URBAN FORESIGHT

FEASIBILITY STUDY
ORKNEY'S ELECTRIC FUTURE

PREPARED FOR

Orkney Islands Council
Council Offices, Kirkwall,
Orkney KW15 1NY

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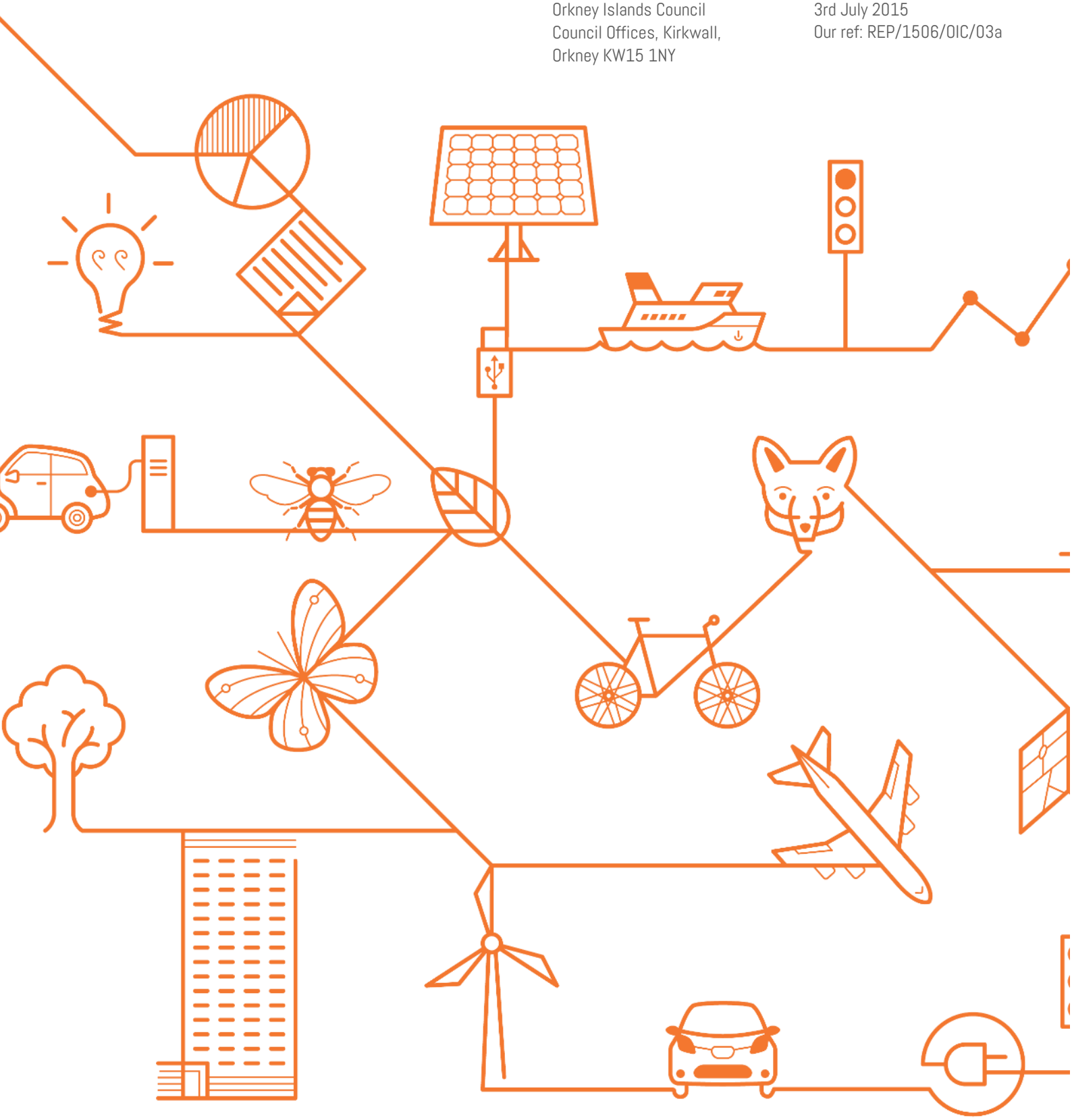

URBAN FORESIGHT

The Core, Science Central
Bath Lane
Newcastle upon Tyne, NE4 5TF
United Kingdom

E: info@urbanforesight.org
T: +44 191 495 7350
W: http://urbanforesight.org

aquatera
environmental services and products

Old Academy Business Centre
Stromness, Orkney, KW16 3AW
United Kingdom

E: office@aquatera.co.uk
T: +44 1856 850 088
W: www.aquatera.co.uk

ROBERT GORDON UNIVERSITY ABERDEEN

Robert Gordon University
Aberdeen AB10 7QE
United Kingdom

T: +44 1224 263 146
W: www.rgu.ac.uk

AUTHORS

Mia McMillan
David Beeton
Elizabeth Middleman
Adam Suleiman
Ian Johnstone
Peter Long
Fiona MacIsaac
Tom Remy
David Gray

Executive Summary

Orkney's Electric Future (OEF) is an ambitious project that integrates Orkney Islands Council's stated ambition to promote the uptake of electric vehicles (EVs) and more sustainable transport options with opportunities offered by Orkney's high renewable energy generation and wider benefits related to tourism.

It is envisaged that this ambition could be achieved by establishing a lighthouse project in the Islands. This feasibility study reviews the potential to develop the OEF project and explores how increased uptake of EVs could provide benefits to residents of, and visitors to, Orkney.

The analysis in this report is informed by a comprehensive desk study and engagement with key stakeholders in Orkney. This includes interviews with 15 experts, a public forum, and a roundtable workshop with representatives of local organisations.

The first section of the report reviews the policy landscape and establishes that the stated ambitions of the OEF lighthouse project are strategically aligned with the policy objectives of Scotland and the UK in the areas of transport, air quality, and ultra-low emission vehicles. By promoting the uptake of EVs, the OEF lighthouse project reflects the overall ambition of the Scottish Government's Switched On Scotland Roadmap and National Transport Strategy to reduce carbon emissions thereby addressing climate change goals.

The report then considers the potential of EV adoption in the Islands where the main opportunities are identified in the following areas:

- Orkney's geography, short distances between parishes, and tourism opportunities, make the Islands an ideal location to adopt EVs. With Orkney's high fuel cost, there is potential to promote EVs as an alternative mode of transport, offering savings of up to 75% compared to petrol-fuelled cars.
- OIC already has six EVs in its own fleet and has potential to adopt more with a number of diesel vans due for replacement in 2015 and 2016. This would result to a reduction of carbon emissions by 36% while potentially saving the Council approximately £67,000 if electric vans are leased.
- Orkney currently does not have its own car club in operation, but the consultation undertaken for this study shows that there is significant interest amongst a range of stakeholders. A car club could provide the opportunity to introduce EVs to the general public, potentially building confidence and encouraging private uptake.
- Converting diesel buses into electric buses on some routes in Orkney could potentially reduce fuel costs by approximately 39%, but this may necessitate some timetable and operational changes to allow for adequate charging times.
- The marine transport sector represent 28% of total energy use in Orkney, compared to 14% for road transport. There is potential to introduce electric or

electric hybrid ferries on the shorter inter-island ferry routes in the future but this will likely require additional funding.

This feasibility study also provides an assessment of how EVs could be linked to existing renewable energy generation in Orkney, where a range of renewable energy sources are available. In the past two years, Orkney has increased its generation capacity and has become a net exporter of electricity. However, as more generation is connected to the network, instances of curtailment have also increased in some turbines in Orkney, resulting to estimated losses of several millions pounds. By increasing local electricity demand through EVs, the OEF lighthouse project could potentially offer a way to alleviate curtailment.

The next section of the feasibility study forecasts the possible levels of EV adoption in Orkney, developing three scenarios (low, moderate, and high) based on an analysis of Orkney's population, vehicle ownership trends, and EV growth projections from previous studies. It is estimated that in a moderate EV uptake scenario, there would be a total of 443 EVs in Orkney by 2020, generating an additional 1,218 MWh in annual electricity demand. By 2030, this number would increase to 2,549 EVs and generate 7,136 MWh.

Comparing the current demand to the hypothetical increase brought about by EVs, it is found that EVs would have minimal impact on Orkney's overall daily energy demand in 2020. However, as EV numbers continue to increase, it is forecasted that by 2030 in a moderate uptake scenario, EVs would have an additional annual electricity demand of 7,136MWh, which is roughly equivalent to 1 years' worth of energy generated by a 2.3MW turbine in Burgar Hill.

Finally, the feasibility study also reviews existing recharging infrastructure in order to assess the requirements for future expansion and support the forecasted increase in uptake of EVs in Orkney by considering factors such as types of users, locations, and charging technologies. To supplement the Council's existing EV infrastructure strategy, 19 rapid chargers and 20 fast chargers at key locations around Orkney are required to support the expected increase in EVs in the Islands by 2020 in a moderate uptake scenario.

The analysis also considers the substantial capital and maintenance expense required to procure and install charge points. As such, a number of market models, charge point fees, and other funding mechanisms are explored in this study in order to cover the investment and ensure the long term viability of the recharging infrastructure.

Building on the findings of this feasibility study, a further two reports set out the potential to establish an OEF lighthouse project. The first of these reviews the opportunities for the lighthouse, identifying a range of technologies and business models that could be integrated into a large-scale demonstration that meets the stated ambition for the OEF project. The third and final report outlines an implementation plan, providing a detailed design of how the lighthouse project could be delivered.

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1 Introduction

1.1 Overview

This feasibility study reviews the potential to develop an ambitious project known as Orkney's Electric Future (OEF). This proposed project integrates Orkney Islands Council's stated ambition to promote the uptake of electric vehicles and more sustainable transport options with opportunities offered by Orkney's high renewable energy generation and wider benefits related to tourism.

A separate review of opportunities report and an implementation plan have been developed as part of this project:

- A review of opportunities report outlines the potential for Orkney to become a "Living Laboratory" for a range of new technologies, products, services and business models by presenting a range of prospective project options with case studies from across Scotland and overseas.
- The implementation plan provides a detailed design of work packages, delivery structures, budgets and funding opportunities to establish a large scale lighthouse project in Orkney and ensure a positive legacy from these investments.

The figure below shows the structure of the three reports prepared for this project.

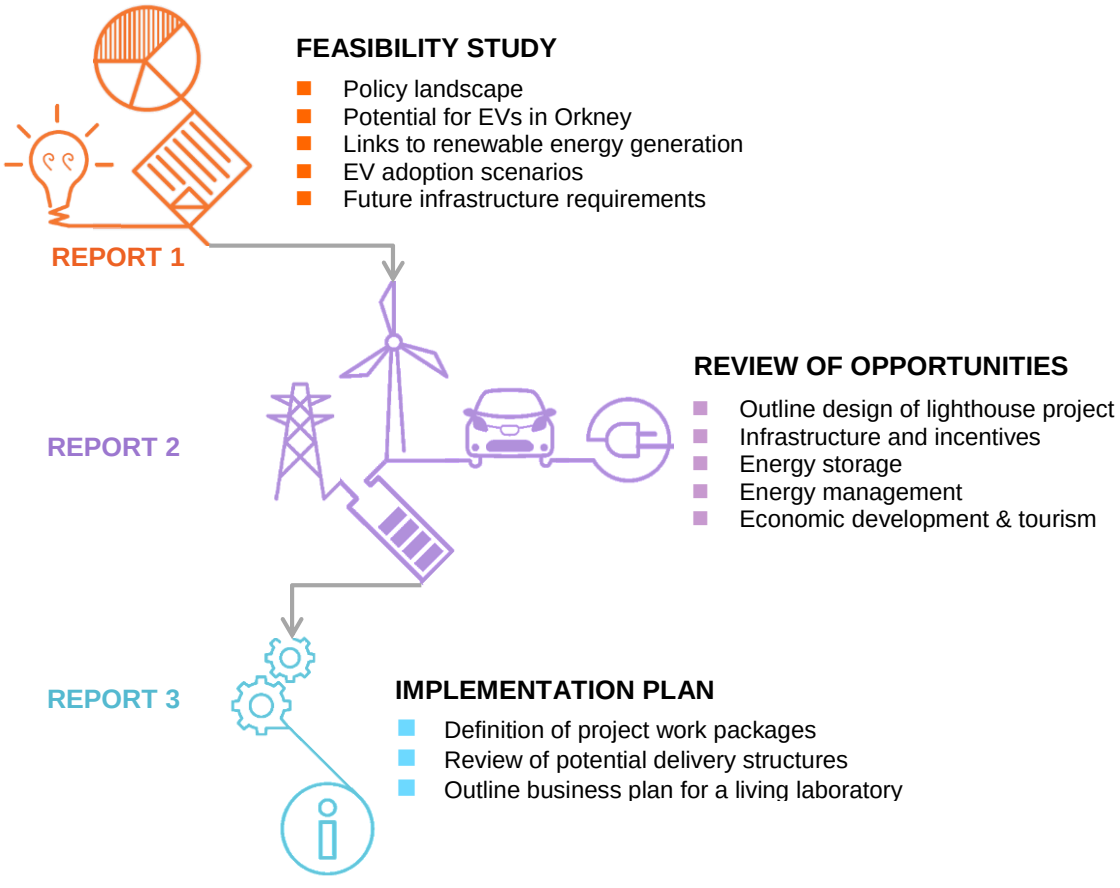

Figure 1.1 - Structure of the reports prepared for the OEF project

These reports have been prepared for Orkney Islands Council and are funded by the Edinburgh Centre for Carbon Innovation (ECCI) Smart Accelerator Sustainable Islands Project.

1.2 Orkney's Electric Future

Orkney Islands Council has stated that the key outcome and vision for the OEF project is to achieve a sustainable future for transport in Orkney. It is envisaged that this could be achieved by establishing a 'lighthouse' project in the Islands.

More specific objectives stated by Orkney Islands Council and the key stakeholders consulted for this project are to:

1. Establish and promote a good practice low carbon transport option for the residents of, and visitors to, the Orkney Islands;

2. Study the feasibility of various options to support increased uptake of electric vehicles (EVs) on the Islands, including the concept of electric hire cars with driver information systems to be positioned at Orkney's main gateways and where energy is curtailed;

3. Determine how surplus energy produced locally can be used to power transport.

1.3 Methodology

This report is informed by the following key activities:

- A comprehensive desk study;
- Interviews with key stakeholders (see Appendix A.1);
- A public forum held on 9th March 2015 in Kirkwall to present initial findings of both the desk study and the interviews and discuss potential challenges and opportunities;
- A smaller, facilitated expert roundtable workshop on 10th March 2015 in Kirkwall engaged key public, private and third sector stakeholders (see Appendix A.3) to help shape the design and scale of the lighthouse project;
- Scenarios were developed for different levels of EV uptake to establish needs for recharging infrastructure and the potential to utilise curtailed renewable energy.

1.4 Structure of the Report

The chapters of this feasibility study and the areas they cover are detailed in the table below.

Table 1.1 - Structure of the feasibility study

CHAPTER	DESCRIPTION
Chapter 1	Presents the outline of the feasibility study including project objectives, methodology, and structure of the report.
Chapter 2	Reviews the landscape of policy objectives in which this project exists to establish the potential case for public funding.
Chapter 3	Analyses the potential for EVs in Orkney including the opportunity for car-sharing, electric buses and electric ferries.
Chapter 4	Discusses Orkney's existing renewable energy generation capacity including energy surplus and grid curtailment issues.
Chapter 5	Outlines EV adoption scenarios which consider the existing fleet of vehicles in Orkney and the future demand for recharging.
Chapter 6	Assesses the infrastructure needed to support the proposed OEF project.
Chapter 7	Summary and conclusions.

2 Policy Context

2.1 Introduction

This chapter establishes how the Orkney's Electric Future project can be aligned with relevant local, national, UK and European policy objectives to support potential funding applications. This considers a range of areas including ultra-low emission vehicles, climate change, air quality, economic development, transport, energy, and smart communities.

2.2 Ultra-Low Emission Vehicles

In 2013, the Scottish Government published Switched On Scotland: A Roadmap to Widespread Adoption of Plug-in Vehicles. The roadmap establishes an ambition that by 2050 Scottish towns, cities, and communities will be free from the damaging effects of petrol and diesel fuelled vehicles. To achieve this, Transport Scotland's ambition is that from 2040 almost all new vehicles sold will be near zero emission at the tailpipe, and that by 2030 half of all fossil-fuelled vehicles will be phased-out of urban environments across Scotland.[1]

Orkney Islands Council has adopted this 2050 vision in its Local Transport Strategy and Low Carbon Strategy for Orkney. The Council's Electric Vehicle Infrastructure Strategy also reflects the local goals and objectives of these strategies, and sets out to support the use of electric vehicles by providing suitable infrastructure.

2.3 Climate Change

In Scotland, a key strategic outcome of the National Transport Strategy is to reduce emissions to tackle climate change.[2] The Climate Change (Scotland) Act 2009 sets world leading emissions reductions targets, including an interim target of a 42% reduction in greenhouse gas emissions for 2020, on the way to the ultimate goal of achieving at least an 80% reduction by 2050.[3]

Similarly, the UK Government has a stated policy to reduce greenhouse gases and other emissions from transport[4] as part of wider aims to reduce the UK's greenhouse gas emissions at least 80% (from the 1990 baseline) by 2050[5], resulting

[1] Transport Scotland, Switched On Scotland: A Roadmap to Widespread Adoption of Plug-in Vehicles
[2] Transport Scotland, National Transport Strategy
[3] Scottish Government, Climate Change (Scotland) Act 2009, 2009
[4] Gov.co.uk, Reducing greenhouse gases and other emissions from transport
[5] Gov.co.uk, Reducing the UK's greenhouse gas emissions by 80% by 2050

from the 2008 Climate Change Act[6] establishing the world's first legally binding climate change target.

Transport emissions make up just over a quarter of Scotland's total CO_2 emissions, with more than two thirds of these emissions coming from road transport. The Scottish Government is therefore committed to the 2050 road sector decarbonisation target identified in RPP2.[7]

The transport chapter of RPP2 focuses on the broad approach of how to reduce emissions from transport, setting out four core packages of proposals around decarbonising vehicles; encouraging behaviour change and promoting sustainable communities; engaging with businesses around sustainable transport; and ensuring efficient use of the road network, all of which support the objectives of smart mobility projects.

The EU aims to cut carbon emissions in transport by 60% by 2050; key goals for 2050 include no more conventionally-fuelled cars in cities and a 50% shift in middle distance passenger and longer distance freight journeys from road to other modes.[8]

Orkney Islands Council has shown its commitment to reduce the Islands' carbon footprint by pronouncing that a Low Carbon Orkney is Priority 4 of the Council Plan 2013-2018.

2.4 Air Quality

There is evidence of significant negative health effects and environmental damage caused by emissions of air pollutants. The UK Environmental Audit Committee estimated that poor air quality reduces the life expectancy of everyone in the UK by an average of seven to eight months and up to 50,000 people a year may die prematurely because of it.[9]

Scotland's National Transport Strategy looks to reduce emissions to tackle the issues of climate change, air quality and health improvement which impact on the high level objective for protecting the environment and improving health.[2]

The Orkney Structure Plan 2007 has outlined the necessity to preserve air quality through preventative policies.[10]

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[6] Webarchive.nationalarchives.gov.uk, Climate Change Act 2008
[7] Scottish Government, Low Carbon Scotland: Meeting The Reduction Targets 2013-2017, The Second Report on Proposals and Policies, 2013.
[8] European Commission, White paper 2011, Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system
[9] Environmental Audit Committee (2010) – Fifth Report Air Quality.
[10] Land Use Consultants for Scottish Environment Protection Agency Research in to Land Use Planning (Air Quality), March 2007.

2.5 Transport

One of the Scottish Government's stated National Outcomes is: *"We live in well-designed, sustainable places where we are able to access the amenities and services we need."*[11]

Achieving long-term sustainable transport solutions will be vital to meeting Scotland's world-leading emissions reductions targets and the transition to a low carbon economy, and partnerships between the public and private sectors will be necessary.[12]

An efficient and sustainable transport system is essential for Scotland's economy, communities, environment, health and general well-being.[13] In addition, a key strategic outcome of Scotland's National Transport Strategy is to improve quality, accessibility and affordability of transport, to give people the choice of public transport and real alternatives to the car.[2] All of the above would be supported by both the aims and activities of the OEF project.

Orkney Islands Council has committed to further develop a more integrated travel network, particularly within rural areas where services can be sparse.[14] Commitments to integrated transport have stemmed from the need to reduce car dependency, promote stronger public transport networks and investigate alternatives to fossil fuelled modes of transport. The overriding policy goal is to better accommodate route connections across various modes of travel; for example, coordinating bus times to be convenient for when ferries arrive so as to cater for daily commutes and other journeys.

2.6 Economic Development

Transport is key to the Scottish Government's aim of increasing sustainable economic growth,[2] and the transition to a Low Carbon Economy is also a priority.[15]

The Government Economic Strategy calls for the reindustrialisation of Scotland as a renewable energy powerhouse and centre for low carbon technologies, as well as positioning the country as a world leader in low carbon activities—a sector which, with the right incentives, could support 130,000 jobs by 2020.[15] The Low Carbon Economic Strategy estimates a potential market of £0.5 billion being generated around low carbon vehicles alone in Scotland—a huge opportunity for Scottish businesses to succeed and create quality new jobs.[16]

Orkney Islands Council's Sustainable Energy Strategy recognises that development and promotion of alternative fuel technologies such as electricity and hydrogen-

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[11] Scottish Government, National Outcomes
[12] Scottish Government, Towards a Low Carbon Scotland: Sustainable Cities, 2012.
[13] Transport Scotland, www.transportscotland.gov.uk
[14] Orkney Island's Council: 'Our Plan', April 2013.
[15] Scottish Government, Government Economic Strategy
[16] Scottish Government, "A Low Carbon Economic Strategy for Scotland", 2010.

powered vehicles could serve as a multi-faceted solution to job creation, vocational learning and carbon emission reduction.[17] Ultimately, local policy reflects the necessity for Orkney to become nationally recognised in key local industries such as tourism and agriculture in order to further stimulate and stabilise economic growth with the further identification of the need to secure EU funding in order to achieve these policy goals.[14]

The last two decades have seen an increase in economic activity in the tourism and renewable energy industries in Orkney. Tourism accounted for £31 million of spending in the local economy in 2012/13 with just over 142,800 people visiting Orkney.[18]

Based on 2012 data on the Scottish labour market, Orkney has a higher level of employment (81.3%) relative to the rest of Scotland (70.6%)[18], more businesses per 10,000 adults and an above average number of start-up businesses in contrast to Scotland overall.[19]

2.7 Energy

The Scottish Government is committed to decarbonising the power sector. Today, over a third of the UK's total renewable electricity output comes from Scotland and there is a commitment to achieve the equivalent of 100% of Scotland's electricity demand from renewables by 2020, and a 12% reduction in Scotland's final energy consumption by 2020.

Transport Scotland's Switched On Scotland Roadmap identifies a "key opportunity is to fully realise the potential of plug-in vehicles to support the development of a cleaner and smarter energy system."

The abundance of green electricity in Scotland to power electric vehicles and other elements of mobility projects will not only maximise the carbon reduction benefit, but also support increased generation from renewable sources. In particular, coordinating the recharging of plug-in vehicles with the fluctuating levels of generation from renewable sources will help to utilise green electricity that may not otherwise be used.

Smart Grids also offer significant potential in this area to accommodate new developments in energy usage in the move to low carbon. Scottish Enterprise launched an industry Smart Grids Strategy in May 2012, setting out a vision for 2020 for Scotland to become an exemplar of Smart Grid adoption and a leading international provider of Smart Grid technologies, creating up to 12,000 new jobs in Smart Grids.

Key themes of the strategy include encouraging innovation, maximising the impact of pilots and demonstrators to make Scotland a place where innovative

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[17] Orkney Islands Council 'A Sustainable Energy Strategy for Orkney', 2009
[18] Visit Scotland, Delivering for Orkney.
[19] Highlands & Islands of Scotland European Partnership, About Orkney.

technologies, pragmatic solutions and consumer engagement models are demonstrated in diverse environments including cities, and supply chain development with a vibrant base of SMEs, research groups and entrepreneurs active in Smart Grids, leading to a globally competitive Scottish supply chain.

The energy security of Scotland and the UK has been one of the primary concerns of the energy policy of the Scottish Government. A report in 2014 stated that the UK is facing the highest black-out risk in a generation with significantly reduced reserve energy margins.[20] As suppliers of over a third of the UK's clean energy, Scotland is identified as the ideal location for renewable energy generation, particularly in the context of reduced supply from coal and oil due to plant closures under European legislation.

A focus on energy resilience and sustainability is reflected in the energy strategy put forward by Orkney Islands Council, which is principally concerned with:[21]

- Ensuring Orkney uses energy as efficiently as possible, and has a secure and affordable energy supply to meet its future needs;
- Adding value to Orkney's renewable energy resources for benefit of the local economy and local communities, whilst minimising damage to the environment;
- Reducing Orkney's carbon footprint.

2.8 Sharing Economy

Orkney Islands Council has a stated interest in the potential of car clubs to be integrated into the OEF project. This is explored further in this report, with this section establishing the wider policy context of the sharing economy.

There has been significant growth in the sharing economy in recent years, and this is widely expected to continue. The UK Government has identified the significance of this opportunity, and has stated that the UK's ambition should be to be the world's leading sharing economy.[22]

The UK government advocates embracing new, disruptive business models and challenger businesses that increase competition and offer new products and experiences for consumers, and that the UK positions itself to take advantage of this growth, developing progressive policies towards the sector. [22]

The UK Government's Independent Review of the Sharing Economy[22] makes a series of recommendations, most notably that:

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[20] Scottish Government, UK energy policy and Scotland's contribution to security of supply, 2014.
[21] Orkney Islands Council, A Sustainable Energy Strategy for Orkney, 2009.
[22] Department for Business, Innovation & Skills: Unlocking the sharing economy: independent review, November 2014.

The government should pilot a UK 'sharing city' – where transport, shared office space, accommodation and skills networks are joined together and residents are encouraged to share as part of their daily lives.

Additional relevant recommendations include that:

- All public bodies that maintain car fleets should investigate whether they can save money by sharing their vehicles with the public when not otherwise in use, or by replacing their fleets with membership of an existing car club scheme.

- Government and regional transport authorities should work with car clubs to integrate them into public sector transport systems. For instance, in London, car clubs should be integrated into the Oyster ticketing system.

3 Opportunities for EV Adoption in Orkney

3.1 Introduction

One of the key deliverables requested for this study by Orkney Islands Council is a detailed analysis of EV potential across the Islands. This chapter combines data from interviews with key stakeholders and a public consultation to examine the potential for EVs in Orkney. It describes the current situation in Orkney, identifying factors which could both potentially support and provide challenges to further EV uptake.

3.2 Cars

Orkney has a well-established network of roads and cars represent the main mode of transport for residents. The total number of licensed vehicles in Orkney was last reported as 16,000 or 584 per 1,000 residents – the tenth highest in Scotland.[23]

Car ownership in Orcadian households is high and it is not uncommon for two or three cars to exist at one residence. The last Scottish Government census found that 81.6% of households on Orkney have access to one or more cars or vans–second only to Aberdeenshire.[24]

Ownership of a car can be considered particularly important on Orkney given its rural setting. In a recent public bus user survey by Orkney Islands Council, 56.6% of respondents stated that their local bus service did not meet their needs.[25] Addressing the frequency of public transport, new routes have been included in the latest bus contract beginning in January 2015, and this should have the potential to increase public transport use. In addition to this, Orkney's high weather variability and strong winds mean individuals are more likely to drive. Interestingly, despite Orkney's weather, cycling and walking have a relatively high level of uptake compared to other parts of Scotland.

Furthermore, a study by Robert Gordon University investigating attitudes towards cars in Kirkwall found that 82% of respondents agreed or strongly agreed that cars were the quickest mode of travel and 89% agreed or strongly agreed that other modes of transport were less convenient.[26]

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[23] Transport Scotland, 2013 data set for Road Transport Vehicles.
[24] Scotland Census, Figure 22, 2013.
[25] Orkney Islands Council, Public Bus User Survey Report, 2014.
[26] Barker, L., Connolly, D. and Gray, D., Understanding Attitudes: research into Kirkwall's car culture, 2009

Examining perceptions towards car sharing, the same study found that respondents were particularly receptive to having a *'guaranteed ride home'* in case of an emergency and in welcoming *'help to find car sharing partners'* as measures that would encourage them to car-share more.

Car ownership is important to individual mobility on Orkney and there is a strong sense of attachment to cars, stemming from issues of accessibility. As such, initiatives that compromise or complicate this ease of access and freedom facilitated by the car (for example, range anxiety associated with EVs) could be counterproductive if not managed correctly.

Robert Gordon University determined that the biggest issue faced by car users in Kirkwall was the cost of fuel with 85% agreeing or strongly agreeing that the cost of petrol/diesel was too high.[26] It is important to note though that in spite of the high cost of fuel, it seems that it has not significantly affected travel patterns or car use, suggesting that residents have accepted the high fuel cost. However, the fact that 85% of survey respondents find fuel costs too high presents promising prospects for alternative modes of travel with little or no use for fuel, such as EVs and plug-in hybrids.

Fuel prices within Orkney are consistently significantly higher than the national average for Scotland and/or the UK. This is marginally reduced through a five pence per litre government subsidy on fuel prices in Orkney. The petrol and diesel prices (pence per litre) for the UK, Scotland and Orkney is compared below in Table 3.1. Orkney is sub-divided to differentiate between the Mainland prices and that found on the outer islands. This table helps to highlight the potential financial and social benefits the roll out of EVs in the Orkney Islands could bring.

Table 3.1 - Fuel price comparison (pence per litre)

FUEL	UK	SCOTLAND	ORKNEY MAINLAND[27]	ORKNEY ISLANDS[28]
Petrol	108.9	108.5	117.9	122
Diesel	116.1	115.5	122.9	125

Table 3.2 - Fuel cost comparison (pence per mile)

REGION	VW GOLF 88.3 MPG	VAUXHALL ASTRA 48.7 MPG	TOYOTA PRIUS 72.43 MPG
UK	5.61	10.17	6.84
Scotland	5.59	10.13	6.81
Orkney Mainland	6.07	11.01	7.40
Orkney Islands	6.28	11.39	7.66

Table 3.2 highlights the calculated running costs, in pence per mile, of the three cars running on petrol at prices available in the UK, Scotland and Orkney. It

[27] Price taken from Ayre Service Station, March 2015.
[28] Average taken from W.I. Rendall, Westray; Olivebank General Merchant, Stronsay; and General Merchant, Shapinsay, March 2015.

demonstrates that the Golf, with the highest advertised fuel economy, running on the cheapest petrol prices seen in Scotland over the last six months cannot match that of the fuel economy of a Nissan LEAF when charged with the cheapest night time rate at 9.42 p/kWh.

This analysis highlights that for those living on the outer islands of Orkney, that cost of road fuel could be quartered. As petrol and diesel prices begin to rise again, this price gap will become more significant making EVs more and more attractive.

The financial implications of each option are shown below based on the average miles driven per year in Orkney (5,300 miles a year). Assuming the three previous discussed vehicles are running on the cheapest available petrol, 108.5 p/L, and a Nissan LEAF is being charged on 9.42 p/kWh then the following would be spent on fuel per year:

Table 3.3 – Annual fuel cost comparison of different vehicles

VEHICLES	COST	COST DIFFERENCE VS NISSAN LEAF	% SAVINGS
VW Golf	£297.37	£164.29	+55%
Vauxhall Astra	£539.17	£406.09	+75%
Toyota Prius	£362.52	£229.44	+63%
Nissan LEAF	£133.08	-	-

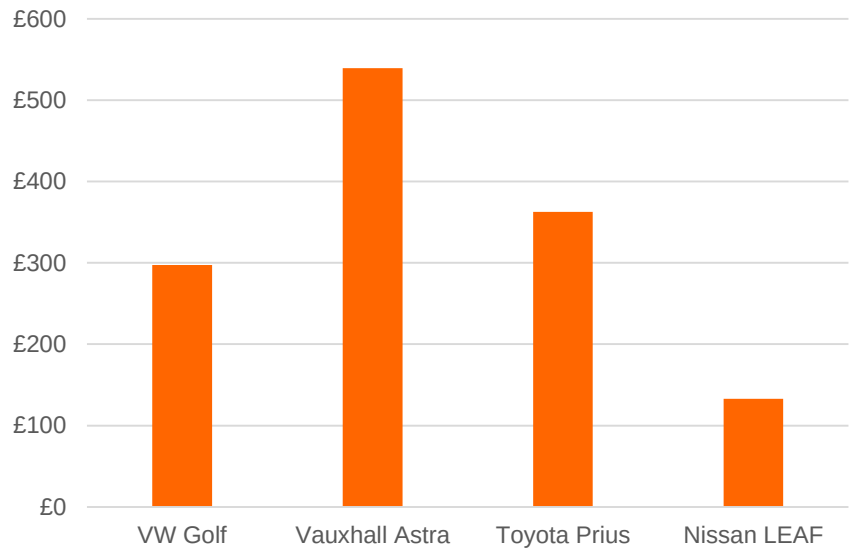

Figure 3.1 - Annual fuel cost comparison of different vehicles

On fuel prices alone, the Nissan LEAF offers a 55%, 75% and 63% fuel cost saving against the VW Golf, Vauxhall Astra and Toyota Prius respectively.

Another challenge worth noting is the perception that EVs are more expensive to own. This poses a significant barrier not just to private individuals but also to businesses who are looking to replace their fleet of vehicles.

It is important to note that misconceptions like these are managed through effective communication and education. The total cost of ownership (TCO) of a vehicle is a factor of capital cost, depreciation, and total running costs. Comparisons between an EV and a fossil-fuelled car show that EVs have a lower TCO in the long run and can offer savings to private owners and businesses. Appendix B shows the detailed cost comparisons between EVs and petrol vehicles.

3.3 Public Sector Fleets

In increasing electric vehicle uptake, the public sector can show leadership by helping to build demand in the early market. A number of local authorities in Scotland have already made significant progress in lowering their carbon emissions through the investment in EVs for their own fleets. In fact, four out of the top five councils in the UK who have the highest number of EVs are located in Scotland.[29] Dundee City Council for example has 62 EVs as of June 2015, the highest number in operation among all local authorities in the UK.

Orkney Islands Council currently have 76 vehicles in active use, six of which are electric. The fleet currently produces 212,419 kg of CO_2 per year.[30] More than half of these vehicles are vans, 14 of which are due to be replaced in 2015 and 2016, highlighted in grey below.

Table 3.4 - Orkney Islands Council fleet replacement schedule

VEHICLE TYPE	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL
Small				1	1		1			3
Medium							1		1	2
Van	3	7	4	10	10	8	2	3	4	51
Luton		1	6	4		1				12
Bus			1	4	1			1	1	8
Total	**3**	**8**	**11**	**19**	**12**	**9**	**4**	**4**	**6**	**76**

If these 14 vehicles were replaced with electric vans through outright purchase, it would cost the council approximately £268,492 for Nissan e-NV200s or £268,164 for Renault Kangoo i-Vans. However, if the vehicles were leased instead, it would offer several benefits to the Council on top of the freed up capital.

Using present values of the lease payments over the duration of the lease, the total lease cost can be compared with total purchase cost. The table below shows cost comparison of purchase and ownership of two electric vans and one diesel van.

[29] Localgov.co.uk, Scottish councils more proactive on electric vehicles, 2015.
[30] Excludes vehicles labeled as 'not for replacement'

Table 3.5 - Cost comparison between vehicle lease and purchase[31]

ITEM	NISSAN E-NV200	RENAULT KANGOO i-VAN	RENAULT KANGOO DIESEL
Purchase			
Unit price	£23,415	£22,450	£18,175
APR (discount rate)	4.5%	4.5%	4.5%
Resale value at end of lease	5,670	4,410	4,410
Present value of resale price	4,549	3,538	3, 538
Total purchase costs	**£18,865**	**£18,911**	**£14,636**
Lease			
Annual lease*	£3,200	£3,274	£1,981
Lease terms	5 years at 50,000 miles	5 years at 50,000 miles	5 years at 50,000 miles
Total lease costs	**£14,051**	**£14,375**	**£8,697**
Saving (cost) of leasing asset	**£4,813**	**£4,535**	**£5,938**
For 14 vans			
Total purchase costs	£264,111	£264,756	£204,906
Total lease costs	£196,727	£201,260	£121,767
Total savings for 14 vans	**£67,383**	**£63,495**	**£83,139**
Total capital freed up if the 14 vans to be replaced were sold	£79,380	£61,740	£61,740

*Annual rental for a 60-month term, 50k total mileage, includes servicing (maintenance, repair and tyres)

As seen in the table above, the Council can expect savings of approximately up to £67,000 if they choose to lease 14 vans to replace the ones due for replacement in 2015 and 2016. They also stand to reduce the fleet's carbon footprint by 36% (76,092 kg of CO_2). The table also shows the capital freed up if the 14 vans are resold. This amount can still vary depending on the current market value of the vans to be replaced. The additional available cash may be used to finance other Council projects, such as the installation of public charge points.

The option of leasing a diesel van is also provided as basis for comparison. Total savings in this case would be approximately £83,000. While it offers £74,960 more savings from leasing electric vans, diesel vans have higher emissions. The savings also does not account for fuel costs. According to data provided by the OIC, average annual fuel costs for the 14 vans due for replacement is £921, or a total of £12,894 per year. Taking this into consideration and given that the lease term is 5 years, the total fuel spend for the diesel vans would be approximately £64,470. The table below shows the cost difference between diesel and electric vans.

Table 3.6 – Cost difference: diesel vs electric vans, purchase and lease

COST DIFFERENCE	PURCHASE		LEASE	
	WITHOUT FUEL COST	WITH FUEL COST	WITHOUT FUEL COST	WITH FUEL COST
Kangoo Diesel vs Kangoo EV	59,850	(4,620)	79,493	15,023
Kangoo Diesel vs Nissan eNV200	59,205	(5,265)	74,960	10,490

[31] Based on sample quotations from LeasePlan UK.

As can be seen from the table, purchasing electric vans would be cheaper by at least £4,600 if fuel costs of diesel vans are taken into account. Leasing electric vans be more expensive by at least £10k. However, it must be noted that the lease includes servicing (maintenance, repairs and tyres) for the duration of the lease period.

3.3.1 Benefits of leasing

Fleet managers consider vehicle leasing for a number of reasons, the most important of which is that it can be a very cost effective and low risk method of funding a fleet of vehicles. It also affords the Council the convenience of not having to worry about servicing and maintenance costs as these are usually included in the monthly rental. This frees up the person in-charge of administrative work related to fleet maintenance to focus on other core services of the Council. The table below gives a summary of the benefits of leasing.

Table 3.7 - Benefits of vehicle leasing[32]

BENEFITS	DESCRIPTION
Simplicity of service	Most leasing companies offer to purchase and manage the preferred vehicles
Cost control	Leasing provides the certainty of fixed known monthly costs that can help with budget management
Low initial cash outlay	With leasing, a brand new vehicle is more affordable and feasible than outright purchase
Tax benefits	Most VAT registered companies can claim back 50% of the VAT (or 100% if the vehicle is exclusively for business use)
Low risk	As the lessee does not own the vehicle, there is no residual value risk involved. The leasing company is responsible for reselling the vehicle at the end of the lease period.
Convenience	Leasing offers usually include servicing and maintenance of vehicles, thus reducing administrative work
Capital release	When switching to leasing, some lessors[33] offer to buy the vehicles to be replaced, resulting to a cash injection that can be used for other investments, e.g. charge point installations.
Off balance sheet	Fleet vehicles do not appear on balance sheet

Appendix B.1 shows the impact of depreciation on EVs. Using a Nissan LEAF as a benchmark vehicle, Figure 3.2 highlights the comparison between the amount spent to lease a Nissan LEAF (blue); the annual residual value of a purchased vehicle of the same model (green); and the cumulative value lost through depreciation of the purchased vehicle each year (orange).

[32] Fleetdrive Electric, How does vehicle leasing work?, 2015.
[33] GE Capital, GE fleet management: Buy vs lease, 2015.

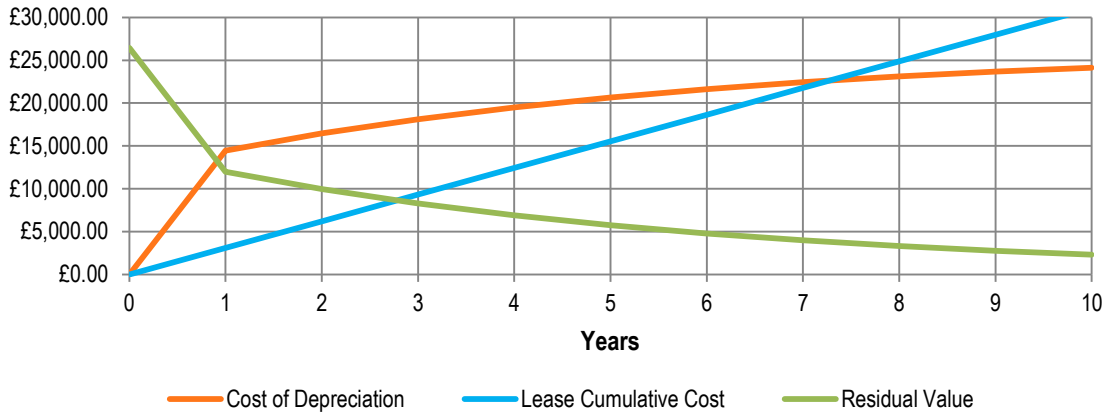

Figure 3.2 - Capital lose comparison purchase vs. lease

Fleetdrive Electric, a major electric vehicle leasing company based in the UK, offer the Nissan LEAF Visia, valued at £26,435, on a £259 per month (including VAT) lease.

The graph shows that at approximately **seven years and 3 months**, the amount spent through leasing overtakes the amount lost through depreciation of a purchased vehicle. At this point, leasing no longer becomes financially beneficial over purchasing. Therefore, if leasing is considered, the lease term should not exceed seven years. This matches well with Orkney's fleet replacement cycle i.e. 5 years for small vans.[34]

KWIKcarcost, a software tool that compares leasing and purchasing by calculating whole life costs (WLC), also found leasing to make more financial sense. A sample comparison found that a leased Nissan e-NV200 would have a gross WLC of £21,674 compared to £27,090 for an outright purchase. See Appendix B.2 for more detailed comparisons for a Nissan e-NV200, Renault Kangoo Maxi (Electric) and Renault Maxi (Diesel).

3.3.2 Wider public sector fleets

With OIC setting an example, other public sector fleets in Orkney such as the NHS, police, fire, postmaster, etc. could follow suit and start their own fleet electrification programmes. The Scottish Government currently reaffirmed its commitment to this initiative by investing £2.5 million to Switched On Fleets—a programme that provides evidence-based analysis and support to Councils, enabling them to make informed choices on EV deployment.[35] Orkney's community planning partnership led by the Council could play an important role in this area to potentially form a procurement consortium in order to consolidate resources to purchase/lease a large number of EVs at a substantial discount.

[34] Email correspondence with Laura Cromarty, 29 April 2015.
[35] Scotland.gov.uk, £2.5 million investment to reduce vehicle emissions, February 2015.

3.4 Car Clubs

Car club business models provide a way to overcome a number of the early market barriers for EVs. Such shared services offer a convenient and cost-effective alternative to the increasing costs of car ownership and limited availability of dedicated parking spaces. Car club models also mean that individuals are no longer faced with the high purchase price of EVs, or concerns related to battery degradation and resale values. Furthermore, car clubs can help to build confidence amongst a community of first time EV drivers, exposing the operational savings, benefits and performance provided by electric motoring.

3.4.1 The potential for car clubs in Orkney

With approximately 80,000 inter-island vehicle movements annually and with Orkney placing a strong emphasis on personal mobility, it is worth considering how car clubs can contribute to transportation around the islands whilst offering scope to reduce car ownership, promote tourism and support Orkney's energy sector through the use of electric vehicles.

Based on consultations with stakeholders, there is significant interest in establishing a car club in Orkney (see appendix C.4). EVs have been successfully used in car clubs across Scotland and could work well in Orkney. This could support EV awareness activities to the general public, potentially building confidence and encouraging private uptake.

The use of ferries for car movements is another avenue to explore. A visitor to Orkney travelling to Shapinsay could expect to pay £27.20 for a return ticket when taking a car to and from Kirkwall. But a local to the island would more than likely take advantage of the books of 50 tickets; at a cost of £340. This reduces the return cost for a car down to £13.60.[36]

Understandably with this arrangement, crossing between islands as a passenger remains economically unfeasible for some residents. For those who need a car to travel further afield regularly, they might choose to have two vehicles situated on either side of the crossing because it makes financial sense to do so. In this case, a car club model which allows residents to use a vehicle within their own home community, cross for free or at a reduced rate and continue their journey post-crossing, can be a more affordable inter-island travel alternative.

3.4.2 Car club setup

Typically a car club site can be set up in three ways:

1. As an extension of an existing car club operator's operations
2. As a franchise which is locally managed as a business
3. As an independent car club wholly-owned and managed by a local company.

[36] Orkney Ferries, Inner Isles Rates, 2014.

For a car club operating in rural and more remote areas such as Orkney, the franchise setup is usually the best option. Having local engagement is important and the franchise owner is allowed to set their own rates and oversee key activities such as marketing. The car club operator provides the 'back-office' services including the vehicle telematics, computer booking system, billing facilities and company support at the cost of a monthly management fee. Doing so allows for local onsite expertise which is key in the franchise model.

An independent car club, either owned and managed by a local company or a community group, is also a viable option. However, it must be noted that booking and payment systems are important elements in managing a car club. Setting up a car club from the ground up will require an investment in these systems, as well as considerable time to develop and test these. On the other hand, a franchise model can provide a turn-key solution that provides management systems and marketing support, making the car club quicker and relatively easier to set up. In addition, franchising a car club could provide a benefit for members of being able to book cars in other areas in the UK where the car club operates. Similarly, this also means existing members of the car club's national network can easily book a car should they visit Orkney.

The use of an 'instant membership' model for quick joining could be implemented in appropriate locations for instant access. For Orkney, a key location for such a model may be its harbour where visitors dock, allowing them quick and instant access to mobility around the Islands. This could be an opportunity for island communities to take forward.

3.4.3 Resource, funding and revenue

Local partners will usually need to source their own vehicles which will likely provide the most substantial set up costs if buying the EVs outright. Consideration should be given as to whether vehicles could be borrowed or leased from within the local community.

Franchises are usually supported through grant funding to assist in the set up process. Although there is not a central source of funding available, there may be funding streams accessible for community groups. For example, the Keep Scotland Beautiful charity offers its Climate Challenge Fund for community led initiatives tackling climate change.[37]

The following charges apply to set up a car club franchise:

- Signing on fee from £500
- £1,320 payable per vehicle prior to installation of telematics kit
- £935 per annum per vehicle, for comprehensive insurance cover on each car
- Service fee of £135 per vehicle per month or 20% turnover, whichever is higher

[37] Keep Scotland Beautiful, Climate Challenge Fund

Revenues are derived from:

- £13 for each member sign-up
- All booking revenues (currently £4.50 per hour or £35 per 24-hour booking)
- Mileage revenues less fuel costs

Table 3.8 below provides an example of the indicative costs based on a franchise scenario from the Co-wheels car club.[38] The scenario is based on a two car start up (which is the recommended minimum) with 10 members per car, and each member driving an average of 8 hours and travelling 55 miles in a month. Year 2 sees the average number of members increase to 14 per car and in year 3 to 16 per car.

Table 3.8 – Costs and revenue of a hypothetical car club scenario as outlined above

COSTS	YEAR 1	YEAR 2	YEAR 3
Signing on fee	£500	-	-
Prelaunch promotions	£500	-	-
Vehicle set up	£2,640	-	-
Insurance	£1,760	£1,760	£1,760
Service fee	£3,240	£3,240	£3,240
Local admin/ops/promotions	£2,000	£2,000	£3,000
Total Costs	**£10,640**	**£7,000**	**£8,000**

REVENUES	YEAR 1	YEAR 2	YEAR 3
Member sign ups	£260	£104	£52
Usage revenue	£8,640	£12,096	£13,824
Mileage	-	-	-
Total Revenues	**£8,900**	**£12,200**	**£13,876**
Surplus/Deficit for year	**(£1,740)**	**£5,200**	**£5,876**
Carried Forward	**(£1,740)**	**£3,460**	**£9,336**

CASE STUDY: ISLE OF BUTE

Image credit: www.buteman.co.uk

The Isle of Bute is home to Car Bute, a community car club accessible to business, residents and tourists.[39] Car Bute currently has around 53 members and holds three cars with the average hire lasting just over 7.5 hours and covering 51 miles.

Initial establishment of Car Bute was supported by Moor Car through provision of vehicles, marketing and operational costs and funding for a part time member of staff to manage the programme.

[38] Co-wheels, Co-wheels in your area
[39] CarBute, About CarBute, 2015.

3.5 Buses

The bus links across the Mainland represent vital services for many Orcadians. Table 3.9 below identifies the routes on the Mainland including the distance, in miles, of each journey. It also details estimates on fuel consumption per journey at 14 miles per gallon. This mileage was achieved by a bus operator using Optare Solo SR models with driver assisting Optare Eco Drive; a device designed to inform the driver if they are not driving economically. Thus, this represents the best case scenario for a bus already seen in Orkney. The table below also details the estimated cost per journey, assuming 122.9 pence per litre of diesel.[40] This equates to approximately 40 pence per mile.

Table 3.9 - Orkney bus routes[41]

ROUTE NO.	ROUTE NAME	DISTANCE (MILES)	FUEL PER JOURNEY (LITRES)	COST PER JOURNEY (£)
2	Kirkwall to Houton	11.0	3.57	£4.39
3	Kirkwall to Deerness (via Tankerness)	14.1	4.58	£5.63
4	Kirkwall to Kirkwall Airport	4.5	1.46	£1.80
5	Stromness to Houton Ferry	8.7	2.83	£3.47
6	Kirkwall to Tingwall Ferry (Evie)	25.5	8.28	£10.18
7	Kirkwall to Birsay (via Dounby)	19.9	6.46	£7.94
8S	Kirkwall to Skara Brae	29.2	9.48	£11.65
9	Kirkwall Town Service	12.3	3.99	£4.91
X1	St Margaret's Hope - Kirkwall - Finstown - Stromness	31.9	10.36	£12.73
X10	Hatston Ferry Link to Stromness	18.6	6.04	£7.42

Figure 3.3 below, illustrates the estimated price comparisons across a number of the current bus routes serviced by Stagecoach. The diesel bus fuel costs are detailed previously in Table 3.9. The electric bus costs are calculated assuming the Optare Solo SR has roughly 100 kWh of energy storage capacity, and a range of 70 to 95 mile of this model translates to a fuel economy of approximately 0.7 to 0.95 miles/kWh. Conservatively, the most expensive public rate for power, 19.43 p/kWh, was used in order to identify the minimum savings achievable. This equates to an estimated 24 pence per mile.

[40] Ayre Service Station, March 2015.
[41] Stagecoach, Bus times, 2015.

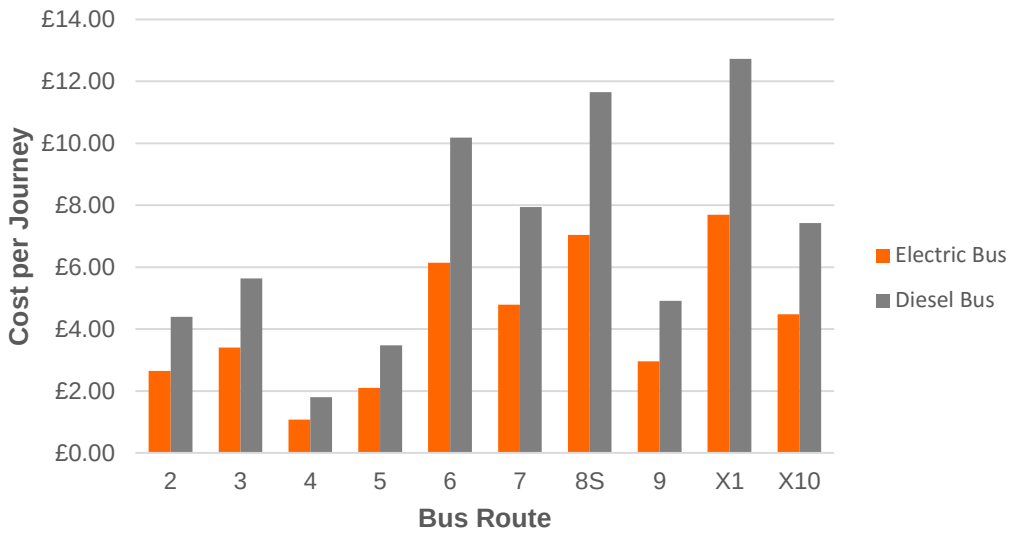

Figure 3.3 - Diesel bus vs. electric bus fuel costs

By taking the cost of each individual journey for electric and diesel models from Table 3.8 into consideration along with the approximate number of journeys completed each week, the costs can then be compared. The public bus operator could potentially reduce fuel costs by approximately 39.6% across the current routes. This could translate to savings for the Council given that they contract the services.

Some routes are more suitable for electrification than others. The Stromness to St. Margaret's Hope route, via Kirkwall, has a total return distance of approximately 60 miles, comfortably within the Optare Solo SR's stated 70-95 mile range, and could present significant savings in fuel costs.

This is also possible for a number of other routes across Orkney, but may necessitate some timetable and operational changes to allow for adequate charging times.

A ten minute charge on a rapid charger at key bus stops would give the vehicle an additional 5.8 to 7.9 miles. Accommodating this charging time within the schedules could significantly increase the possibility of electrification of Orkney's bus routes.

In order to accommodate the current routes, it would be recommended to have dedicated rapid chargers for the bus fleet located at:

- Kirkwall Travel Centre
- Stromness Travel Centre
- Houton Ferry Terminal
- Kirkwall Airport
- Birsay
- St. Margaret's Hope
- Tingwall Ferry Terminal

CASE STUDY: AIRPORT TO KIRKWALL ALL-ELECTRIC BUS

In 2014, Orkney Islands Council was awarded funds from the Scottish Government's Green Bus fund and match funding from the Low Carbon Vehicle Allocation Fund to purchase the first fully electric bus for the islands. The bus will run on the airport service between the Kirkwall Travel Centre to the nearby airport. The bus is advertised to have a range of 70-95 miles on a single charge, and the return journey to the airport and back is approximately 10 miles. This means the bus would be able to make approximately seven and nine complete runs before needing to return for a charge. However, this does not take into consideration mileage lost due to weather conditions; internal temperature control when required; or passenger numbers. Charge time is estimated to be six hours using the 15kW charging and just two hours with the use of a 50kW DC rapid charger.[42]

Without the ability to stop long enough during operation for trickle charging the current conventional Internal Combustion (ICE) bus would be required to remain in operation in conjunction with the new electric model during charging periods. For example, on the Monday to Friday service the current schedule has the buses making a complete return journey in 27 minutes.[43] Therefore, the bus could approximately operate between three and four hours before requiring 2 hours on rapid charge.[42] The addition of another similar fully electric bus would then allow the airport shuttle run in Orkney to be completely electric and emission free; a strong image for visitors to the island. In the interim period the existing diesel shuttle bus will be retained while the electric bus is being charged. There is a rapid charger situated on Great Western Road for the bus' use.

Image credit: Orkney Islands Council

3.6 Ferries

An estimated 30 GWh per annum are used in the marine transport sector in Orkney for inter-island ferries and another 183GWh are used by ferries to the mainland. This represents a large proportion of the total energy use in Orkney; approximately 4% and 24% respectively for inter-island and ferries to the mainland, compared to 14% for road transport.

There is a potential to introduce electric or electric hybrid ferries on Orkney's internal routes and services in the future, as Calmac have done on some routes in the Western Isles. This could be considered as part of the Council's ferry replacement programme. However, opting for an electric or hybrid ferry is likely to require additional funding.

Electric ferries rely on an electric motor for propulsion using electrical energy stored in an energy storage device rather than being propelled by a petroleum based combustion motor. Hybrid electric ferries which combine traditional diesel power

[42] Optare, Solo R, 2013.
[43] Stagecoach, Bus times, 2015.

with electric battery power, resulting in reductions in fossil fuel consumption, carbon emissions and other pollutants.

In addition to electric engines, there is potential for 'cold ironing' which is the process of providing shore-side electrical power to a ship at berth while its main and auxiliary engines are turned off. This is currently in practice with the vessels operating in the inter-isle routes and many of the newer smaller guest vessels which visit the harbours.

Cold ironing is also being considered for the external ferries (ferries to mainland Scotland operated by the Northern Isles Ferry Services contract). These vessels have a much larger requirement and would have a significant impact on electricity demand. Converting ferries of this size to electric power is more conceptual and will be some years away from being a viable option. This service is the responsibility of the Scottish Government and as such, will be subject to availability of government funding.

CASE STUDY: CALMAC HYBRID ELECTRIC FERRY

The MV Hallaig is the first hybrid ferry in the world, developed under the Low Emission Hybrid Ferries Project. Owned by Caledonian Maritime Assets and operated by Caledonian MacBrayne the roll-on roll-off ferry is capable of accommodating 150 passengers, 23 cars, two 44t HGVs and three crew members and operates between the Isle of Skye and Raasay at a speed of 9kts.[44]

The award winning ferry uses a diesel-electric hybrid propulsion system and is capable of operating solely on batteries on some crossings and at port reducing CO_2 emissions by up to 38% compared to a diesel system.[45] Much of Hallaig's operations occur at a low level of power where the use of diesel is inefficient, it is here where the efficiency of the hybrid system is realised. In addition the ship's design allows for the future retrofitting of technology as progress is made in green technology research.

The ferry batteries are charged overnight for up to 12 hours when the electricity prices are at their cheapest.[45] Wind, tidal and solar power can be used to charge the batteries, further reducing the carbon emissions of the vessel.

A sister vessel, MV Lochinvar was launched in 2014. The investment and build of both ferries at Fergusons in Port Glasgow supported 175 jobs and 20 apprenticeships in the community and supported the local economy.

Image credit: www.pressandjournal.co.uk

[44] CM Assets, MV Hallaig.
[45] Volvo Penta, The Industry's Best Kept Secret is out.

CASE STUDY: WORLD'S FIRST ELECTRIC CAR FERRY, NORWAY

The world's first electric car ferry powered entirely by batteries has begun its operations in Norway. With capacity for 360 passengers and 120 vehicles, the ferry, run by Norled is operating on a 6km route on the Sognefjord, Norway's largest fjord, between the areas of Lavik and Ytre Oppedal. The journey which takes approximately 20 minutes is undertaken 34 times every day and uses 150 kWh of electricity per route, the equivalent of 3 days electricity in a standard Norwegian household.

Siemens in partnership with shipbuilders Fjellstrand provided the electric propulsion system which contains a lithium-ion battery charged by hydro power, thereby reducing the cost of fuel by up to 60%. In addition due to the weak power grid in the area, Siemens and Norled have installed battery packs at each of the piers so the ferry can recharge when docking at the respective locations to drop off passengers. These battery packs then gradually recharge via the grid when the ship is undocked. The ferry itself is recharged at night when it is out of use and is saving on the consumption of at least one-million litres of diesel annually, 570 tons of carbon dioxide and 15 tons of nitrogen oxides.[46]

The electric ferry represents an important step for renewable transport in Norway which relies on maritime mobility due to its large coastline. Fifty other routes can currently support battery-operated vessels and if the market develops as expected and battery costs decrease whilst their efficiency increases, electric could replace diesel as the main power source.

Image credit: www.siemens.com

[46] Siemens, First electrical car ferry in the world in operation in Norway now, 2015.

4 Existing Renewable Energy Generation and Management

4.1 Introduction

This chapter addresses the requirement to review the links to existing renewable energy generation in Orkney. It describes the renewable energy landscape in Orkney to show the current generation capacity, level of demand, and amount of energy curtailed.

4.2 Renewable Energy Generation

Orkney has a range of renewable energy generation sources, including wind, solar PV, wave, and tidal. A further important characteristic of renewable generation in Orkney is the high levels of community energy projects.

4.2.1 Wind

Over the last decade, Orkney has seen a large increase in the amount of renewable energy generation capacity particularly from wind. The total installed capacity for wind turbines in Orkney up to the end of 2014 is around 48.657MW as shown in Figure 4.1, made up mostly from turbines over 50kW[47] and 6,044kW of small wind turbines (under 50kW).[48] The turbine locations are shown in Figure 4.2 and Figure 4.3. No publically available data is available to ascertain what proportion of the small wind turbines that have been granted planning permission have been installed but data published by Ofgem[49] shows that a total of 5034.3kW of small wind turbines (under 50kW) are registered for the Feed-In Tariff (FITs).[50]

Monthly generation output from the operational turbines show as expected, a seasonal variation with higher outputs during the winter as well as the impact of increasing generation capacity.[51]

[47] See Appendix C.1 for more details. Ofgem, Feed in tariff installation report, 2014.
[48] OIC, Planning online applications.
[49] Ofgem Renewables and CHP Register
[50] Ofgem, Feed in tariff installation report, 2014.
[51] See Appendix C.2 for more details.

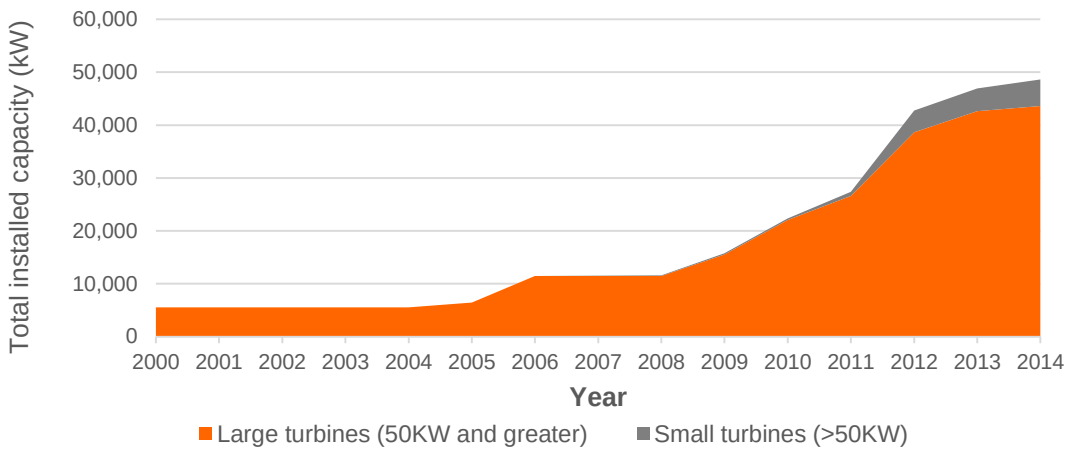

Figure 4.1 - Total installed capacity of all turbines in Orkney
Source: Ofgem Renewables and CHP Register, OIC planning portal and Variablepitch.co.uk

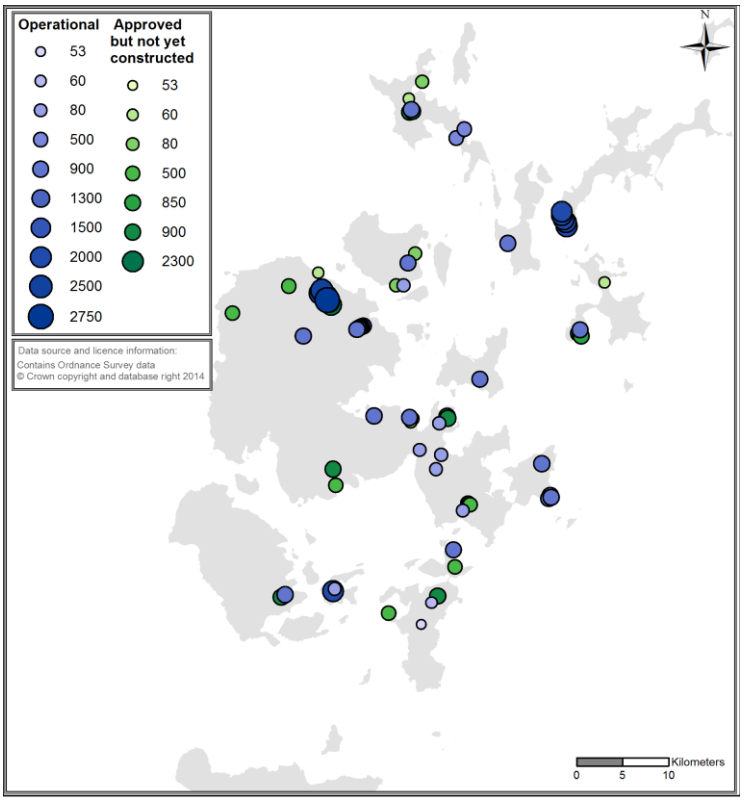

Figure 4.2 - Locations of large wind turbines (50kW and above) operational, and approved but not yet operational
Source: OIC planning portal and Variablepitch.co.uk

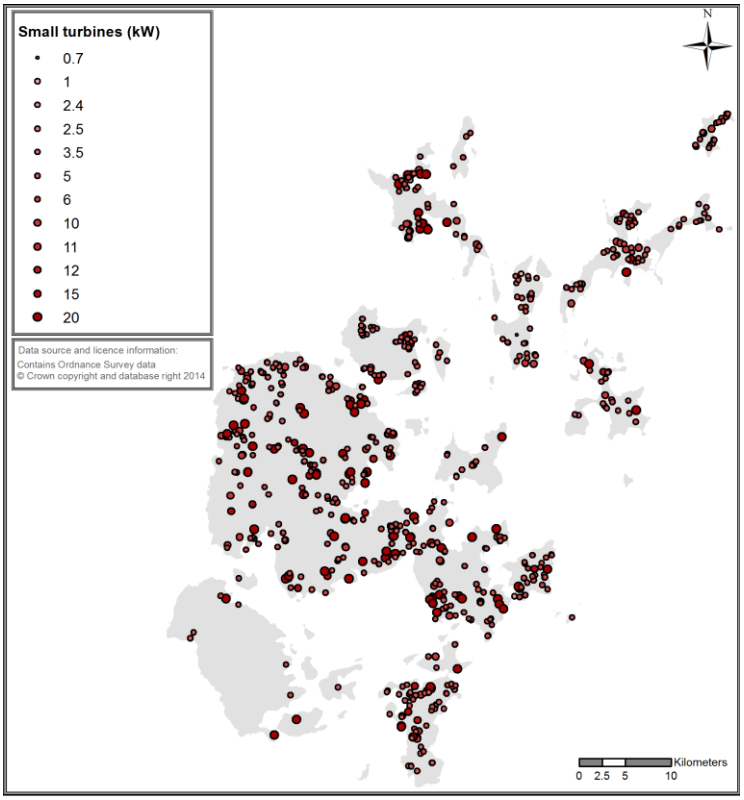

Figure 4.3 - Locations of small wind turbines (up to 50kW) with planning permission
Source: OIC (http://planningandwarrant.orkney.gov.uk/online-applications/)

4.2.2 Solar PV

Similar to wind turbines, photovoltaic (PV) systems have become increasingly common in Orkney with a total of 1281kW of photovoltaic panels now installed as of the end of 2014. This is around 0.1% of all the PV installations in the UK and 0.05% in terms of installed capacity which are registered for feed-in-tariffs (FiTs).[52]

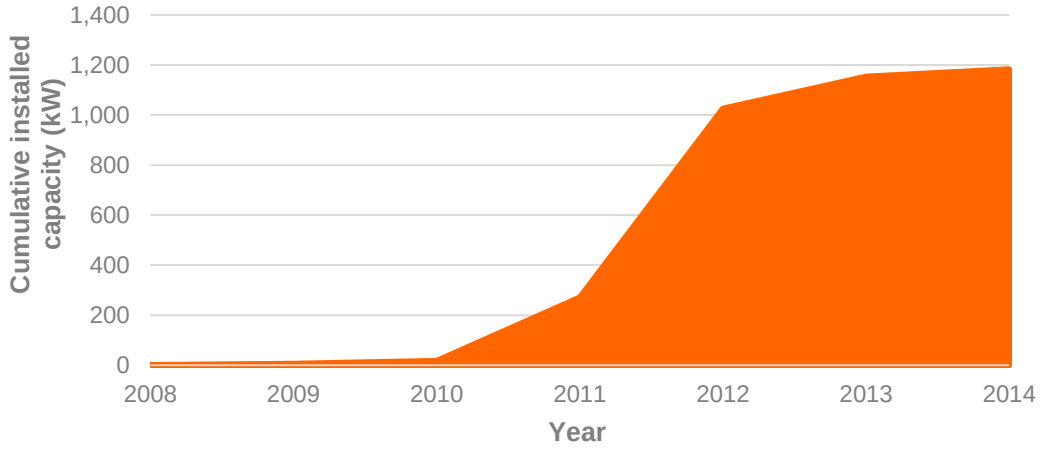

Figure 4.4 - Cumulative installed capacity for photovoltaic panels
Source: Ofgem Renewables and CHP Register

[52] www.gov.uk, Sub-regional Feed-in Tariffs Statistics, 2014

4.2.3 Wave and tidal

Orkney holds a prominent position in the wave and tidal industry with the world leading testing facility EMEC and the world's first leasing round for commercial wave and tidal projects.

Since its establishment in 2003, EMEC has attracted many developers to its wave and tidal test facilities located at Billia Croo and the Fall of Warness respectively; 12 companies are currently using the test sites. The tidal test site has a non-firm grid connection of 4MW and the wave test site has a non-firm grid connection of 7MW. These technologies are still at an early stage of development and therefore the number of GWh generated is small day-to-day, but this is expected to rise in the future. Some data is available via the Renewable Obligation Certificates (ROC) register but, as some developers choose not to register for ROCs, this is not a complete picture. In addition, as it is a test site, this does not give a firm indication of what generation levels can be expected in the future.

In 2011, the Crown Estate held a leasing round for commercial and demonstration marine energy project in the Pentland Firth and Orkney waters. There are currently leases held for 550MW of wave energy project and 530MW of tidal project in Orkney waters.

4.2.4 Community energy generation

There are at present six community wind energy projects in Orkney in five of the north isles and Hoy in the south isles as shown in Table 4.1 below.

Table 4.1 - Community energy generation projects

GENERATOR NAME	LOCATION	TOTAL MW	COMMISSION DATE
Gallowhill	Gallow Hill, Westray	0.9	11.9.2009
Ore Brae Wind Farm	Hoy Community Turbine, Ore Brae, Hoy	0.9	21.9.2011
Kingarly Hill Wind Turbine	Kingarly, Rousay	0.9	22.9.2011
Braefoot Wind Farm	Howe, Shapinsay	0.9	21.10.2011
Rothiesholm Head Wind Farm	Rothiesholm Head, Stronsay	0.9	17.11.2011
Sandybank Wind Farm	Sandybanks, Eday	0.9	27.11.2012

Collectively, these community-owned turbines are called Community Power Orkney (CPO). Community Energy Scotland (CES), a registered charity, provides practical help for communities on green energy development and energy conservation.

Some of the community turbines are suffering curtailment issues due to the lack of adequate grid to the islands. In some cases, it is well over 50% which is a severe drop in revenue. The communities are looking at a range of projects that can increase demand within the islands and increased EV uptake is one of these. Other

islands are looking at heated growing spaces, hydrogen production and electrifying ferries.

4.3 Energy Surplus and Grid Curtailment

The general trend over the last decade has been towards more export as increasing amounts of renewable energy are installed in Orkney. Figure 4.5 shows the total imports, exports and net flow of electricity for each of the last five years, which shows that in 2013 and 2014 Orkney was a net exporter of electricity.

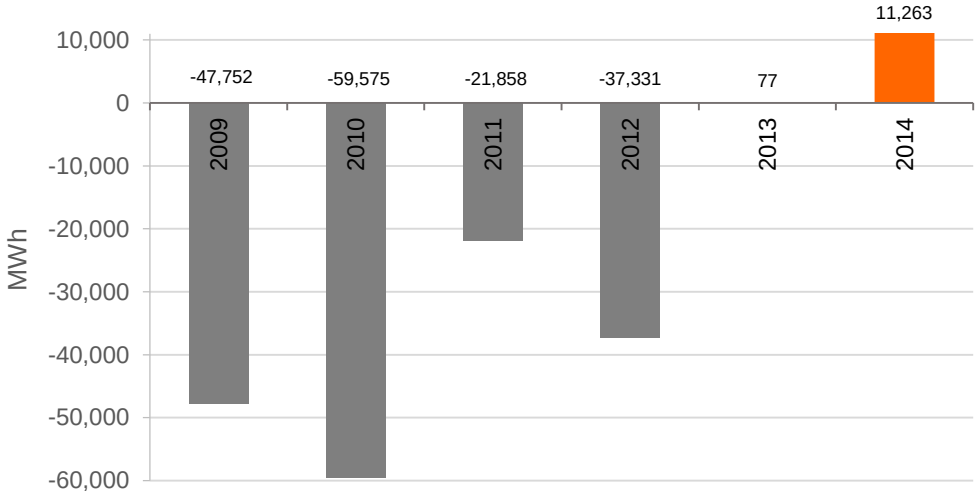

Figure 4.5 - Yearly net flows calculated from half hourly average values (January 2009 – December 2014). *Source: SSE*

Positive values show exports from Orkney and negative values show imports into Orkney. Net monthly flows averaged over several years show that as expected imports are higher in the winter months when demand is higher (Figure 4.6).

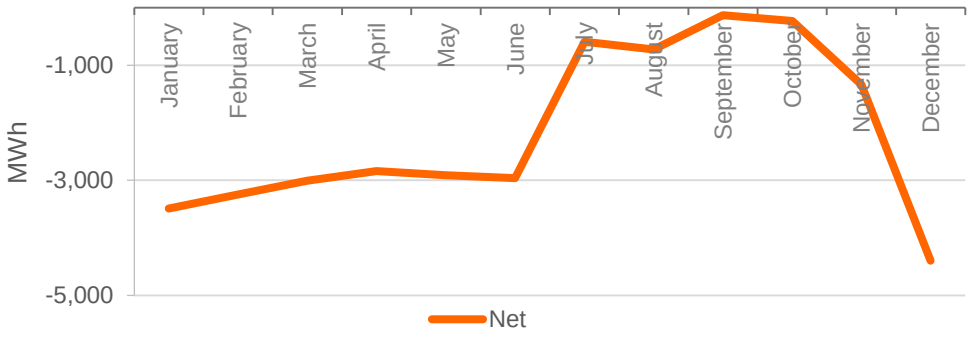

Figure 4.6 - Average monthly variation in totals for import, export and net flows calculated from half hourly average values, average over 5 years (January 2009 – December 2014). *Source: SSE*

Demand data for Orkney (Figure 4.7 and Figure 4.8) shows that the demand normally varies between 10 and 25MW depending on the time of day and the season. Figure 4.8 also shows how the demand and generation compare over the last four years.

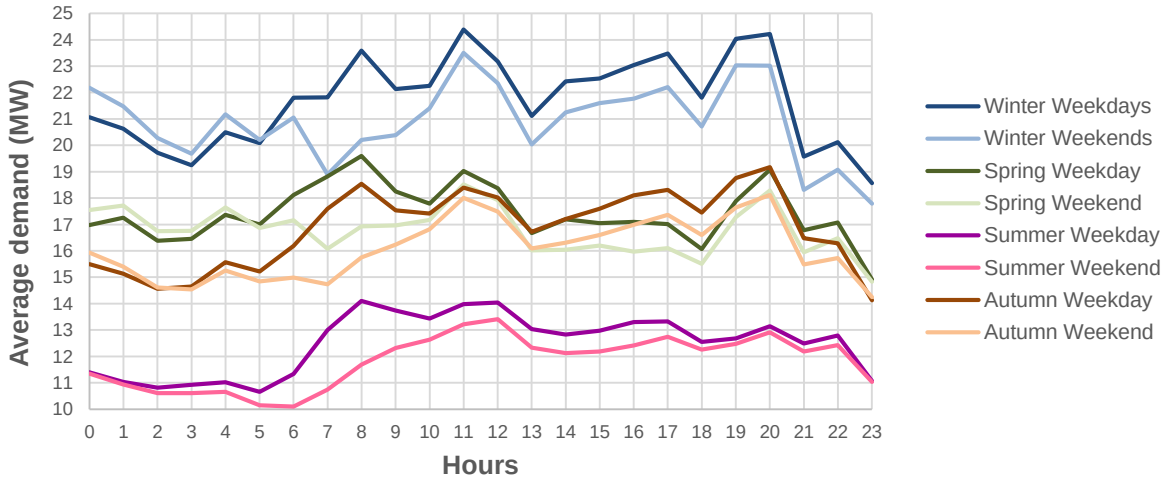

Figure 4.7 - Average hourly demand by season[53]
Source: Data logged at 10 minute intervals by Aquatera from http://anm.ssepd.co.uk/

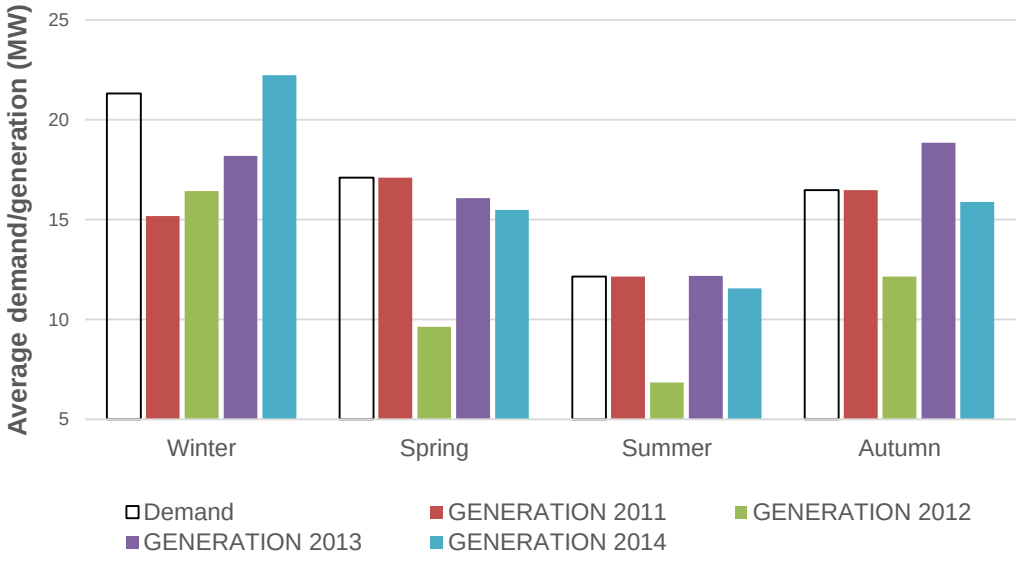

Figure 4.8 - Seasonal demand and generation
Source: Data logged at 10 minute intervals by Aquatera from http://anm.ssepd.co.uk/

[53] Winter: December, January & February; Spring: March, April & May; Summer: June, July & August; Autumn: September, October & November

Over the last few years as more generation has been connected to the network, some turbines in Orkney have been experiencing more curtailment than was initially predicted. It has not been possible to obtain actual curtailment figures for individual turbines for this study but some figures are available from conference papers. For example, Lost Productivity of 79,000kWh or 38.5% of potential was seen for the Rousay community turbine in September 2014 and the Hoy community turbine saw Lost Productivity of 38,000kWh or 13.2% of potential.[54]

In general, higher levels of curtailment are seen on the north isles to the north of the pinch points labelled 3 and 5 in Figure 4.9 in the next section.

It has been suggested that the communities have lost several million pounds of revenue due to curtailment. This gives a strong incentive to look at increasing the local electrical demand of which electric vehicles could play an important part.

4.4 Active Network Management System

Orkney is currently connected to the national grid via two 33kV (20MVA) submarine cables. This allows generators on Orkney (mainly wind but also wave, tidal, solar and gas) to export electricity to the Scottish mainland and for energy to be imported from the mainland when generators on the island are not generating. Internally, there are several spurs and circuits. One of these circuits connects the north isles to the mainland.

Before the implementation of the Active Network Management (ANM) system, two types of connection were possible: Firm Generation (FG) and Non-Firm Generation (NFG). FG were the first group of generators to the Orkney system that account for 26MW. NFG provided 20MW of further capacity which is based on both subsea circuits plus the minimum demand. If one of the subsea cables goes out of operation then the NFG may be required to cease production. Currently, FG and NFG capacity have been fully taken up by contracted generators.

In 2009, an Active Network Management (ANM) system was set up in Orkney which has allowed more generators to connect to the grid than would otherwise have been possible without substantial upgrades being necessary.[55] This new category was classed as New Non-Firm Generation (NNFG).

[54] Community Energy Scotland, Community Power Orkney, 2014
[55] Scottish Southern Electric Power Distribution, Orkney Active Network Management Live

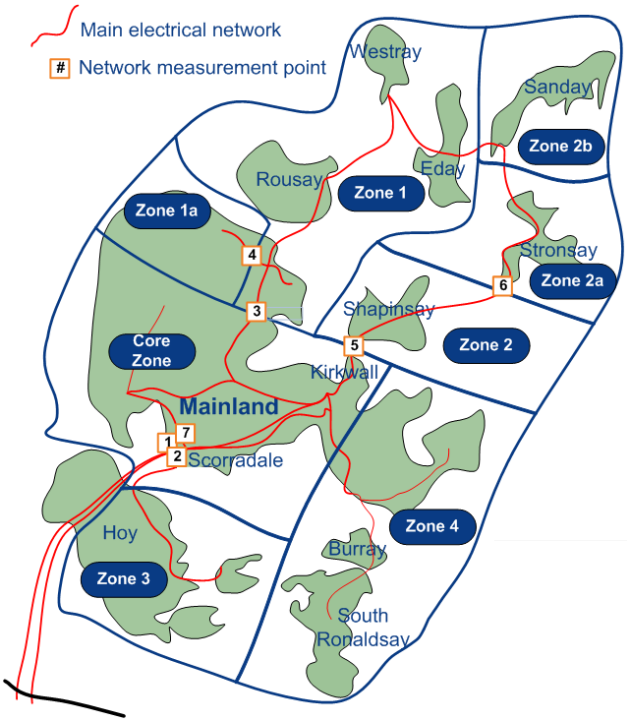

Figure 4.9 - Orkney's Active Network Management system demarcating the generation zones, main electrical flows and measurement points

The ANM system monitors the electrical network and controls the distributed generation. The system receives real-time information from network measurement points. These points represent constraints on the network (pinch points) on account of the additional generation. The network is divided into DNO (Distribution Network Operator) zones based upon the pinch points as shown in Figure 4.9. When a threshold at these points is breached, the system will take over the turbines under the control of the ANM system (NNFG) and temporarily reduce their output.[56]

Having established the first smart grid in the UK that allows Orkney to unlock additional generation revenue previously curtailed, Orkney's world-leading reputation in this field continues to attract research and design expenditure from around the world with companies looking to innovate further on distributed generation.[55]

An estimated 400 jobs on the Islands depend on renewable related activity[57] and Orkney is in a privileged position as 1 of only 3 designated power zones in the UK.[58] Registered Power Zones (RPZs) were setup under Ofgem to research, develop and demonstrate technology associated with distributed generation. Exploiting this to

[56] Scottish Southern Electric Power Distribution, Orkney ANM Flyer, n.d.
[57] Orkney Islands Council, 'Response to OFGEM…', 2014.
[58] OfGem, The Innovation Funding Incentive & Registered Power Zones Annual Reports, 2006.

its full potential offers the possibility of additional jobs and economic development for the Islands.

The majority of this work has come about due to the lack of grid capacity that Orkney has at present. The two 33 kV cables that exist are already at capacity and the justification for a new cable requires commitment from transmission developers. There has been some work completed on the possibility of a 132kV cable that will be built in 2021. This would open Orkney up for more developments and will include tidal and possibly wave projects. There is still some doubt about the dates as it is not clear when the tidal and wave projects will be fully commercialised. There is therefore a need to increase demand locally in the intervening period. The recent study published by OREF lays out the various options available to increase the demand locally.[59] There is a keen demand for more wind generation within the islands due to very good capacity factors and local supply chain. A recent landscape capacity study completed for the OIC has indicated that there is limited scope for any large wind projects but some areas where there could be a limited number of turbines. This report is still under review and has not been accepted by the OIC yet. There is however possibilities for more small turbines and a number of companies looking for sites. These small turbines could link into EV charging on a domestic or small business scale and some enthusiasts who have an integrated domestic system.

4.5 Orkney Energy Storage Park

Scottish and Southern Energy (SSE), in conjunction with Mitsubishi Heavy Industries (MHI), operate a 2MW Lithium-Ion battery within the Active Network Management (ANM) system, located within the Orkney Energy Storage Park at the Kirkwall Power Station (see Figure 4.10).

The initiative was the first tier of a project designed to attract outside developers to deploy their technologies on to Orkney's active smart grid by creating incentives to do so, while also creating the infrastructure for such technologies and selecting the most appropriate technology for Orkney's requirements.[60]

The project investigates how large-scale batteries could play a role in the release of capacity on the electricity distribution network and explore how the intermittency issues affecting renewable generation could be resolved. However, the deployment of this battery is a test of viability and not a long-term solution. This particular project is due to last for a total of three years; from the beginning of 2013 to the end of 2015, at which point MHI will either recover the units or sell them to SSE.[61]

[59] OREF, Orkney Energy Audit, 2014.
[60] SSE, LCNF Tier 1 Close-Down Report, 2012.
[61] Correspondence with Stephen Burns (Kirkwall Power Station Manager)

Figure 4.10 - MHI 2MW lithium-ion battery in Kirkwall, Orkney

The batteries are housed in two 40-foot containers, with a third container for the power conditioning electronics. In total, the capacity of the batteries is approximately 800kWh. At rated capacity the system can provide rated power to the grid for 15 minutes.[62] The battery is integrated into the ANM system and controlled to charge and discharge when required.

By introducing energy storage, this project aimed to further develop the ANM scheme to show that Orkney's smart grid is capable of monitoring and controlling energy storage technologies in real-time while also allowing energy that would otherwise be constrained from the network to be stored.[63]

[62] Sandia National Laboratories, n.d.
[63] Energy Networks Association, Orkney Energy Storage Park Project, 2014

5 EV Adoption Scenarios

5.1 Introduction

This chapter outlines electric vehicle adoption scenarios generated for this report. These analyses consider the different type of vehicles existing in Orkney and evaluate the demand for recharging as uptake of EVs increases in the future, the times of day at which the recharging is likely to happen and the location and the infrastructure needed.

To date, there are estimated to be around 60[64] electric cars, two electric light good vehicles (LGVs) and one electric bus in Orkney, with EV charging infrastructure in place since 2011.[65]

5.2 Methodology

The methodology used to create the scenarios is explained in this section. The following assumptions are considered in order to create the model for the scenarios.

- Energy consumption in Orkney
- Expected vehicles increases
- Vehicles' energy consumption in Orkney
- Daily energy distribution
- Type of chargers and daily demand
- Infrastructure cost
- Variables
  - The targeted fleet mix, that is to say the number of electric vehicles we want the Orkney's fleet to be composed of in the future
  - The vehicle turnover rate (VTR), which is the percentage of vehicles from the previous year that are being renewed
  - The transition period, which is the number of year to reach the targeted fleet mix

5.2.1 Energy consumption in Orkney

Limiting the scope of work to road transport was the first assumption made. Terrestrial road transport only represents 47% of the total road transport consumption in Orkney (Figure 5.1), however this is the sector that is the most likely to be impacted by the development of electric vehicles. This can be explained by the fact that the agriculture sector accounts for more than 50% of the fuel consumption in Orkney and for nearly 100% of the non-road transport.

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[64] Personal communication with Jonathan Porterfield.
[65] Conway, G., The Orkney iOn: Peugeots pure electric goes rural, 2011.

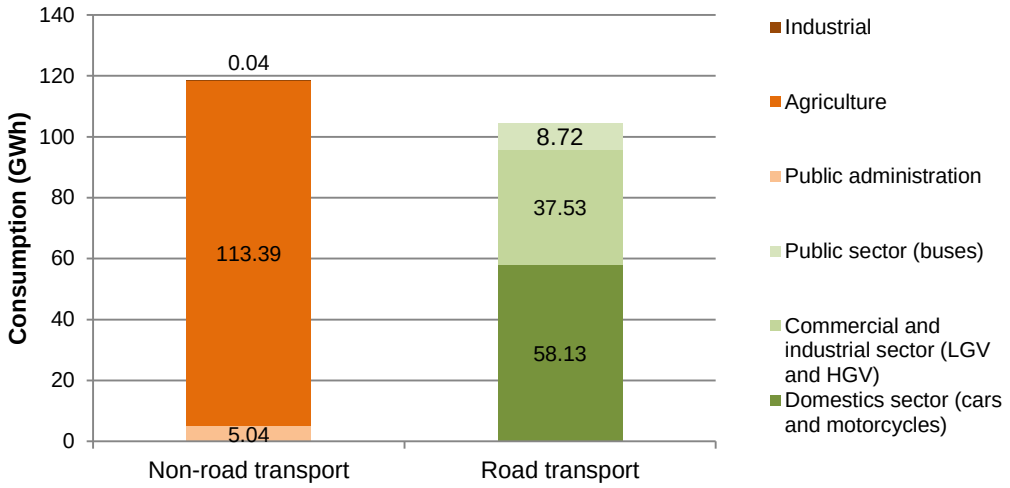


Figure 5.1 Consumption per sector in GWh in Orkney (Aquatera Ltd, 2014)

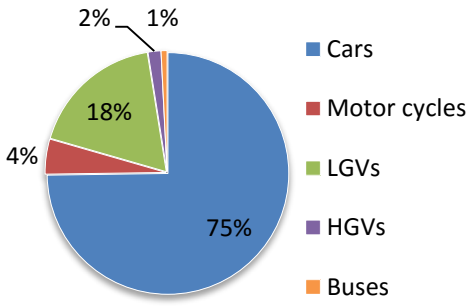
The use of fossil fuel vehicles (FFVs), such as tractors, is the main source of energy demand in this sector. However, there are very few electric agricultural vehicles available on the market. The new generation of tractors are diesel-electric hybrid vehicles that do not need an access to the grid.

5.2.2 Expected electric vehicle increases

The terrestrial road transport includes cars, motorcycles, Light Goods Vehicles (LGVs), Heavy Goods Vehicles (HGVs) and buses. The table below gives the number licensed vehicles in Orkney by body type in Orkney in 2014. Note that 75% of total vehicles are cars.

Table 5.1 - Licensed vehicles by body type in Orkney[66]

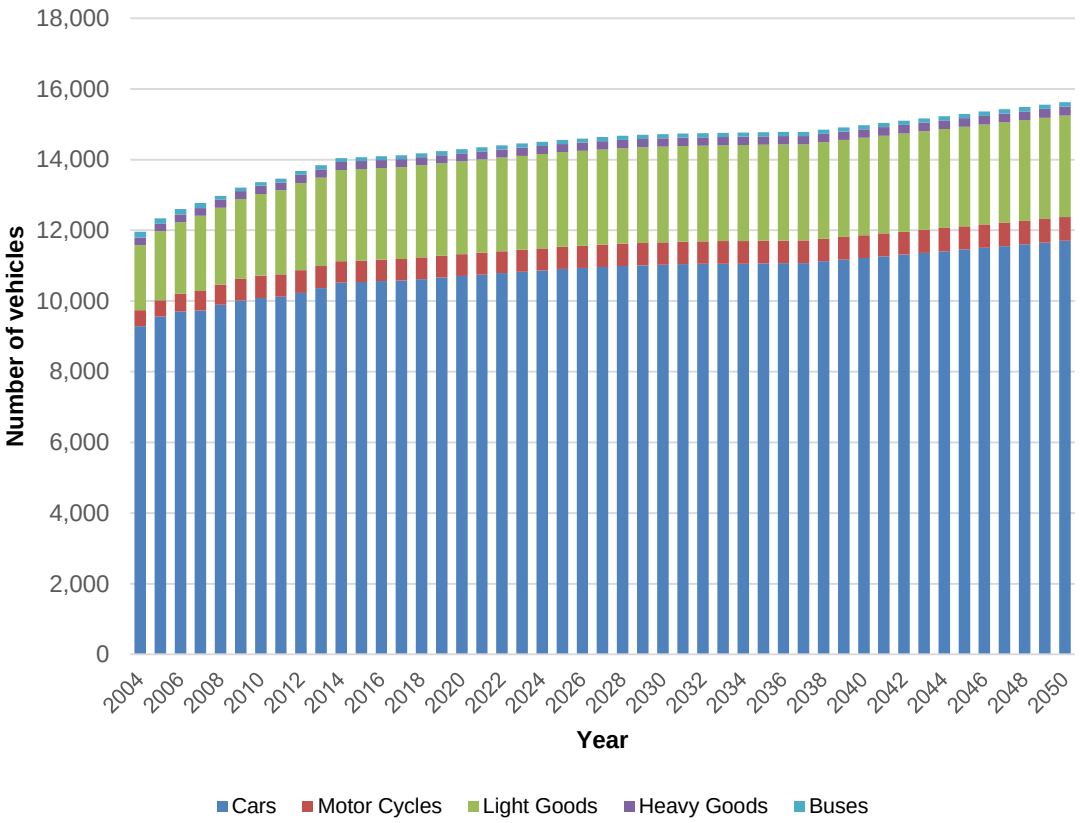
BODY TYPE	NUMBER OF VEHICLES	%
Cars	10,520	75%
Motorcycles	606	4%
LGVs	2,584	18%
HGVs	224	2%
Buses	109	1%
Total	14,406	100%



[66] Department for Transport, Licensed vehicles by make and model, 2014.
www.gov.uk, Licensed vehicles, 2014.

The energy consumption generated by these vehicles is directly linked to their number. The expected electric vehicles increase in the future is illustrated by Figure 5.2. This was predicted by using the estimated evolution of the population in Orkney[67] and linking this to the current number of vehicles per person and the vehicles registered in Orkney at present.[68]

Figure 5.2 - Evolution of the number of vehicles in Orkney for the next 35 years[69]



In 2050, the total number of vehicles in Orkney is expected to reach **15,624**.

This increase in total numbers of vehicles was then used to determine the total energy demand generated by electric vehicles.

5.2.3 Vehicles' energy consumption in Orkney

In order to calculate the energy demand generated by each type of EV, two main data sets are required: the number of vehicles and their average annual consumption in Orkney.

In order to determine the annual consumption of EVs, it was necessary to consider how people currently use their vehicles. Table 5.2 shows the total petrol and diesel

[67] National Records Office, Population Projections for Scottish Areas, 2012.
[68] Department for Transport, Vehicle statistics, 2014.
[69] Department for Transport, Licensed vehicles by make and model, 2014.

consumption in Orkney for each type of vehicles in 2012. Note that the majority of this consumption is due to domestic cars.

Table 5.2 - Orkney's fuel consumption per body type of vehicle in 2012* (GWh)[70]

VEHICLE TYPE	DIESEL	PETROL
Cars	23.25 GWh	34.4 GWh
Motorcycles	-	0.48 GWh
LGV	20.42 GWh	0.97 GWh
HGV	16.14 GWh	-
Buses	8.72 GWh	-

**2012 figures are the most recent data available.*

In order to extract the actual annual consumption from these data, it is assumed that the average consumption per 100km for each body type of vehicles will stay constant in the future. The values used in the model are the one given in Table 5.3 and were determined by comparing different sources.

Table 5.3 Average consumption per 100km for each body type of vehicle[71]

VEHICLE TYPE	AVERAGE CONSUMPTION PER 100KM
Petrol cars/ LGVs	65.42 kWh
Diesel cars/ LGVs	65.82 kWh
Buses/ HGVs	265.08 kWh
Motorcycles	55.50 kWh
Electric motorcycles	9.00 kWh
Electric HGVs	96.00 kWh
Electric cars	24.40 kWh

Using the total number of vehicles in Orkney in 2014, the petrol and diesel consumption in Orkney for each type of vehicles in 2014 and the average consumption per 100km for each body type of vehicles, it is possible to determine the average distance travelled by each type of vehicle, their annual consumption and the annual consumption of equivalent electric vehicles (see Table 5.5). Due to time constraints, in this model, the average consumption per 100km for each body type of vehicles is assumed to remain constant in the future. However, it is important to note that vehicles are likely to become much more fuel efficient as technologies improve and also to meet the emission targets set by government.

The methodology used is explained in the table below, with an explanation of how it is applied to motorcycles.

[70] Department of Energy & Climate Change, Road transport energy consumption at regional and local authority level, 2014.
[71] Zeromotorcycles, Specifications, 2015.
E-cars, Energy efficient, 2008.
Packer, N., A guide to energy and power, 2011.
Emoss, Emoss products, 2015.

Table 5.4 - Formulas - Average distance travelled and energy consumption

VARIABLE	FORMULA	REFERENCE
Total number of motorcycles	N_{bM} = 606	Table 5.1
Average consumption per 100km for a fossil fuel motorcycle	$C_{FFM/100km}$ = 55.50 kWh	Table 5.3
Average consumption per km for a fossil fuel motorcycle	$C_{FFM/km} = C_{FFM/100km} / 100$ = 0.555 kWh	Calculation
Average consumption per 100km for electric motorcycles	$C_{EM/100km}$ = 9.00 kWh	Table 5.3
Average consumption per km for electric motorcycles	$C_{EM/km} = C_{EM/100km} / 100$ = 0.09 kWh	Calculation
Annual energy consumption due to fossil fuel motorcycles	$E_{TFFM/year}$ = 0.48 GWh	Table 5.2
Annual energy consumption per year per fossil fuel motorcycle	$E_{FFM/year} = (E_{TFFM/year} / N_{bM})$ x 1,000,000 = 792.08 kWh	Calculation
Annual average distance travelled by fossil fuel motorcycle per year (km)	$D_{FFMkm/year} = E_{FFM/year} / C_{FFM/km}$ = 1,427.17 km	Calculation
Annual average distance travelled by fossil fuel motorcycle per year (miles)	$D_{FFMm/year} = D_{FFMkm/year}$ x 0.62= 884.84 miles	1km = 0.62 miles
Equivalent consumption of an electric motorcycle	$C_{EqEM/year} = D_{FFMkm/year}$ x $C_{EM/km}$ = 128.45 kWh	Calculation

The table below gives the results from the calculations for each type of vehicle.

Table 5.5 Average consumption and distance travelled per year for each body type of vehicle in Orkney

2014	kWh PER YEAR PER VEHICLE	KM PER YEAR PER VEHICLE	MILES PER YEAR PER VEHICLE	Eq. EVs (kWH)
Diesel car	5,525.19	8,394.01	5,215.80	2,048.14
Petrol car	5,449.94	8,330.18	5,176.13	2,032.56
Motorcycle	792.08	1,427.17	886.80	128.45
Diesel LGV	8,318.40	12,637.52	7,852.59	3,083.56
Petrol LGV	7,507.74	11,475.51	7,130.55	2,800.03
HGV	72,053.57	27,181.82	16,890.00	26,094.55
Bus	77,857.14	29,371.19	18,250.41	28,196.34
TOTAL	**177,504.06**	**98,817.41**	**61,402.29**	**64,383.62**

Note that from the table above, electric vehicles consume around 2.8 times less energy than fossil fuel vehicles (65,384 kWh against 177,504 kWh, highlighted in grey).

5.2.4 Daily energy distribution

In order to determine the daily energy demand distribution generated by EVs, the average distributions of energy demand for public and private chargers over the days were estimated and applied to the daily demand mix by each type of chargers.

5.2.5 Type of chargers and daily demand

It is believed that only a fraction of EV users will use public chargers and that most of them will use home and private chargers (see Chapter 6.4.2 for more details). The use of home chargers is expected to increase even further once a charging mechanism for the public chargers is put in place. The table below gives the assumed energy demand mix by public, private and home chargers for each type of vehicles.

Table 5.6 - Energy demand mix by type of chargers

TYPE OF CHARGER	CARS	MOTORCYCLES	LGVS	HGVS	BUSES
% public chargers	20%	20%	--	--	--
% home chargers	80%	80%	20%	0%	0%
% private chargers	--	--	80%	100%	100%

Note that car and motorcycle users are assumed to mainly use home chargers while LGVs, HGVs and buses are assumed to use private chargers.

5.2.6 Public and private chargers

Public charging stations are used primarily during the day, with increased potential overlap with peak periods.

Figure 5.3 shows the distribution of energy demand with the vast majority of charging sessions occurring between 9:00 a.m. and 7:00 p.m.

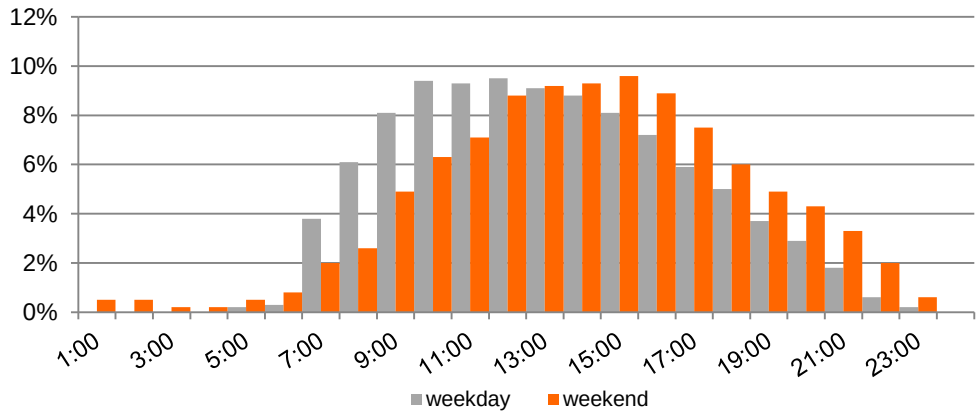


Figure 5.3 - Average hourly distribution of energy demand during weekend and weekdays for public chargers[72]

[72] OLEV, High-level analysis of Plugged-in Places charge point usage data, 2013.

The hourly energy demand distribution for private chargers (LGVs, HGVs and buses) are assumed to follow the same pattern.

5.2.7 Home chargers

The home chargers are assumed to meet most of the energy demand generated by electric cars. In the case where no smart management are carried out, most of the domestic charging events start between 3pm and 8pm as shown in Figure 5.4.

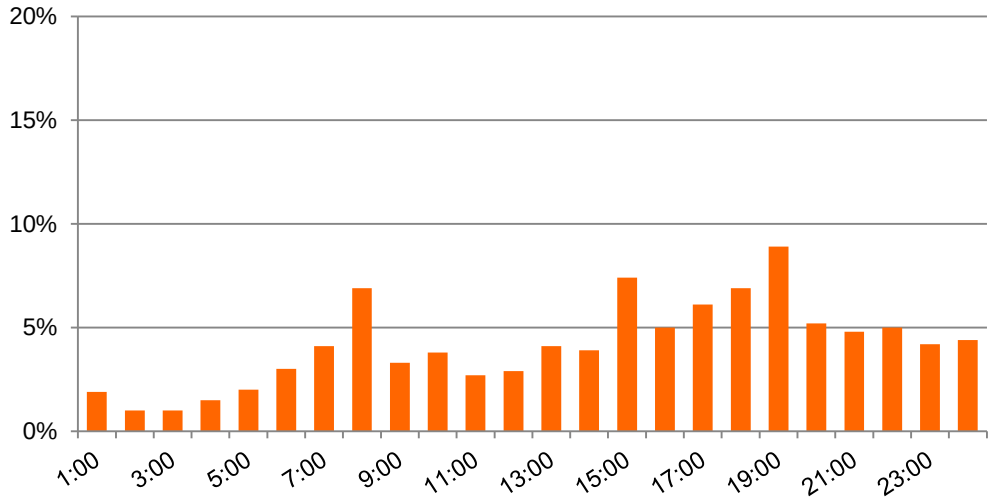


Figure 5.4 - Average hourly distribution of energy demand per day for home chargers[73]

With smart charging management, it is possible to modify the shape of the curve in order to primarily use home charging stations during the night when total energy demand is at its lowest. The graph below shows the daily distribution of energy demand for home chargers in this situation.

[73] OLEV, High-level analysis of Plugged-in Places charge point usage data, 2013.

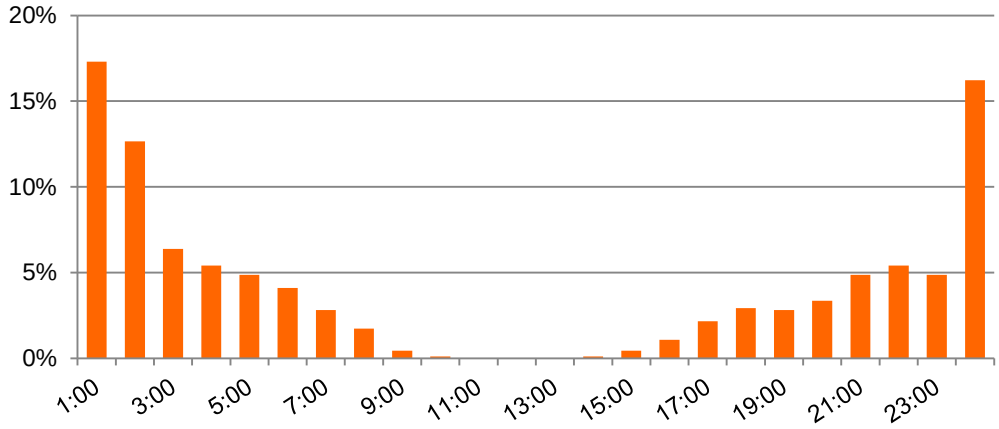


Figure 5.5 - Average hourly distribution of energy demand per day for home chargers[74]

Using such management would help evenly distribute the energy demand generated by EVs during the day.

5.2.8 Public infrastructure cost

The last assumption made in this model concerns the average cost for slow, rapid and fast public chargers. In order to obtain the most reliable figure, costs from different sources were compared. The table below gives the cost used to calculate the public infrastructure cost generated by the rate of penetration of EVs in Orkney.

Table 5.7 - Public infrastructure costs[75]

COSTS (£)	SLOW CHARGER	FAST CHARGER	RAPID CHARGER
Charger purchase	2,040	12,000	23,800
Installation cost	3,740	6,256	27,200
Sum CAPEX	**5,780**	**18,256**	**51,000**
Maintenance/repairs (per year)	374	625	1,700
Data and connectivity (per year)	325	325	325
Sum OPEX	**699**	**951**	**2,025**

These costs were then applied to the number and type of chargers required for each type of public chargers.

It is worth noting that Home chargers are substantially cheaper and are at the moment grant aided by the government so are entirely free as long as you have an EV ordered. This is subject to change later this year (Autumn 2015).

[74] Mashable UK, While you're asleep, electric car owners are guzzling power, 2014.
[75] NYC Taxi and Limousine Corp., Take charge: electric taxi task force report, 2013.
CleanTechnica, EV charging station infrastructure costs, 2014.
Change, et al., Financial viability of non-residential electric vehicle charging stations, 2012.

5.3 Scenarios

In order to generate the scenarios, two out of three of the variables were set, namely the target fleet mix and the vehicle turnover rate.

The **targeted fleet mix (TFM)** values are given in the table below. For instance, it has been estimated that all the electric cars and LGVs will be electric in the future, while it has only been estimated that 1% of the HGVs will be electric.

Table 5.8 - Targeted fleet mix of fossil fuel vehicles (FFVs) and electric vehicles (EVs) used in the scenarios

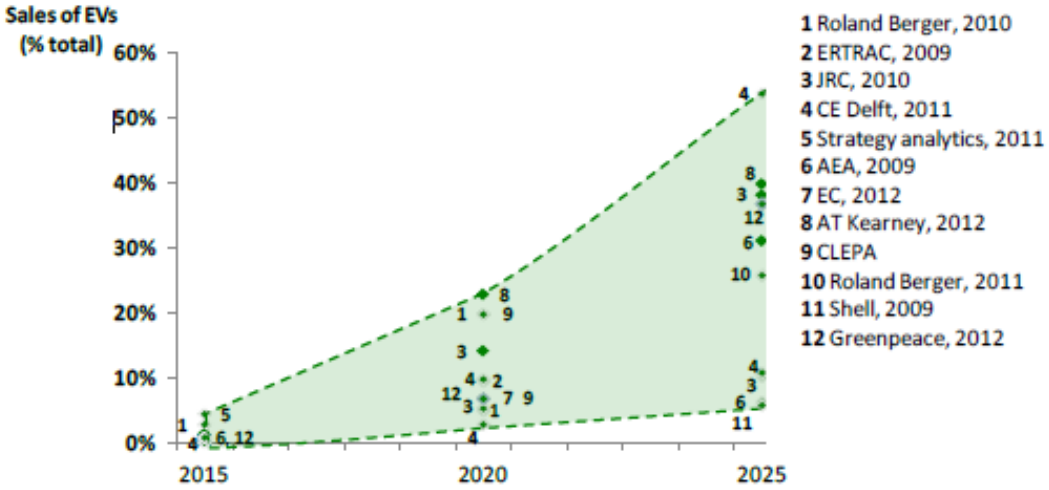
CARS		MOTORCYCLES		LGV		HGV		BUSES	
FFVs	EVs	FFVs	EVs	FFVs	EVs	FFVs	EVs	FFVs	EVs
0%	100%	95%	5%	0%	100%	99%	1%	70%	30%

The **vehicle turnover rate (VTR)** is the percentage of Orkney's fleet that is being renewed for a given year. This was set at 6.6%, which for the purposes of this report is aligned with the rest of the UK.[76]

The **transition period (TP)** is the number of years to reach the targeted vehicle turnover for each body type. It was set at different values in order to generate three different scenarios as will be explained below.

Forecasts for electric and electric hybrid vehicles have been carried out by a number of studies. However there is a high level of uncertainty within these forecasts as the prospects for EVs depend on a great number of factors. These studies have been summarised by Ricardo AEA[77] as shown in Figure 5.6 and include estimates for PHEV (Plug-in Hybrid Electric Vehicles), BEV (Battery Electric Vehicles) and FCEV (Fuel Cell Electric Vehicles). Even though FCEVs are not part of this study, we have used the total forecast sales which includes FCEVs as BEVs are much more prominent in Orkney. Therefore any forecasted FCEVs are likely to actually be BEVs in Orkney.

[76] Centre for Automotive Management, Used Car Market Report, 2013.
[77] Ricardo AEA, Exploring possible car and van CO_2 emission targets for 2025 in Europe, 2012.



Notes: where literature sources provide figures in terms of percentages, we have converted them to absolute figures using the new fleet volumes estimated based on extrapolation from 2010 sales provided in ICCT (2011). Estimates from Greenpeace (2012) are based on the weighted average of projections for the small, medium and large market segments.

Figure 5.6 - Comparison of annual car sales for electric vehicles (PHEV, BEV and FCEV) in Europe

Based on the data from Figure 5.6, three different scenarios were defined and generated. The details are given below.

- **Scenario 1 (Low EV uptake)**: 10% of the total number of new cars and LGVs sales are electric by 2025[78]
- **Scenario 2 (Moderate EV uptake)**: 33% of the total number of new cars and LGVs sales are electric by 2025[79]
- **Scenario 3 (High EV uptake)**: 54% of the total number of new cars sales and LGVs sales are electric by 2025[80]

This establishes three levels of uptake based on the different evidence bases. The uptake levels will very much depend on the incentives in place and the public's willingness to use an EV. These incentives and options are discussed in more detail in the review of opportunities that accompanies this feasibility study.

[78] Based on average of CE Delft (2011) and JRC (2010).
CE Delft, Impacts of electric vehicles, 2011.
JRC, Plug-in hybrid and battery electric vehicles, 2010.
[79] Based on Berger (2011), JRC (2010), AT Kearney (2012).
Berger, R., Automotive landscape 2025 - Opportunities and challenges ahead, 2011.
JRC, Plug-in hybrid and battery electric vehicles, 2010.
AT Kearney, Powertrain 2025: A global study on the passenger car powertrain market, 2012.
[80] Based on Berger (2010).
Berger, R., Electro-mobility: challenges and opportunities for Europe, 2010.

5.3.1 Electric vehicle adoption

Taking these assumptions and variables in consideration, the following tables show the different projections of vehicle numbers for each scenario. The impact of the corresponding increases in the number of electric vehicles on energy demand are also projected (see Appendix C.3).

Scenario 1: Low EV Uptake

Table 5.9 outlines the forecasted numbers of electric and fossil fuelled vehicles in Orkney from 2015 to 2050 under a low EV uptake scenario. It is likely that this scenario will happen if there were only minimal intervention or incentive from government and other relevant stakeholders like local authorities, car manufacturers.

Table 5.9 - Number of EVs and FFVs for different years under Scenario 1

SCENARIO 1: LOW EV UPTAKE									
VEHICLE TYPES	2015	2016	2017	2018	2019	2020	2030	2040	2050
Electric									
Cars	60	66	78	96	121	152	636	1,369	2,355
Motorcycles	0	0	0	0	0	0	0	1	4
LGVs	2	3	6	10	16	23	151	337	578
HGVs	0	0	0	0	0	0	0	0	0
Buses	1	1	1	1	1	1	1	1	5
Sub-total	**63**	**70**	**85**	**107**	**138**	**176**	**788**	**1,708**	**2,942**
Fossil Fuelled									
Cars	10,479	10,493	10,501	10,501	10,519	10,531	10,394	9,815	9,315
Motorcycles	607	608	609	610	612	614	630	635	655
LGVs	2,587	2,590	2,592	2,592	2,596	2,599	2,561	2,416	2,291
HGVs	224	225	225	225	226	227	236	238	248
Buses	111	111	111	111	111	111	111	111	111
Sub-total	**14,008**	**14,027**	**14,038**	**14,039**	**14,064**	**14,082**	**13,932**	**13,215**	**12,620**
Total	**14,071**	**14,097**	**14,123**	**14,146**	**14,202**	**14,258**	**14,720**	**14,923**	**15,562**

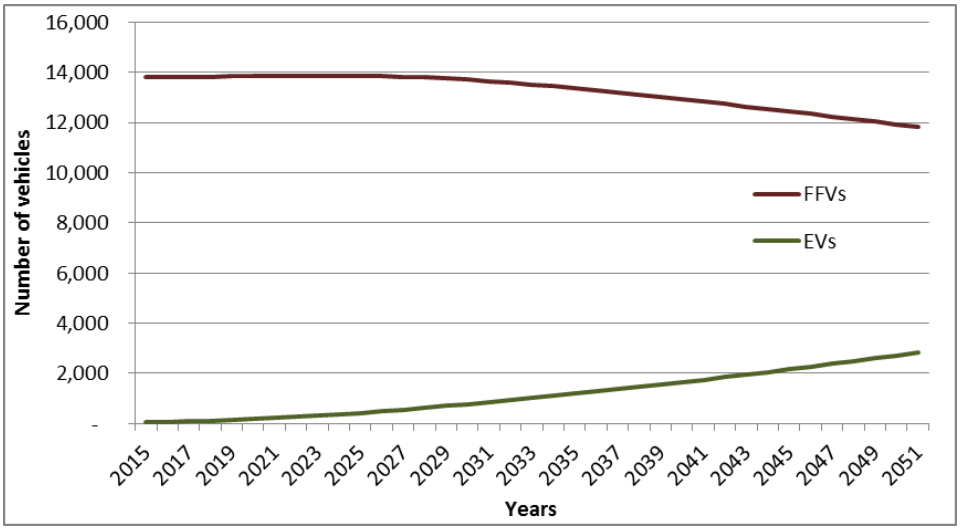


Figure 5.7 - Number of EVs and FFVs under Scenario 1 (2015 -2050)

Scenario 2: Mid-range EV Uptake

Under Scenario 2, moderate EV uptake is foreseen to happen as a result of increased popularity of EVs through effective intervention and promotion of the government and car manufacturers. Intervention can be in the form of local incentives that encourage residents to switch to an EV or provision of exclusive taxi bays, electrification of fleets, or establishment of car clubs. The options that could be considered are discussed in the review of opportunities report that accompanies this feasibility study. The table below shows the projected number of EVs for the next years until 2050.

Table 5.10 - Number of EVs and FFVs for different years under Scenario 2

SCENARIO 2: MODERATE EV UPTAKE									
VEHICLE TYPES	2015	2016	2017	2018	2019	2020	2030	2040	2050
Electric									
Cars	60	80	120	181	263	366	2,040	4,552	8,346
Motorcycles	0	0	0	0	0	0	8	17	31
LGVs	2	7	16	31	51	76	493	1,114	2,047
HGVs	0	0	0	0	0	0	0	0	1
Buses	1	1	1	1	1	1	8	18	30
Sub-total	**63**	**88**	**137**	**213**	**315**	**443**	**2,549**	**5,701**	**10,455**
Fossil Fuelled									
Cars	10,479	10,478	10,458	10,415	10,375	10,315	8,989	6,639	3,326
Motorcycles	607	608	609	610	612	614	630	635	653
LGVs	2,587	2,586	2,581	2,570	2,561	2,546	2,215	1,633	818
HGVs	224	225	225	225	226	227	235	237	247
Buses	111	111	111	111	111	111	111	105	101
Sub-total	**14,008**	**14,008**	**13,984**	**13,931**	**13,885**	**13,813**	**12,180**	**9,249**	**5,145**
Total	**14,071**	**14,096**	**14,121**	**14,144**	**14,200**	**14,256**	**14,729**	**14,950**	**15,600**

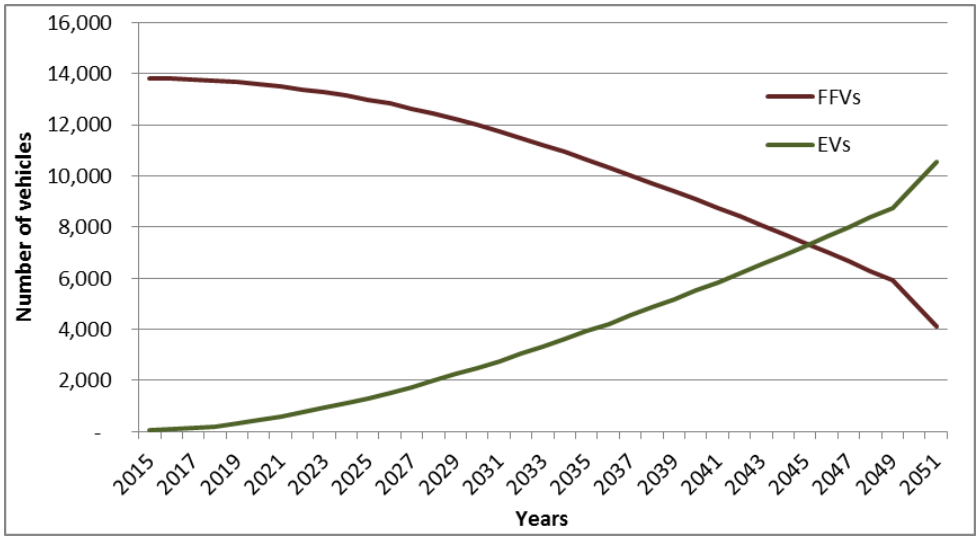


Figure 5.8 - Number of EVs and FFVs under Scenario 2 (2015 -2050)

Scenario 3: High EV Uptake

Lastly, high EV uptake is expected when there is increased confidence in EVs due to advances in battery technology, effective promotion of the advantages and benefits of EVs, and increased availability and reliability of recharging infrastructure. There is a high likelihood of this happening if both public and private sector support and work together to promote EVs. The table below shows the forecast for scenario 3.

Table 5.11 - Number of EVs and FFVs for different years under Scenario 3

SCENARIO 3: HIGH EV UPTAKE									
VEHICLE TYPES	2015	2016	2017	2018	2019	2020	2030	2040	2050
Electric									
Cars	60	93	160	260	393	561	3,331	8,662	11,652
Motorcycles	0	0	0	0	0	0	10	30	34
LGVs	2	10	26	50	83	124	810	2,121	2,862
HGVs	0	0	0	0	0	0	0	2	2
Buses	1	1	1	1	1	2	12	28	37
Sub-total	**63**	**104**	**187**	**311**	**477**	**687**	**4,163**	**10,843**	**14,587**
Fossil Fuelled									
Cars	10,479	10,466	10,420	10,338	10,247	10,122	7,699	2,526	-
Motorcycles	607	608	609	610	612	614	626	618	637
LGVs	2,587	2,583	2,571	2,551	2,529	2,498	1,898	624	-
HGVs	224	225	225	225	226	227	235	237	247
Buses	111	111	111	111	111	111	107	93	87
Sub-total	**14,008**	**13,993**	**13,936**	**13,835**	**13,725**	**13,572**	**10,565**	**4,098**	**971**
Total	**14,071**	**14,097**	**14,123**	**14,146**	**14,202**	**14,259**	**14,728**	**14,941**	**15,558**

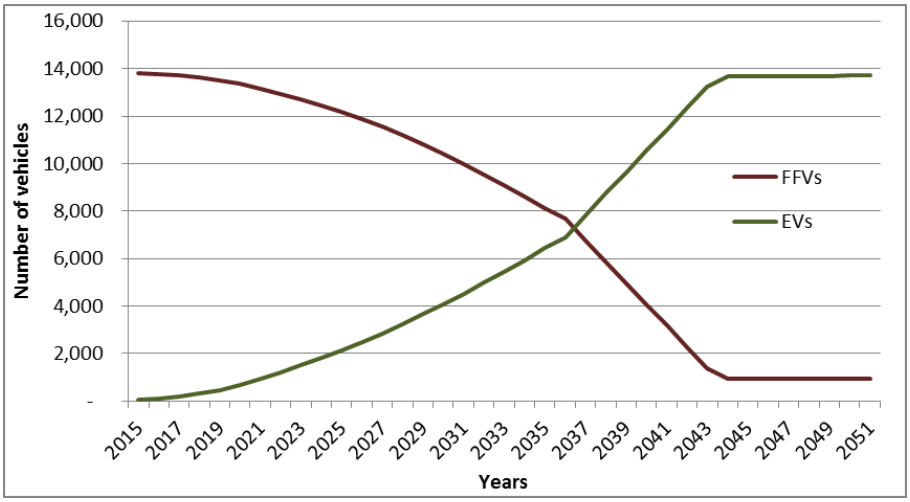


Figure 5.9 - Number of EVs and FFVs under Scenario 3 (2014 -2050)

5.3.2 Electric vehicle energy demand

The estimated annual electricity demand resulting from electric vehicle uptake under the three different scenarios are shown in Appendix C.3 and summarised in Table 5.12.

Table 5.12 - Estimated annual electricity demand from EVs – Scenarios 1, 2, 3 (MWh)

	YEAR								
SCENARIO	2015	2016	2017	2018	2019	2020	2030	2040	2050
1. Low	179	199	239	300	385	489	2,169	4,685	8,153
2. Mid-range	179	247	381	590	868	1,218	7,136	15,985	29,268
3. High	179	292	518	856	1,310	1,910	11,640	30,291	40,766

5.3.3 Daily energy demand

To gauge the impact of EVs on Orkney's overall daily energy demand, current demand was compared to the hypothetical increase that would be generated in 2020 with the three different scenarios. In Table 5.13, it can be seen that EVs would not have a significant impact on the daily energy demand in 2020. However, in 2050 EVs will increase Orkney's overall average daily energy demand by 5% under Scenario 1, 19% under Scenario 2 and 24% under Scenario 3.

In Table 5.13, the average increase in the overall Orkney's daily energy demand generated by electric vehicles is given for each scenario and for different years.

Table 5.13 - Average hourly increase in energy demand - Scenarios 1, 2, 3

SCENARIO	2015	2016	2017	2018	2019	2020	2030	2040	2050
Scenario 1	0%	0%	0%	0%	0%	0%	2%	3%	5%
Scenario 2	0%	0%	0%	1%	1%	1%	5%	10%	19%
Scenario 3	0%	0%	1%	1%	1%	2%	8%	20%	24%

It is observed that the pattern of the daily energy demand curve is not changed by the increase in number of vehicles (see Figure C.4 in Appendix C). In order to flatten this curve, another distribution than the one used in this model is required. This will warrant smart management of the charging system for electric cars, illustrated by Figure C.5 in Appendix C, where home charging is carried out during low tariff periods.

Figure C.6 in Appendix C shows that an increased number of EVs will have an effect on the overall daily demand picture for Orkney. These may be minimal on an Orkney-wide scale but could have a larger effect on a more localised scale. There would also be the opportunity to further refine the charging time periods to link with wind power generation.

The Rousay, Egilsay and Wyre Development Trust[81] has already started looking at this opportunity alongside Hoy Energy Ltd, Community Energy Scotland, and VCharge. They developed a project that aims to help community-owned wind turbines generate more, and to divert that extra energy towards controllable heating and electric vehicle charging devices in homes and public properties. The project received Phase 1 funding from the Local Energy Challenge Fund but unfortunately did not get through to Phase 2.

The project would have allowed the Trust to show, in practice, how grid-smart control of local electrical demands can ease local grid congestion, allowing community-owned generators to produce more of their own natural local energy. It would allow residents/drivers and building owners to carry on buying all their electricity from their existing supplier, but be offered the opportunity to benefit from a rebate making the units of electricity the local system offers them cheaper.

The Trust is currently considering other sources of funding to further develop this project.

[81] Orkney Communities, Demand side management, 2015.

6 Infrastructure Requirements

6.1 Introduction

This chapter gives an overview of existing recharging infrastructure in Orkney and assesses the requirements for expansion to support the forecasted increase in uptake of EVs in Orkney.

6.2 Geography

As shown in Figure 6.1, Orkney is an archipelago of approximately 70 islands in northern Scotland situated between the North Sea and Atlantic Ocean. There are 16 inhabited islands in addition to the mainland. The islands comprise a total area of approximately 990 sq km. Terrain on the Islands is mainly low lying with some hilly areas and cliffs around the coastal regions.

There are five different destinations that people can fly from to reach Kirkwall, Orkney's main hub. They are: Inverness, Aberdeen, Edinburgh, Glasgow and Shetland. In addition, it is possible to reach Orkney by car, bus or on foot using the ferry connections.

Orkney's climate is cool and temperate in line with the rest of the UK. However wind has a particular incidence there, ranking it as the third windiest place in the UK based on an annual average wind speed of 14.3 knots.[82] The exposure to wind and sea based energy has made Orkney an ideal hub for renewable energy generation, renowned globally for its wind, wave and tidal energy resources.

[82] Met Office, Where are the windiest parts of the UK.

Figure 6.1 - Map illustrating the Orkney Islands and their relation to mainland Scotland[83]

[83] Visit Scotland, Map of Orkney.

6.3 Existing Recharging Infrastructure

There are currently 31 public EV charge points in 14 locations on Orkney, as shown in Figure 6.2, which are located on the Mainland (as of July 2015). The types of charger technologies in use are discussed in detail in Appendix C.4.

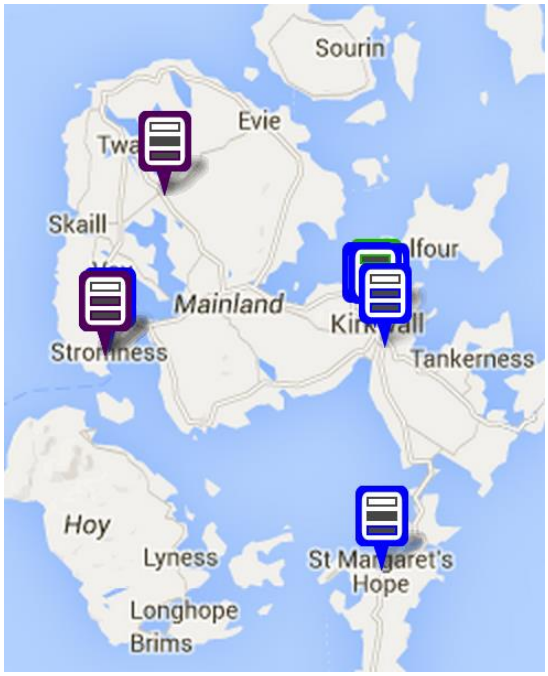


Figure 6.2 – Existing charge point locations in Orkney

Charge points generally require an EV owner to subscribe to a membership in order to use any of the charge points in the network. This can prove to be quite an inconvenience if an EV driver travels outside Orkney as they may have to be a member of a number of these charging networks.

There are two charging networks that operate across the Islands: Charge Your Car (CYC) which also includes ChargePlace Scotland (CPS), and ZeroNet. Details such as charge point locations, charging network, charger type, and number of available connectors are summarised in Table 6.1.

Table 6.1 –Charge point locations in Orkney[84]

LOCATION	AREA	CHARGING NETWORK	SLOW	FAST	RAPID	TOTAL*
Public			**4**	**17**	**9**	**31**
Dounby Primary School	Dounby	CYC		2	1**	3
Orkney Crofts	Firth	ZeroNet	1	1		2
St. Rognvalds House	Kirkwall	CYC		2		2
Ticketyboo, Ayre Service Station	Kirkwall	CYC			3	3
East Kirk Car Park	Kirkwall	CPS	1	1		2
Great Western Road Car Park	Kirkwall	CYC		1	1	2
St Margaret's Hope Care Home	St Margaret's Hope	CYC		2		2
Old Academy Business Car Park	Stromness	CYC		2		2
Orkney Islands Council Car Park	Kirkwall	CPS	2	1		3
Pickaquoy Centre	Kirkwall	CYC		2		2
Lynnfield Hotel	Kirkwall	CYC		2		2
Houton Ferry Terminal Car Park	Orphir	CYC		1**		1
Church Road	St Margaret's Hope	CYC			1**	1
Ferry Road	Stromness	CYC		2	2	4
Private			**4**	**1**	**0**	**5**
Marness Garage	Kirkwall	N/A	3			3
Unit 1 Warness Park (EMEC)	Kirkwall	N/A		1		1
Eco Cars	Kirkwall	N/A	1			1
TOTAL			**8**	**18**	**9**	**36**

**Number of available charge point connectors*
***To be operational by 2015/2016*

There are also a number of privately-owned chargers in Orkney that are made available to the public, but are not technically part of the public charging network. This includes private households and the Type 2 charger unit on EMEC's Warness Park, which are made available to the public on request.

The existing locations, although limited in number, offer enough spread to serve the top-up charging needs of current EVs in Orkney and are conveniently located to provide acceptable range comfort.

6.4 Key Considerations for Infrastructure Expansion

A key consideration for infrastructure expansion are the types of chargers to be installed and their advantages and disadvantages.

Aside from having cost implications, the type of charger also has a significant bearing on achieving the desired objectives of the proposed lighthouse project.

The Council has stated that Orkney's desire to increase EV uptake goes beyond achieving carbon emission reduction through a transport model that is both

[84] Sources: Orkney's Electric Vehicle Infrastructure Strategy. Presentation by Laura Cromarty (OIC Transport Manager). March 2015.
ChargeYourCar.org.uk
Zap-Map.com

sustainable and marketable to tourists and investors alike. Through the OEF lighthouse project, the Council also aims to create an impact on energy demand and consumption that will eventually attain energy system benefits for Orkney such as grid balancing and alleviating grid curtailment.

The following sections analyse the advantages and disadvantages of the different charger types and how these might be relevant to Orkney.

6.4.1 Rapid and slow charging

Publicly availably charging stations have been growing across the UK as illustrated in Figure 6.3.[85] In roughly two years, the number of stations has approximately tripled.

As EV charging infrastructure continues to grow around the world, the trend is showing that majority of new charging stations would be that of the fast and rapid variety. Figure 6.3 shows the number of slow chargers in the UK has remained relatively constant over the last two years.

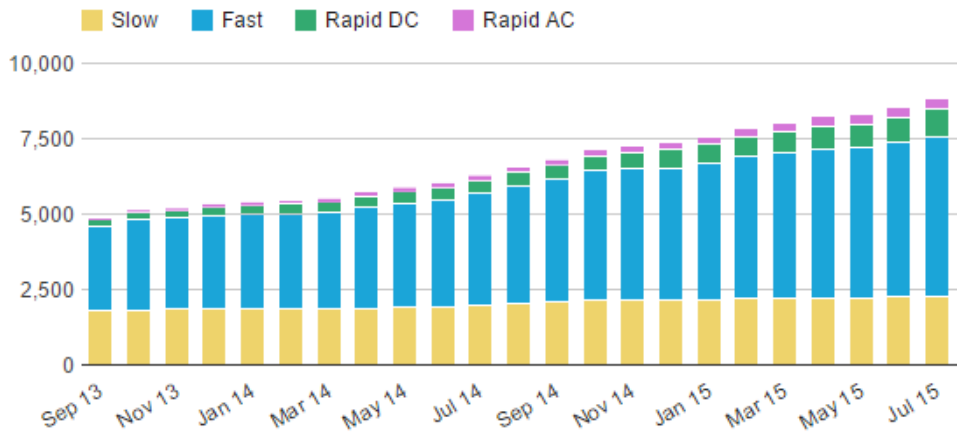


Figure 6.3 – Public EV infrastructure growth in the UK
Source: Zap-Map

Fast chargers meet a balance between the lower cost of slow chargers and the convenience of rapid chargers. However, fast chargers still require a minimum of three hours to fully charge and thus will require longer parking stay. Table 6.2 highlights the approximate times required to fully charge a battery of a typical EV through the three charging standards, as well as the typical capital cost of each charger type.

[85] Zap-Map, Charging point statistics, 2015.

Table 6.2 - Charging categories in the UK

CATEGORY	HOME	SLOW	FAST	RAPID
Specifications	3.3kW, 16A	3kW, 13A	7-22kW	43kW(AC) 50kW(DC)
Plug & socket configuration	Type 1	Type 1, Type 2	Type 1, Type 2	CHAdeMO, CCS
Charge time	6-8 hours	6-8 hours	1-4 hours[86]	80% charge in 30 mins[87]
Cost per unit	£350[88]	£2,000	£12,000	£15-20,000
CAPEX cost per unit	See above (maybe some remedial works)	£5,780[89]	£18,256[90]	£51,000
OPEX costs	None	£699[91]	£951	£2,025
Advantages	Charge at home Avail of off-peak tariff rates	More affordable Grid benefits	Combination of affordability of slow chargers and convenience of rapid chargers	Fast and convenient Ideal for journey extension (top-up charging)
Disadvantages	Slow charging	Slow charging Adequate only for long parking times	Still relatively slow Adequate only for long parking times	Cost Additional charging plug and socket configuration
Ideal for	Households	Households, workplace, depots	Workplace, depots	Gateways, car parks, retailers, highway stations

The disadvantage of rapid charging in comparison to fast charging comes from the requirement of an additional charging plug and socket configuration. Where the Type 1 and Type 2 configurations cover both slow and fast charging, either the CHAdeMO or the CCS configuration are often required for rapid DC charging. However, rapid charging still offers a significant advantage in terms of quick charge times and is ideal for top-up charging to extend journeys. Appendix C.5 shows details on charging technologies currently available in the market.

[86] Charging time of three to four hours at 7kW 1-phase, one hour charge at 22kW 3-phase. Most EV models are not capable of charging at 22kW and limited to 7kW.
[87] Correct for modern small and medium EVs equipped for rapid charging. This excludes Tesla models.
[88] Nissan, Charging and battery, 2015.
[89] UCLA, Non-residential charging stations, n.d.
[90] NYC.gov, Electric taxi task force report, 2013.
[91] CleanTechnica.com, EV charging station infrastructure costs, n.d.

6.4.2 Charging habits and their impact on energy demand

Over the years of EV adoption, a variety of charging habits have been observed, each with differing impacts on the grid. A study in the USA of over 700 EVs found that 65% were charged at home even if charging facilities were available at work. From the remaining 35%, 32% of the charging events occurred at work and 3% at 'other' locations.[92] UK data research such as the OLEV charge point usage report supports these findings.[93]

The U.S. Department of Energy (DoE) investigated behaviours of EV owners and also the impacts EV charging can have on power grids. One of the findings was that fast charging was mainly conducted within typical working hours. This was due to the availability of fast chargers at public locations such as carparks, leisure centres, and work places. Figure 6.4 demonstrates this by illustrating the percentage of charging events that occurred at public charging stations throughout the 24 hour day, differentiated between weekday and weekend averages.[94] The result of this daytime charging impacts local grids which already experience peak loading during these hours.

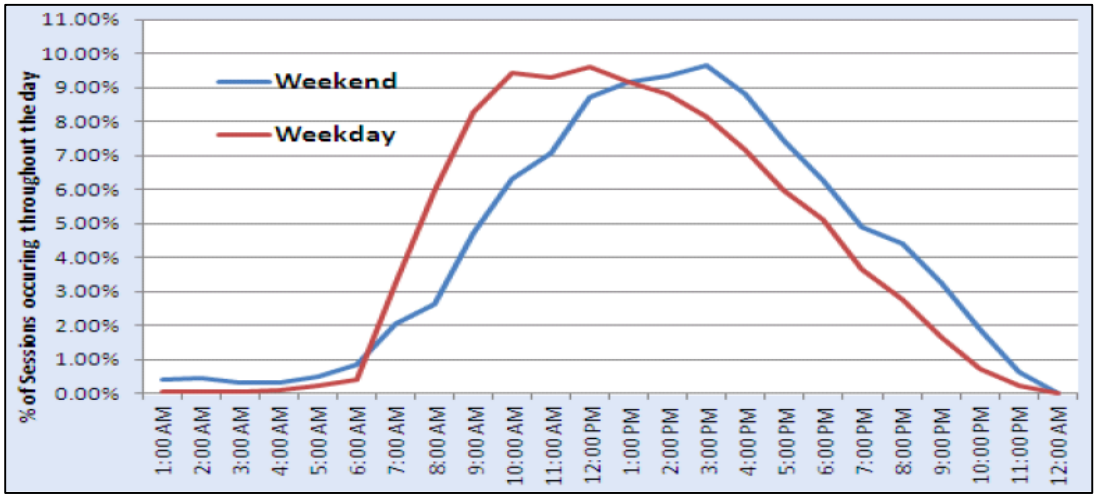


Figure 6.4 - Percentage of charging sessions at public stations throughout the day[94]

Typically, daily power demand is low during the night, before increasing sharply at about 8am when people begin to wake and start using electrical appliances. There is then a relatively stable power demand as people are at work. As people arrive home from work/school at about 6pm, power demand then spikes again. Power then drops steadily to night time demands again.

It is likely that a similar demand profile will also apply to rapid charging. Currently, these charging events do not occur in sufficient quantities to cause significant impact to the grid, but future growth in EV numbers will likely have a growing impact to the grid especially if charging events are unmanaged (i.e. no controls or measures to influence when and how people charge).

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[92] Idaho National Laboratory, The EV project, 2014.
[93] OLEV, High level analysis of the Plugged-in Places charge point usage data, 2013.
[94] U.S. Dept of Energy, Evaluating EV charging, 2014.

The DoE study also found that the majority of slow charging took place during the evening and through the night as a result of the majority of slow chargers being located in the homes of EV owners. Most people who returned home from work at 6pm, one of the points in the day with the highest demand, would immediately plug in their EVs to charge using slow chargers. Programmable charging stations coupled with financial incentives in the form of off-peak tariffs saw a significant reduction in the number of charging events occurring at this peak power demand period. However, preferable tariffs, without the addition of pre-programmable chargers, also produced a shift in charging trends to later in the evening.[95]

6.5 Options to Expand Orkney's Recharging Infrastructure Network

To date, the development of infrastructure within Orkney has been driven by grant funding opportunities, which specified the type of charger to be installed. Future expansion of this recharging infrastructure needs to consider the types of users and the most suitable locations and charging technologies. Table 6.3 categorises different types of locations across Orkney, the likely dwell time at each of these locations and charging technology that would be most suited.

Table 6.3 - Charger location types

LOCATION TYPE	APPROX DWELL TIME	CHARGER TYPE	KEY STAKEHOLDERS
Visitor attractions	0.5-1h	Rapid	Owners or operators of visitor attractions (e.g. Historic Scotland)
Gateways	0.5h	Rapid	OIC, Marine services, Airport
Islands	0.5h	Rapid	OIC, Community trusts
Residential without off-street parking	12-15h	Fast	OIC, Entrepreneurs
Residential with dedicated parking	12-15h	Slow	Homeowners
Workplaces	4-8h	Fast	Businesses

As shown in Table 6.3, a number of stakeholders are responsible for the provision of charging infrastructure. Therefore, while Orkney Islands Council has a key role to play in coordinating and promoting the installation of infrastructure across the islands, this can only be achieved through engagement with these other stakeholder groups.

Moreover, as shown in Table 6.3 different types of chargers are better suited to these locations. This analysis is summarised in this section, with a more detailed explanation provided in Appendix D.

[95] U.S. Dept of Energy, Evaluating EV charging, 2014

The tables below show the number of charge points required per scenario and their indicative costs based on figures from Table 6.2. It must be noted that the number of charge points indicated are cumulative and not additional charge points to be installed per year. For example, in Scenario 1, a total of 5 charge points at visitor attractions would be sufficient until 2020. As such, the organisation(s) responsible for sourcing funding for these charge points have the option to either install all 5 in one year or over five years to spread the capital cost.

The CAPEX row reflects the amount required to fund these charge points, initially frontloaded in 2015, with the cost of additional charge points reflected in succeeding years. Subject to external funding, this can be adjusted and spread over five years. For example, in an ideal situation where funding is secured, all seven charge points at the Gateways can be installed in 2015. However, if funding is limited, one to two charge points may be budgeted per year until the target 7 charge points is achieved in 2020.

The OPEX row reflects the expected maintenance and connectivity costs assuming the target number of charge points for each year are installed.

The tables also consider the Council's current infrastructure strategy (phase 3) where plans to install one charge point at Houton Ferry Terminal, and a number of publicly accessible charge points in Kirkwall and Stromness, are underway. However, it is noted that the planned charge points in Kirkwall and Stromness are not suitably close to residential areas so these are considered additional charge points from the total number required per year. Only the Houton Ferry Terminal costs were deducted from 2015 CAPEX projections.

Table 6.4 - Scenario 1 recharging infrastructure projections and costs

SCENARIO 1	OIC PLAN (PH 2-3)	2015	2016	2017	2018	2019	2020
Visitor attractions		5	5	5	5	5	5
Gateways	1	7	7	7	7	7	7
Islands		7	7	7	7	7	7
Residential on-street							
Kirkwall	3	3	3	3	4	5	6
Stromness	3	1	1	1	1	1	2
Total no. of chargers	**7**	**23**	**23**	**23**	**24**	**25**	**27**
Rapid	1	19	19	19	19	19	19
Fast	6	4	4	4	5	6	8
CAPEX (£)	**160,536**	**991,024**	**-**	**-**	**18,256**	**18,256**	**36,512**
Charging unit	95,800	476,400	-	-	12,000	12,000	24,000
Installation cost	64,736	514,624	-	-	6,256	6,256	12,512
OPEX (£)	**7,725**	**42,275**	**42,275**	**42,275**	**43,225**	**44,175**	**46,075**
Maintenance/ repairs	5,450	34,800	34,800	34,800	35,425	36,050	37,300
Data and connectivity	2,275	7,475	7,475	7,475	7,800	8,125	8,775

Table 6.5 - Scenario 2 recharging infrastructure projections and costs

SCENARIO 2	OIC PLAN (PH 2-3)	2015	2016	2017	2018	2019	2020
Visitor attractions		5	5	5	5	5	5
Gateways	1	7	7	7	7	7	7
Islands		7	7	7	7	7	7
Residential on-street							
Kirkwall	3	3	3	5	8	11	16
Stromness	3	1	1	1	2	3	4
Total no. of chargers	**7**	**23**	**23**	**25**	**29**	**33**	**39**
Rapid	1	19	19	19	19	19	19
Fast	6	4	4	6	10	14	20
CAPEX (£)	**160,536**	**991,024**	**-**	**36,512**	**73,024**	**73,024**	**109,536**
Charging unit	95,800	476,400	-	24,000	48,000	48,000	72,000
Installation cost	64,736	514,624	-	12,512	25,024	25,024	37,536
OPEX (£)	**7,725**	**42,275**	**42,275**	**44,175**	**47,975**	**51,775**	**57,475**
Maintenance/ repairs	5,450	34,800	34,800	36,050	38,550	41,050	44,800
Data and connectivity	2,275	7,475	7,475	8,125	9,425	10,725	12,675

Table 6.6 - Scenario 3 recharging infrastructure projections and costs

SCENARIO 3	OIC PLAN (PH 2-3)	2015	2016	2017	2018	2019	2020
Visitor attractions		5	5	13	18	24	29
Gateways	1	7	7	7	7	7	7
Islands		7	7	7	7	7	7
Residential on-street							
Kirkwall	3	3	4	7	11	17	24
Stromness	3	1	1	2	3	4	6
Total no. of chargers	**7**	**23**	**24**	**36**	**46**	**59**	**73**
Rapid	1	19	19	27	32	38	43
Fast	6	4	5	9	14	21	30
CAPEX (£)	**160,536**	**991,024**	**18,256**	**481,024**	**346,280**	**433,792**	**419,304**
Charging unit	95,800	476,400	12,000	238,400	179,000	226,800	227,000
Installation cost	64,736	514,624	6,256	242,624	167,280	206,992	192,304
OPEX (£)	**7,725**	**42,275**	**43,225**	**63,225**	**78,100**	**96,900**	**115,575**
Maintenance/ repairs	5,450	34,800	35,425	51,525	63,150	77,725	91,850
Data and connectivity	2,275	7,475	7,800	11,700	14,950	19,175	23,725

Considering the amount of investment required for installation and maintenance of charge points, it may be desirable to share responsibility for these with private sector organisations as shown in Table 6.3.

There are a number of funding bodies such as Energy Saving Trust that provide financial support to businesses and workplaces for charge point installations. The Council is in a position to encourage local businesses to install charge points that can serve both customers and their employees by:

- Actively promoting these funding opportunities to local businesses
- Providing incentives to local businesses who install charge points at their premises.

6.6 Commercial Viability of Recharging Infrastructure

Procurement and installation of recharging points require substantial capital and maintenance expense. In order to cover this investment, a number of market models have been developed to ensure the viability of the recharging infrastructure. In this section, these different business models are explored.

6.6.1 Existing recharging infrastructure market models

The figure below illustrates market models for rolling out public infrastructure for charging of EVs. These models consider that infrastructure investment will have to be recovered and thus shows where cash flows. The model represents only three parts of the whole EV value chain:

- Electricity distribution
- Charging station ownership and/or operation
- Retail of electricity to EV drivers

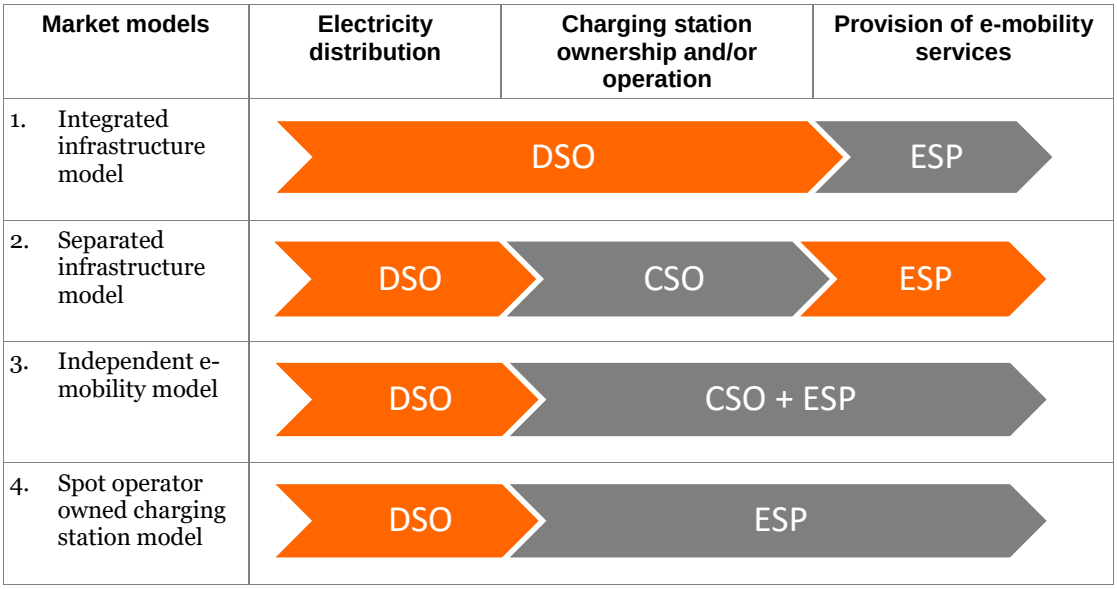

Figure 6.5 - Market models for recharging infrastructure

The model does not take into consideration other services such as battery leasing, operation and maintenance of vehicles, real-time information to drivers, etc. The market models also present different market players. The primary roles are highlighted below:[96]

[96] Eurelectric, Deploying publicly accessible charging infrastructure for electric vehicles: how to organise the market?, 2013.

Table 6.7 – Primary market players

ROLE	DESCRIPTION
Electricity supply retailer (ESR)	Entities that hold licences to sell electricity that they produce themselves or purchase on the electricity markets to end users, with whom they have power contracts with fixed locations for the supply.
Distribution system operator (DSO) or distribution network operator (DNO)	A party that holds and manages the assets for low voltage (LV)/medium voltage (MV)/high voltage (HV) distribution networks, responsible for connecting all loads to the electric system and maintaining a stable, safe and reliable network for the supply of electricity to all customers.
Charging station equipment owner	A party that owns the charging station. For example, a city owns the public charging stations but outsources the operation to a commercial party. Or in a public parking space, a company can both own and operate the charging station.
Charging station operator (CSO)	A party that operates the charging infrastructure from an 'operational technical' point of view, i.e. access control, management, data collections, repair etc. There can be a differentiation between the 'technical' operator and the 'commercial operator' that offers services to the electric vehicle driver by using the charging infrastructure. The charging station operators engaged in commercial activities may buy electricity on the supply market and sell a charging service all included, or may sell a charging service not including electricity supply.
E-mobility service provider (ESP)	A party that sells an e-mobility service to e-mobility customers. For example, the service can be a fluid and money-free access to charging stations from different CSOs. It may be bundled with other services (EV location, parking etc.), it may include electricity supply and other services.
E-mobility customer	A party that consumes e-mobility services using an electric vehicle, including electricity and charging services.

In Europe, there are two market models currently being implemented: the independent e-mobility market model and the integrated infrastructure model with the Distribution System Operator (DSO) playing a primary market role along with E-mobility service providers.[96] The table that follows summarise the details of these models.

Table 6.8 - Comparison of market models

COMPONENT	INTEGRATED INFRASTRUCTURE MODEL	INDEPENDENT MODEL	SPOT OPERATOR OWNED MODEL
Model description	The current electricity supply market structure is kept in place with the charging infrastructure fully integrated into the DSO's assets	An independent e-mobility provider installs a proprietary network of EV charging sockets and provides electricity bundled with other services	In this model, the charging stations and the sale of electricity are conducted by the parking spot owner or operator, who does not directly own the spot but has the right to or license to operate the spot.
Implemented in	Italy, Ireland, Luxembourg	Germany, France, Spain, Denmark, UK	UK, US
Financing	Collectively financed by DSO	User pays principle	User pays principle
Charging fees	The customer is charged a price determined by the market. Customers can charge anywhere with an access card, and the charging fees will be reflected in their energy bill.	Instead of charging users per kWh, e-mobility providers might charge using a monthly or annual subscription rate, similar to a mobile phone network provider	Operators to determine charging fees freely, considering each spot's potential and competitive landscape
Deployment of charging infrastructure	Integrated with government or authority for electricity and gas Installs and manages the public charging stations, allowing different e-Mobility Service Providers to compete by providing Business to Customer (B2C) services (e.g. basic and smart charging) to their customers on the charging stations	Independent from the regulated DSO/grid business Building, owning, and running charging stations is a competitive activity that can be carried out by any market participant	The spot owners build the EV charging sockets and control the selling or reselling of electricity in the spots they manage. Councils own the spots on public pavements but they can introduce a licensing scheme for companies to bid for high-interest locations.
Role of DSO	DSO acts as the charging station operator Treats charging service market as part of the DSO service to its customers	DSO provides a network meter for the charging station New connection points for charge points are treated as any other new connection points to the distribution grid	DSO provides a network meter for the charging station New connection points for charge points are treated as any other new connection points to the distribution grid
EV customer charging components	Energy fee + Service fee + Grid fee (includes infrastructure fee)	Energy fee + Service fee + Grid fee + Infrastructure fee	Energy fee + Service fee + Grid fee + Infrastructure fee

In the **integrated model**, all publicly accessible recharging infrastructure becomes part of the regulated asset base of the DSO. This means that the costs for deploying the public recharging infrastructure are spread over all grid customers, not just the EV users of the charge points, as part of the grid fee.

The implementation of an integrated infrastructure model presents many advantages from a technology adoption perspective. This approach provides a guarantee that infrastructure investments are done even at the early adopter phase for electric vehicles where a "chicken and egg" dilemma is present: a critical mass of EVs is needed to recover infrastructure investment vs. potential customers need to be reassured to have a decent infrastructure network coverage. However, the implementation of such is a governance decision that can only be taken by the national governments and mandated to local DSOs.

In the **independent e-mobility model**, the installation, ownership and management of charge points is a competitive activity that can be carried out by any market participant. The e-mobility provider installs the EV sockets and provides electricity bundled with other services such as roaming (i.e. the ability to charge at any location that is part of the charging network). In this model, e-mobility providers might charge a subscription fee instead of charging users per kWh. A number of charging networks in the UK use this model (see Appendix E for more details).

Another market model worth considering is the **Spot operator owned charging stations model**. In this model, businesses actively compete for locations and build the EV charging stations in the same way that petrol companies compete for locations for their petrol stations. The potential for OIC is that because it owns the spots on public pavements and carparks, it is possible to introduce a licensing scheme for multiple market players (from ESPs like Charge Your Car and POLAR to local entrepreneurs) to bid for the license to operate a charging station at these high-potential locations. This relieves the Council from the responsibility of securing funding for all charging stations and allows the private sector to actively participate in the expansion of recharging infrastructure in Orkney.

6.6.2 Charging station fees

Currently, the majority of charge points in Scotland are free to use. Transport Scotland has encouraged local authorities to put this in effect until end of March 2016. However, it is still the decision of local authorities whether to start collecting fees for use of charge points or continue offering the service for free.[97]

In Scotland, for example, Moray Council has opted to charge customers £3.80 for using charge points.[98] In other parts of the UK, there are different price points available as there are currently no standardised rates for charge point fees.

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[97] Email correspondence with Zak Tuck of Transport Scotland, 2015.
[98] Moray Council, Charging points for electric cars, 2014.

Appendix E summarises the charging fees from various charge point networks and operators.

ZeroNet is a registered charity that donates 32 amp charging equipment to qualified businesses in the tourism and leisure industry. These businesses only need to satisfy the selection criteria and shoulder the cost of installation, maintenance and electricity usage. Businesses are encouraged not to charge more than they do for WiFi access and never more than £10 for a full charge.[99] The business can set their charging fees to cover the cost to the business plus a small premium. For example, it costs the business around £1.40 to fully recharge a small EV on a fast charger. If the business adds an access fee of £1 (or more if parking fee is included), the total fee charged to the customer would be £2.40.

Table 6.9 - ZeroNet charging costs

BATTERY SIZE	CHARGING TIME (FLAT TO FULL) ON 32 AMPS	CHARGING COST (10p/KWH)	COST TO BUSINESS (FULL CHARGE)
Small (8kWh-12kWh) Seen in plug-in hybrids	As quick as 1.5 hours	Up to 70p per hour	£1.40 max
Regular (18kWh-26kWh) Seen in Renaults, Nissans, Citroens, Mitsubishis	Around 4 hours	Up to 70p per hour	£2.50 max
Large (53kWh-85kWh) Seen in Teslas	Around 8 hours	Up to 70p per hour	£5 max

Standardisation of rates is one of the options that ChargePlace Scotland is considering for the future of charging infrastructure in Scotland. This is related to actions stated in the Switched On Scotland Roadmap where the Scottish Government will support the creation of a commercial market for recharging in Scotland.[100] This includes reviewing the opportunities to transition ChargePlace Scotland from a government funded pilot to a private sector-led initiative that meets Scotland's long term needs for recharging infrastructure. The transition is not expected to commence until at least after 2016, so in the meantime, Councils can formulate their own pricing schemes for public recharging to fund expansion and maintenance of the charge points. Although free charging is ideal to encourage potential and existing EV drivers, it is not thought to be sustainable in the long term.

[99] Zero Carbon World, Free charging stations, 2015.
[100] Transport Scotland, Switched On Scotland: a roadmap to widespread adoption of plug-in vehicles, 2013.

6.6.3 Advertising

A recently concluded European project called Green e-Motion studied the viability of business models for EV recharging infrastructure.[101] It found that while traffic hotspots are close to profitability, it is more difficult to do business with highway charging. Publicly-accessible on-street charge points are not profitable yet, with private home charging still offering the cheapest option.

The study recommends that additional revenue be generated through advertising, or by including charging attached to shops or restaurants or tourist attractions, especially with highway fast charging, in order to co-finance charge points. The graph below shows the required charge point (EVSE) usage rate for the charge point operator to offer competitive prices against diesel vehicles.[102]

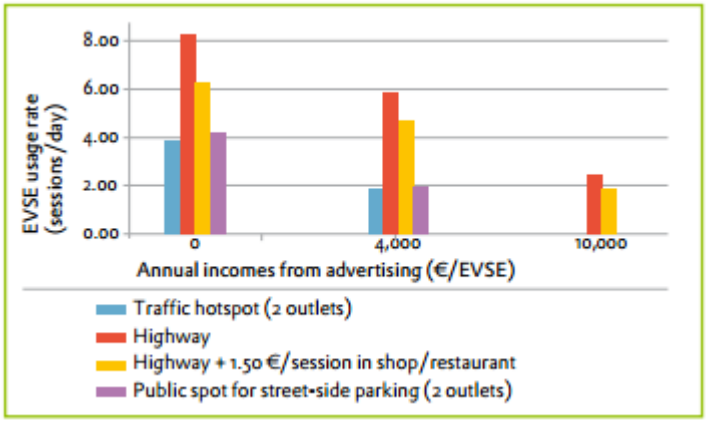

Figure 6.6 - Charge point usage required to offer competitive rates[101]

6.6.4 Green parking permits and fines

Another source of revenue from charge points are parking permits for ultra-low emission vehicles (under 75g CO2 per km). With a green parking permit, vehicles can park at designated EV parking bays. Drivers only have to pay for the use of the charge point, not per hour spent parked. For example, if they park at 9am and only use £2 of charge, they can remain in the space for the remainder of the day without making any additional payment. Some councils charge £75 per annum for a green parking permit.[103]

As usage of charge points increases, this policy can be adjusted to limit overstaying vehicles and to prevent non ultra-low emission vehicles from using the EV parking bays. Fines can be issued against those misusing EV parking bays.

It must be noted however that due to the limited number of charge points in Orkney, a high turnaround in charging bays is ideal so that more people can use it during the day. As such, green parking permits might not be suitable in Orkney.

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[101] Green e-Motion, Results and findings, 2015.
[102] Chargepoints are also often referred as EVSE=electric vehicle supply equipment.
[103] Milton-Keynes.gov.uk, Electric vehicle charge points, 2015.

6.6.5 Other funding mechanisms

The high capital cost of charging stations is a significant barrier that prevents smaller companies or entrepreneurs from participating in the recharging market. Government grants or bank loans are the usual way to fund charging stations. One option to circumvent this cost barrier that is worth considering is **leasing the charging stations**.

An example of this is offered by charge point manufacturer POD Point offers a low cost way of providing EV charging through a 3-year lease of their POD Point units.[104]

Starting at £50 per month, the offer includes the POD Point rental, installation, and access to full pay-as-you-go (PAYG) facilities—processing all charging payments and paying a revenue each month. According to POD Point's calculations, if the Council charges £2 Park and Charge fee per hour, it would only take two charges a day to cover rental and energy costs. As the market grows, anything beyond two charges per day would generate additional revenue.

The Orkney Islands Council can also consider entering into a **contract with a charge point manufacturer**. For example, Chargemaster plc has an agreement with Milton Keynes Council where they supply and operate the charge points at no cost to the Council.[105] Chargemaster pays for the cost of electricity, maintenance, and administration, saving Milton Keynes Council over £100,000 over the contract period based on the current level of usage. The Council foresees the actual savings to be higher as charge point usage is doubling every quarter.

It is must be noted that Transport Scotland and ChargePlace Scotland have chosen Charge Your Car (CYC) as their preferred back office provider, with all Scottish government-funded charge points required to be part of CYC. With nationwide plans for an interconnected charging infrastructure still to be revisited and reviewed, compliance to communications standards followed by ChargePlace Scotland such as OCPP (open charge point protocol), should be considered when exploring alternative charge point manufacturers and operators.

[104] POD Point, Purchase options, 2015.
[105] Milton-Keynes.gov.uk, Electric vehicle charge points, 2015.

7 Conclusion

This feasibility study reviews the potential to develop an ambitious project known as Orkney's Electric Future (OEF). The stated objectives of this project as articulated by Orkney Islands Council and key stakeholders consulted in this study are to:

- Establish and promote a good practice low carbon transport option for the residents of, and visitors to, the Orkney Islands;
- Study the feasibility of various options to support increased uptake of electric vehicles (EVs) on the Islands, including the concept of electric hire cars with driver information systems to be positioned at Orkney's main gateways and where energy is curtailed;
- Determine how surplus energy produced locally can be used to power transport.

Through a review of the local and national policy landscape, it is established that the stated objectives of the OEF lighthouse project are strategically aligned with the policy objectives of Scotland and the UK in the areas of transport, air quality, and ultra-low emission vehicles. By promoting the uptake of electric vehicles, the OEF lighthouse project reflects the overall ambition of the Scottish Government's Switched On Scotland Roadmap where it is envisaged that Scottish towns, cities, and communities will be free from the damaging effects of petrol and diesel fuelled vehicles by 2050. It is also aligned with Scotland's National Transport Strategy to reduce emissions to tackle climate change goals.

The Scottish Government has also set objectives to prioritise the reindustrialisation of Scotland as a renewable energy powerhouse and a world leader for low carbon activities and technologies. These areas are seen as key to increasing sustainable economic growth. The Orkney Islands Council recognises this and sees the OEF lighthouse project as a multi-faceted approach that could lead to job creation and vocational learning in the areas of smart electric mobility, energy technologies, and tourism.

As gathered from interviews with key stakeholders and a public consultation to examine the potential for EVs in Orkney, the main opportunities for EV adoption are identified in the following areas:

- **Private cars** – Car ownership is important to individual mobility in Orkney. However, the most significant issue faced by car users is the cost of fuel, which is higher than the national average. EVs could be promoted as an alternative mode of transport which can offer savings of up to 75% compared to petrol-fuelled cars. This, coupled with Orkney's geography, short distances between parishes, and tourism opportunities make the Islands an ideal location to adopt EVs.
- **Public sector fleets** – OIC already has six EVs in its own fleet and has potential to adopt more with a number of diesel vans due for replacement in

2015 and 2016. This would result to a reduction of carbon emissions by 36% while potentially saving the Council approximately £67,000 if the electric vans are leased.

- **Car clubs** – Orkney currently does not have its own car club in operation, but the consultation undertaken for this study shows that there is significant interest amongst a range of stakeholders. EVs have been successfully used in car clubs across Scotland and could work well in Orkney. This could also provide the opportunity to introduce EVs to the general public, potentially building confidence and encouraging private uptake.

- **Buses** – Converting diesel buses into electric buses on some routes in Orkney could potentially reduce fuel costs by approximately 39%, but this may necessitate some timetable and operational changes to allow for adequate charging times.

- **Ferries** – The marine transport sector represent 28% of total energy use in Orkney, compared to 14% for road transport. There is potential to introduce electric or electric hybrid ferries on the shorter inter-island ferry routes in the future but this will likely require additional funding.

This feasibility study also assesses how EVs could be linked to existing renewable energy generation in Orkney, where a range of renewable energy sources which include wind, solar PV, wave, and tidal, are available. In the past two years, Orkney has increased its generation capacity and has become a net exporter of electricity. However, as more generation is connected to the network, some turbines in Orkney have been experiencing more curtailment than was initially predicted. It has been suggested that the communities have lost several million pounds of revenue due to curtailment. By increasing local electricity demand through EVs, the OEF lighthouse project could potentially offer a way to alleviate curtailment. This is possible if a significant level of EV uptake in Orkney is achieved.

Based on an analysis of Orkney's population, vehicle ownership trends, and previous EV forecast studies, three EV uptake scenarios and their respective impact on energy demand, are defined:

- **Scenario 1 (Low EV uptake)**: 176 electric vehicles with a corresponding estimated annual electricity demand of 489 MWh by 2020;

- **Scenario 2 (Moderate EV uptake)**: 443 electric vehicles with a corresponding estimated annual electricity demand of 1,218 MWh by 2020;

- **Scenario 3 (High EV uptake)**: 687 electric vehicles with a corresponding estimated annual electricity demand of 1,910 MWh by 2020.

Comparing the current demand to the hypothetical increase brought about by EVs, it is found that EVs would have minimal impact on Orkney's overall daily energy demand in 2020. However, as EV numbers continue to increase, it is forecasted that EVs will have a more significant effect on energy demand. In a moderate uptake scenario, the additional annual electricity demand from EVs is projected to reach 7,136 MWh, which is roughly equivalent to 1 years' worth of energy generated by a

2.3MW turbine in Burgar Hill. It also must be noted that the impact of EVs on overall energy demand may be marginal on an Orkney-wide scale but it could have a larger effect on a more localised scale, especially at the level of community energy generation and consumption.

While the actual uptake levels will depend on a number of factors such as incentives and the public's willingness to use an EV, the OEF lighthouse project could offer options and activities that could encourage and promote the use of EVs. These are discussed in the review of opportunities report that accompanies this study.

In order to support the forecasted increase in uptake of EVs in Orkney, a review of existing recharging infrastructure was undertaken to assess the requirements for expansion. The Council has an existing EV infrastructure strategy that has seen 31 charging stations installed in key locations around the Islands. To date, the development of infrastructure within Orkney has been driven by grant funding opportunities, which specified the type of charger to be installed. Future expansion of recharging infrastructure will continue to be subject to external grant funding and as such needs to consider the types of users and the most suitable locations and charging technologies. By considering these factors and the EV uptake scenarios, the total number of charge points required by 2020 and their indicative costs have been projected for this report. In a moderate uptake scenario, 19 rapid chargers and 20 fast chargers at key locations around Orkney are required to support the expected increase in EVs in the Islands by 2020.

Because procurement and installation of charge points require substantial capital and maintenance expense, a number of market models, charge point fees, and other funding mechanisms are explored in order to cover the investment and ensure the long term viability of the recharging infrastructure.

Building on the findings of this feasibility study, a further two reports set out the potential to establish an OEF lighthouse project. The first of these reviews the opportunities for the lighthouse, identifying a range of technologies and business models that could be integrated into a large-scale demonstration that meets the stated ambition for the OEF project. The third and final report outlines an implementation plan, providing a detailed design of how the lighthouse project could be delivered.

Appendix A

1. List of Interviewees

NAME	ORGANISATION
David Campbell	Drive Orkney
Matt Eastwood	Car Plus
Barbara Foulkes	Visit Scotland
Pierre Fox	Co-Wheels
Ian Garman	Community Energy Scotland
Liz Gray	Co-Wheels
Mark Hull	Community Energy Scotland
Michael Morrison	Marine Services
David MacLeman	Scottish Southern Electric Power Distribution
Jimmy Poke	J&V Coaches
Jonathan Porterfield	Eco Cars
Steven Sankey	Orcadian Wildlife/The Peedie House
Jack Shearer	John G Shearer & Sons
Mark Smith	Scottish Southern Electric Power Distribution
Harvey Stevenson	Highlands & Islands Enterprise
Steve Walker	Stagecoach
Nic Thake	Shapinsay Development Trust

2. Interview Highlights by Theme

The interviews identified the following key themes:

THEME	KEY POINTS
Extent and Speed for EV Adoption	■ The high incidence of tourists and importance of the industry to income generation suggests tourism is a key industry for widespread uptake. ■ A high level of inter-island vehicle movement could provide opportunity for integrated mobility with ferry and hire services. ■ An electrified bus service is a strong possibility once an assessment of other trials currently underway has taken place. ■ Size and terrain for Orkney would facilitate an easy uptake of EVs. ■ Visitor attractions with a high footfall (e.g. Skara Brae, Italian Chapel) could be ideal locations for vehicles and infrastructure in terms of exposure. ■ Car use is very high and part of Orkney's island culture.
Opportunities for Adoption	■ Shuttle service for cruise liner transportation ■ Airport pickup bus to Kirkwall ■ It is suggested the educated 50+ demographic of tourists would welcome EV opportunities. ■ The frequency and short distances involved in local travel such as school transport suggests an ideal area of adoption. ■ The airport and ports are key locations for infrastructure. ■ The daily downtime of public bus services makes them well suited to an electric model.
Local Challenges	■ Windfarms can be a blight on the landscape for tourists. ■ Cruise operators may not be receptive to developing an EV strategy as it lies outside of their commercial interests. ■ Work is seasonal for many businesses and depreciation affects the cost/benefit analysis for businesses. ■ The cost of EVs compared to their combustion counterparts is a major barrier. ■ Range is considered an issue for some residents despite the small size of Orkney. ■ Some tours around the Islands may exceed range capability and due to their continuous use, downtime to charge will be limited. ■ Longer journeys off Orkney are not wholly feasible due to limited availability of infrastructure off the Islands. ■ Orkney's separate communities have different needs suggesting a blanket strategy or solution for the Islands as a whole may not be feasible.
Integration with Renewable Energy	■ Orkney is well established in the renewable energy sector with a thriving research base and catalogue of past, present and future initiatives. ■ Electrified mobility would be better implemented when incorporated as part of other larger projects such as an energy storage initiative. ■ Turbine to EV connections already exist on Orkney and there is a scope to pursue this more widely.

3. List of Workshop Participants

NAME	ORGANISATION
Neil Kermode	OREF
Norman McLennan	Orkney Renewables Ltd
Clive Brookes	The Eday Partnership
Ian Garman	Community Energy Scotland
Johnathan Porterfield	Eco Cars
Shona Croy	OIC
Simon Butcher	OIC
Jan Falconer	OIC
Christina Bristow	OREF
Nic Thake	Shapinsay Development Trust
Brian Clegg	The Island of Hoy Development Trust
Harvey Stevenson	Highlands & Islands Enterprise
Steven Sankey	Orcadian Wildlife/The Peedie House
Barbara Foulkes	Visit Scotland
Simon Treasure	Orkney Crofts (ZeroNet charging station)
Andy Makin	Westray Development Trust
Conrad Omand	CSOmand Garage

4. Key Findings of the Workshop

Infrastructure and Incentives

OPPORTUNITIES	CHALLENGES
■ EV events are useful to increase awareness (advertising, EV owners sharing their own experiences via case studies, word-of-mouth, real cost is not widely known, common misconceptions about prices) ■ Commercial opportunities must be promoted to interested parties ■ People react positively when they experience riding an EV ■ 2nd user market is a good market to explore for first-time EV buyers ■ Car dealers, car hire presence in Orkney means that there is a demand for cars. ■ Orcadians is all about saving money, EV use can be packaged in such a way that it allows the user to save on fuel costs ■ Current financial incentives to purchase EVs are a good reason to buy ■ There are now more EV models to choose from. ■ National framework of local incentives ■ Oil reserve fund can be used for incentive schemes (preferential rate): loan for first car buyers, home chargers ■ Scale of micro-generation penetration and EVs ■ PCP=£100 per month for 18 months, with subsidy ■ Leasing market for 2nd hand cars ■ Congestion charge has impact on residual value ■ Preferential charging for EVs on ferries ■ Taxis, buses are a good opportunity ■ Address traditional fuel poverty: bring together these groups of people through car clubs? ■ Buses and freight (have game-changing impact) ■ OIC infrastructure strategy is a good start but the public must know about the Council's policies (planning, carbon management, etc.)	■ Public's general aversion to change ■ Prevailing range anxiety ■ Ability to charge anywhere is not yet realised ■ Perceived high cost to purchase ■ Too much focus on cars. How about electric tractors? No availability yet ■ Off-island travel for EVs is a challenge ■ Warranty issues (some EVs have to be serviced off-island) ■ Cost barrier to mini-buses

Tourism and Economic Opportunities

OPPORTUNITIES	CHALLENGES
■ Tourist promotion is focused on tidal, wave renewables, not so much on wind. ■ Orkney as a green and sustainable destination. ■ Tourism approach should be re-evaluated to fully capture all renewables. ■ Tie-up with LoganAir to promote Orkney as a green island. ■ Amplify publicity efforts. ■ Need to have private hire car companies on board. ■ Tourist market that visits Orkney are interested in sustainability. ■ Tourists are fascinated not just by "green" but also by innovation.	■ Some people don't like wind turbines. ■ Wind is not considered "green" nationally.

Energy Storage

OPPORTUNITIES	CHALLENGES
■ 2nd life of batteries as storage units ■ Trial projects to address constraints and curtailment ■ Isolated self-contained area- conducive for a test bed, laboratory ■ Storage for heating ■ Dispersed fleets ■ Supplementary storage ■ Vehicle-to-grid, vehicle-to-building	■ Orkney has highest levels of fuel poverty ■ Sensitivities re priority on energy storage than heating

Energy Management

OPPORTUNITIES	CHALLENGES
■ EV database to capture mileage of all EVs in Orkney ■ Flatten supply and demand: buy more electricity at the same price ■ ANM curtailment signals, pilot for manufacturers to consider external factors e.g. wind ■ Pre-heat window ■ Aggregator type marketplace that connects generators to community (SSE is working on this – V-Charge: developing the technology, can be scaled up, they are finding funding for this)	■ Big 6 power companies ■ SSE should be more involved

WHAT WOULD YOU LIKE TO SEE HAPPEN IN ORKNEY?

- A project that is big enough to make a difference but realistic as well
- Awareness of the business opportunity
- Focus on Marine transport, hydrogen-powered vessels
- Communication to potential EV owners, raise awareness by working closely with Council
- Link with people in Orkney
- Car-sharing scheme is important to jumpstart EV awareness initiatives
- Rapid charging vs standard charging, need to work with SSE in terms of curtailment
- Keep momentum, keep innovative edge to capitalise on opportunities
- Changing mind sets and behaviours towards EVs
- Using innovation as a means to move to EVs, they become demonstrators of the EV
- There are opportunities in tourism (focus on young people and perhaps, retirees)
- Lack of information can be addressed by education and outreach, can be something as simple as a leaflet
- Why are charge points in Orkney not included in the Charge Your Car charge point map or the app?
- Charge points in Orkney to be included in the website
- One website to consolidate all charge points from different providers (plug it in Google maps?). Information should be reliable.
- Include charge points in the annual travel brochure
- Case studies in Orkney: Orkney is the place to test innovations.
- We have to do something game-changing.
- And something that is good for the long term as well.

5. SWOT Analysis

The table below summarises the feedback from interviews and the roundtable workshop.

STRENGTHS	WEAKNESSES
■ Established renewables industry and expertise in research, development, demonstration and deployment ■ Home to UK's first Active Network Management System. ■ High rate of community and privately owned wind turbines, 10% of all wind turbines in the UK. ■ OIC's commitment to sustainable energy, improving efficiency, and reducing CO2 and fossil fuel dependence; compact geography, with short distances between locations, make Orkney well suited to EVs. ■ High level of EV ownership per capita compared to rest of Scotland (early market potential) and an active EV community ■ Third highest level of gross disposable income in Scotland ■ High community involvement ■ Active development trusts ■ Historic visitor attractions	■ Grid is at capacity ■ Independent projects and proposals originating in Orkney but driven by different stakeholders (sometimes competing for the same funding sources) ■ Car culture is an integral part of Orkney's identity – any perceived threat or change to this ease of movement could be a barrier. ■ Current lack of charging infrastructure for long distance journeys
OPPORTUNITIES	**THREATS**
■ Reducing lost revenue from curtailment ■ High fuel costs ■ High number of tourists per year – potential market for EV use. ■ New business opportunities in the EV and energy services space are available ■ People react positively when they experience riding or driving an EV ■ Car dealers and hire cars in Orkney ■ Isolated self-contained location ideal for a living laboratory, test bed for innovation ■ Potential to further establish Orkney's innovation and green credentials to attract further inward investment and tourism	■ Perceived high cost of EVs ■ Public's general aversion to change ■ Sensitivities about prioritisation of energy storage than heating ■ Seasonal trade in tourism resulting to low levels of activity in certain times of the year ■ Limited access to funding ■ Time-limited opportunities: Orkney's high renewable grid and active network management system expected to be less rare

Appendix B

1. Cost Comparison: EVs vs. ICEVs

There are a number of factors that need to be taken into consideration in order to compare the cost of choosing an EV over a conventional Internal Combustion Engine (ICE) vehicle. These include the capital cost, running cost and depreciation.

Capital Cost

EVs are currently perceived to cost more when compared to many comparative ICE models. This misconception is a significant barrier for those who wish to invest in an EV. Current available EV models range between £15,000 and £25,000 for the small car category. Plug-in car grants, battery technology development and second-hand market development would contribute to further reduction of the unit price.

Depreciation

Depreciation is another significant hurdle for EV buyers. All vehicles depreciate in value over time. However, the rate of depreciation on EVs is significantly faster because EVs have only been in the market for five years, its ability to retain value has not been conclusive. As more and more manufacturers release more EV models onto the market and there is more industry confidence in technologies such as battery life, then this will begin to change. Depreciation of EVs is currently determined by the willingness of potential owners to purchase second or third hand vehicles which is completely subjective to the individual.

The UK car buyer's guide 'What Car?' produces a database of depreciation through different models of cars available within the country.[106] Through this database it is possible to compare a wide variety of vehicles on the market.

Through this comparison, demonstrated in Table B.1, it is possible to determine that Nissan LEAFs have an average 54.7% depreciation in value after its first year. After the first year, the price drops in value by 16.7% on average each consecutive year. Other commercially available electric cars have a similar rate of depreciation. The Mitsubishi i-Hatchback MiEV drops 61.1% in value in the first year, followed by an average 16.76% thereafter; the Peugeot iOn loses 61.95% of its value after one year, and drops an additional 16.77% every year after; and the BMW i3 depreciates by 54.5% after year one, and 16.8% each year following.

[106] What Car?, Depreciation Index, 2015.

Table B.1 - Electric car depreciation

DEPRECIATION FROM YEAR BEFORE	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Nissan Leaf Hatchback 80kw Visia 5dr	52.91%	17.63%	18.01%	14.53%
Nissan Leaf Hatchback 80kw Visia + 5dr	53.52%	17.73%	18.02%	14.44%
Nissan Leaf Hatchback 80kw Tekna 5dr	57.18%	17.94%	17.67%	14.69%
Nissan Leaf Hatchback 80kw Acenta 5dr	55.14%	17.74%	18.00%	14.47%
Mitsubishi i Hatchback MiEV Keiko 5dr	61.13%	17.78%	17.81%	14.69%
Peugeot iOn Hatchback 63 5dr	61.95%	17.79%	18.00%	14.50%
BMW i3 Hatchback i3 EV 5dr	54.53%	17.92%	17.90%	14.62%

By choosing a selection of modern cars to represent conventional ICE vehicles from the same database, it is possible to make comparisons to the depreciation of EVs. Four petrol powered cars for this comparison are: Honda Civic, Toyota Yaris, Fiat Punto and a Vauxhall Astra. Table B.2 details the comparison of these vehicles. This shows that the average drop in value in the first year is 39.64%. Then each consecutive year results in an additional average drop of 16.75% in residual value.

Table B.2 - Petrol car depreciation

DEPRECIATION FROM YEAR BEFORE	YEAR 1	YEAR 2	YEAR 3	YEAR 4
Honda Civic Hatchback 1.6 i-DTEC SR 5dr	37.50%	17.73%	17.98%	14.60%
Toyota Yaris Hatchback 1.4 D-4D Icon 5dr	37.46%	17.86%	17.69%	14.71%
Fiat Punto Hatchback 1.4 8v GBT 5dr	42.39%	17.77%	18.21%	13.99%
Vauxhall Astra Hatchback 1.6 CDTi 5dr	41.22%	17.99%	17.84%	14.59%

In a comparison of an ICE car and EV, both valued at £25,000, after one year the ICE vehicle will have retained approximately £3,765 more of its value than the EV. Figure B.1 shows that electric cars depreciate faster than conventional ICE cars.

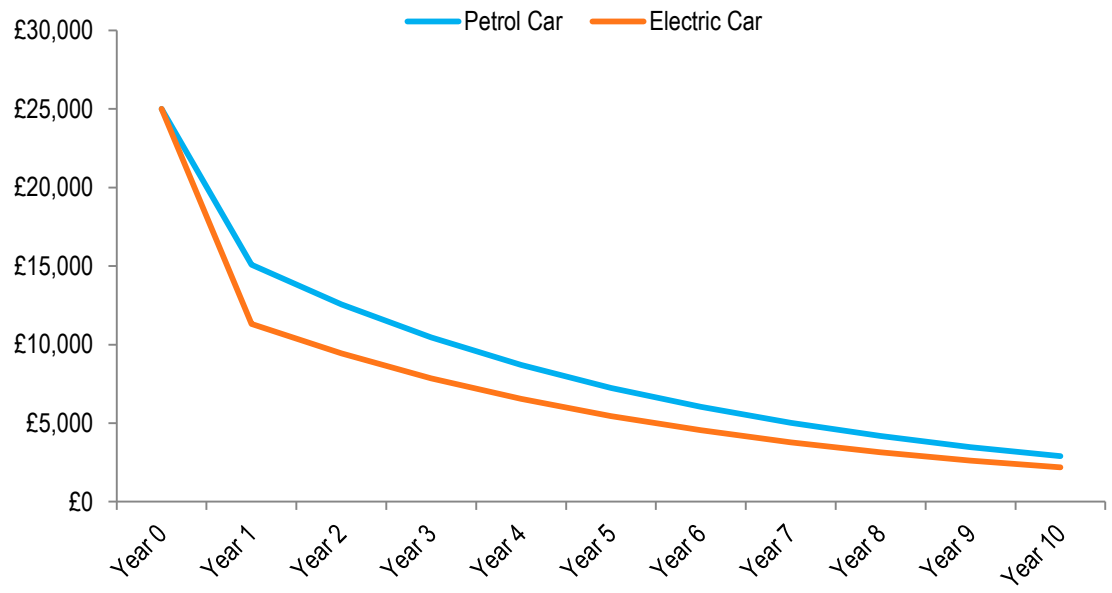


Figure B.1 - Depreciation comparison (Petrol vs. Electric)

An alternative to those concerned with depreciation is to consider leasing an EV. Taking the Nissan LEAF as an EV example, it is possible to make a comparison against purchasing a vehicle outright and leasing the same model for a period of time.

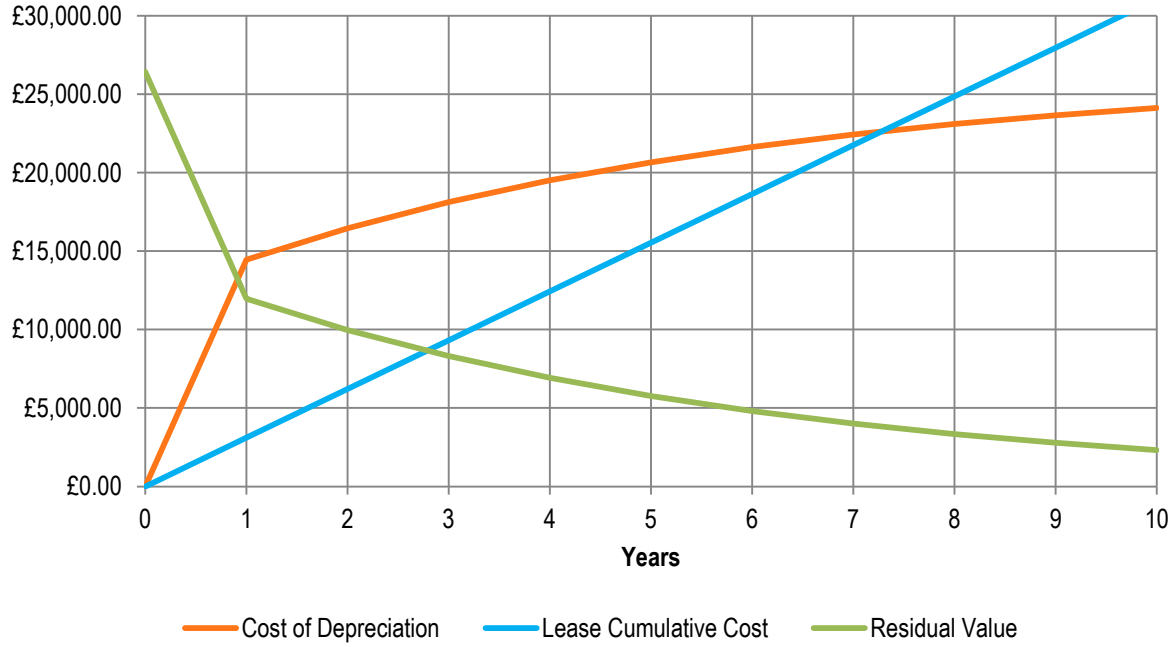


Figure B.2 - Capital lose comparison purchase vs. lease

Fleetdrive Electric, a major electric vehicle leasing company based in the UK, offer the Nissan LEAF Visia, valued at £26,435, on a £259 per month (including VAT) lease. Figure B.2 highlights the comparison between the amount spent to lease a Nissan LEAF (blue); the annual residual value of a purchased vehicle of the same model (green); and the cumulative value lost through depreciation of the purchased vehicle each year (orange).

The graph shows that at approximately seven years and 3 months the amount spent through leasing overtakes the amount lost through depreciation of a purchased vehicle. At this point leasing no longer becomes financially beneficial over purchasing. So for potential car owners that will tend to purchase a new car, this theoretically highlights an avenue to enter the EV market without the risk of committing to new technology.

The financial benefit of leasing shown in Figure B.2 above only applies to the comparison to purchasing a new EV. As the 2nd hand market develops, EVs can be purchased in the region of £10,000. The depreciation of a 2nd hand model would constantly remain less than the cumulative leasing cost; as highlighted below in Figure B.3. As such, it is cheaper to purchase a 2nd hand EV over leasing.

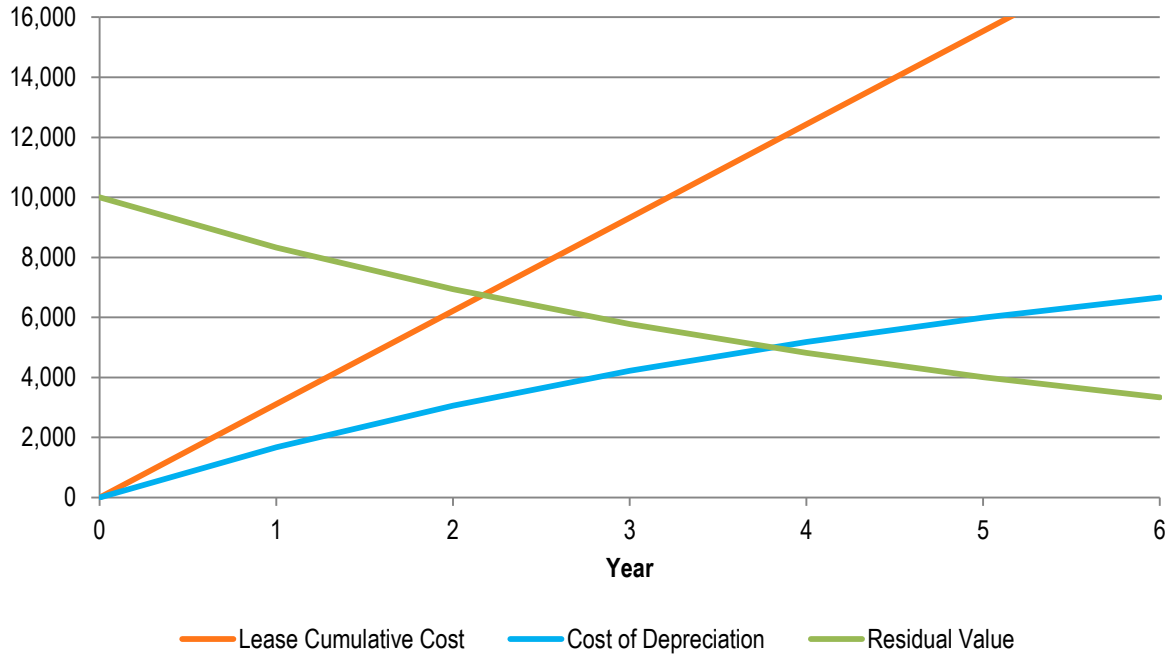


Figure B.3 - Capital lose comparison 2nd hand purchase vs. leasing

Running Costs

The most significant advantage of EVs is the money saved from using mains electrical power instead of petrol or diesel. For example, the Nissan LEAF has a 24 kWh battery and a range of approximately 90 miles. Thus, a fuel efficiency of 0.266 kWh/mile. This is only as beneficial as the cost of the electricity used to charge the vehicle. As the local DNO, Scottish and Southern Electricity (SSE) offer a number of tiered tariffs with day-time rates and night-time rates; which is commonly utilised by EV owners for cheaper charging overnight.

Assuming domestic charging would be done at the cheapest rate, 9.42 p/kWh,[107] then mileage of this model is approximately 2.5 p/mile. However, in the scenario of charging within the most expensive day-time rate, 19.43 p/kWh, then it would cost the EV driver 5.17 p/mile.

The following highlights the comparisons of the above rates with conventional petrol and diesel cars. Towards the end of 2014 oil prices began to fall to significant low levels; as illustrated in Figure B.4. Petrol and Diesel prices dropped to approximately 108.5 and 115.5 pence per litre in February 2015 respectively.

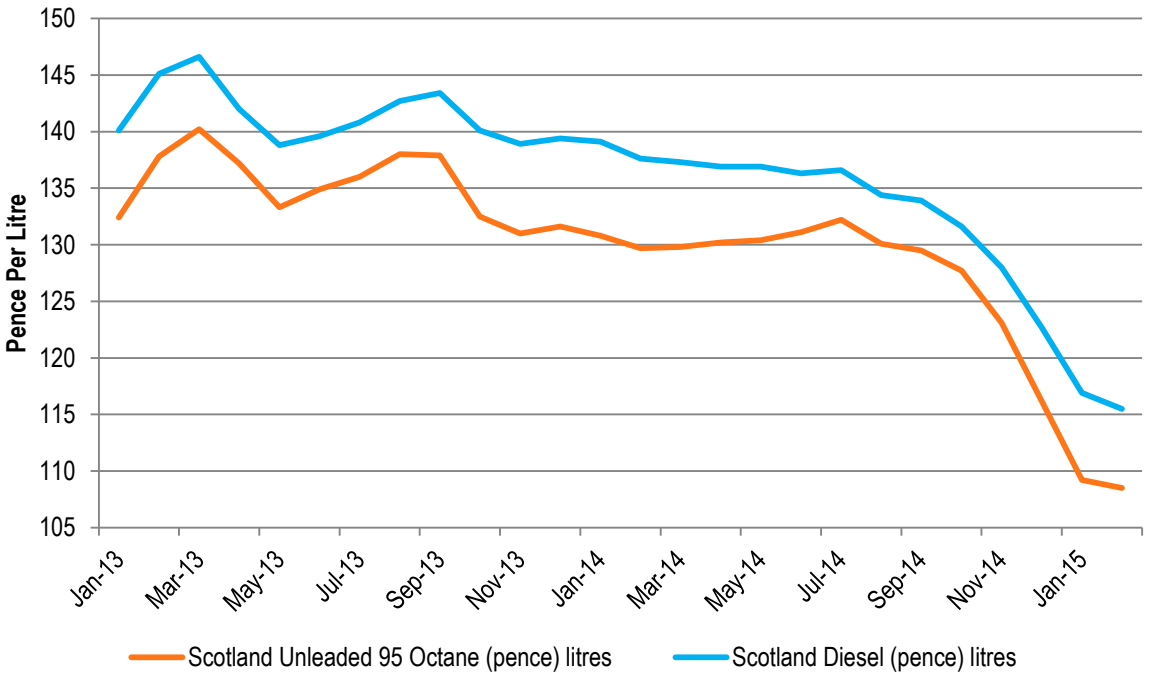


Figure B.4 - Scottish average price for petrol and diesel

Fuel prices within Orkney are consistently significantly greater than the national average for Scotland and/or the UK. This is marginally reduced through a five pence per litre government subsidy on fuel prices in Orkney. The petrol and diesel prices (pence per litre) for the UK, Scotland and Orkney is compared below in Table B.3. Orkney is sub-divided to differentiate between the Mainland prices and that found on the outer islands. This table helps to highlight the potential financial and social benefit the roll out of EVs among the Orkney Islands could have.

[107] SSE, Price and tariff information, 2015

Table B.3 - Fuel price comparison (pence per litre)

FUEL	UK	SCOTLAND	ORKNEY MAINLAND[108]	ORKNEY ISLANDS[109]
Petrol	108.9	108.5	117.9	122
Diesel	116.1	115.5	122.9	125

Table B.4, below, demonstrates the range of fuel costs, pence per mile, that could be expected in the UK, Scotland and Orkney. It compares the fuel economy of the three vehicles mentioned against the range of petrol prices detailed in Table B.3.

Table B.4 - Fuel cost comparison (pence per mile)

REGION	VW GOLF 88.3 MPG	VAUXHALL ASTRA 48.7 MPG	TOYOTA PRIUS 72.43 MPG
UK	5.61	10.17	6.84
Scotland	5.59	10.13	6.81
Orkney Mainland	6.07	11.01	7.40
Orkney Islands	6.28	11.39	7.66

Table B.4 highlights the calculated running costs, in pence per mile, of the three cars running on UK, Scotland and Orkney petrol prices. It demonstrates that the Golf, with the highest advertised fuel economy, running on the cheapest petrol prices seen in Scotland over the last six months cannot match that of the 2.5 p/mile possible in EVs. This highlights that for those living on the outer islands of Orkney that cost of road fuel could be quartered. As petrol and diesel prices begin to rise again, this price gap will become more significant; making EVs more and more attractive.

Comparing the average miles driven per year in Orkney (5,300 miles a year), the financial implications of each option become pronounced. Assuming the three previous discussed vehicles are running of the cheapest available petrol, 108.5 p/L, and a Nissan LEAF is being charged on 9.42 p/kWh then the following would be spent on fuel:

Table B.5 - Cost comparison of different vehicles

VEHICLES	COST	COST DIFFERENCE VS NISSAN LEAF	% SAVINGS
VW Golf	£297.37	£164.29	+55%
Vauxhall Astra	£539.17	£406.09	+75%
Toyota Prius	£362.52	£229.44	+63%
Nissan LEAF	£133.08	-	-

[108] Price taken from Ayre Service Station, March 2015.
[109] Average taken from W.I. Rendall, Westray; Olivebank General Merchant, Stronsay; and General Merchant, Shapinsay, March 2015.

On fuel prices alone, the Nissan LEAF offers a 55.25%, 75.32% and 63.29% cost saving against the VW Golf, Vauxhall Astra and Toyota Prius respectively.

Other running costs that make EV beneficial over conventional ICE vehicles include road tax and servicing costs.

Another benefit of EVs is the promise of minimised cost and time spent maintaining the vehicles. Modern breed of EVs have significantly less moving parts than conventional ICE vehicles. As a result EVs have a much lower chance of breaking down and also have fewer parts that a mechanics would be required to service.

Conrad Omand, of C S Omand garage, is located in Hamnavoe, Stromness. He is currently Orkney's only mechanic qualified to service EVs. By having this service located on the island significantly reduces the chances of EV owners being required to have their vehicles serviced on mainland Britain and adding significant inconvenience to vehicle owners.

A typical service of an EV involves changing the pollen filter; stripping and cleaning the brakes; and changing cooling fluids if required. On average, this can be expected to cost £70 per year. In comparison, servicing on conventional ICE vehicles costs £170 annually.[110]

Scenarios

The following aims to highlight the total cost comparison between:

- Scenario 1: Buying a new EV
- Scenario 2: Leasing an EV
- Scenario 3: Buying a new ICE vehicle

Scenario 1

This scenario again uses the Nissan LEAF model offered by Fleetdrive Electric, valued at £26,435. Servicing costs were previously detailed to be £70 a year, and fuel cost in Orkney to be 133.08 per year. Combining these figures with the previously analysis depreciation produces Figure B.. After five years the total cost to the owner would be £21,687; of which £1,015 is running costs.

[110] Correspondence with Conrad Omand (C S Omand), 20th March 2015

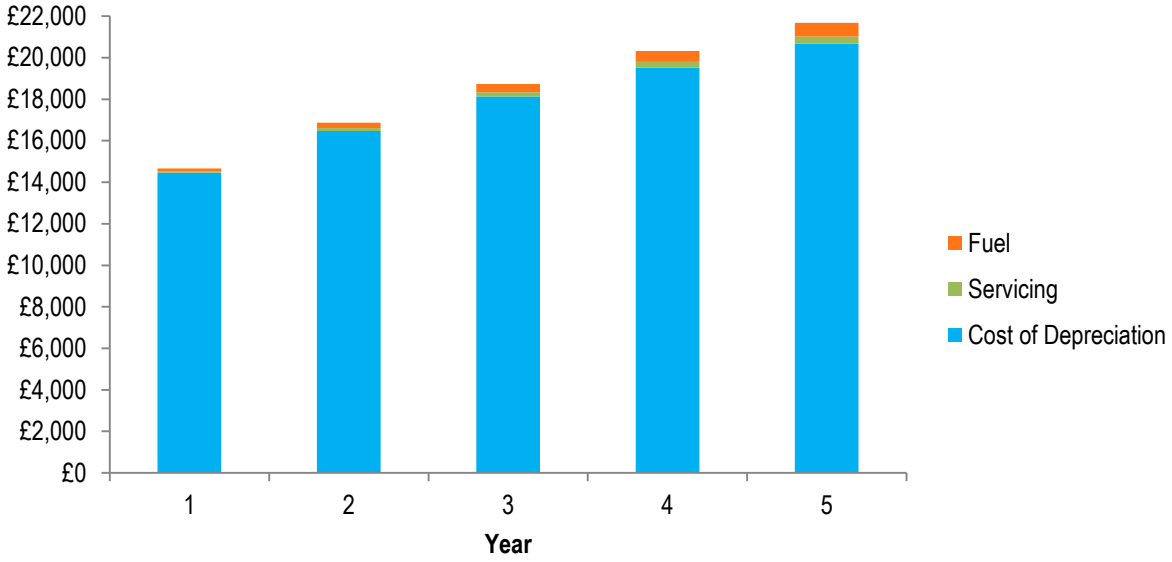


Figure B.5 - Scenario 1: Buying an EV (Cumulative Costs)

Scenario 2

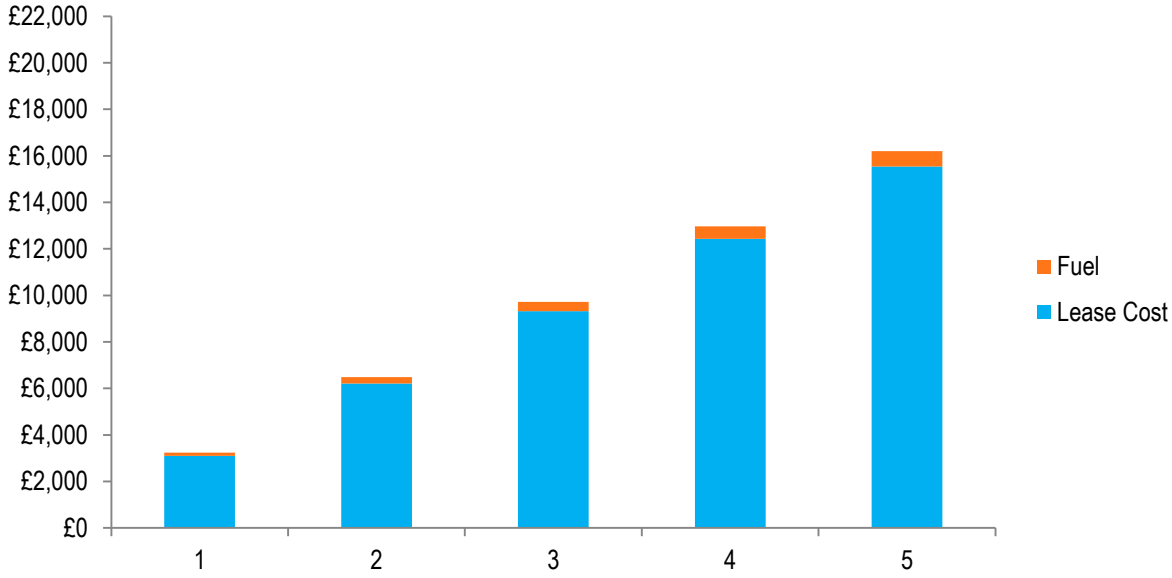


Figure B.6 - Scenario 2: Leasing an EV (Cumulative Costs)

Figure B.6, above, illustrates the results of the 2nd scenario; the leasing of an EV. The only running costs to the EV owner is the leasing rate and the fuel costs; as leasing costs are included. This is an approximately uniform yearly expenditure of £3,241; resulting in £16,205 over a five year period.

The third scenario, the buying of new ICE car, is illustrated below inFigure B.7. The car in question is the Vauxhall Astra, discussed previously, valued at £18,000. It shows that an Astra is cheaper purchase but the running costs are significantly greater than compared to

EVs. Where EVs have an annual running cost of £203 in Orkney, an Astra would be approximately £740 per year.

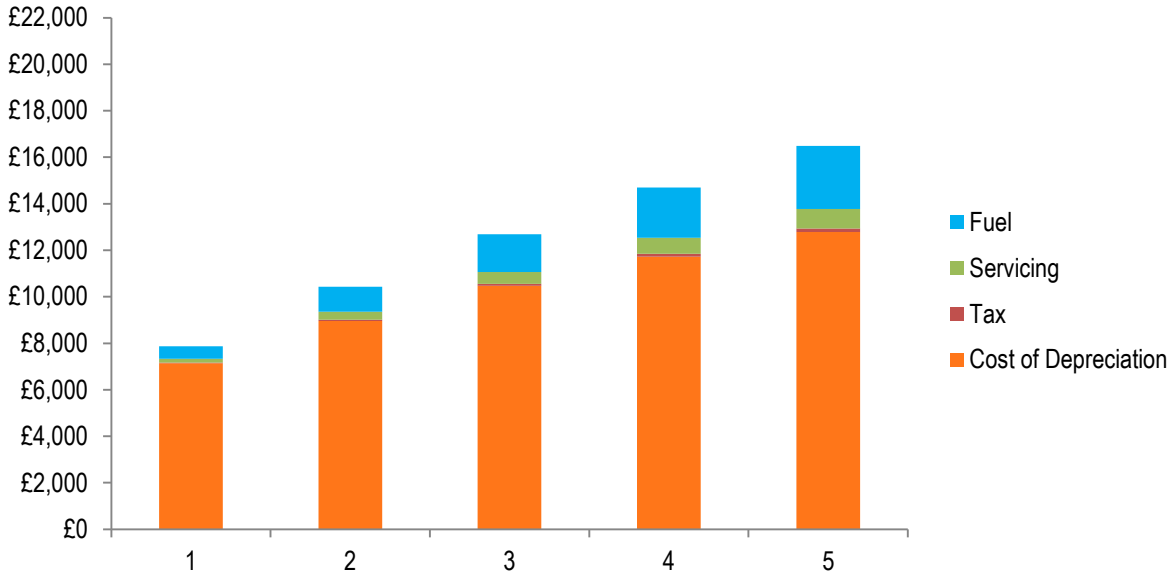


Figure B.7 - Scenario 3: Buying a new ICE Vehicle (Cumulative Costs)

These scenarios represent an approximate average representation of options in Orkney but cheaper EVs would make significant differences within the comparison. For example, a LEAF bought for £18,000 instead would mean that within four years the EV becomes cheaper than the purchase of an ICE car as a result of the cheaper running costs; demonstrated below in Figure B.8.

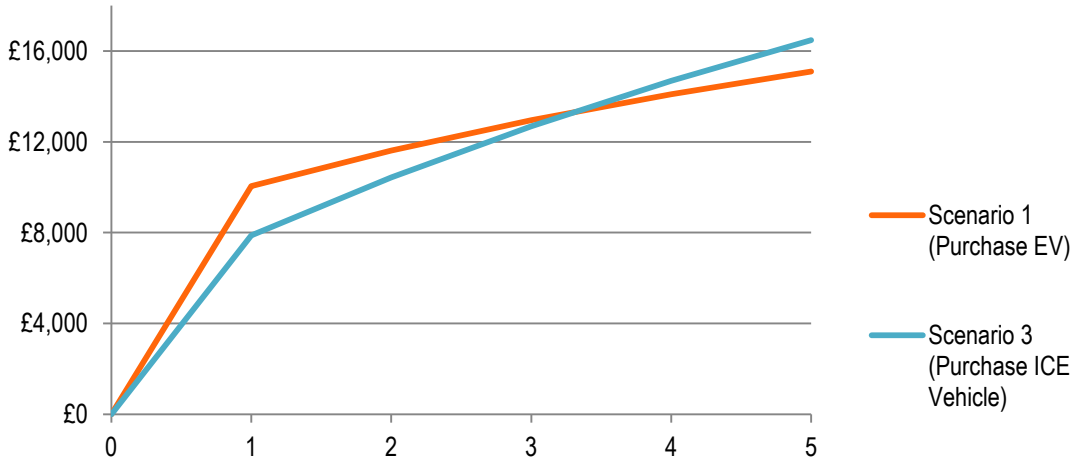


Figure B.8 - Equal Value EV vs. ICE Car Comparison

2. KWIKcarcost Lease vs Purchase Comparison

KWIKcarcost is a tool for analysis and comparison of vehicle whole life costs.[111] Using model year specific vehicle data, KWIKcarcost delivers whole life costs on up to 20,000 new vehicles. The table below is a sample comparison between lease and outright purchase of the following vehicles: Renault Kangoo Maxi (Diesel), Renault Kangoo Maxi (Electric), and Nissan e-NV200, for a term of 60 months, 50,000 total mileage. The finance rate used for outright purchase comparison is 4.5%.

Manufacturer	Renault		Renault		Nissan	
Model Series	Kangoo Light Commercial		Kangoo Light Commercial		NV200 Light Commercial	
Vehicle	ML19 1.5dCi eco2 75 Van		Maxi ZE 0.0Electric 60 i Van Auto		e-NV200 LCV Electric 109 Acenta Rapid Plus Van Auto	
Model Year	2014		2014		2013	
P11D of Vehicle	18,175		27,535		28,098	
P11D of Options	0		0		0	
P11D Total	18,175		27,535		28,098	
Discount	0		22,450		23,415	
CO2	130		0		0	
BIK (£)	3,090		3,090		3,090	
BIK (%)	-		-		-	
Acquisition Method	Outright Purchase	LeasePlan	Outright Purchase	LeasePlan	Outright Purchase	LeasePlan
Vehicle depreciation	12,472.83	0	14,418.33	0	14,658.50	0
Sum effective rentals	0.00	8,485.80	0	14,968.20	0	14,749.80
Est. rental for options	0	0	0	0	0	0
Excess Mileage	0	0	0	0	0	0
Finance	3,407.81	0	4,209.37	0	4,390.31	0
Fees	0	490	0	0	0	0
Forecast SMR	2,233	0	929	0	847	0
Sum of contracted SMR	0	1,420.20	0	1,270.20	0	1,255.20
Forecast Tyres	250	0	250	0	255	0
Sum of contracted tyres	0	0	0	0	0	0
Fuel	4,781.85	4,781.85	1,966.25	1,966.25	2,084.70	2,084.70
Employers NI	0	0	0	0	0	0
Insurance	2,750	2,750	2,375	2,375	3,675	3,675
VED	1,180	0	1,180	0	1,180	0
Gross WLC (term)	27,075.49	17,927.85	25,327.95	20,579.65	27,090.51	21,764.70
Value of tax reduction	4,866.90	3,585.57	4,513.79	4,115.93	4,890.76	4,352.94
Net WLC (term)	22,208.59	14,342.28	20,814.16	16,463.72	22,199.75	17,411.76
Whole life cost (per month)	370.14	239.04	346.90	274.40	370.00	290.20

SMR – Service, maintenance, repair

[111] KeeResources.com, Kwikcarcost, 2015.

Appendix C

1. Planning Application Details for Wind Farms in Orkney

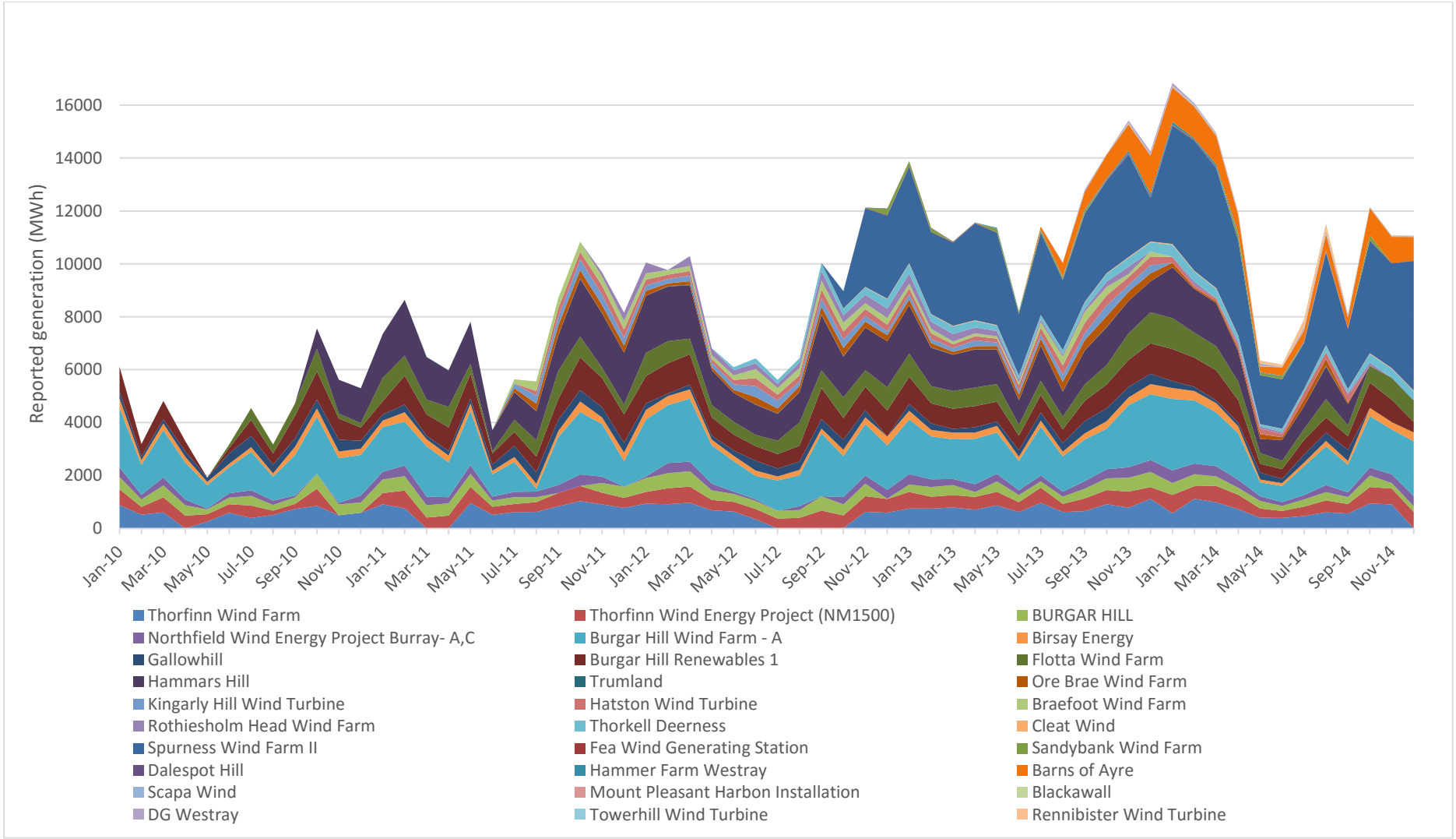
GENERATOR NAME	LOCATION	TURBINE SIZE (MW)	TOTAL MW	COMMISSION DATE	STATION NUMBER AT WWW.VARIABLE PITCH.CO.UK	DNO ZONE
Thorfinn Wind Farm	Burgar Hill, Evie	2.75	2.75	1.4.2000	1905	Zone 1a
Thorfinn Wind Energy Project (NM1500)	Burgar Hill, Evie	1.5	1.5	1.4.2000	656	Zone 1a
Burgar Hill	Burgar Hill, Evie	1.3	1.3	1.11.2000	113	Zone 1a
Northfield Wind Energy Project Burray- A,C	Northfield, Burray	0.9	0.9	1.2.2005	486	Zone 4a
Burgar Hill Wind Farm – A	Burgar Hill, Evie	2 x 2.5	5	1.12.2006	114	Zone 1a
Birsay Energy	Holodyke, Dounby	0.9	0.9	1.9.2009	854	Core zone
Gallowhill	Gallow Hill, Westray	0.9	0.9	11.9.2009	906	Zone 1
Burgar Hill Renewables 1	Burgar Hill, Evie	2.3	2.3	1.10.2009	772	Zone 1a
Flotta Wind Farm	West Hill, Flotta	2	2	18.6.2010	925	Zone 3
Hammars Hill	Hammars Hill	5 x 0.9	4.5	23.8.2010	926	Zone 1
Trumland	Trumland Farm, Rousay	0.08	0.08	18.2.2011	111	Zone 1
Ore Brae Wind Farm	Hoy Community Turbine, Ore Brae, Hoy	0.9	0.9	21.9.2011	128	Zone 3
Kingarly Hill Wind Turbine	Kingarly, Rousay	0.9	0.9	22.9.2011	1287	Zone 1
Hatston Wind Turbine	Crowness Business Park, Hatston Industrial Estate, Kirkwall	0.9	0.9	5.10.2011	1436	Core zone
Braefoot Wind Farm	Howe, Shapinsay	0.9	0.9	21.10.2011	1323	Zone 2
Rothiesholm Head Wind Farm	Rothiesholm Head, Stronsay	0.9	0.9	17.11.2011	1462	Zone 2a
Thorkell Deerness	Upper Stove, Deerness	0.9	0.9	9.3.2012	1800	Zone 4a
Cleat Wind	Cleat, Work Road, St. Ola	0.08	0.08	17.9.2012	2046	Core zone
Spurness Wind Farm II	Spurness, Sanday	5 x 2.0	10	22.10.2012	2269	Zone 2b
Fea Wind Generating Station	Fea, Holm	0.08	0.08	6.11.2012	2288	Zone 4
Sandybank Wind Farm	Sandybanks, Eday	0.9	0.9	27.11.2012	2274	Zone 1
DJ & JA Fairbairn	Wasbister, South Ronaldsay	0.053	0.053	28.11.2012	3121	Zone 4a
Dalespot Hill	Dale Spot Hill, Kirkwall	0.08	0.08	29.1.2013	2150	Core zone
Hammer Farm Westray	Hammer, Skelwick, Westray	0.5	0.5	27.2.2013	2744	Zone 1
Barns of Ayre	Barns of Ayre, Deerness	3 x 0.9	2.7	3.7.2013	3601	Zone 4a
Scapa Wind	Scapa, St Ola	0.08	0.08	26.9.2013	3111	Core zone
Mount Pleasant Harbon Installation	Mount Pleasant, Haybrake Road South Ronaldsay	0.06	0.06	8.10.2013	3120	Zone 4a
Blackawall	Blackawall Cottage, Flotta	0.08	0.08	16.10.2013	3415	Zone 3
DG Westray	Newark, Skelwick, Westray	0.5	0.5	17.10.2013	3092	Zone 1
Towerhill Wind Turbine	Towerhill, St Ola	0.08	0.08	3.3.2014	3468	Core zone
Rennibister Wind Turbine	Rennibister, Firth	0.9	0.9	28.3.2014	3385	Core zone
New Holland	Stratheast Road	0.5	0.5	20.11.2014	4712	Zone 4

2. Generation Output in MWh by Large Turbines in Orkney (Jan 2010-Dec 2014)

MONTH	THORFINN WIND FARM	THORFINN WIND ENERGY PROJECT (NM1500)	BURGAR HILL	NORTHFIELD WIND ENERGY PROJECT BURRAY- A,C	BURGAR HILL WIND FARM – A	BIRSAY ENERGY	GALLOWHILL	BURGAR HILL RENEWABLES 1	FLOTTA WIND FARM	HAMMARS HILL	TRUMLAND	ORE BRAE WIND FARM	KINGARLY HILL WIND TURBINE	HATSTON WIND TURBINE	BRAEFOOT WIND FARM	ROTHIESHOLM HEAD WIND FARM	THORKELL DEERNESS	CLEAT WIND	SPURNESS WIND FARM II	FEA WIND GENERATING STATION	SANDYBANK WIND FARM	DALESPOT HILL	HAMMER FARM WESTRAY	BARNS OF AYRE	SCAPA WIND	MOUNT PLEASANT HARBON INSTALLATION	BLACKAWALL	DG WESTRAY	TOWERHILL WIND TURBINE	RENNIBISTER WIND TURBINE	TOTAL
Jan-10	881	602	459	366	2254	349	269	930																							6110
Feb-10	519	293	284	177	1129	178	148	462																							3190
Mar-10	606	570	446	303	1788	254	153	698																							4818
Apr-10		482	393	212	1404	211	205	389																							3296
May-10	257	279	182	35	883	122	160																								1918
Jun-10	592	323	249	165	986	126	396	205	130																						3172
Jul-10	391	473	365	214	1453	176	426	600	448																						4546
Aug-10	510	162	217	162	907	122	329	426	337																						3172
Sep-10	735	192	242	71	1537	309	317	852	465																						4720
Oct-10	851	649	560		2163	314	334	1069	850	767																					7557
Nov-10	496	3	409	60	1686	253	448	796	185	1282																					5618
Dec-10	591		389	260	1539	236	300	497	170	1317																					5299
Jan-11	911	424	516	289	1688	248	229	505	878	1660																					7348
Feb-11	759	671	544	405	1656	354	291	1091	760	2107	4																				8642
Mar-11		411	463	328	1905	262	130	811	561	1601	13																				6485
Apr-11		484	465	229	1319	256	176	892	770	1377	12																				5980
May-11	960	610	494	332	2044	277	197	941	359	1588	12																				7814
Jun-11	514	305	233	150	846	131	229	428	88	785	12																				3721
Jul-11	616	305	261	199	1133	183	428	523	457	1042	12	139	167	9	160																5634
Aug-11	624	371	187	211	111	189	429	592	623	1094	9	278	303	170	366																5557
Sep-11	834	505		299	1816	223	420	788	1063	1339	12	374	318	321	385																8697
Oct-11	1032	571		436	2361	398	431	1235	787	2182	17	311	401	292	380																10834
Nov-11	906	443	368	240	1991	248	379	1109	391	2051	12	300	392	341	348	158															9677
Dec-11	777	378	420		969	325	368	1077	370	1950	4	275	283	323	327	311															8157
Jan-12	936	443	525	58	2156	364	244	1034	875	2160		184	204	221	239	408															10051
Feb-12	915	603	569	384	2187	346	91	1147	835	2065	18	104	162	163	176																9765
Mar-12	971	609	583	360	2384	346	183	1146	591	2017	20	132	214	178	188	366	5														10293
Apr-12	684	393	360	256	1447	217	148	691	464	1320	2	111	169	137	147	257	11														6814
May-12	636	366	299	89	1154	200	199	602	486	1089		121	210	159	173	197	112														6092
Jun-12	344	391	303	64	884	200	373	551	425	1139	13	278	410	308	343	212	190														6428
Jul-12		370	292		1151	153	295	547	506	1021	10	189	300	220	253	163	142														5612
Aug-12		399	296	145	1169	201	311	606	875	1141	11	226	178	229	279	206	160														6432
Sep-12		675	538	2	2380	177	362	1174	667	2091	24	298	315	333	330	376	292	4														10038
Oct-12	14	476	418	276	1551	237	382	818	780	1542	16	310	322	305	334	274	241	15	658												8969
Nov-12	626	593	474	304	1950	252	268	887	621	1613	7	222	215	258	220	318	282	19	2971	18		11									12129
Dec-12	593	520	10	335	1680	334		986	881	1734		233	141	253	252	355	353	24	3140	26	226	18									12094
Jan-13	752	626	280	392	2068	326	258	1026	881	1825		221	187	234	176	376	370	28	3654	28	169	7									13884

MONTH	THORFINN WIND FARM	THORFINN WIND ENERGY PROJECT (NM1500)	BURGAR HILL	NORTHFIELD WIND ENERGY PROJECT BURRAY - A.C	BURGAR HILL WIND FARM – A	BIRSAY ENERGY	GALLOWHILL	BURGAR HILL RENEWABLES 1	FLOTTA WIND FARM	HAMMARS HILL	TRUMLAND	ORE BRAE WIND FARM	KINGARLY HILL WIND TURBINE	HATSTON WIND TURBINE	BRAEFOOT WIND FARM	ROTHIESHOLM HEAD WIND FARM	THORKELL DEERNESS	CLEAT WIND	SPURNESS WIND FARM II	FEA WIND GENERATING STATION	SANDYBANK WIND FARM	DALESPOT HILL	HAMMER FARM WESTRAY	BARNS OF AYRE	SCAPA WIND	MOUNT PLEASANT HARBON INSTALLATION	BLACKAWALL	DG WESTRAY	TOWERHILL WIND TURBINE	RENNIBISTER WIND TURBINE	TOTAL
Feb-13	749	449	366	291	1626	243	245	759	651	1442	25	161	154	215	167	273	265	21	3097	20	133	15									11367
Mar-13	791	468	378	231	1496	256	141	762	670	1372	9	104	142	140	105	283	287	25	3144	22	6	10	4								10846
Apr-13	707	484	183	297	1716	235	200	802	700	1439	9	117	220	156	107	223	252	22	3657	21		10	5								11562
May-13	870	512	395	284	1564	251	163	750	667	1293	13	131	134	146	89	197	207	20	3491	20	127	3	36								11363
Jun-13	619	370	274	180	1113	155	244	549	412	930	8	200	148	214	104	114	129	14	2325	2	78	3	23								8208
Jul-13	966	575	236	223	1844	233	300	666	537	1327	10	251	167	246	211	101	163	15	3108		81	17	21	111							11409
Aug-13	620	308	271	188	1336	178	330	512	474	955	12	350	274	354	331	73	159	14	2650		82	20	25	513				26			10055
Sep-13	652	479	369	285	1576	233	461	768	618	1284	7	384	263	388	423	106	242	22	3332	15	97	20	29	655				90			12798
Oct-13	914	536	442	344	1535	282	486	901	732	1429	16	406	403	383	315	207	292	24	3499	23		24	35	891	16	12	6	2			14155
Nov-13	784	609	522	397	2351	289	394	1024	1001	1227		351	253	296	119	273	339	31	3874	26		25	84	1002	25	23	19	79			15417
Dec-13	1119	442	575	447	2491	382	390	1147	1177	1167		304	311	321	192		348	34	1640	28		21	112	1440	27	19	14	99			14247
Jan-14	575	691	447	481	2700	412	264	1207	1169	1921		176		224			449	36	4463	31		14	110	1300	26	26	13	107			16842
Feb-14	1119	478	453	403	2388	351	157	1107	940	1654		54		79		139	382	33	4919	27		5	52	1197	26	25	21	52	20		16081
Mar-14	986	621	358	384	2032	350	101	1139	912	1630		72		111			355	30	4530	24		7	101	1086	23	22	14	39	6	22	14955
Apr-14	726	545	264	300	1764	259	136	851	699	1153		93		124		125	232	21	3591	16	194	8	60	675	13	17	13	54	10	10	11953
May-14	403	349	284	179	527	105	261	332	411	526		186		215		73	80	8	1850	6	89	13	19	209	5	9	8	81	16	101	6345
Jun-14	395	264	190	143	612	106	167	364	313	789		103		128		66	117	11	1865	8	95	8	25	315	7	6	7	8	9	70	6191
Jul-14	465	359	271	163	1096	134	301	553	415	864		249		275			113	13	1732	11		19	31	421	9	8	8	77	24	297	7908
Aug-14	609	450	311	268	1466	202	312	571	700	1223	36	253		260			243	22	3501	17		17	45	615	12	14	15	94	21	247	11524
Sep-14	564	357	263	176	1045	144	424	513	409	809		60		282		67	139	13	2278	10		20		389	8	9	7	86	25		8097
Oct-14	941	623	438	301	1944	308		954	634							122	330	27	4255	23	181			1021	21	21	14				12158
Nov-14	908	598	206	329	1699	278		846	830								337	26	3955	22				985	14	22	15				11070
Dec-14		619	220	374	2081	340		391	808								348	31	4895	8				900	21	11	9				11056

Source: Variablepitch.co.uk and www.oref.org.uk/


Reported generation (MWh)
16000
14000
12000
10000
8000
6000
4000
2000
0
Jan-10
Mar-10
May-10
Jul-10
Sep-10
Nov-10
Jan-11
Mar-11
May-11
Jul-11
Sep-11
Nov-11
Jan-12
Mar-12
May-12
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Nov-12
Jan-13
Mar-13
May-13
Jul-13
Sep-13
Nov-13
Jan-14
Mar-14
May-14
Jul-14
Sep-14
Nov-14
Thorfinn Wind Farm
Thorfinn Wind Energy Project (NM1500)
BURGAR HILL
Northfield Wind Energy Project Burray- A,C
Burgar Hill Wind Farm - A
Birsay Energy
Gallowhill
Burgar Hill Renewables 1
Flotta Wind Farm
Hammars Hill
Trumland
Ore Brae Wind Farm
Kingarly Hill Wind Turbine
Hatston Wind Turbine
Braefoot Wind Farm
Rothiesholm Head Wind Farm
Thorkell Deerness
Cleat Wind
Spurness Wind Farm II
Fea Wind Generating Station
Sandybank Wind Farm
Dalespot Hill
Hammer Farm Westray
Barns of Ayre
Scapa Wind
Mount Pleasant Harbon Installation
Blackawall
DG Westray
Towerhill Wind Turbine
Rennibister Wind Turbine

3. Electric Vehicle Energy Demand

The following tables outline the estimated annual electricity demand resulting from electric vehicle uptake under the three different scenarios.

Table C.1 – Estimated annual electricity demand from EVs under Scenario 1 (MWh)

SCENARIO 1: LOW EV UPTAKE									
VEHICLE TYPES	2015	2016	2017	2018	2019	2020	2030	2040	2050
Electric									
Cars	144.9	161.7	193.0	241.1	307.4	390.4	1,678.4	3,622.7	6,237.6
Motorcycles	-	-	-	-	-	-	-	0.1	0.5
LGVs	5.9	9.0	18.2	30.6	49.1	70.6	462.8	1,033.5	1,773.8
HGVs	-	-	-	-	-	-	-	-	-
Buses	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.2	141.0
Total	178.9	198.8	239.4	299.9	384.6	489.2	2,169.4	4,684.5	8,152.8

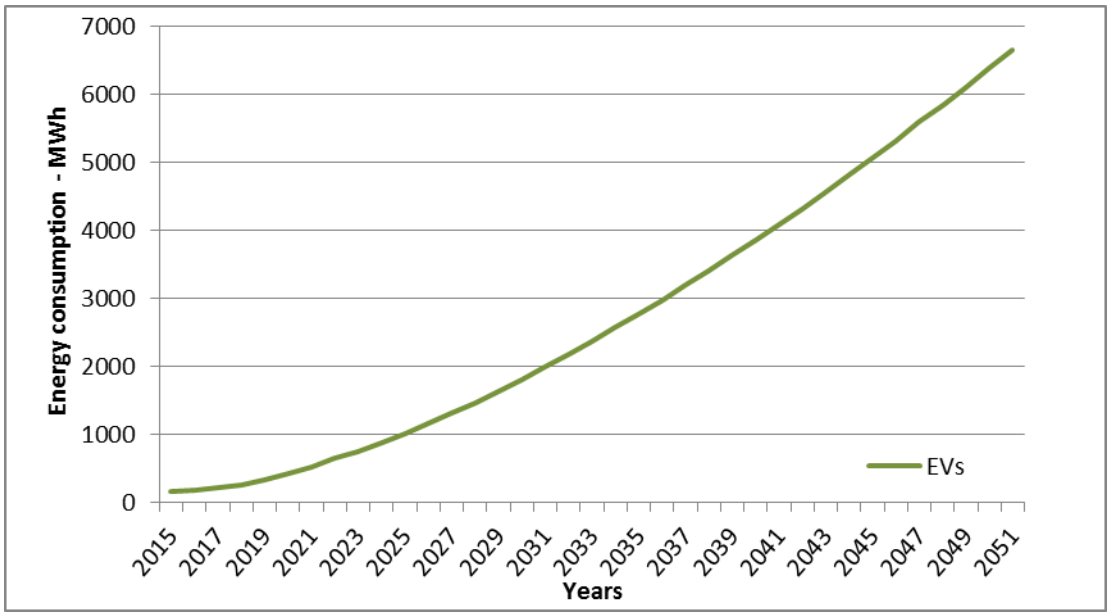


Figure C.1 - Estimated annual electricity demand from EVs under Scenario 1

Table C.2 – Estimated annual electricity demand from EVs under Scenario 2 (MWh)

SCENARIO 2: MODERATE EV UPTAKE									
VEHICLE TYPES	2015	2016	2017	2018	2019	2020	2030	2040	2050
Electric									
Cars	144.9	197.8	303.8	466.3	683.0	956.3	5,396.2	12,056.2	22,108.9
Motorcycles	-	-	-	-	-	-	1.0	2.2	4.0
LGVs	5.9	21.3	49.1	95.0	156.4	233.2	1,513.1	3,418.9	6,282.8
HGVs	-	-	-	-	-	-	-	-	26.1
Buses	28.2	28.2	28.2	28.2	28.2	28.2	225.6	507.5	845.9
Total	178.9	247.3	381.0	589.5	867.6	1,217.7	7,135.9	15,984.8	29,267.7

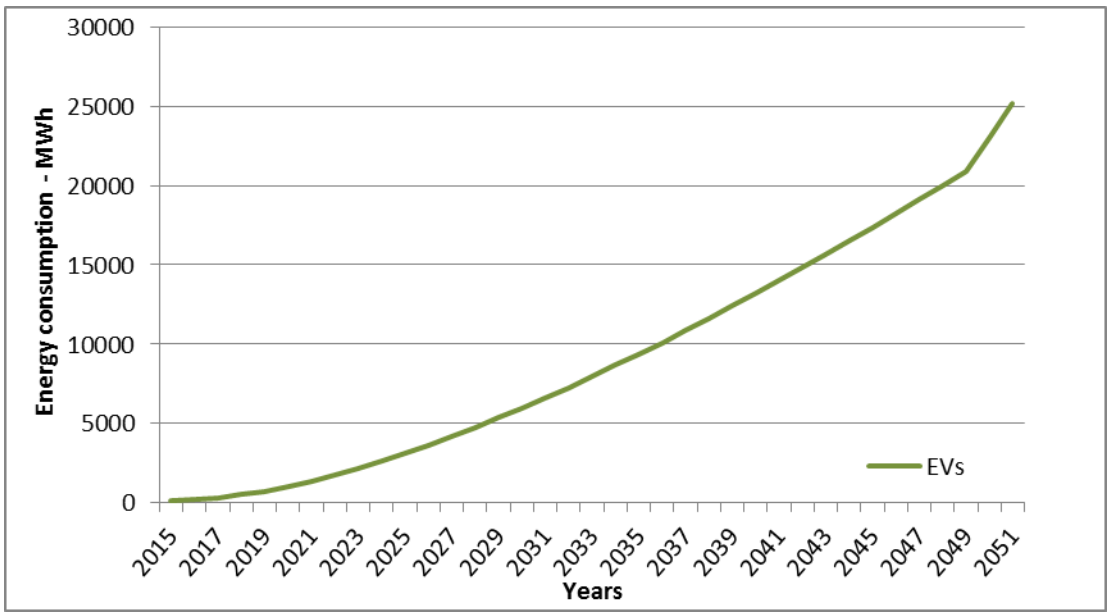


Figure C.2 - Estimated annual electricity demand from EVs under Scenario 2

Table C.3 – Estimated annual electricity demand from EVs under Scenario 3 (MWh)

SCENARIO 3: HIGH EV UPTAKE									
VEHICLE TYPES	2015	2016	2017	2018	2019	2020	2030	2040	2050
Electric									
Cars	144.9	232.7	409.7	674.6	1,027.3	1,472.8	8,814.2	22,935.1	30,862.8
Motorcycles	-	-	-	-	-	-	1.3	3.9	4.3
LGVs	5.9	30.6	79.6	153.3	254.5	380.4	2,486.1	6,510.5	8,785.0
HGVs	-	-	-	-	-	-	-	52.2	64.7
Buses	28.2	28.2	28.2	28.2	28.2	56.4	338.4	789.5	1,049.4
Total	178.9	291.5	517.5	856.1	1,310.0	1,909.5	11,639.9	30,291.1	40,766.2

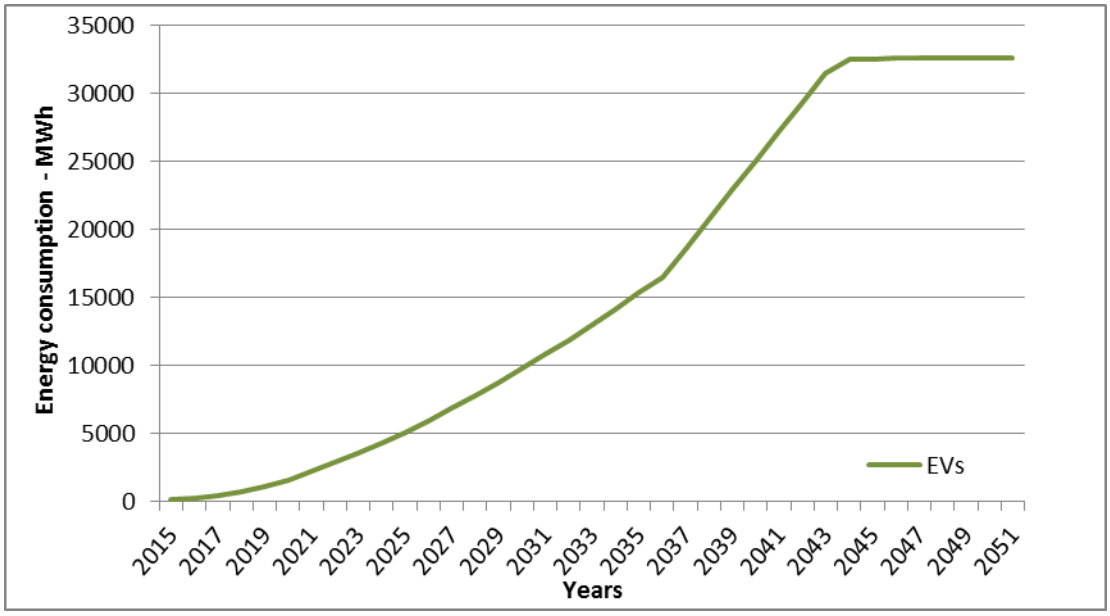


Figure C.3 - Estimated annual electricity demand from EVs under Scenario 3

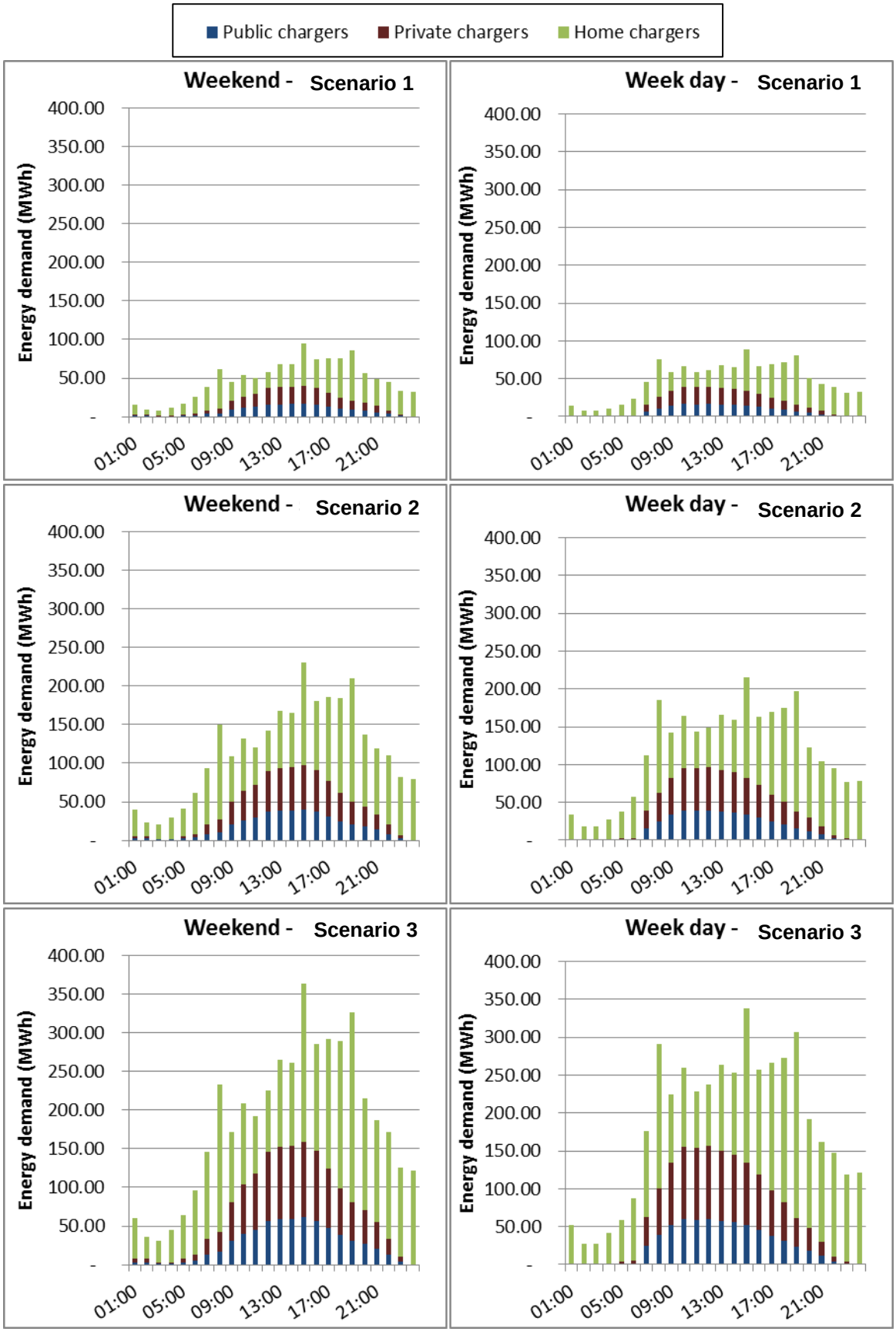


Figure C.4 – Total energy demand per type of charger for all scenarios in 2020 – not inclusive of smart charging management

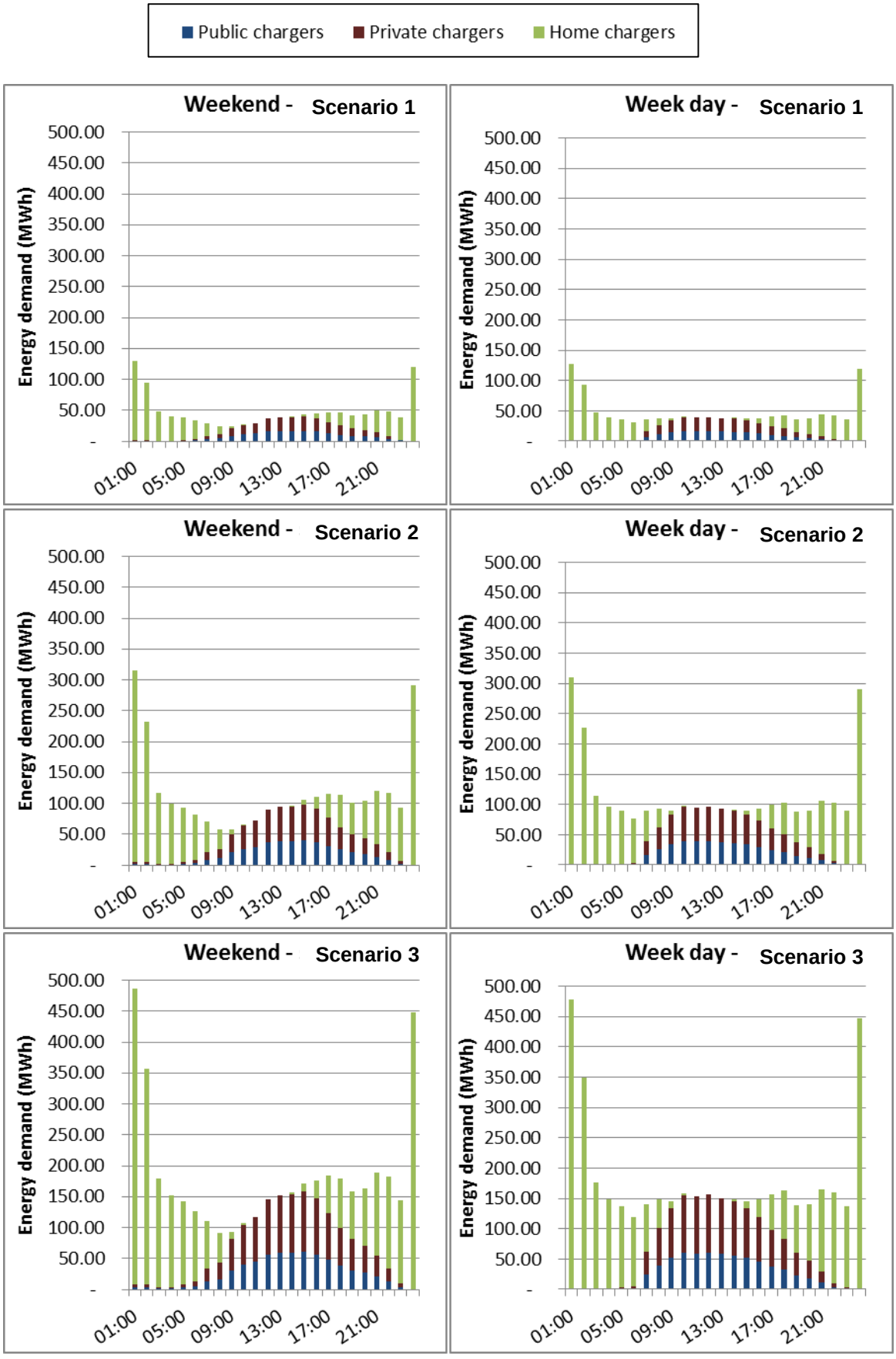


Figure C.5 - Total energy demand per type of charger for all scenarios in 2020 – inclusive of smart charging management

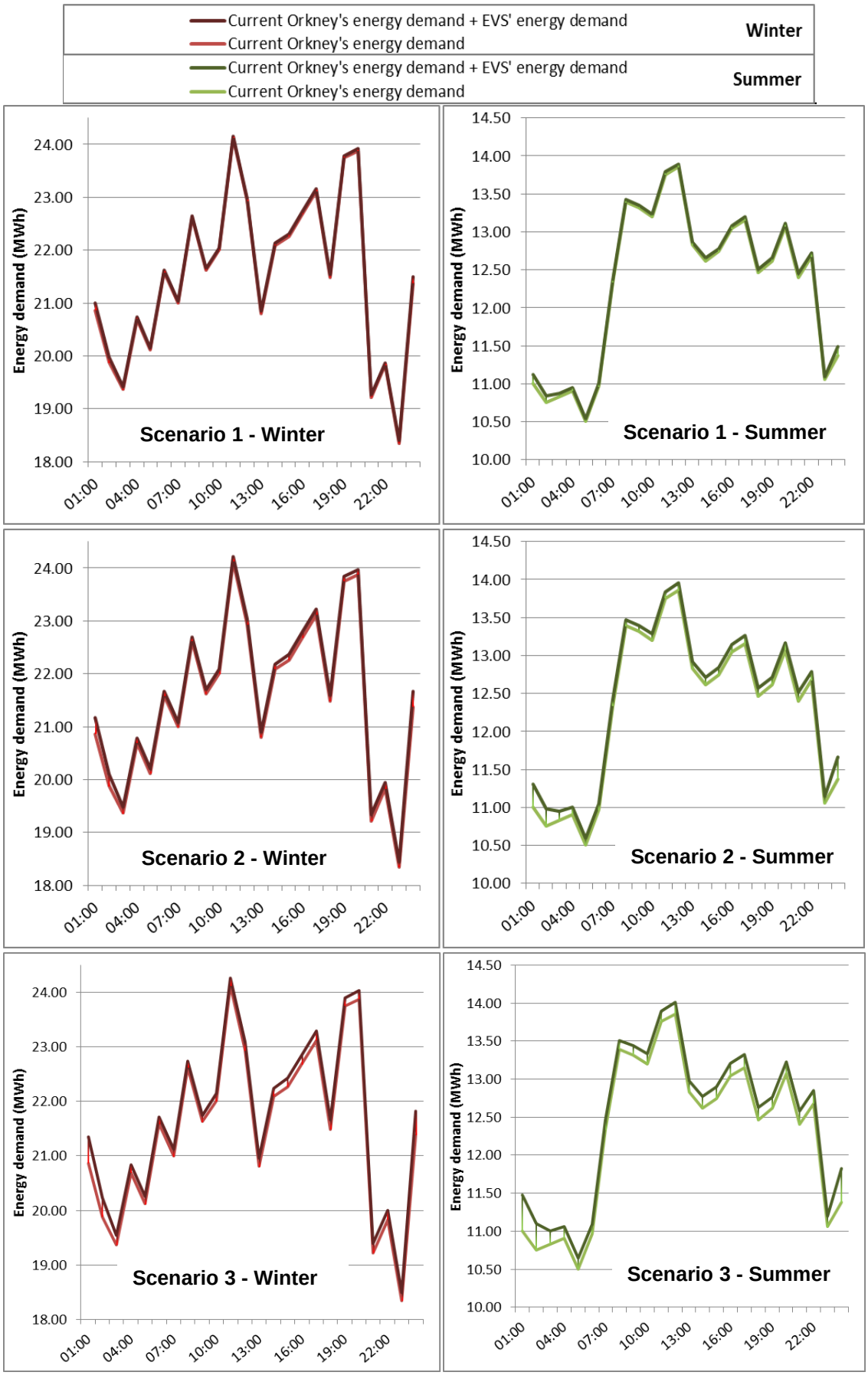


Figure C.6 - Current vs. hypothetical energy demand in 2020

4. Orkney's Charger Technologies

At the time of this document being produced, Orkney had ten EV charging stations available to the public. The following investigates these in detail.

Elektromotive

Elektrobay 305

The photo to the right identifies the current EV charging station located to the rear to the Old Academy Business Centre in Stromness. The unit is the pedestal model of the Elektrobay 305, manufactured by Electromotive.

Old Academy Charging Station

The unit itself can service two charging sessions simultaneously through two Type 2 (Mennekes) sockets. The station is listed as a Fast charger; rated at 7kW, 32A (single phase). However, this has yet to be verified.

The charging station is owned by OIC, but managed under the Charge Your Car (CYC) public network. An RFID tag is required in order to start charging as well as to stop charging, prior to the car battery being full.

The St. Margaret's Hope Care Home; the Dounby Community Centre; and St. Rognvalds House all currently have the same Elektromotive Elektrobay 305 located at their premises. Again it can simultaneously charge two EVs through two Type 2 (Mennekes) sockets.

Elektrobay 280

The Warness Industrial park, located at the Hatston Industrial Estate, in Kirkwall has five units constructed for the marine renewables industry to promote further growth. Each unit was fitted with Elektromotive Elektrobay 280.

Warness Park Charging Station

Each charging station has a single Type 2 (Mennekes) socket capable of Fast charging at 7kW, 32A (single phase).

These charging units are not managed by a public charging station as they are predominately for the use of the business within each of the respective units. However, EMEC openly advertise their own charging station for public use as long as prior notice is given.

DBT Rapid Charger

There is a single DBT charging station currently located on Orkney. It is situated outside Ticketyboo, at the Ayre Service Station, in Kirkwall. It is currently Orkney's only Rapid charger in operation and was purchased using a full grant. Conditions of the grant ensure the charger is free for the public, but the charger owner has to pay for the power used for a limited time. After which, a tariff can be introduced to cover the expense.

Ticketyboo Charging Station

This particular model is capable of charging two EVs simultaneously. It is fitted with a tethered CCS plug on the left, supplying 50kW (DC) at 125A; a tethered CHAdeMO plug on the right, again at 50kW (DC) at 125A; and a tethered Type 2 (Mennekes) supplying 43kW (AC) at 63A in three phase.

This charging station is also managed by the CYC public network and can be accessed by using the appropriate RFID tag for initiating and halting charging sessions.

Circutor (PVE-PM3 3G)

The photo to the right shows the charger that is currently located at the Great Western Road car park.

Great Western Road Charging Station

This particular charger is capable of charging two EVs simultaneously at 7kW using type 2 sockets. It also has the capacity for the transfer of information through an in-built 3G modem.[112]

This particular model is protected from tampering by the use of two metal flaps covering the sockets, held in place with electromagnets. A valid RFID tag is required to gain access to the charger.

This particular model of charger can also be found within the East Kirk carpark, next to the OIC offices. This location was the first to be used in Orkney for EV charging.

[112] Circutor, Electric vehicle smart charge, 2015

5. Available Charging Technologies

1. Rate of Charge

The charging infrastructure for EVs is generally described by the rate at which the stations are capable of charging the vehicles: Slow, Fast and Rapid.

Slow

Slow chargers are those which can provide power up to 3kW. At this rate a full charge period for a conventional EV would be approximately 6-8, and best suited for overnight charging at home or at work during a full working day. Initially public charging stations utilised Slow charging rates, but this has been generally superseded by Fast and Rapid charging networks. As of late February 2015, there were approximately 2,309 registered publicly available Slow chargers. Slow chargers have the advantage of being significantly cheaper than Fast or Rapid chargers, but are disadvantaged by the significantly greater charging times.[113]

Fast

Fast charging networks are capable of providing power at 7kW. However, some are capable of providing power at 22kW using three phase instead of single phase. Chargers rated at 7kW are more common and capable of reducing full charging time to typical EVs to approximately 3-4 hours. This type has become the most commonly publicly available chargers. As of February 2015, there were roughly 4,780 Fast chargers made publically available.

Rapid

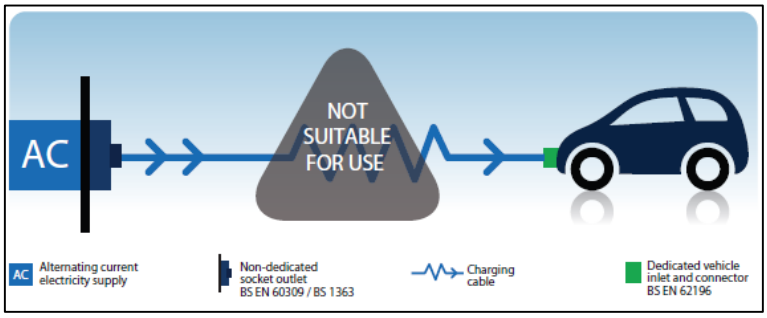
Rapid chargers have the potential to significantly reduce waiting times for EV drivers. They can also be sub-categorised into either AC or DC Rapid chargers. AC chargers are capable of providing power at rates up to 43kW (three phase) and 63A. At this rate a typical (compatible) EV will receive 80% full charge within 30 minutes to an hour. DC Rapid chargers are capable of providing power at rates up to 50kW and 125A. The charger internally converts grid AC power to DC before supplying the EV and is why greater power supplies are possible. At this rate a compatible EV will be charged to 80% capacity within 30 minutes. Rapid chargers, both AC and DC, are being strategically placed throughout the country at key locations where shorter charging times will be key to supporting a growing EV industry. As of February 2015 there were 259 AC and 625 DC Rapid chargers.[113]

[113] Zap-maps, Charging point basics, 2015.

2. Mode 1,2,3,4

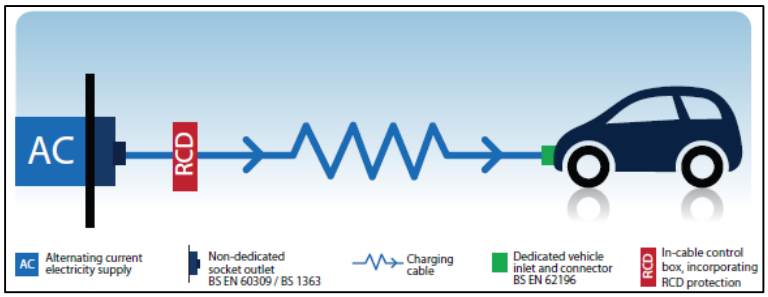
Another means of categorising the range of charging methods available is to describe the connection between the charging station and the EV. These are differentiated between:

- **Mode 1:** The mode describes the charging connection that is not on a dedicated circuit and connected to the grid via a 3-pin plug (BS 1363) or a 3-pin (IEC60309) socket. It will be connected to the EV using a type 1 (5-pin J1772) or type 2 (7-pin IEC62196) plug. There will also be no Residual Current Device (RCD) protection to ensure against unsafe power levels. This mode is no longer advised as it does not provide adequate safety precautions for EV owners.[114]



Mode 1 Charging [114]

- **Mode 2:** This mode of charging has the same charger to EV plug and socket combination as seen in Mode 1 charging. However, the cable also incorporates RCD protection between the grid and EV. This cable is the connection generally seen during domestic charging and public charging station with either a 3-pin (BS 1363) or 3-pin (IEC60309) socket. Again, as seen in Mode 1 cables, the EV plug will either be a type 1 (5-pin J1772) or type 2 (7-pin IEC62196) plug; depending on the EV model requirements.[114]



Mode 2 Charging[114]

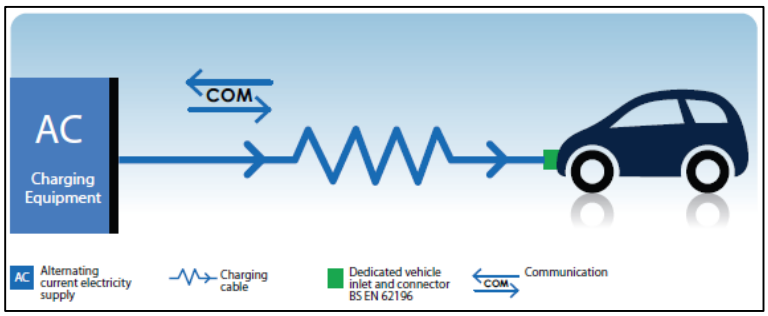
- **Mode 3:** Mode 3 charging is the advancement upon Mode 2 in order to sufficiently accommodate public charging stations. The connection to the grid, via the charging station, can be either a tethered cable, fixed connection to the charger, or plug and socket configuration; utilising either type 1 (5-pin J1772) or

[114] BEAMA, Guide to electric vehicle infrastructure, 2012.

type 2 (7-pin IEC62196). In the latter case, the driver is required to supply the cable and carry it within them where ever they travel. Again, as seen in the previously discussed modes, the EV connector depends on the model of EV; either a type 1 (5-pin J1772) or type 2 (7-pin IEC62196).[114]

Mode 3 charging allow for the greater currents required for 'Fast' charging. This can reduce the 6-8 hours of 'Slow' charging, seen in Mode 1 and Mode 2, down to 3-4 hours.

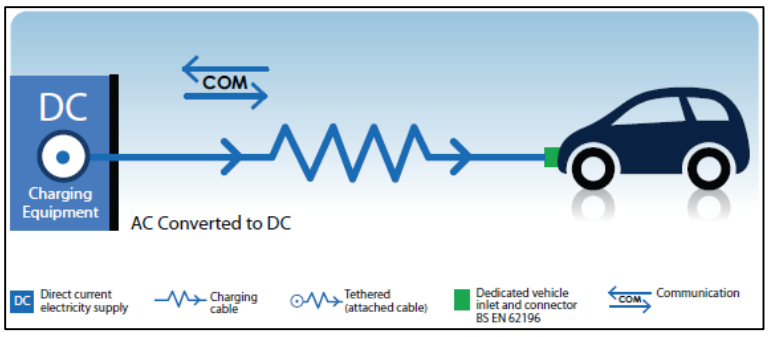
Mode 3 charging differs further by incorporating two way communications between the EV and charging station, which allows for smart charging. This is the preferred method of charging as the industry and grid operators move towards smart grid and pay per use billing.[114]



Mode 3 Charging [114]

- **Mode 4:** Mode 4 charging was developed to incorporate 'Rapid' charging; which can use voltages up to 500V and currents of 125A. Whereas the previous three modes can be seen within domestic installations, Mode 4 is only present in selected public stations. Due to the significantly higher power levels EV can be charged in approximately 20 minutes.[114]

  As seen in Mode 3 charging, two way communication between the charging station and EV provides future avenues for smart charging and smart grids.



Mode 4 Charging [114]

3. Connector Types

The EV charging infrastructure utilises a number of connection types; a few of these have been discussed earlier. These can be described as either non-dedicated or dedicated types

a. Non-dedicated

Non-dedicated charging connectors are those which are utilised in other areas than just EV charging; domestic and industrial connections.

The conventional 3-pin, also categorised as 'BS 1363', uses mains power at 230V and 13A, and provides power up to 3kW. For this reason is can also fall under the 'Slow' charging category. It is most commonly found in home charging station. But also found within the public charging infrastructure as well.

3-Pin BS 1363

The industrial 'commando' configuration is a lesser common configuration utilised within EV charging infrastructure. But is capable of supplying greater power supply up to 22kW, and thus can be categorised under 'Slow' and 'Fast' charging capacity.

b. Dedicated

The dedicated charging connector types are those that have been purposely designed and standardised for the EV industry. These mainly include the Type 1 and Type 2 configurations. The type of connector depends upon the safety standards it applies to, the power supplied and the country the EV originates from.

- **Type 1**

The Type 1 plug and socket, also referred to as the "Yazaki", is a five pin configuration; two AC pins, an earth and two signal pins. It only has the capacity to supply single-phase power, with a maximum current and voltage of 32A and 250V respectively.

Type 1 Charging Plug and Socket

The Type 1 plug and socket are subject to standards that ensure that it is compatible across countries. The J1772 details the physical and electrical specifications of the plug and socket. It also is detailed within the IEC 62196-2 standard, which covers the connectors specifically use for EV charging

Type 2

The Type 2 plug and socket was an advancement upon the Type 1 configuration. It is also known as the "Mennekes" configuration. The addition of a further two pins for power supply (seven in total) this allows for the supply of either single or three-phase power. Due to this it is capable of being utilised for 'Slow', 'Fast' and also 'Rapid' charging. In AC, the power supplied can range from 3-43kW and 16A (single phase) to 63A (three phase).[114]

Type 2 Charging Plug and Socket

CHAdeMO

CHAdeMO is one of the two currently available connectors specifically available for Rapid charging. This is seen in models such as the Nissan Leaf and Peugeot iOn. The CHAdeMO connector accommodates DC Rapid charging in particular, supplying up to 50kW at 125A. Along with the significant power supply there is also significant accommodation of data transfer. Within the connector there are two power lines, six control lines and two communication lines that will cancel charging if a malfunction is detected.[115]

CHAdeMO Charger

Combined Charging System

The second dedicated EV charging connector produced specifically for Rapid DC charging is Combined Charging System (CCS), or 'Combo' connector. The Combo connector differs from the CHAdeMO connector by incorporating the type 1 connector and utilising its control pins and applying a further two DC power supply pins. This arguably makes charging less complicated for EV drivers, by only needing to have one socket on the car for Slow, Fast and Rapid Charging.

[115] CHAdeMo, Technological strengths, n.d.

Appendix D

1. Visitor Attractions

In order to understand the number of chargers that would suitably accommodate the number of tourists visiting the range of Orkney's attractions, it is important to understand the number of visitors each location receives annually/seasonally. The Orkney Visitor Survey produces a record of the percentage of visitors that go to key attractions.[116] The same survey estimates that approximately 142,000 visitors came to Orkney between 2012 and 2013. Thus, it is possible to estimate the annual visitor numbers at each attraction. This is illustrated in Table D.1.

Table D.1 – Visitor attractions in Orkney

REGION	ATTRACTION	NO OF VISITORS PER ANNUM	% OF TOTAL VISITORS	PARKING AVAILABILITY*
Kirkwall	St Magnus Cathedral	95,140	67%	Not directly associated
	Bishop's Palace	48,280	34%	Not directly associated
	Highland Park Distillery	31,240	22%	Parking
	Pickaquoy Centre	21,300	15%	Parking
	Orkney Wireless Museum	8,520	6%	Not directly associated
Stromness	Stromness Museum	28,400	20%	Not directly associated
	Pier Arts Centre	26,980	19%	Not directly associated
	Ness Battery	17,040	12%	Parking
East Mainland, Burray / South Ronaldsay	Lamb Holm - Italian Chapel	82,360	58%	Parking
	Tomb of the Eagle	35,500	25%	Parking
	Fossil and Vintage Centre	24,140	17%	Parking
	Sheila Fleet Visitor Centre	11,360	8%	Parking
	Smithy Museum	2,840	2%	Limited parking
West Mainland	Ring of Brodgar	99,400	70%	Parking
	Skara Brae	96,560	68%	Parking
	Standing Stones	95,140	67%	Limited parking
	Brough of Birsay	63,900	45%	Limited parking
	Maeshowe	58,220	41%	Limited parking
	Skaill House	55,380	39%	Parking
	Evie - Broch of Gurness	39,760	28%	Parking
	Earl's Palace	36,920	26%	Limited parking
	Marwick Head	26,980	19%	Limited parking
	Orkney Brewery Visitor Centre	24,140	17%	Parking
	Kirbuster Museum	11,360	8%	Limited parking
	Corrigall Museum	4,260	3%	Limited parking

**Parking = dedicated parking; Limited parking = some dedicated spaces but often not marked or rough parking; Not directly associated = no dedicated parking but some within a reasonable distance*

[116] Visit Scotland, Orkney Visitor Survey: 2012-2013, 2013.

The Orkney Visitor Survey also includes a record of the approximate seasonality through the year in terms of visitor numbers to Orkney. This is displayed in Table D.2

Table D.2 - Orkney visitor seasonality

MONTHS	JAN-MAR	APR-JUN	JUL-SEP	OCT-DEC
Percentage	3%	34%	58%	6%

By applying this seasonality to the visitor numbers of the locations with dedicated parking, such as Skara Brae and the Italian Chapel, and excluding locations without dedicated parking, such as St. Magnus Cathedral and the Stromness Museum, then it is possible to estimate the average daily visitor numbers of each location. This is illustrated in the table below.

Table D.3 - Daily average visitor numbers

ATTRACTION	DAILY AVERAGE			
	JAN-MAR	APR-JUN	JUL-SEP	OCT-DEC
Ring of Brodgar	33	370	632	65
Skara Brae	32	360	614	63
Lamb Holm - Italian Chapel	27	307	523	54
Brough of Birsay	21	238	406	42
Maeshowe	19	217	370	38
Skaill House	18	206	352	36
Evie - Broch of Gurness	13	148	253	26
Tomb of the Eagle	12	132	226	23
Highland Park Distillery	10	116	199	21
Marwick Head	9	101	171	18
Fossil and Vintage Centre	8	90	153	16
Orkney Brewery Visitor Centre	8	90	153	16
Pickaquoy Centre	7	79	135	14
Sheila Fleet Visitor Centre	4	42	72	7
Kirbuster Museum	4	42	72	7
Corrigall Museum	1	16	27	3

The Moffat Centre for Travel and Tourism Business Development produces Visitor Attraction Monitor reports. The most recent report details further data on the habits of those visiting attractions in Orkney.[117] On average people visiting an attraction in Orkney will spend 59 minutes in total. Informal discussions with travel guides in Orkney back up this estimate with the suggestion that around 1 hour to 1 hour 15 minutes is the normal time for a visit to Skara Brae which is one of the most visited sites.

[117] The Moffat Centre for Travel and Tourism, Visitor attraction monitor, 2010.

Table D.4 below shows the distance between the main tourist attractions on the mainland of Orkney[118] that have a reasonable amount of dedicated parking (longer distances are shown in red and shorter distances are shown in green). The longest distance possible is between the Tomb of the Eagles in South Ronaldsay and Marwick (43 miles and 86 miles for a return journey).

Table D.4 - Distance between major tourist sites

Destination	Marwick Head	Birsay	Skara Brae	Orkney Brewery	Broch of Gurness	Stromness Terminal	Stromness	Tingwall Ferry Terminal	Ring of Brodgar	Houton Ferry Terminal	Hatson Ferry Terminal	Kirkwall	Kirkwall Ferry Terminal	Kirkwall Airport	Italian Chapel	St. Margaret's Hope	Burwick Ferry Terminal	Tomb of the Eagle
Marwick Head	0	4	5	4	13	12	12	15	10	17	19	21	21	25	29	35	41	43
Birsay	4	0	7	6	10	13	13	12	11	19	18	19	20	24	27	34	40	42
Skara Brae	5	7	0	3	12	8	8	14	6	13	16	17	17	21	25	32	38	39
Orkney Brewery	4	6	3	0	11	9	9	13	7	15	16	17	17	21	25	32	38	39
Broch of Gurness	13	10	12	11	0	17	17	4	14	20	15	16	16	20	24	31	37	38
Stromness	12	13	8	9	17	0	0	14	6	8	14	15	15	19	23	30	36	37
Ring of Brodgar	10	11	6	7	14	6	6	11	0	9	11	12	12	16	20	27	33	34
Kirkwall	21	19	17	17	16	15	15	13	12	11	2	0	0	4	8	15	21	22
Italian Chapel	29	27	25	25	24	23	23	21	20	18	10	8	8	8	0	7	13	14
Tomb of the Eagle	43	42	39	39	38	37	37	35	34	32	24	22	22	22	14	8	2	0

Therefore cars with a longer range such as the Nissan Leaf with a range of 124 miles[119] under normal rural driving conditions will manage most journeys on Orkney without charging during the day. Other cars such as the Peugeot Ion with a maximum range of 93 which from local knowledge, it is known to be more like 60 miles then a charge may be necessary if a journey from South Ronaldsay to the North of the West Mainland is undertaken.

If it is assumed that the EV starts its journey with a full charge and makes a return journey, Table D.5 shows how many miles are left once returning to the starting point. The journeys shown in dark red are negative and are therefore not possible without a top-up charge during the journey, while the journeys highlighted in yellow show where the battery level falls below 25% and would therefore be likely to cause some range anxiety.

The Peugeot Ion has been used as it illustrates an example of a smaller car with more limited range that might be used within a hire car fleet.

[118] Distances from AA route planner
[119] Nissan, Nissan LEAF range, n.d.

Table D.5 - Miles remaining for a Peugeot Ion making a return journey

Destination	Marwick Head	Birsay	Skara Brae	Orkney Brewery	Broch of Gurness	Stromness Terminal	Stromness	Tingwall Ferry Terminal	Ring of Brodgar	Houton Ferry Terminal	Hatson Ferry Terminal	Kirkwall	Kirkwall Ferry Terminal	Kirkwall Airport	Italian Chapel	St. Margaret's Hope	Burwick Ferry Terminal	Tomb of the Eagle
Marwick Head	60	53	49	52	34	36	36	30	40	25	21	19	19	11	3	-11	-23	-25
Birsay	53	60	45	48	41	34	34	37	38	23	23	21	21	13	5	-9	-20	-23
Skara Brae	49	45	60	54	35	45	45	31	49	34	28	25	25	17	9	-4	-16	-19
Orkney Brewery	52	48	54	60	39	42	42	35	46	31	29	26	26	18	10	-4	-15	-18
Broch of Gurness	34	41	35	39	60	25	25	52	32	20	30	28	28	20	12	-2	-14	-16
Stromness	36	34	45	42	25	59	60	31	48	43	33	30	30	22	14	1	-11	-14
Ring of Brodgar	40	38	49	46	32	48	48	37	60	43	39	37	36	28	21	7	-5	-8
Kirkwall	19	21	25	26	28	30	30	34	37	39	57	60	59	52	44	30	18	15
Italian Chapel	3	5	9	10	12	14	14	18	21	24	40	44	44	44	60	46	34	31
Tomb of the Eagle	-25	-23	-19	-18	-16	-14	-14	-10	-8	-4	12	15	15	16	31	44	56	60

In situations where top-up charging to 80% of battery capacity with a rapid charger can be done at key tourist sites (as shown in Table D.6), the return journeys are possible, albeit with some range anxiety likely for the longest journeys.[120] In this case, two top-up charges may be necessary in order to provide comfort that the charge won't run out for the return journey.

Table D.6 - Miles remaining - Peugeot Ion, return journey & top-up charge with rapid chargers

Destination	Marwick Head	Birsay	Skara Brae	Orkney Brewery	Broch of Gurness	Stromness Terminal	Stromness	Tingwall Ferry Terminal	Ring of Brodgar	Houton Ferry Terminal	Hatson Ferry Terminal	Kirkwall	Kirkwall Ferry Terminal	Kirkwall Airport	Italian Chapel	St. Margaret's Hope	Burwick Ferry Terminal	Tomb of the Eagle
Marwick Head	60	53	49	52	35	36	36	33	40	31	29	28	27	23	20	13	7	5
Birsay	53	60	45	48	41	35	35	37	38	30	30	29	29	25	21	14	8	7
Skara Brae	49	45	60	54	36	45	45	34	49	35	32	31	31	27	23	16	10	9
Orkney Brewery	52	48	54	60	39	42	42	36	46	34	32	31	31	27	23	16	10	9
Broch of Gurness	35	41	36	39	60	31	31	52	34	28	33	32	32	28	24	17	11	10
Stromness	36	35	45	42	31	59	60	34	48	43	34	33	33	29	25	18	12	11
Ring of Brodgar	40	38	49	46	34	48	48	37	60	43	39	37	36	32	28	22	16	14
Kirkwall	28	29	31	31	32	33	33	35	37	39	57	60	59	52	44	33	27	26
Italian Chapel	20	21	23	23	24	25	25	27	28	30	40	44	44	44	60	46	35	34
Tomb of the Eagle	5	7	9	9	10	11	11	13	14	16	24	26	26	26	34	44	56	60

[120] For shorter journeys where the charge does not fall below 80% we have assume that the user would not charge the vehicle.

For an average stop at a tourist site which lasts around an hour using a fast charger, a 25% top-up could be provided. As shown in Table D.7, the journeys shown in dark red are negative and therefore return journeys are not feasible even with a top-up charge at the destination. The journeys shown in yellow show where the battery level falls below 25% and would therefore be likely to cause some range anxiety.

Table D.7 - Miles remaining - Peugeot Ion, return journey & top up charge with fast charger

Destination	Marwick Head	Birsay	Skara Brae	Orkney Brewery	Broch of Gurness	Stromness Terminal	Stromness	Tingwall Ferry Terminal	Ring of Brodgar	Houton Ferry Terminal	Hatson Ferry Terminal	Kirkwall	Kirkwall Ferry Terminal	Kirkwall Airport	Italian Chapel	St. Margaret's Hope	Burwick Ferry Terminal	Tomb of the Eagle
Marwick Head	60	57	55	56	47	48	48	45	50	40	36	34	34	26	18	4	-8	-10
Birsay	57	60	53	54	50	47	47	48	49	38	38	36	36	28	20	6	-5	-8
Skara Brae	55	53	60	57	48	52	52	46	54	47	43	40	40	32	24	11	-1	-4
Orkney Brewery	56	54	57	60	50	51	51	48	53	46	44	41	41	33	25	11	0	-3
Broch of Gurness	47	50	48	50	60	40	40	56	46	35	45	43	43	35	27	13	1	-1
Stromness	48	47	52	51	40	60	60	46	54	52	46	45	45	37	29	16	4	1
Ring of Brodgar	50	49	54	53	46	54	54	49	60	51	50	48	48	43	36	22	10	7
Kirkwall	34	36	40	41	43	45	45	47	48	49	58	60	60	56	52	45	33	30
Italian Chapel	18	20	24	25	27	29	29	33	36	39	50	52	52	52	60	53	47	46
Tomb of the Eagle	-10	-8	-4	-3	-1	1	1	5	7	11	27	30	30	31	46	52	58	60

It is therefore suggested that rapid chargers are deployed at tourist sites given the short time visitors will be at these locations.

The potential number of EVs likely to visit the tourist sites will have an impact on the numbers of charging posts needed at each location. The total number of hire cars on Orkney has been estimated through a phone survey of the hire car companies within Orkney to be around 260 cars at the height of the season. Using the same assumptions for the number of EVs within the whole fleet as was used for the entire Orkney car fleet (see Chapter 5), it is possible to estimate the number of rental EVs over the next few years under the different scenarios.

Table D.8 - Estimated number of electric hire cars on Orkney

SCENARIO	SCENARIO 1 LOW UPTAKE	SCENARIO 2 MODERATE UPTAKE	SCENARIO 3 HIGH UPTAKE
2015	1	1	1
2016	1	2	9
2017	1	3	26
2018	1	5	43
2019	2	7	60
2020	3	10	77

It is unlikely that a visitor would find it acceptably convenient to return to their car half way through their visit to move their vehicle and allow another vehicle to charge in their place. Hence, each charging event is likely to last an hour even if the whole hour is not needed, unless a smart charging system could be installed which could switch to the next car once the first one has had a full charge.

Given that most tourists will visit a site in the middle of the day then for Scenario 1 on the busiest day, 77 cars might need to be charged over a 4 hour period needing a maximum of 20 charging points (10 charging posts) at the most popular tourist sites. However, if more than one tourist site is visited in one day then recharging does not have to occur all at one site. In addition, using the summer peak daily numbers of visitor numbers for each site (see Table D.3), a proportionately smaller number of chargers could be placed at the less frequented tourist sites.

Table D.9 - Estimated number of charging posts for Skara Brae – Scenario 3 on the busiest days

ITEM	DETAILS
Number EV rental cars	77
Charging time (hours)	1
Charging events per day	77
Period (hours)	4
Charging points needed	20
Posts needed	10
Posts needed if two sites are visited per day	5

If this methodology is applied to the numbers of cars estimated for each year for the high, medium and low scenarios, the number of rapid charging posts per scenario can be calculated and are shown below.

Table D.10 - Rapid charging posts – Scenario 1 (Low EV uptake)

YEAR	2015	2016	2017	2018	2019	2020
EV rental cars	**1**	**1**	**1**	**1**	**2**	**3**
Ring of Brodgar	1	1	1	1	1	1
Skara Brae	1	1	1	1	1	1
Kirkwall	1	1	1	1	1	1
Italian Chapel	1	1	1	1	1	1
Brough of Birsay	1	1	1	1	1	1
Broch of Gurness	0	0	0	0	0	0
Tomb of the Eagle	0	0	0	0	0	0
Stromness	0	0	0	0	0	0
Marwick Head	0	0	0	0	0	0
Orkney Brewery	0	0	0	0	0	0
Total	**5**	**5**	**5**	**5**	**5**	**5**

Table D.11 - Rapid charging posts - Scenario 2 (Moderate EV uptake)

YEAR	2015	2016	2017	2018	2019	2020
EV rental cars	**1**	**2**	**3**	**5**	**7**	**10**
Ring of Brodgar	1	1	1	1	1	1
Skara Brae	1	1	1	1	1	1
Kirkwall	1	1	1	1	1	1
Italian Chapel	1	1	1	1	1	1
Brough of Birsay	1	1	1	1	1	1
Broch of Gurness	0	0	0	0	0	0
Tomb of the Eagle	0	0	0	0	0	0
Stromness	0	0	0	0	0	0
Marwick Head	0	0	0	0	0	0
Orkney Brewery	0	0	0	0	0	0
Total	**5**	**5**	**5**	**5**	**5**	**5**

Table D.12 - Rapid charging posts - Scenario 3 (High EV uptake)

YEAR	2015	2016	2017	2018	2019	2020
EV rental cars	**1**	**9**	**26**	**43**	**60**	77
Ring of Brodgar	1	1	2	3	4	5
Skara Brae	1	1	2	3	4	5
Kirkwall	1	1	2	3	4	5
Italian Chapel	1	1	2	2	3	4
Brough of Birsay	1	1	1	2	3	3
Broch of Gurness	0	0	1	1	2	2
Tomb of the Eagle	0	0	1	1	1	2
Stromness	0	0	1	1	1	1
Marwick Head	0	0	1	1	1	1
Orkney Brewery	0	0	0	1	1	1
Total	**5**	**5**	**13**	**18**	**24**	**29**

The purchase and installation of these publicly available charge points will need to be funded by the organisations supervising these tourist attractions, with possible support from Visit Scotland, as part of their customer facilities. They can opt to include EV recharging in the parking fee or charge on an hourly basis as a new revenue-generating source. Charging fees are discussed in more detail in section 6.6. Alternatively, another possible funding source is ZeroNet which donates charging stations to businesses related to tourism. Section 6.6 will also discuss this in more detail.

2. Gateways

In order to promote greater EV penetration across the inhabited islands of Orkney, it is important to involve the key gateways within the development of recharging infrastructure. The OIC has already identified this desire within their Orkney's Electric Future infrastructure strategy. The seven key gateways identified that will support transport links among the islands and to mainland Scotland are listed in the table below and shown in Figure D.1.

Table D.13 - Gateway charge point locations

GATEWAY	KEY CONSIDERATIONS	PROPOSED LOCATION
Kirkwall Airport	Extremely busy transport hub for Orkney, tens of thousands of locals and visiting passengers pass through every year	Between the car hire spaces and the short and long term car parking adjacent to the airport terminal building. This will minimise installation costs by siting them together.
Hatston Ferry Terminal	Located just outside of Kirkwall, Orkney's largest commercial pier and Scotland's longest deep-water commercial Infrastructure for EV charging would complement the already strong green technology image of the Hatston estate.	Long stay car park provided by Orkney Islands Council located 200 metres from the terminal building where the future infrastructure could be installed.
Kirkwall Ferry Terminal	Main transport hub for those travelling to Shapinsay, Stronsay, Sanday, Westray, Eday and North Ronaldsay. Providing a Rapid charger at this location would significantly increase the strength of the infrastructure with reference to the outer island communities.	There are a number of car parks and spaces in the vicinity of the terminal.
Tingwall Ferry Terminal	Best known as the Mainland terminal for the roll-on roll-off ferry to the islands of Rousay, Egilsay and Wyre	The available car park at Tingwall would effectively lend itself to a future charging point to be installed.
Stromness Ferry Terminal	Located right in the heart of historic Stromness. It is the base for the daily Northlink ferry to Scrabster; the Hoy Head ferry to Hoy and Graemsay; the base for the local lifeboat; and numerous fishing and dive boats. Rapid charging would allow those leaving the island to top-up their car before boarding the ferry.	There is a short term parking available at the terminal, with long-stay parking available on Ferry Road, a short distance from the terminal. The numerous parking locations within a short distance to the terminal would make a suitable location for Rapid charging.
Houton Ferry Terminal	Services to Hoy and Flotta arrive and depart from Houton Pier, which is around half way between Kirkwall and Stromness on the A964 road.	There is a small car park next to the pier that would provide a location for a Rapid charger.

St. Margaret's Hope Ferry Terminal	One of the busiest ferry terminals on Orkney. Pentland Ferries operate here. The ferry MV Pentalina connects to the Gills Bay ferry terminal in Caithness.	Land near the ferry terminal could provide the location for a Rapid charger and provide locals the chance to top-up their cars before leaving the island, or visitors the chance to top-up to ensure the required range required to reach Kirkwall.

Figure D.1 - Gateway charging locations

All of these gateways would be expected to receive Rapid chargers as time spent at these locations would generally be limited. It is expected that EV users are unlikely to want to spend more than half an hour charging. The analysis in the previous section holds true for gateways as it does for tourist sites except that the potential charging times using a rapid charger would be approximately 0.5 hours rather than an hour. Therefore rapid chargers would be more appropriate than fast chargers.

Servicing these locations will ensure that those arriving from the islands or those departing to the islands would not be caught short of range capacity. For example, someone living on Hoy driving from Rackwick to Lyness ferry terminal to reach the Mainland, would use at least 13 miles of their range. Allowing for just a 10 minute charge before they get on the ferry would ensure full range capacity is again achieved. Conversely, those visiting Hoy would have the potential to arrive with ample time before the ferry departs to top-up their EV battery before reaching Hoy. The relatively even dispersal of these locations will also maximise their effectiveness and social benefit to locals and visitors. In addition to the already planned charging points, it is recommended that the next phased island charging point should be on the individual island side of the ferry route for three key reasons:

- This would ensure at least one charging point on each island;
- The cost of fuel on the islands is higher than the mainland;

- The islands that have community turbines are suffering from the most curtailment so increasing demand on the islands is a priority.

Prioritising the islands to receive charging points is more difficult and would notionally be dependent on population levels. In reality, this may be done on islands that want to support the developments by looking for funding opportunities themselves.

3. Chargers on Inner and Outer Isles

To estimate the number of chargers needed on each island, an analysis of the annual total single journeys of vehicle numbers for the inter-island ferries was done.

The average number of cars per journey as a percentage of the total number of cars on Orkney can be used to estimate the number of electric cars on each ferry journey.

$$\textit{Estimate number of electric cars per journey} = \textit{Total number of electric cars in Orkney} \times \frac{\textit{Average number of cars per journey}}{\textit{Total number of cars on Orkney}}$$

For example, using the island of Westray in 2012 (latest figures available), the estimated number of electric cars per journey can be calculated.

$$\textbf{0.219} \text{ electric cars per journey} = \textbf{60} \text{ electric cars in Orkney} \times \frac{\textbf{14,037} \text{ cars on ferry per year} / \textbf{361} \text{ number of ferry journeys on Christmas or New Year's days}}{\textbf{10,555} \text{ total number of cars on Orkney}}$$

Table D.14 - Estimated number of chargers required per island

ISLANDS	2012 NUMBER OF CARS ON FERRY PER YEAR	AVERAGE NO. OF CARS TRAVELLING ON FERRY PER DAY	% OF EVs	NUMBER OF EVs PER JOURNEY	CHARGERS REQUIRED
Westray	14,037	38	0.36	0.219	1
Sanday	11,225	31	0.29	0.175	1
Stronsay	6,046	17	0.16	0.094	1
Eday	3,548	10	0.09	0.055	1
Shapinsay	12,114	33	0.31	0.189	1
Rousay/Eg/Wyre	15,897	44	0.41	0.248	1
Lyness/Flotta	23,959	66	0.62	0.374	1

If we assume the worst case would be that these cars may need a charging point each at the ferry terminal, then the number of chargers can be estimated. In reality, not all the electric cars will need to charge before going on the ferry depending on the distance travelled to get to the ferry terminal from their home.

Number of charging posts needed = Estimate no of electric cars per journey / 2

Once the formulas above are applied over the annual estimates for the different scenarios, it can be seen that one charging post on each of the isles would be sufficient until 2019 for Scenario 1 (and 2020 for Scenario 2) when 2 charging posts on the larger islands may be needed.

4. Residential

It is also understood that there is a proportion of the population that will not be able to charge an EV outside their home due to the absence of any dedicated off-street parking. It is difficult to estimate which houses have parking but a broad estimate assumes that those living in terraced and flat accommodation do not have parking. There will be some that do but equally there will be some other housing types that do not have parking. Table D.15 below illustrates the analysis of the housing in Orkney by postcode area: KW15, KW16 and KW17.

Table D.15 - Orkney housing for KW16, KW16 and KW17[121]

HOUSING TYPE	KW15 (Kirkwall)		KW16 (Stromness & Hoy)		KW17		TOTAL	
	NO OF HOMES	%	NO OF HOMES	%	NO OF HOMES	%	NO OF HOMES	%
Detached	1,699	40.6%	1,148	57.9%	3,624	80.7%	**6,472**	60.7%
Semi-Detached	1,345	32.2%	481	24.2%	670	14.9%	**2,497**	23.4%
Terraced	608	14.5%	201	10.1%	83	1.8%	**892**	8.4%
Flat (Purpose-Built)	328	7.8%	74	3.7%	38	0.8%	**440**	4.1%
Flat (Converted)	141	3.4%	44	2.2%	26	0.6%	**211**	2.0%
Residence in Commercial Building	55	1.3%	27	1.4%	20	0.4%	**102**	1.0%
Caravan/Park/ Temporary	7	0.2%	9	0.5%	28	0.6%	**44**	0.4%
Total	**4,183**		**1,984**		**4,489**		**10,656**	

The terraced home and flats that come under the KW15 and KW16 postcode areas will significantly consist of homes in Kirkwall and Stromness respectively. Thus, it can be assumed for the purpose of this study that 25.7% of the housing in Kirkwall and 16.1% of the housing in Stromness will not be able to charge EVs via a home charging unit. For this, other charging units in public locations would need to be made available.

Based on the numbers of EVs in Scenarios 1, 2 & 3 (see Chapter 5), if an even distribution of EVs across the population is assumed, then the same distribution of EVs can also be assumed which will give us the numbers of EVs in Kirkwall and Stromness. Applying these figures to the housing statistics above gives the percentage of those that may not have off-street parking.

In the example tables below, if the distribution of population within Orkney is applied to the total number of EVs in Orkney, it is then possible to apply this to the

[121] https://www.streetcheck.co.uk/postcodedistrict/kw15

number of households without dedicated parking to estimate the number of charging points needed for people without dedicated parking.

Table D.16 - Estimated number of EVs by area, 2015 (Scenario 3)

TOWN	POPULATION	% OF TOTAL POP.	ESTIMATED NUMBER OF EVs 2015 (SCENARIO 3)
Kirkwall	7,045	33.0%	20
Stromness	1,609	7.5%	5
Orkney	21,349	100.0%	60

Table D.17 - Percentage of terraced and flat housing by area

HOUSING TYPE	% OF TOTAL HOUSING
Terraced and Flat Housing (%) KW15 (Kirkwall)	25.7%
Terraced and Flat Housing (%) KW16 (Stromness)	16.1%

Table D.18 - Example Scenario 3 - Estimated number of public chargers required to service people without dedicated parking

TOWN	NUMBER OF EVs	NUMBER OF EVs WITHOUT DEDICATED OFF-STREET PARKING	NUMBER OF PUBLIC CHARGING STATIONS REQUIRED
Kirkwall	20	5	3
Stromness	5	1	1

Using the methodology above, it is possible to calculate the public charging station requirements until 2020.

KIRKWALL - EVs	2015	2016	2017	2018	2019	2020
Scenario 1	3	3	3	4	5	7
Scenario 2	3	3	5	8	11	16
Scenario 3	3	4	7	11	17	24

STROMNESS - EVs	2015	2016	2017	2018	2019	2020
Scenario 1	1	1	1	1	1	2
Scenario 2	1	1	1	2	3	4
Scenario 3	1	1	2	3	4	6

The issues that arise from this estimation are: who would pay for these charging stations and how would access be controlled. There has also been a resistance to allocated spaces within car parks for residents so dedicating areas will need to be resolved.

For residents who do have access to their own off-street parking, it is likely that they would put in home chargers and are therefore not considered here. There are individual schemes in place at the moment that support home chargers such as

funding from the Energy Saving Trust and Office of Low Emission Vehicles. Even without this scheme, the cost to install a home charger is relatively low.

Similarly for workplaces, it would be the responsibility of businesses to install charging points for charging their business vehicles and are therefore not considered here. With the workplace as the second most likely location where EV drivers recharge, it would be beneficial for the Council to encourage businesses to install charging stations for their employees. **Switched On @Work**, a programme headed by Transport Scotland and the Energy Saving Trust—soon to be launched in August 2015, offer support to employers who wish to provide charging stations for their employees or their business fleet. Once signed up to the programme, organisations may be eligible for funding of up to £10,000 to cover purchase and installation cost of charging stations at their work premises.[122]

If more workplaces install charge points at their premises, these could possibly offset the number of public recharging infrastructure required.

[122] For further information, email SwitchedOn@est.org.uk.

Appendix E

1. Charging Networks and Payment Options

ORGANISATION	PAYMENT OPTIONS	ADDITIONAL INFORMATION
A. Charging station networks and examples of their CSO partners		
1. POLAR/ Chargemaster[123]	Annual (Standard): £20 Monthly (Economy Plus): £12 Pay as you go: £1.20 (3kW) £1.70 (7kW) £7.50 (Rapid)	Standard tariff: i) £1 per hour (3kW) ii) £1.50 per hour (7kW) iii) £7 for 30 minute rapid charge Economy Plus tariff: Includes the use of up to 20 charging credits through a combination of below options: i) 3kW charging is one credit per hour ii) 7kW charging is 1.5 charging credits per hour iii) One half hour triplex rapid charging session is 10 charging credits Charging over the allowed limit is then charged at the additional rates of: i) £0.95 per hour for 3kW ii) £1.45 per hour for 7kW iii) £6 for 30 minute rapid charge Both tariffs and any extra use are payable by direct debit. For Pay as you go (PAYG), there is no need to register for a card or fill a subscription. This is carried out via smart phone App.
■ **Milton Keynes Council**[124]	Annual: £20 Monthly £12 Pay as you go: £1.50 (3kW) £2.25 (7kW)	Milton Keynes Council chargepoints are operated by POLAR/ Chargemaster therefore operating under the same tariff as outlined above with the exception that pay as you go is 50% more than the standard rate as reflected in the adjusted rate per hour. EV car owners are not required to pay for parking time within a charging bay, i.e. if a car is in a parking bay for five hours but only uses one hour of charging the owner will only be charged for the one hour spend charging.

[123] http://www.chargemasterplc.com/index.php/polar_online/
[124] https://www.milton-keynes.gov.uk/streets-transport-and-parking/parking/electric-vehicle-charge-points

2.	**Charge Your Car**[125]	One off card purchase: £20	There is a combination of free to use and pay to use charge points across the Charge Your Car (CYC) network. Any chargepoint tariffs in place are set by the chargepoint owner not CYC but typically if payment is required it should be approximately £3.50 for a standard charge and £5-£8 for a rapid charge. Any charges amounting to more than £5 are invoiced via e-mail at the beginning of each month. Payment is then debited from payment card.
	■ **Source West**[126]	FREE (For anyone who lives and works within the Source West region) Members outside of the specified area pay £20 per annum	Signing up to CYC through the Source West platform allows those eligible to claim a free RFiD Card. Although the card and use of electricity is free the EV owner is still required to pay car parking charges. As Source West is operated as part of the CYC Network it is not guaranteed that use of any chargepoint is free outside of the Source West area, however within this region standard charging is free but the use of rapid chargers will incur an additional fee.
	■ **GMEV**[127]	One off registration fee: £10	A GMEV access card also allows access to chargepoints within the GMEV area in addition to all other charge points on the CYC network. Even if free charging is given the EV driver may still be liable to pay car parking costs. As GMEV is part of the CYC network it is not guaranteed that each chargepoint host will accommodate free charging or parking therefore it is at the discretion of the chargepoint owner to establish this tariff.
	■ **Energise Network**[128]	Annual fee: £20	Energise Network comes under the broader remit of CYC, therefore after the initial registration fee most charge points aim to provide free charging however this is at the discretion of the chargepoint owner.
3.	**POD Point**[129]	One off registration fee: £12.50	The network was initially established as free however pay as you go tariffs are currently being rolled out at selected charge points across the network. PAYG is enforced at the discretion of the site manager however POD Point advises charging no more than £2 per hour including parking.
	■ **Plugged-In Midlands**[130]	Annual Fee: £24	After paying initial membership fee the cost of charging is free, there is discussion as to whether to roll out a PAYG scheme however this is yet to be decided. Chargepoints used within this network are mainly provided by POD Point, Chargemaster and Elektromotive.
	■ **Source East**[131]	Annual Fee: £10	Access to charging facilities is free once the registration fee has been paid however Source East is currently discussing the option of rolling out a PAYG scheme.

[125] http://chargeyourcar.org.uk/ev-driver/faqs/
[126] http://www.sourcewest.info/driver-signup
[127] http://ev.tfgm.com/faq.html
[128] http://www.energisenetwork.co.uk/ev-driver/ , http://www.energisenetwork.co.uk/ev-driver/
[129] [https://www.zap-map.com/charge-points/public-charging-point-networks/] [http://pod-point.com/shop/charge-card/]
[130] Email correspondence with Plugged-In Midlands., 'Chargepoint Tariff, 13 May 2015.
[131] Email correspondence with Source East., 'Costings and Eventual PAYG', 29 April 2015; https://www.zap-map.com/charge-points/public-charging-point-networks/

B. Charging station owners/operators (CSO)

Source London[132]	Annual registration: £5	After paying the annual registration fee any power used to charge an EV is free of charge however there may still be parking charge to be met by the EV owner.
Ecotricity[133]	Free	If an EV driver is registered to Ecotricity there is unlimited access to all Ecotricity points which are free of charge to use. If an EV driver is already registered under CYC, Source West, Source East or Plugged-In Midlands there is no need to re-register for an Electric Highway card however this does not work vice versa. A driver with an Electric Highway card will not be able to access charge points on other networks.
Zero Carbon World[134]	Free	Chargepoints installed by Zero Carbon Network are centred around businesses, hotels and tourist attractions. Therefore in most cases the cost to charge is covered by the business in return for trade. However in the instance there is a cost associated with using a chargepoint, there is a strict fair pricing policy in operation to ensure additional costs should be no more than the rate to access WiFi.
Tesla[135]	Free	Although there is no charge to use a Tesla charging station usage is limited exclusively to Tesla owners. No need to register or pay subscription fee towards membership. All Tesla charging stations have 120kW capability as standard taking only 20-30 mins to charge batteries up to 80%.

[132] Email correspondence with Source London, 'Service Information Rates', 27 March 2015.
[133] https://www.ecotricity.co.uk/for-the-road/faqs/general-faqs
[134] http://zerocarbonworld.org/free-charging-stations
[135] https://www.zap-map.com/charge-points/public-charging-point-networks/

URBAN FORESIGHT

The Core, Science Central, Bath Lane,
Newcastle upon Tyne, NE4 5TF, United Kingdom

E: info@urbanforesight.org
T: +44 191 495 7350
W: http://urbanforesight.org

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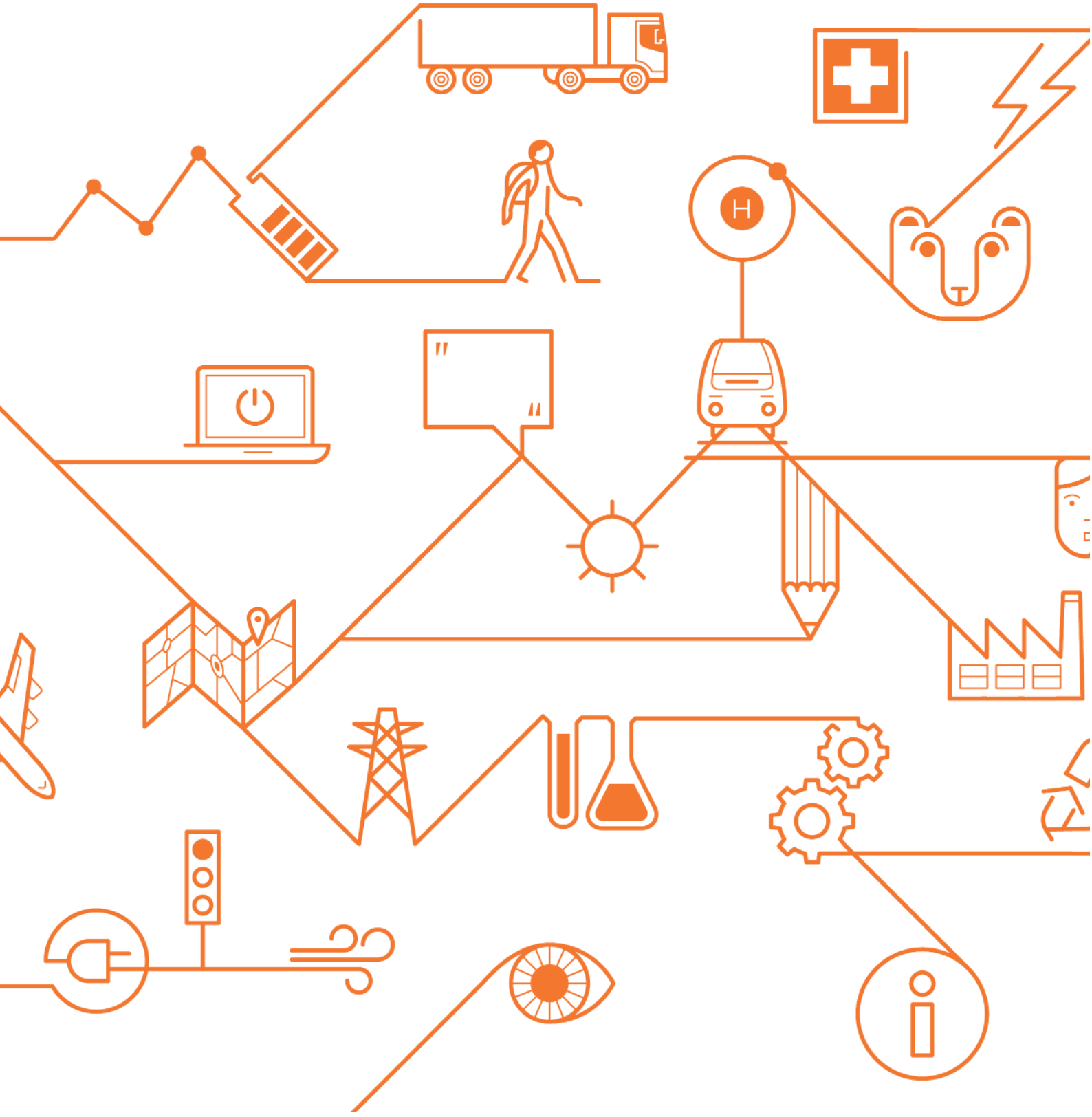
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