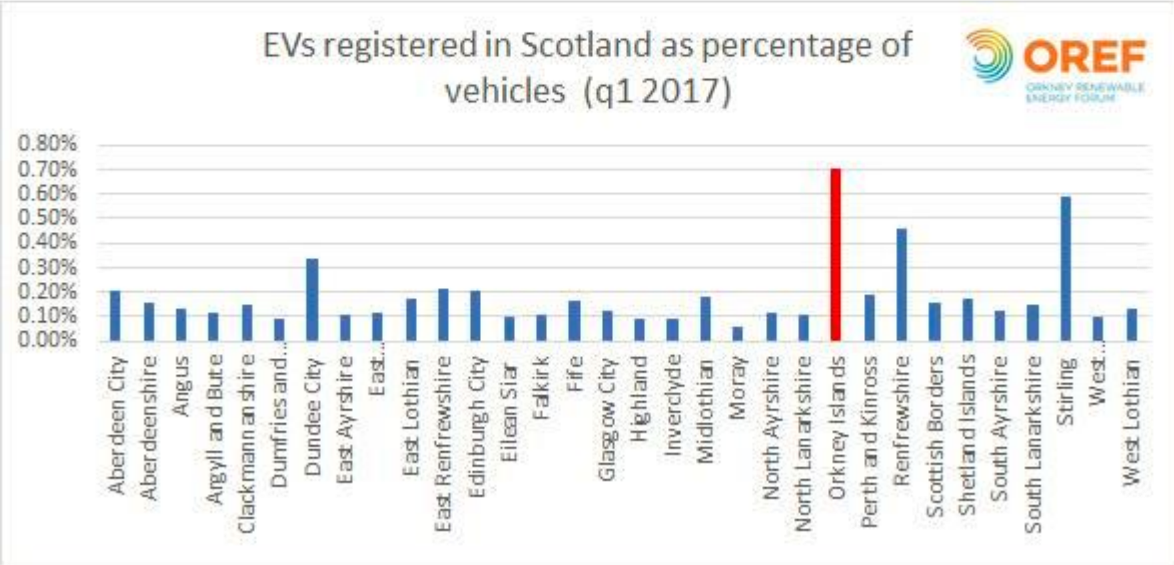

Figure 21: EV's registered in Scotland as a percentage of vehicles

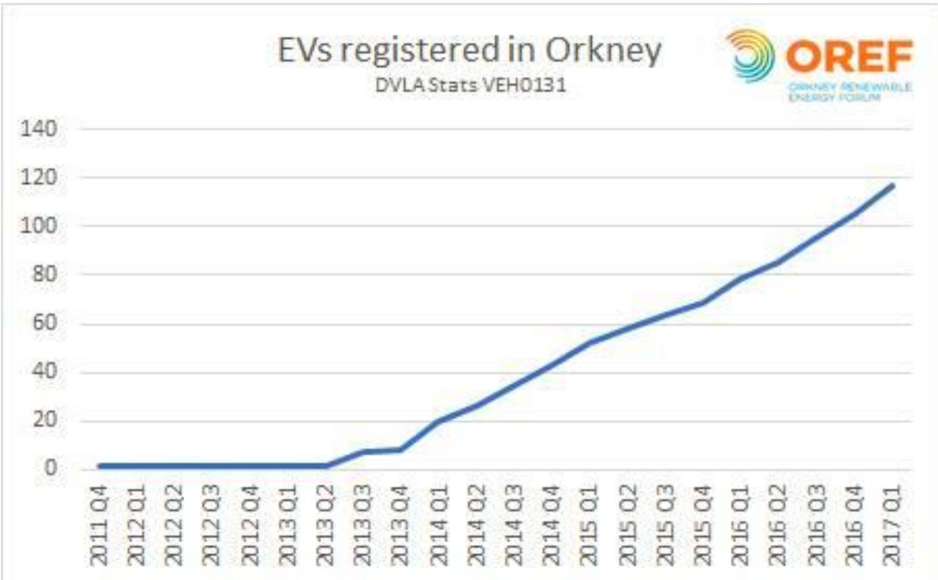

Figure 22: EV's registered in Orkney

There is good cooperation with local EV users group and OREF (Orkney Renewable Energy Forum).

[12] https://www.gov.uk/government/statistical-data-sets/all-vehicles-veh01#table-veh0131

EVs have been already been demonstrated to be able to be charged from a curtailment signal, in some of the early projects looking at demand response on Rousay, for example the smart EV charging project: P42236.[13]

3.4.2 Description

The largest current scope for EV charging is to do smart charging on domestic/small scale, typically 7 kW chargers.

The EV charge points will comprise of domestic households (scenario 1) and local tourism sites and accommodation (scenario 2) within Zone 1, that either have an EV that they currently charge at home, or a business/facility that would benefit from being able to offer EV charging to customers/ visitors.

In the case of local tourism sites, it would be the case that multiple drivers/ visitors would use the charger with different vehicles and have different demand patterns, as opposed to the same EV always being charged at one property, which is more typical in scenario 1.

There is a target of 30 EV's to be smart charged, which will be divided across the two separate scenarios, with one set of the chargers being controlled by Route Monkey and the other set by VCharge, as detailed in Table 3.

Table 3: EV scenarios

Scenario	Target	Type	Control signal from	Chargers managed/ optimised by	Charger type	User interface
1 (RouteMonkey)	15	Domestic households	Vnet platform	Route Monkey CPBO	OCPP 1.6 Compliant	Not required – telematics installed in EV
2 (VCharge)	15	Local tourism sites/accom.*	Vnet platform	Vnet platform	VCharge API compliant	User interface. Details to be confirmed

*Some domestic EV's could be included, depending on recruitment number

The most common EVs in Orkney, therefore most likely to be applicable for using in the trial are: **Nissan Leaf (by far)**, Renault Zoe, BMW i3, Peugeot Ion, Tesla Model S, Tesla Model X, Nissan eNV 200, Renault E-Kangoo, Citroen C zero, Reva G-Wiz, KIA Soul.

The most common existing chargers are Chargemaster and Pod point, or other similar models. To be able to control the charging smartly, it is very likely that charge points will need to be upgraded or replaced to either Open Charge Point Protocol (OCPP) 1.6 complaint charging points[14] or to a similar standard that can be controlled remotely (VCharge are developing their own product internally that does not require a dynamo). VCharge Charge Points will be integrated into Vnet, and the Route Monkey charge points will need to test and integrate each EV charge point onto their CPBO.

The techniques applied for the smart charging will be smart/ slow charging that will charge the EVs, when available at the charge points, during set windows of opportunity and responding to curtailment

[13] http://www.localenergyscotland.org/media/91333/The-Rousay-Egilsay-and-Wyre-Development-Trust-EV-Projects-x2-Final-Combined-Report.pdf

[14] http://www.openchargealliance.org/protocols/ocpp/ocpp-16/

events the same way as the domestic heating will be 'charged'. The EVs will need to be charged appropriately and in time for the users next use, which will be determined using telematics in the vehicle and predictive behaviour algorithms or a user interface. It is **not** the scope of the project to look into any of the other smart charging options such as using the EV battery in reverse (i.e. vehicle to grid etc).

3.4.3 Architecture Overview

The figures below illustrate the architecture of the system for the two scenarios.

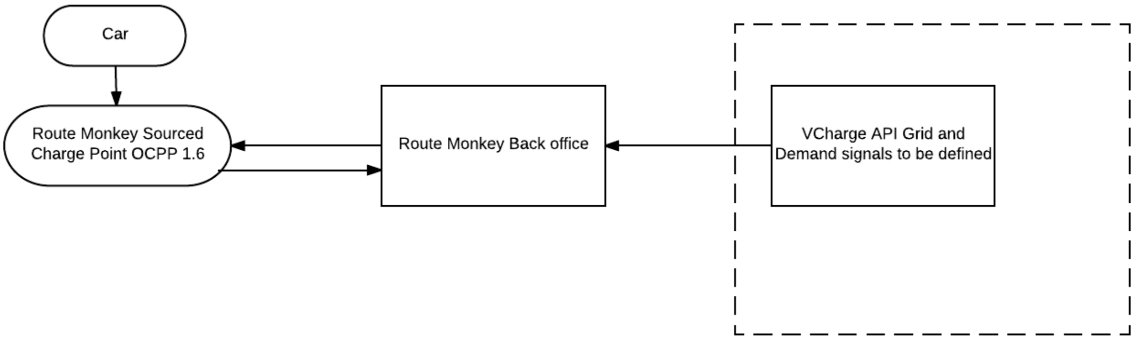

Figure 23: EV system architecture, scenario 1

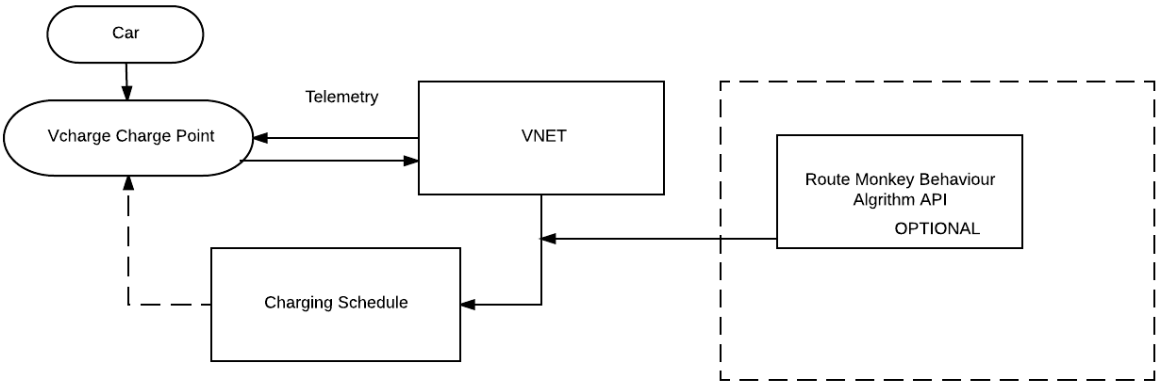

Figure 24: EV system architecture, scenario 2

3.4.4 Model use case

Scenario 1

An indicative charging user journey is outlined below:

- User plugs in the EV
- User starts the charge on the EV charger using an authentication mechanism if the charger supports this
- The Route Monkey back office optimises the charging process based on available data
    - Grid signals provided by VCharge
    - The predicted behaviour of the vehicle, based on past charging transactions
    - Potential user input (mechanism for this needs to be discussed)
    - Battery state of charge information if this becomes available to the system
- A web interface could provide users information on whether the charging process has completed (please note that without the state of charge of the battery, it is impossible to work out the charging percentage before the battery stops accepting charge)

The optimisation of charge depends on the following:

- The format and frequency of grid signals provided by VCharge.
- The accuracy of prediction of
    - Arrival and departure time of vehicles
    - State of charge of the vehicle upon arrival
- The amount of information provided to the system by drivers to improve prediction

For instance, a grid signal that requires multiple hours of charging interruption is inadvisable in cases where a vehicle arrives at 10% charge and must depart only a few hours later.

Scenario 2

An indicative charging user journey is outlined below:

- User plugs in the EV (input from customer/ car authentication if supported)
- The VCharge back office optimises the charging process based on available data:
    - Grid and demand signals
    - Potential user input State of Charge (SOC), Timestamp, car id (via a user interface)
    - Battery state of charge information if this becomes available to the system (via user interface)
    - Route Monkey API on driver behaviour (Domestic only)

  Car output: User interface could provide users with information on whether the charging process has completed.

3.4.5 Hardware and Software Requirements

The hardware necessary includes:

- Charge point (preferably existing or where applicable, upgraded to the required standard)
- Monitoring equipment

Software required

- User interface for defining user charge requirements
- Device management API

3.4.6 Partner Technologies

Scenario 1
Route Monkey are responsible for supplying aggregator software for EV charging and algorithms, with a focus on operating the aggregated management of the EV charge points, in conjunction with development of an API interface with VCharge.

CES would be responsible for purchasing the charge points, specified by Route Monkey.

Route Monkey will provide a smart charging ecosystem with the following system components (bottom up):

- **Charge point back office (CPBO)**, which executes the commands of the Smart charging system.
- **External systems inputs integration bus**, which will comprise all external asset systems (power data, telematics (if used), external API used to fine tune predictions (weather), other). Route Monkey will provide the integration of external systems.
- **Smart charging system (SCS)**, purpose of which is to gather all external information and serve as medium between the users, assets and optimisation
- **Algorithm Suite**, which at a high level will include:
    - Predictive algorithm for vehicles
    - Predictive Algorithm for power mix
    - Optimisation algorithm

Scenario 2
VCharge will be responsible for supplying aggregator software for the EV Charging and optimisation algorithms to ensure curtailment is minimised whilst ensuring optimised car charging.
Optionally VCharge could also develop an API interface with Route Monkey and their predictive behaviour algorithm.
VCharge will be providing compliant charge points and the control platform for these devices.

3.4.7 Data collection and parameters for analysis

Parameters to capture during the trial for comparison with UK equivalents are:

- Annual mileage and daily range expectations for EVs compared to mainland UK.
- Local weather and ambient temperature (affects battery range); ideally at hourly intervals, or more frequent if possible.
- Topography of routes driven (affects battery range and could be potentially integrated into Route Monkey's charge management algorithm)
- Typical charging patterns

Parameters for analysis pre/post installs:

- Cost of charging EV
- Electricity used from otherwise curtailed electricity, off peak rates or standard tariff; micro generation
- System efficiency

Suitable data logging technology will need to be installed to gather this information.

3.5 Industrial load

3.5.1 LECF project: Surf 'n' Turf

SMILE builds on the Surf 'n' Turf project, funded by the Scottish Government Local Energy Scotland Challenge Fund. This is led by Community Energy Scotland, with project partners EMEC, Eday Renewable Energy, ITM Power and Orkney Islands Council. The European Marine Energy Centre (EMEC) invested in an electrolyser that will use power from tidal turbines operating at the company's test site off Eday to produce hydrogen. To build on this, Community Energy Scotland and partners created Surf 'n' Turf, so that power from the community wind turbine in Eday can also be used to produce hydrogen using EMEC's electrolyser, and then this energy (gas) is transported to where it will be used elsewhere in Kirkwall, as illustrated in Figure 25[15]. The project is also part of the BIG HIT project[16]. The BIG HIT project has received funding from the Fuel Cells and Hydrogen Joint Undertaking under grant agreement No 700092. The Joint Undertaking receives support from the European Union's Horizon 2020 research and innovation programme.

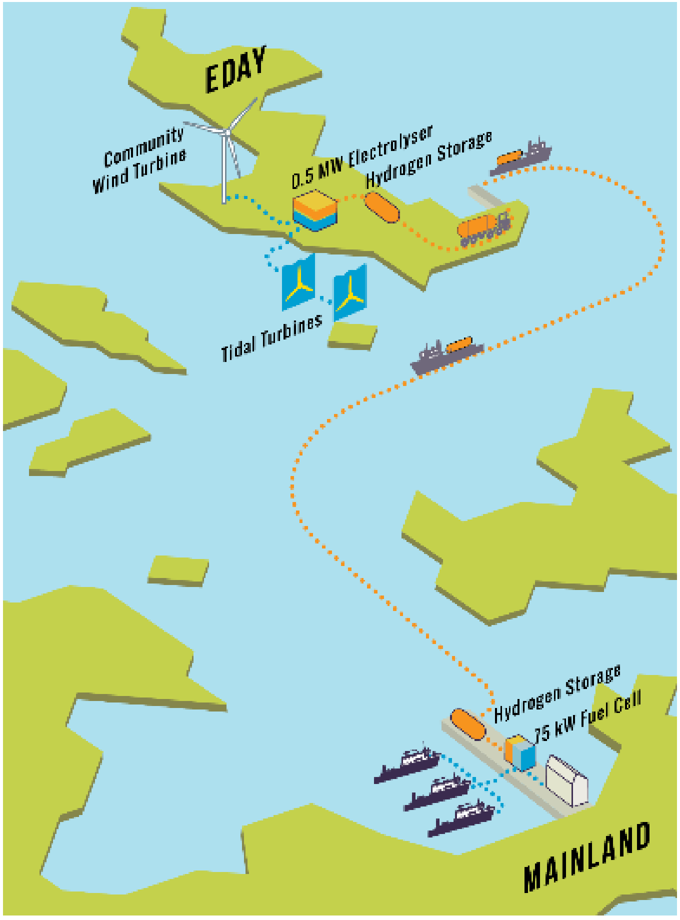

Figure 25: Surf 'n' Turf logistic diagram

The main technical differences between the two projects are highlighted in Table 4 below.

[15] (http://www.surfnturf.org.uk/page/renewables)
[16] https://www.bighit.eu/

Table 4: Basic description of Surf 'n' Turf and SMILE installations

Item	Surf 'n' Turf	SMILE
Methodology	Electrolyser operates when curtailment is experienced by ERE or EMEC. Either one supply or the other, never blended	Scope to be negotiated.
Interaction with ANM	Only indirect	Aim to integrate the two generation sources better on the grid and potentially create option for grid services through local grid-smart storage and switching.
Payment mechanism	Surf 'n' Turf generate income per kWh from ERE when their wind turbine is allowed to generate when would otherwise be curtailed	To be negotiated.

3.5.2 Description

Control of the EMEC 11kV switching and storage system is the scope for the industrial load in SMILE. This would involve improving the switching mechanism and electrolyser production to work more intelligently than the existing system in operation.
As a summary of the capacity of each part of the system:

- Wind 900kW (curtailed on ANM system)
- Tide 4000kW (no curtailment but limited to this capacity). Current maximum peak generation as of November 2017 around 2000kW on spring tides (during tidal ebb and flood cycles)
- Electrolyser 500kW

The existing switching between wind and tide is solely off-grid and is controlled by a switch that can be operated manually or via the PLC. By improving the control of the switching between the two forms of generation, it will help to maximise the amount of hydrogen that is produced. It will also future-proof access for the 900kW WTG to the electrolyser if/ when tidal generation exceeds 4MW, based on the predictable tidal cycles, Figure 26, and providing the potential for the large demand assets to be more flexible through smart grid connection.

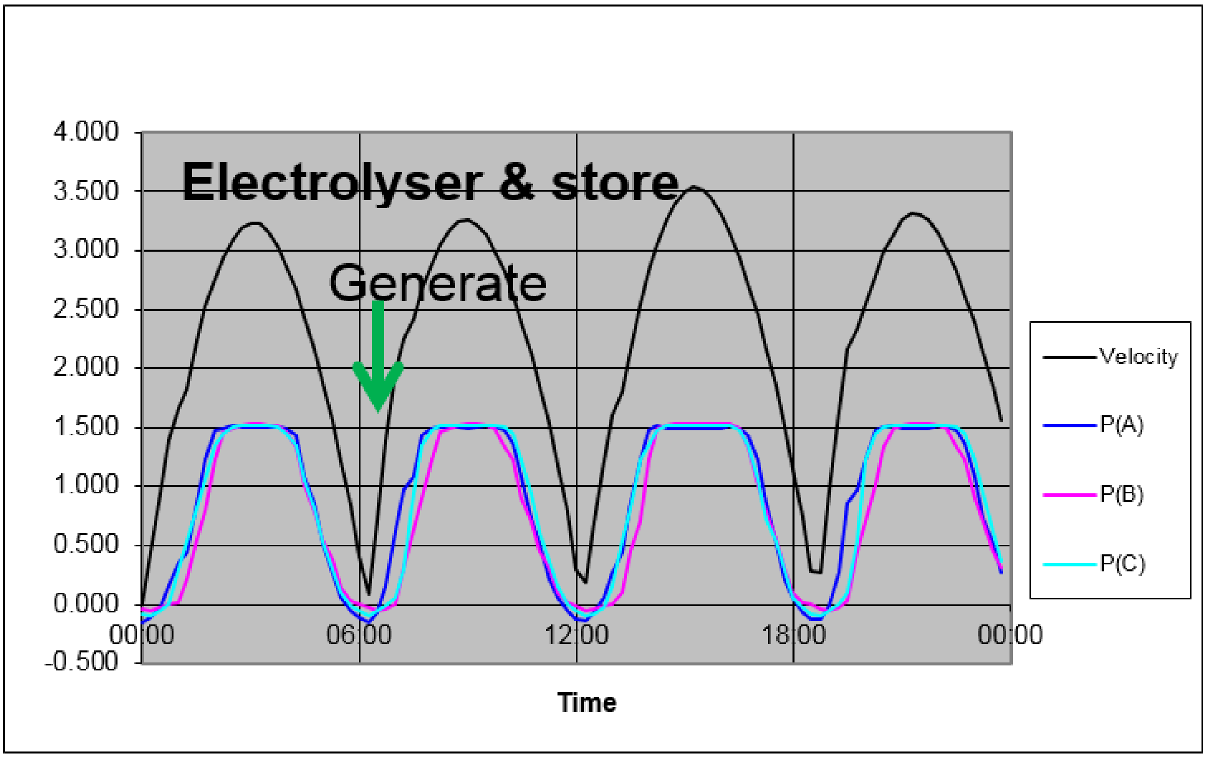

Figure 26: Tidal velocity plotted against time to show fluctuating hydrogen generation

The existing electrolyser itself is a 500kW PEM electrolyser supplied by ITM Power. Additionally there is 500kg of high pressure storage at 200 bar and 3 mobile storage units which can each carry 250kg of hydrogen at 200 bar (see Figure 27). Hydrogen is transported to Kirkwall where it is converted back to electricity in a 75kW fuel cell to provide auxiliary power for the island internal ferries while docked.

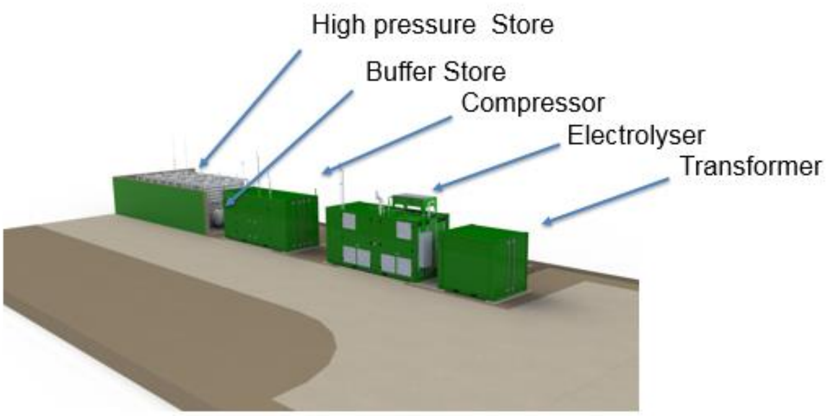

Figure 27: Electrolyser equipment layout

3.5.3 Architecture Overview

To be confirmed once plans are more advanced between partners and EMEC, although Figure 10 in Section 3.2 does give an overview of how it is currently envisaged to be set up, showing the various PLCs, generators and interaction with the VC platform and VScons.

3.5.4 Hardware and Software Requirements

To be confirmed once plans are more advanced and defined with EMEC/ electrical contractor.

3.5.5 Partner Technologies

CES will be involving their project partners in Surf n Turf (EMEC) as well as other subcontractors where appropriate and necessary.
The role of VCharge is anticipated but not yet fully defined.

3.5.6 Large industrial load plan B

If the smart electrolyser controls is not feasible for commercial, practical or financial reasons then the project would look to move the budget over to another industrial load. One exploration so far has been a battery backed rapid charger in a location where there is insufficient grid capacity, suitable total volume and/ or peaks of demand, it where could be utilised as a DSM controlled asset.
CES has identified candidate sites and potentially has access to a suitable charging system, but this could also have other commercial, practical or financial complications such as a requirement to look for additional funding, or overcoming other complications not foreseen on the electrolyser site such as planning permission, site design etc.

3.6 Integration with non-distribution network services and interfaces

The integration with non-distribution network services and interfaces (e.g. ancillary services for transmission network) is to be confirmed once project has been progressed further.

National Grid is responsible for balancing supply and demand on a second-by-second basis. It performs this duty using a number of response and reserve services (ancillary services) that allow Grid to respond quickly to any unexpected changes in supply or demand and maintain security of supply. There is growing interest in the ability of new technologies, including behind-the-meter (BTM), to provide these services at a distributed level. The ability of technologies to participate depends on the technical characteristics (response time, duration, capacity etc.), as well as commercial requirements from Grid. As we deploy new technologies in novel contexts, we will explore the technical capabilities and social constraints on the flexible systems, with a view to demonstrating their suitability to perform grid balancing at scale.

The chart attached shows Grid's current perspective on the suitability of technologies for each of the ancillary services, as well as network charge avoidance and capacity market. [Source National Grid]

	Dynamic / Firm Frequency Response	Frequency Control by Demand Management	Enhanced Frequency Response	Short Term Operating Reserve	Fast Reserve	Demand Turn Up	Triad management	Red Zone management	Capacity Mechanism
Heating, cooling, air-conditioning & ventilation systems	Y					Y	Y	Y	Y
Fridges, freezers & chillers	Y		Y				Y		
Electrical appliances							Y		
Lighting							Y		
Cooking									
Wet appliances									
Hot water, electric heating/ storage heaters	Y		Y						
Electric heat pumps							Y	Y	
Electric vehicles	Y								
Back-up / distributed generation				Y	Y		Y	Y	Y
Renewable generation / CHP	Y			Y		Y	Y	Y	Y
Battery / electricity storage	Y	Y	Y	Y	Y	Y	Y	Y	Y
Pumps / motors / compressors	Y	Y		Y		Y	Y	Y	Y
Industrial & manufacturing processes	Y	Y		Y		Y	Y	Y	Y

Figure 28: Technologies suitable for non-distribution network services and interfaces [Source National Grid]

4 Participants Recruitment Process

Heat Smart Orkney Ltd, who have been responsible for the Heat Smart Orkney project (detailed in section 3.3.2) participant recruitment will be responsible leading on the delivery of the customer interactions for this task (T2.2) in SMILE, as a third party of, and in partnership with, CES.
This will involve producing marketing materials, literature about the project for household, day-to-day management of participation agreements, Informed Consent Forms, household visits, technical surveys. They will be the customer interface, answering questions about the project. They will be responsible for gathering data about existing bills for heat, and mileage/ fuel use for and transport for analysis/ reporting purposes.

4.1 Domestic heat households

Around 45 households will be included in the project (target)
The next step is to confirm priorities and requirements for recruitment households for example:

- Existing wet heating systems
- Current heating and/or electrical systems
- Property location
- Space for equipment indoors/ outdoors for installation
- Metering and current tariff
- On-site generation
- Internet connection
- Assisting with affordable warmth
- Quality of insulation and air leaks/ draughts (suitable for low grade HP heat)
- Suitability for a particular domestic heating type (1 to 4)

4.2 Electric Vehicle charging points

A target of 30 EV charge points will be used for the smart charging (target) in the project.
Due to the rural location of the installs, organisations with fleets of vehicles within zone 1 of the grid are unlikely. Orkney Islands Council are the only organisation in Orkney with an obvious 'fleet' (at least 10 EVs). Most of the island development trusts have EVs but these are limited to 1 EV each. REWDT operates a car club scheme with its vehicle, which was previously used for EV smart charging trials with VCharge[17].
The next step is to consider priorities and requirements for recruitment of EV charging for example:

- Current electrical systems
- Property location
- Metering and current tariff
- On-site generation
- Internet connection
- Participation in the domestic installs side of the project
- Frequency of use
- EV model and charger type
- Charging preferences and patterns

[17] http://rewdt.org/index.php?link=car&name=car

5 Conclusions

The demonstrator will aim to focus on installing the controllable demand within zone 1 of the existing ANM scheme, in order to maximise the positive impact on curtailed generation.
The new system architecture was defined by detailing each of the types of demand:

- Domestic heat
- Electric Vehicles
- Industrial load

For each demand type, the report provided:

- The description
- The architecture overview
- The hardware and software requirement
- The partner technologies

5.1 Domestic heat installs

Concerning the domestic heat installs, they will consist of approximately 45 properties with a variety of different types of technologies to be implemented, including flow boilers, heat pumps, Sunamp PCM heat battery thermal store, hot water tanks, and batteries combined with VCharge dynamos (or similar) as below:

- **House Type 1:** 15 x 5.6kW Internally heated Sunamp PCM heat battery thermal store , VCharge controls
- **House Type 2:** 15 x 5kW Air to water heat pump, Sunamp PCM heat battery thermal store , VCharge controls
- **House Type 3:** 10 x 5kW Air to water heat pump, hot water thermal store, VCharge controls
- **House Type 4:** 5 x 5kW Air to water heat pump, hot water thermal store, Battery Energy Storage System (BESS) VCharge controls

The types of houses and final quantities recruited will largely depend on the uptake of participants (household energy use, size, existing heating system) and their existing or preferred way of providing heat and hot water to their homes. The heat pumps mentioned above have an 11kW output but due to the Coefficient of Performance (CoP) the load only equates to about a 5kW load.

5.2 EV smart charging

The EV charge points will comprise of domestic households **(scenario 1)** and local tourism sites and accommodation **(scenario 2)** within Zone 1, that either have an EV that they currently charge at home, or a business/ facility that would benefit from being able to offer EV charging to customers/ visitors.
Some of the advantages of this dual approach are that it allows two independent but interlinked DSM systems to be demonstrated interacting and being coordinated to the same generation ANM system. With scenario 1, where considerable intelligence can be gathered on the patterns of charging and vehicle use, DSM curtailment response can be refined with predictive knowledge and learning algorithms in this situation. Whilst in parallel, DSM installations in scenario 2 can be best tested and shown to be robust, compatible and effective whilst being agnostic to the connected vehicle technologies and use patterns.

The specific detail of types of vehicles and quantities recruited in each scenario will depend to some degree on the uptake of participants (car type, charger type) and their existing or preferred charging methods. Where existing chargers are not able to be adapted to make smart connections, these could be upgraded under the scope of the SMILE project if budget allows and new controlled charge points will be installed in places where no charging is currently in place.

5.3 Large industrial load

The industrial load is proposed to be the smart control of the 11kV on-site switching and storage system, including the existing electrolyser (operational November 2017), on Eday which is owned by EMEC (The European Marine Energy Centre). It is currently a part of the Surf 'n' Turf project funded by the Scottish government CARES Local Energy Challenge Fund and also a FCH JU funded project called BIG HIT. The electrolyser (and potential other on site storage) uses electricity from tidal energy at the test site and wind energy from the ERE turbine 600m away; SMILE will help implement the smart control of switching between the two generators and the local grid to maximise generation and hydrogen production from both of the sites (wind and tide).

5.4 Summary

The domestic heat installs, EV smart charging and large industrial load will support in increasing the electricity demand to reduce levels of curtailment. Figure 29 below summarises the where the demand will be included geographically across the zone.

The total controllable demand foreseen in the installation is approximately 944kW, as in Table 5.

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Table 5: Total controllable demand

Load type	**No**	**kW**	**kW**
Domestic heat installs type 1	15	5.6	84
Domestic heat installs type 2	15	5	75
Domestic heat installs type 3	10	5	50
Domestic heat installs type 4	5	5	25
EV smart slow chargers	30	7	210
Industrial load (500kW electrolyser)	1	500	500
TOTAL			**944**

The system architecture has been defined, although this is likely to evolve and be improved upon as the project is more clearly mapped out for installation and delivery.

The next stages will be looking at the participant recruitment, as well as modelling the system based on the defined system architecture. Trial installations will also hope to validate this method and allow for modifications and improvements before the full installation.

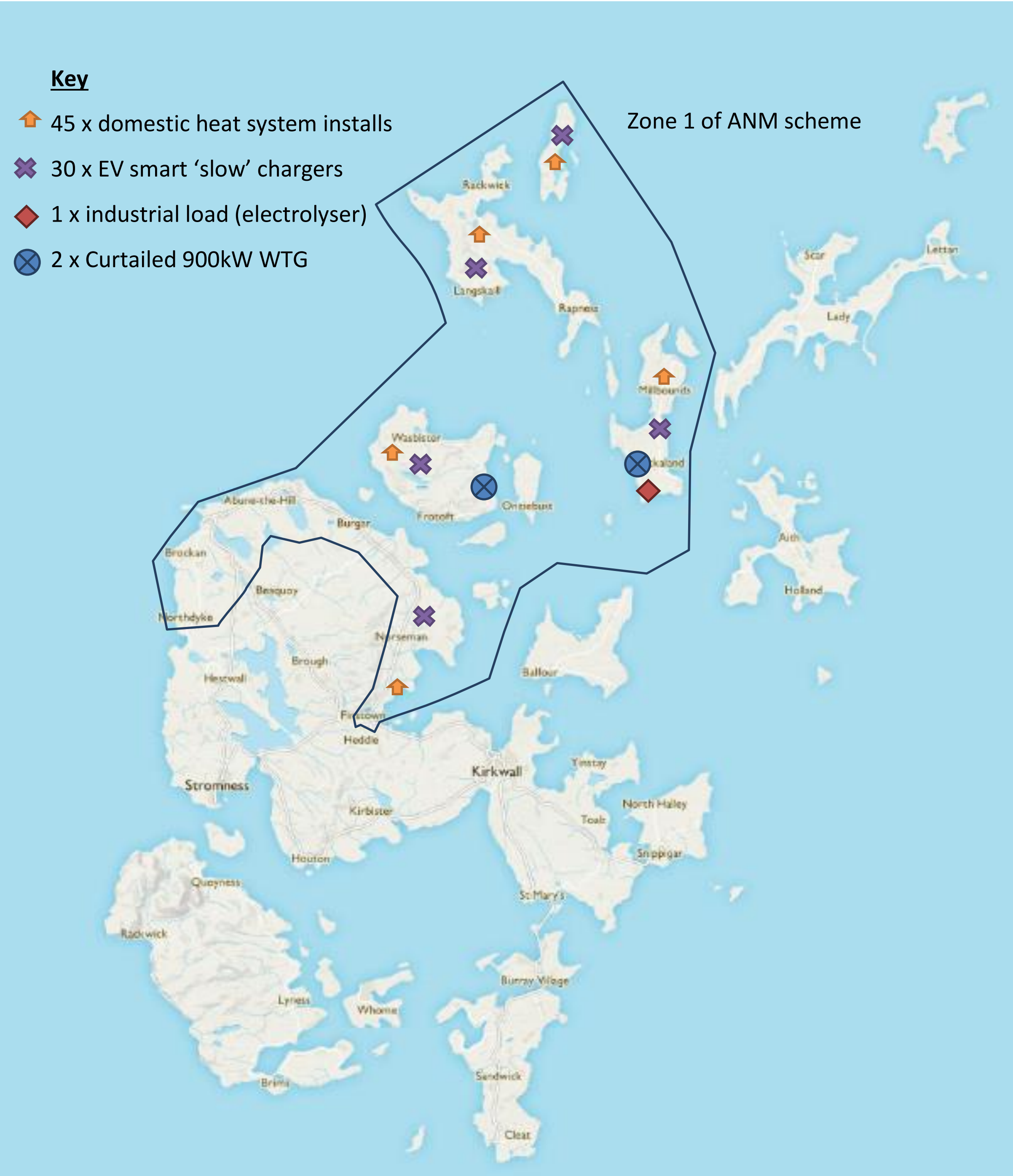

Figure 29: Location of SMILE DSM within Orkney