Greenbridge Renewables
Carbon Reduction & Mitigation Report

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LCEI

UNIVERSITY OF LIVERPOOL

Executive Summary

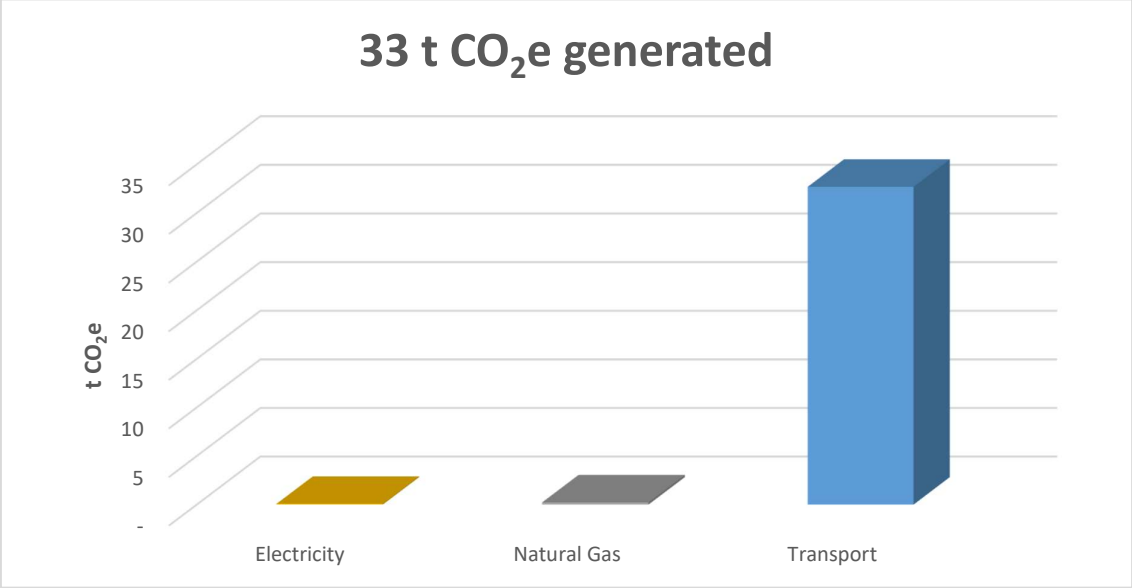
This report provides an overview of the work undertaken to date and is supported by the information provided by the company, and estimations done with the current guidelines. Greenbridge Renewables, The University of Liverpool, and the Low Carbon Eco-Innovatory (LCEI) have collaborated on this venture, with all parties committed to developing a strategy to reduce carbon emissions and improve energy efficiency in business operations. This project provides the opportunity for a successful case study leading the way in sustainable energy development, and carbon reduction for comparable businesses. A successful project could serve as an exemplar for future research within the field, in addition proving a future framework for golf clubs based around the Liverpool City Region and beyond. Below is a summary of the key information and data established during the assessment of Greenbridge Renewables' operations.

Carbon Footprint

The operational carbon footprint of Greenbridge Renewables in 2021 was 33 tonnes of carbon dioxide equivalent (CO_2e) emissions. This is based on the data provided by Greenbridge Renewables and considers the fuels required for business-as-usual operations. These fuels include grid-purchased electricity, natural gas and diesel. Diesel consumption by the company's vehicles account for the majority of the company's carbon footprint at 99.06%, with domestic uses of electricity and gas accounting for the remaining.

Emissions Source	Emissions Scope	Annual Usage	Unit	Annual [kg CO_2e]	Annual Tonnage [t CO_2e]	%
Electricity	2	374.40	kWh	79.50	0.08	0.24%
Gas	1	1,269.23	kWh (Gross CV)	232.47	0.23	0.70%
Transport	1	84,000	miles	32,685.82	32.69	99.06%
Total	**-**	**-**	**-**	**20,621.61**	**33.00**	**100%**

Table A: Carbon footprint breakdown



Graph A: Carbon footprint breakdown

Emissions Facts:

33 tonnes CO_2e is equivalent to a person taking 38 round trip flights from London Heathrow to Toronto Pearson. [1]

Significant Energy Users (SEUs)

The most prominent areas of normal business activities that have the greatest impact on carbon emissions have been identified. This should help Greenbridge Renewables to identify where significant carbon savings can be made.

SEU	mi in a year	t CO_2e
Ford Ranger #1	22,000	7.34
Ford Ranger #2	12,000	4.00
Ford Transit #1	30,000	12.81
Ford Transit #2	20,000	8.54
Domestic gas		0.23
Domestic electricity		0.08
	Total	33.00

Strategic Implementation Plan

The strategic implementation plan has been developed specifically for Greenbridge Renewables and consists of 2 measures to improve energy efficiency and reduce carbon emissions. For further details on implementation, please refer to section 0.

Greenbridge Renewables proposed energy & carbon reduction implementation plan:

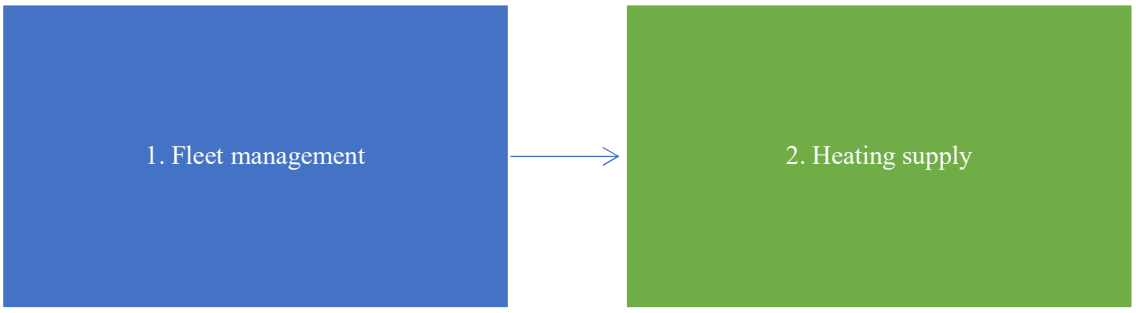


Table of Contents

1. Introduction

NOTE
In section 1-5 of this report, a colour coding system has been used for the text,
- BLACK text represents general descriptions, guidance, and information
- BLUE text represents information relating directly to Greenbridge Renewables

1.1. Purpose

The need for sustainability within the business sector has been an area of public awareness for many years, with countries and global businesses all taking steps to combat the large-scale concern of climate change. In more recent years, the general public have started to consider their personal impact on the environment and how their actions and decisions are adding to the already growing problem of increased carbon emissions. The world has seen an upsurge in the level of action required to achieve a low carbon world, with frequent global protests calling for action on the climate emergency. In 2016, the United Nations announced the Paris Agreement, an agreement to abate and mitigate against the threat of global warming. The long-term goal set out in the Paris Agreement was to maintain "the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels" [2].

Significant pressure has been placed on governments over the last decade to become more environmentally conscious and to significantly reduce domestic emissions. So far, the UK government have focused on transforming the energy infrastructure from fossil fuels to renewable energy, as a result, the UK is one of the leading countries in renewable development and uptake. In the business sector, the government have targeted large corporates that produce a large proportion of domestic emissions, they have achieved this through a mixture of mandatory regulations and optional incentives. As of yet, small and medium-sized enterprises (SMEs) have been mostly forgotten about and left to their own devices when it comes to accounting for carbon emissions, it is therefore up to individuals and the companies themselves to begin the transformation to a more sustainable, environmentally friendly way of operating.

With this in mind, the purpose of this report is to provide Greenbridge Renewables with a baseline to explain where the business currently stands when considering their environmental impact and the emissions generated from regular business activities.

1.2. Technical Language

Throughout this report the term 'carbon' has been used to account for all greenhouse gas (GHG) emissions, this is because carbon dioxide is the most common anthropogenic GHG emitted, and poses the greatest impact on global warming. The term 'carbon' is shorthand for 'carbon-dioxide equivalent' which is a term used to describe different greenhouse gases in a common unit, it is also written as CO_2e for use in tables, charts, and specific text.

The term "zero-carbon" is commonly used when discussing projects of this nature, and is regularly confused with "net zero-carbon" or "carbon neutral". The principal of 'net zero' refers to a highly energy efficient system/building that is powered from on-site and/or off-site renewable energy sources. However, net zero or carbon neutrality sometimes can refer to offsetting carbon emissions with no real intention to reduce energy consumption or consider energy conservation measures, therefore, it is advised to avoid this method unless all other attempts to reduce emissions have be completed.

It is important to be clear that to achieve true zero carbon status, a two-phase strategy will need to be considered. This report, or Phase 1, aims to achieve zero-carbon emissions in business-as-usual operations within a 25 year period, Phase 2 should then consider the whole-life carbon footprint of the company including scope 3 and embodied emissions (as discussed in sections 2.4 & 8.5).

1.3. Document Structure

This report concludes the following:

1. Scope of the project to establish the aim & objectives, key drivers, targets set, and project boundaries.
2. Baseline data to define the current state of the business (or business as usual) including:
    a. Energy
    b. Emissions
    c. Expenditure
3. Historic & forecast data to predict future outcomes considering the business as usual case.
4. Financing strategies to help deal with the financial burden of carbon reduction investments.
5. Implementation of carefully chosen solutions to integrate into the principal strategy (or master plan) to improve energy efficiency, reduce energy expenditure, and lower the company's carbon footprint.
6. Futureproofing the business to ensure a continuous improvement plan is in place that can seamlessly integrate with the company's master plan.

2. Project Scope

This section of the report defines the aim and objectives of the project, evaluates the key drivers defining the decisions of the work, and defines the project boundaries. The supporting documents and protocols will also be discussed, explaining and outlining the structure of the proposed project. The scope will also express the problems currently faced in the company's existing operational strategy in terms of energy efficiency and energy management.

2.1. Aim & Objectives

The principal aim for this project is to increase energy efficiency, establish a carbon footprint baseline from which all future actions can be quantified and measured against, and to develop an overarching sustainability strategy in order to influence decision making throughout the business.

To achieve this principle aim, the project key objectives are as follows:

- To establish a baseline carbon footprint.
- To develop a energy & carbon reduction strategy.
- To move toward becoming a net zero operational[1] carbon business through a series of strategic changes to existing operations.
- To futureproof the integrity of the business through environmental strategic planning[2].

[1] This specific project will focus on reducing the company's operational carbon rather than embodied carbon. Operational carbon reduction is often the most efficient way to mitigate emissions.
[2] As the UK begins its move toward a sustainable future, companies will face increased pressure to improve their green credentials and demonstrate environmental consideration within their ethos.

2.2. Key Drivers

The key drivers for this project are the leading factors that will affect any future decisions relating to company infrastructure and building management. As a company that offers sustainability as part of their solutions, Greenbridge Renewables can benefit from the reduction of their carbon footprint as a selling point against competitors. Leading by example is an important way of achieving this, however, companies have to consider a number of factors when considering investing company resources into a project, and often simply reducing their carbon footprint does not provide sufficient reasons to undertake such a project.

Table 1. Greenbridge Renewables Key Drivers & Reasons

Driver	Reason
Environmental considerations	*To reduce emissions and transform into a more sustainable, energy and carbon conscious business.*
Financial opportunities and energy savings	*To take advantage of available grants and government incentives.*
Public relations (PR)	*To be regarded as a company committed to the reduction of carbon emissions.*
Legislative & Regulatory	*To be prepared for government regulations targeting SMEs.*

The following provides the company with a brief, generalised description of the related project drivers:

- **Environmental considerations –** The issues of climate change, global warming, and other environmental issues are repeatedly discussed in politics, news articles, and amongst peers, justifying the scientific evidence discussing the urgency to combat these issues immediately. Companies have the opportunity to act now rather than later, by considering operational changes to reduce environmental impact, businesses can educate themselves and others around them.
- **Financial opportunities and energy savings** – For any company, finances are one of the major influences when making decisions, whether it be through profitable investments or financial savings of existing operations. Most decisions made by a company are financially analysed before implementation, for example; will it be profitable? What is the return on investment? Are we still able to operate the business and pay the employees?
- **Public Relations (PR)** – PR is an important factor for any company to consider. In order for a company to build and establish a positive public image, sharing information is vital for success and development of a business. Leading the way in a worldwide issue could provide a company with a positive image that can be shared with the public.
- **Legislative & Regulatory –** An increasing number of government and intergovernmental policies are coming into play requiring businesses to comply with a new set of rules and regulations, particularly concerning carbon emissions. These policies will inevitably filter down to smaller companies and possibly individuals. To avoid any future fines or taxes, it is advised that companies get ahead of the game, so that when any new regulations are introduced the company is ready, thus futureproofing the business and getting a step ahead of the competition.

2.3. Project Targets

It is important for any company to set a number of targets whilst attempting to reduce carbon emissions, especially for companies who offer sustainability as a product in order to lead by example.

Time-related Targets

In order to achieve the primary aim, it is important to set time-based targets to encourage the company to push themselves to achieve the objectives set out at the start of the project. Targets and business objectives are unmeasurable and unquantifiable if there is no deadline; a target date is recommended to be set so that the company has a timeframe in which to measure its results.

- The **baseline period** for the project was the 2021 calendar year. The data provided by Greenbridge Renewables is understood as being 12 months of millage of their vehicles, their energy use was estimated considering two people working from home. Greenbridge Renewables sees their use of diesel as their primary emission source and are looking into upgrading their vehicles once the current leases finish.

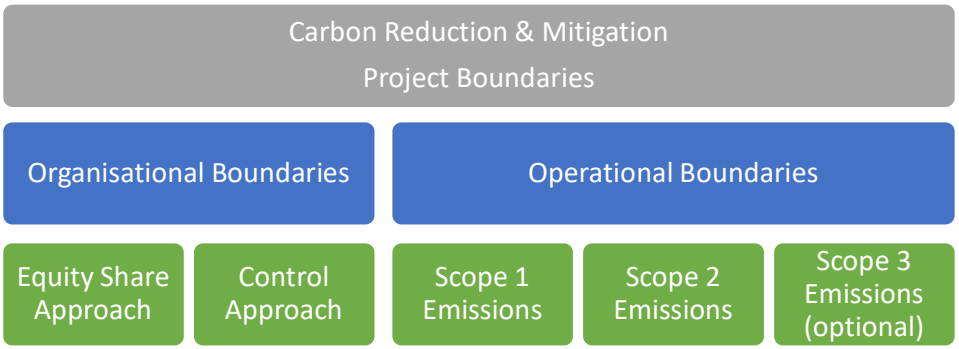
Science-Based Targets (SBTs)

When setting targets to abate carbon emissions, whether it be a company, organisation or government policy, these targets are considered "science-based" if they are in line with any given future goal, such as the level of decarbonisation required to keep global temperature increase below 2°C relative to pre-industrial levels [3], as set out in the Paris Agreement.

For more information on how SBTs can benefit SMEs, see the recently published article by WWF and Science-based Targets Initiatives (SBTi):
https://wwf.panda.org/?362371/Small-medium-businesses-science-based-climate-targets

2.4. System Boundaries

System boundaries of a project comprise of 'organisational boundaries' and 'operational boundaries', both are important to consider during the process of an emissions reduction project.



Organisational Boundaries

Set first are a company's organisational boundaries. This is done to define which parts of the business structure is being considered for review. In accordance with the Greenhouse Gas Protocol [4], Two common approaches are taken when defining organisational boundaries:

(1) Equity Share approach - the organisation accounts for emissions from operations based on its share of equity in the organisation

(2) Control approach - the organisation accounts for 100% of emissions from operations over which it has control. Control can either be defined in financial or operational terms

Since Greenbridge Renewables is independent of any other party and is considered as the sole entity, all operations performed within the site boundaries are to be considered for review.

Operational Boundaries

Following the determination of the organisational boundaries, the businesses operational boundaries are then defined. This involves identifying emissions by a company's operations, classifying them as either 'direct' or 'indirect' emissions, and deciding on the scope of accounting and reporting for 'indirect' emissions [4]. Definitions taken from the GHG Protocol [4]:

"*Direct* GHG emissions are emissions from sources that are owned or controlled by the company"

"*Indirect* GHG emissions are emissions that are a consequence of the activities of the company but occur at sources owned or controlled by the company."

In order to allocate direct and indirect emission sources, three 'scopes' (scope 1, scope 2, and scope 3) are defined for GHG accounting and reporting purposes:

- **Scope 1** emissions are the *direct* emissions that occur from sources that are owned or controlled by the company. For example, emissions produced from combustion in owned or controlled boilers, furnaces, or vehicles.
- **Scope 2** accounts for *indirect* emissions that occur as a result of the generation of purchased electricity.
- **Scope 3** is an optional reporting category, whereby the company can decide on what emissions are reported as a result of all other indirect emissions. For example, visitor cars when onsite company property, water usage, or delivery of products to be used or sold by the company.

For Greenbridge Renewables the operational boundaries and scopes were set as follows:

Table 2. Greenbridge Renewables Operational Boundaries

Scope 1	Combustion engines of four owned vehicles, two Ford Ranges and two Ford Transits.
	The use of natural gas for heating.
Scope 2	Consumption of purchased grid electricity need to run operations.

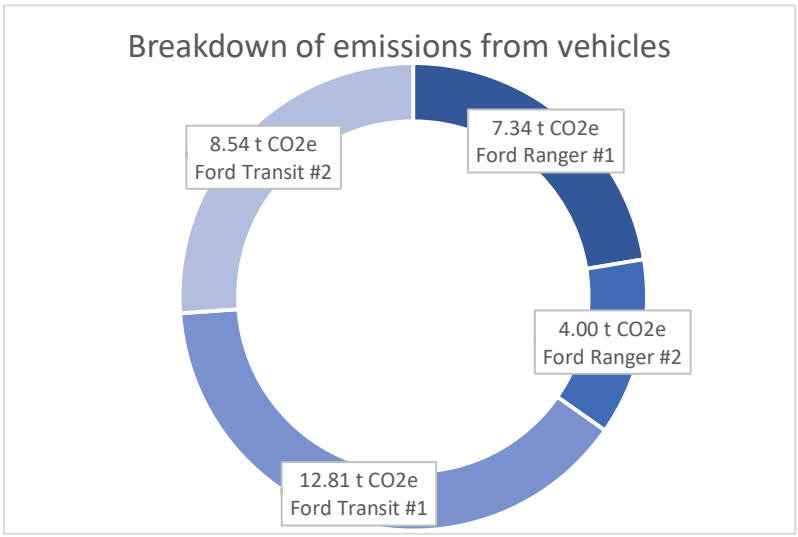
3. Baseline Data

This section outlines the current state of business operations, it will provide a baseline against which to measure, monitor, and asses the businesses energy use and relative emissions. Baseline figures for the assessment period (2019 calendar year) are concluded within this section including measured energy data, operational carbon footprint, and estimated total energy expenditure.

3.1. Energy Demand

Electricity, transportation, and heat are the three main sectors that define energy demand for any business [5]. Greenbridge Renewables has five people working within the company, two of them work from home and the remaining three do the installation of the equipment. The following section outlines the typical energy demand required by the company over a 12-month period using the information provided by them.

99.06% of Greenbridge Renewable's carbon footprint is a direct result of the combustion engines in their owned vehicles. Ford Ranger #1 was driven 22,000 miles releasing 7.34 t CO_2e to the atmosphere. Ford Ranger #2, 12,000 releasing 4.00 t CO_2e. Ford Transit #1 releasing 12.81 t CO_2e and finally Ford Transit #2 releasing 8.54 t CO_2e.



Ford Ranger.

Ford Transit.

Fig1. Breakdown of the four vehicles owned by Greenbridge Renewables and their emissions in the last 12 months.

Since such a big percentage of the business emissions comes from their vehicles, the upgrading of their fleet to hybrid or electric would have a huge effect of the company's carbon footprint. This option was discussed with the company and they have understandable reservations about it. The current state of the technology and the infrastructure in the UK are not suitable for their business to go fully electric at the moment. Their need to drive around the country carrying heavy loads does not currently match up with the use of fully electric vehicles since the current range and recharge times would mean a delay in their operations. Despite their reservations, the company is open to analyse the option of changing their vehicles once the lease on their current fleet finishes.

If Greenbridge Renewables were to fully electrify their fleet the operational emissions from the driving of their vehicles would be reduce to zero. Seeing how the upgrade of all their vehicles is impractical at the moment, the upgrade of at least some of their vehicles would be an option to reduce the company's operational emissions in the near future.

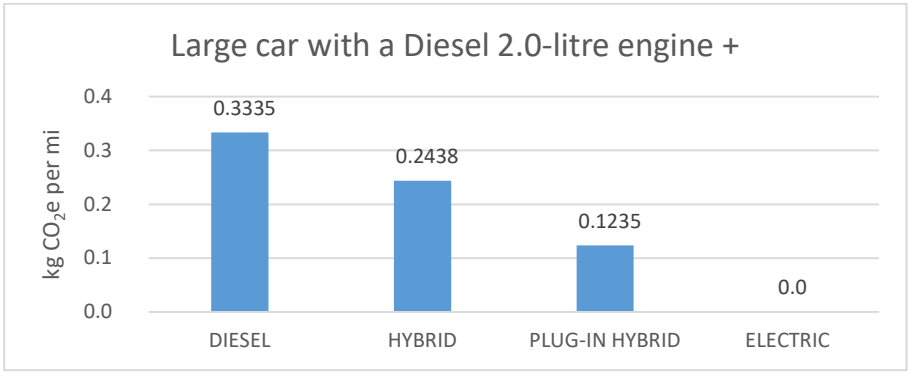


Fig2. Comparison of emissions from large cars taken from DEFRA's 2021 conversion factors.

It is important to point out that the reduction of the emissions on the driving of the fleet has an associated Scope 2 emission if the vehicles are being charged from the grid since electricity from the grid has its own operational emissions.

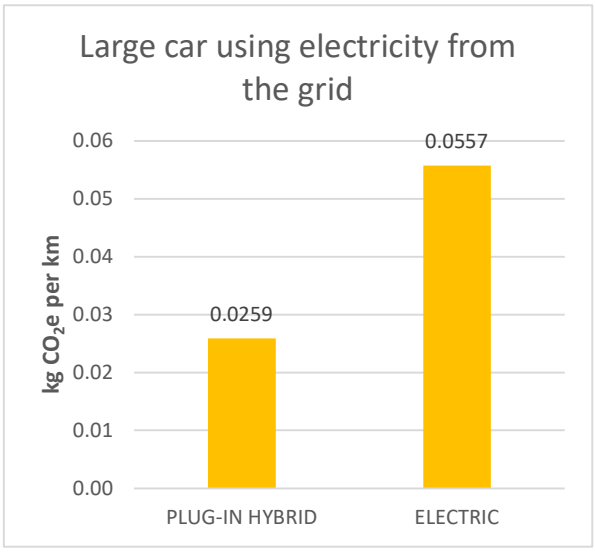


Fig3. Comparison of emissions from large cars using electricity from the grid taken from DEFRA's 2021 conversion factors.

Electricity from the grid in the UK is decarbonizing, meaning that every year each kWh used from the grid has a lower carbon emission and if the UK hits its goal of having a zero emission grid, the charging of the EVs from it would also be zero.

In the meantime the operational emissions from charging EVs from the grid can be avoided if the source of the electricity is generated by the company using sustainable sources, like connecting their own solar panels to their EV charging points, achieving a zero emission fleet even before the complete decarbonisation of the grid.

Since the operations of Greenbridge Renewables are done from home, and that there has been a recent house move, electricity and gas bills were not available so estimations had to be made. Their gas and electricity uses were estimated using EcoAct's 2020 Homeworking emissions whitepaper [6] considering 40hr weeks and working 48 weeks a year.

The average workstation according to CIBSE Guide F establishes 140W per workstation desk, plus 10w for lighting adding up to 576 kWh of electricity use a year. One of the households produces 70% of its electricity with solar panels reducing the electricity use from the grid to 374.4 kWh a year, which result in 0.08 tCO_2e a year.

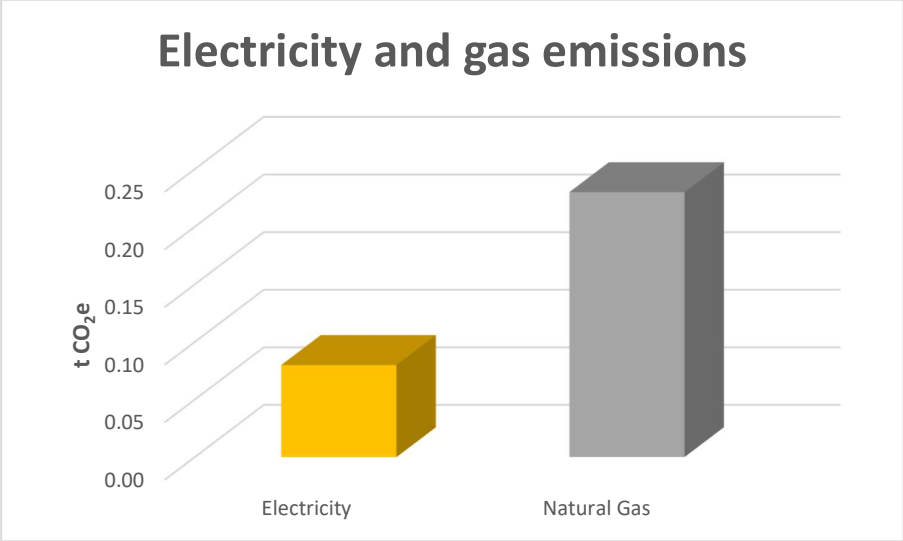


Fig4. CO_2e emissions from electricity and gas using DEFRA's 2021 conversion factors.

Both households used to run Greenbrige Renewable's operations have gas-heating systems. Considering 8 working hours a day, that the heating is used for six months in the period from October to March, that the typical domestic gas consumption is 12,000 kWh [6] and that 77% of the gas use is for heating, 1,269.23 kWh are being used per year. This usage releases 0.23 tCO_2e to the atmosphere.

3.2. Fuel Cost

As discussed in section 2.2, financial opportunities and energy savings are amongst the key drivers set for this project. It is important to understand the cost of energy and how that cost is distributed throughout a calendar year. The cost of fuel has been estimated using the Royal Automobile Club's figures (https://www.rac.co.uk/drive/advice/fuel-watch/) for diesel prices between January and December 2021.

Month	Diesel price per litre
Jan-21	£1.2005
Feb-21	£1.2335
Mar-21	£1.2668
Apr-21	£1.2911
May-21	£1.2964
Jun-21	£1.3179
Jul-21	£1.3436
Aug-21	£1.3666
Sep-21	£1.3671
Oct-21	£1.3978
Nov-21	£1.4790
Dec-21	£1.5064

Diesel prices fluctuated greatly during 2021 so an average of £1.33 per litre was calculated. It was also estimated that the fuel consumption of Greenbridge Renewables vehicles is 0.23 litres per mile of the Ford Transit and 0.17 litres per mile for the Ford Ranger using the average fuel consumption for its 2020 model.

Using this approximations we estimate that Greenbridge Renewables spent £23,587.85 for the diesel needed to run their operations, meaning that their diesel consuming vehicles are not only a large part of their operational carbon emissions but also represent an expense the company could invest in the electrification of their fleet.

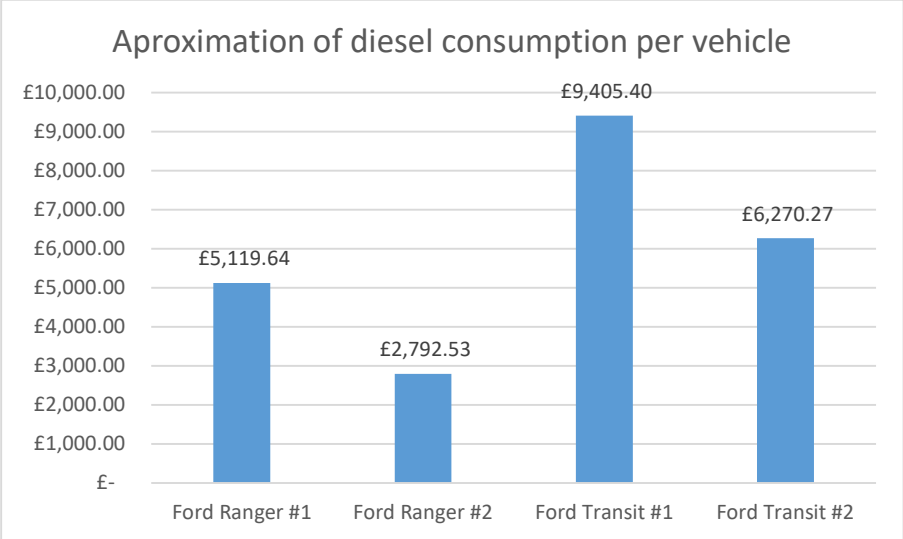


Fig5. Approximations made using an average of RAC's 2021 diesel prices.

3.3. Significant Energy Users (SEUs)

Significant Energy Use/Users has been defined by the ISO 50001 standard on energy management systems. The standard defines SEUs as energy use that represents a considerable portion of the total energy consumption and/or offering considerable potential for improvements in energy performance and efficiency [7]. According to Engie, the sum of SEUs should cover at least 80-90% of energy consumption.

The majority of energy and fuel required by Greenbridge Renewables is its diesel usage covering 99.06% of all the business operational emissions.

3.4. Existing Sustainable Practices

Greenbridge Renewables are a forward thinking, proactive company with a drive to reduce their carbon emissions. When discussing the possibility of upgrading their vehicles to electric they expressed that they are not closed to the idea. Part of their electricity is already coming from their own solar panels and the remaining is being purchased from the grid which is undergoing its own process of decarbonisation.

3.5. Benchmark Data & Carbon Footprint

A carbon footprint is the total emissions released from business activities expressed in kilograms (or tonnes) of carbon dioxide equivalent emissions. Carbon dioxide equivalent emissions (or CO_2e as hereby referred to) is a globally recognised unit for grouping all 7 greenhouse gases (GHGs) as set out by the Kyoto Protocol [8]. When measuring a carbon footprint, carbon units are typically presented in kg CO_2e. Carbon footprints can be a useful tool to measure the current state of a business and can provide a baseline from which the company can then measure and quantify any future improvements made through implementing, what is known as, energy conservation measures (ECMs) (see section 5.1 for more on ECMs).

Figure 6 shows the breakdown of Greenbridge Renewables carbon footprint into their source of their operational emissions. Only 0.24% of the company's carbon footprint comes from its electricity use, and this figure will decrease even further year-on-year as a result of the decarbonisation of the national grid. Considering this, the 0.70% of the carbon footprint attributed to their gas usage can also be reduced with the installation of electric heating systems.

The remaining, and vast majority of the footprint for the company comes from the diesel used for their vehicles and, it will be hard to completely eliminate it at the moment due to the current state of the technology and infrastructure.

Emissions Source	Emissions Scope	Annual Usage	Unit	Annual [kg CO_2e]	Annual Tonnage [t CO_2e]	%
Electricity	2	374.40	kWh	79.50	0.08	0.24%
Gas	1	1,269.23	kWh (Gross CV)	232.47	0.23	0.70%
Transport	1	84,000	miles	32,685.82	32.69	99.06%
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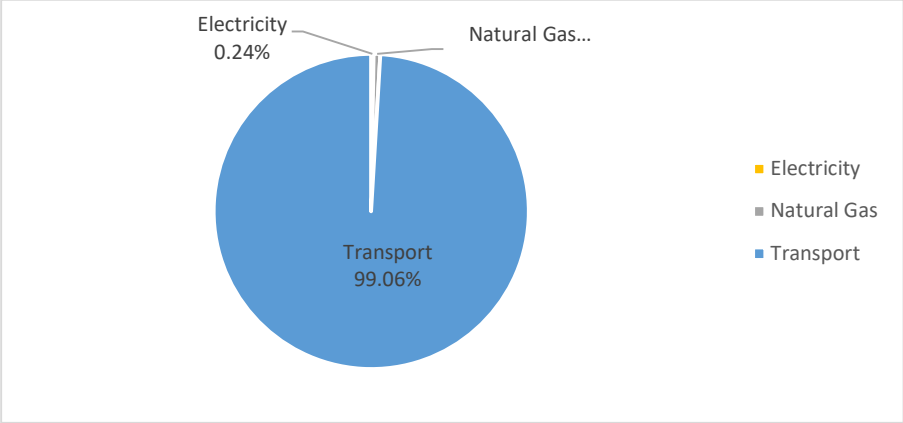

Fig6. How the 33.00 tCO_2e are divided within the company's carbon footprint.

4. Historic Data & Forecast

It imperative to gather historical energy data in order to predict future energy use. In this section, a business-as-usual (BAU) forecast is presented based on the company's normal execution of regular business operations. BAU forecasts are important to give a sense of energy performance based on current business operations and historical data. It helps to visualise the current state of the business' energy and emissions use and is a way of predicting how these figures will change in the coming years.

Greenbridge Renewables is a newly formed company and they have provided approximations of their millage for the last year. They are expecting to double their turnover for this year, which could mean they plan on installing double the amount of solar panels and EV charging points. This could mean they could potentially double the millage driven by their vehicles and since their carbon footprint consists 99.06% of their diesel usage, it could be estimated for their carbon footprint to double as well.

4.1. Limitations

Whilst emissions forecasts are a useful tool to help visualise the state of the business and the expected emissions generated, there are a number of limitations that need to be considered whilst analysing the data. In order to gain a more accurate forecast is it recommended that historic energy data is gathered dating as far back as available, this will help to eliminate any anomalies caused as a result of an external input such as varying winter temperatures. Univariate time-series forecasting only accounts for historic energy data and the general seasonality trend, this method relies entirely on the quality and quantity of historic data. To mitigate against the lack of quality data, a multivariate time-series forecast can be used, this method considers a number of variables to contribute to a more accurate forecast.

5. Energy & Carbon Reduction Solutions

This section of the report will present a number of solutions to provide opportunities for carbon reduction at Greenbridge Renewables, these scenarios are more commonly known as energy conservation measures (ECMs) and can also be referred to as energy efficiency measures (EEMs)[3]. There are four varying types of ECMs, presented from the less expensive simple solutions to highly technical and costly solutions, the different types of scenarios are listed as follows:

- **Operational** – based on changes made to the existing structure of a business in order to adapt to a more energy efficient and sustainable way of operation.
- **Technical** – solutions that are generally more advanced looking at new, more efficient technology to replace old, tired equipment.
- **On-site Renewables** – renewable energy which is generated through systems located on company owned land.

The ECMs discussed in this section are separated into mostly individual solutions to demonstrate the benefits of each scenario. It is also important to note that all ECMs discussed are taken from research conducted at the time of writing and a number of assumptions have been made to estimate a number of values. The company should contact suppliers for highly detailed feasibility studies to help decide which scenarios are most suited to the business for the required needs.

5.1. Energy Conservation Measures (ECMs)

Following is a brief description of the ECMs considered fit for purpose at Greenbridge Renewables:

The ECMs considered in this section are not a complete list of solutions, rather it provides Greenbridge Renewables with a starting point and identifies ECMs best suited to the business. For a full list of ECMs please visit The Renewable Energy Hub where more information can be found on any of the solutions mentioned in this section.

https://www.renewableenergyhub.co.uk/

Fabric Retrofit

Considers the fabric efficiency of existing buildings including the maintenance and upgrade of building insulation, draught proofing in leaky areas, and general building maintenance. A relatively low-cost solution that is guaranteed savings through quick simple fixes to existing structures. Improving the thermal efficiency of the existing buildings is of high priority in the early stages of carbon reduction, by increasing the thermal efficiency it will minimise any heat loss, therefore, reducing the amount of energy required for heating.

Energy Management System (EnMS)

Energy management Systems (EnMS) can be considered a costly solution that may involve setting up sophisticated systems to monitor and measure highly detailed energy data that must be observed by a skilled team. However, it can simply refer to having a basic understanding of the

[3] Generally, the terms ECM & EEM are used interchangeably and there is some debate over the differences between the two terms. For this report ECMs has be used throughout as it is defined to include both conservation and efficiency actions [14].

businesses operating energy use, and occasionally (monthly, quarterly, or annually) updating and recording energy and fuel consumption. Alongside this report, Greenbridge Renewables will be provided with a basic **energy and carbon analysis excel model** to enable the company to stay on top of energy management.

Lighting & Controls

Upgrading all lighting to low-energy LEDs, combined with smart lighting controls (e.g. PIR sensors, and daylight harvesting) is one of the most efficient and affordable ways to reduce energy use. The average payback period for low-energy lighting upgrades is usually between 1-3 years. It is one of the more straightforward scenarios to implement to reduce the company's carbon footprint and whilst Greenbridge Renewables have already begun to replace existing lighting, a suggestion to continue changing all lighting to LEDs as soon as possible will provide some quick wins in terms of energy reduction.

Electric Heating

The use of electric heaters could eliminate the use of gas (and its associated emissions) from the company.

Solar Panels

Solar is rapidly becoming one of the most installed renewable energy sources in the world, this is due to the global decrease in manufacture and installation costs created from mass production and improvements in technology. Solar panels have very low maintenance making them a worry-free addition or alternative (depending on installed capacity) to grid purchased electricity. Solar panels have an expected lifespan of around 25-30 years (if properly maintained), therefore, a suitably sized solar panel array could reliably contribute 100% renewable electricity to the company for at least 25 years. It is important to note that solar power system inverters have a lifespan of around 10 years and will need replacing. It is unsure how suitable solar panels may be for Greenbridge Renewables without a full inspection of the roof condition, size, and potential space available, however, it remains a potential source of renewable energy for the business.

Air & Ground Source Heat Pumps (ASHP & GSHP)

Heating, ventilation, and air conditioning (HVAC) units are all in one system that can be efficient, low-energy, low cost replacements for existing systems. There are a few different types of HVAC systems, however, the systems most suited to Greenbridge Renewables are air source heat pumps (ASHP) and ground source heat pumps (GSHP).

ASHPs can be used as a heating system and an air conditioning unit, which make it an ideal solution to the varying temperatures experienced in the main building. Installation of ASHP can be fairly straight forward and are ideal for buildings that are lacking in external land or internal space as the system fits neatly to the outside of any building, in the case of Greenbridge Renewables, the system could be installed on the roof of the building, keeping the system discrete and out of view. There are two main types of ASHPs, air to water systems that send the heat to water-based heating systems, and air to air systems that produce a flow of warm air that can be used as space heating. As the business currently operates a central heating system, an air to water ASHP may be more suited to the existing environment.

Ground source heat pumps (GSHP) are one of the most reliable sources of renewable heat. This is due to the ground temperature remaining fairly constant, even through the winter months. The technology can be used to produce hot water and operating warm air heating systems, and there are a number of different types of systems to suit any site. The technology is relatively expensive to install but have very low maintenance and are easy to run. Whilst Greenbridge Renewables operates on a large site, GSHPs would require trenching into the ground which may not be suitable on the highly maintained greens, however, it should not be ruled out as GSHPs are a very reliable source of renewable energy.

ASHPs & GSHPs also benefit from the governments RHI scheme (see section 6.6 for more information), and could provide a source of income for the company, however RHI payments only apply to air-to-water systems which would mean installing a wet central heating system in addition to the HVAC system.

Fleet Management

Given that transport is the highest contributor to the carbon footprint for Greenbridge Renewables, this report recommends that the client investigate implementing some fleet management techniques to help reduce its carbon footprint. This could include three central pillars:

- Driving less miles where possible.
- Fuel-efficient driving- this could be done by giving driver training, providing incentives and targets to staff, or introducing speed limiters.
- Replacing vehicles with lower-emission alternatives.

6. Financing Strategies

This section briefly discusses the financial options available for funding the carbon reduction scenarios discussed in section 5.1. A brief analysis of the ECMs typical financial indicators have been included for reference, and may not be 100% accurate for the case of Greenbridge Renewables. It is the responsibility of Greenbridge Renewables to decide on which financial methods are chosen for investment. The information in this section is based on research conducted, as well as investigation into case studies of businesses with similar credentials.

Proposed financial strategy:

Step 1: Obtain quotes

Contact suppliers of equipment and services to acquire several quotations and further infomation on products and services.

Step 2: Identify available subsidies

Search for appropriate grants available and explore technological solutions eligible for tax benefits/deductions.

Step 3: Self-fund low cost ECMs

If available, self-fund less expensive energy conservation measures (ECMs) such as fabric retrofits, lighting & controls, HVAC, and energy management.

Step 4: Explore financing options

If self-financing is not an option then consider the financing options available in this section. Careful consideration of financing options will ensure the most suitable options are chosen with the required metrics for the company.

Step 5: Monitor and measure savings

Keep a record of all savings made through ECMs and invest the savings in further energy efficient investments.

6.1. Self-financing

Self-financing is one the more traditional financing options and refers to the funding of energy conservation measures (ECMs) without the need for additional lending or grant support [9]. It is unlikely that a company will be in the position to self-finance an entire carbon reduction strategy and may need external support to achieve net zero carbon status. Companies that are in a unique position to self-fund a project of such magnitude, also need to be aware of the difficulties involved with certain investments:

- The company will take the full risk in case the investment does not perform as expected.
- Maintenance will be the sole responsibility of the company and it may need to be outsourced to a technical professional, adding an additional cost to the overall system.
- A large capital expenditure is required and must be paid for upfront.

Self-financing does, however, have a number of pros over other methods of financing,

- Company will receive all benefits, e.g. RHI payments, and energy savings.
- The company has total control over the system management and has complete autonomy over decision-making.
- No financing costs e.g. high interest rates.
- Company can decide on the best way to handle operation & maintenance (O&M).

6.2. Loans

The majority of companies will need to borrow money to fully or part fund their carbon reduction strategy through a loan from a bank, finance provider, or equipment supplier [10]. Straightforward bank loans however, carry even higher risks than self-funding due to high interest rates increasing the longevity of the payback period. An investment can seem much less appealing with longer-term paybacks and higher overall costs, in spite of that, it is important to consider the potential savings that come with energy conservation measures. It is therefore imperative that potential savings are estimated before considering investing in ECMs, if the savings outweigh the interest payments then it can still be an attractive proposition and the company will still see a return on investment (ROI).

6.3. Grants

There are a number of non-repayable grants and schemes available for funding energy efficiency projects, a large portion of these are typically funded by the government or EU commision and are managed by local authorities, local enterprise partnerships or NGOs [10]. Generally grants and schemes are often regional and typically have strict eligibility criteria, dispite that they are certainly worth investigating as they greatly reduce the capital expenditure required. Often grants and schemes are supported by a funded consultancy service, to assist in identifying the most appropriate ECMs. The following resources will help in finding a suitable grant, if one is available [10]:

- Your Local Enterprise Partnership and Growth Hub
- Your Local Authority
- Online search using key words – such as “energy efficiency grants“

6.4. Asset-based Financing

Asset-based financing allows a business to receive a loan for their ECMs based on the value of certain assets, in comparison to a traditional loan that generally depends on the company's credit rating. Accounts receivables (invoice financing) are the most widely secured against assets, in addition machinery, equipment, inventory, or real estate can also be used to secure a loan [10]. The benefit of asset-based financing is that it enables a company to receive cash faster and under more flexible terms compared to a traditional loan. On the other hand, the cost of debt is usually higher than a traditional business loan, and potential complications can occur with asset appraisal.

6.5. Leasing

Leasing can be another method of funding energy conservation measures (ECMs), whereby a set agreement between the lessor and the company (lessee), enables energy efficient equipment upgrades without the outlay of capital expenditure. There are a number of different leasing agreements available to a company including, finance lease, operating lease, and hire purchase. Each agreement has its pros and cons over the other and will depend on the company's requirements which they choose. In general, leasing can be a more expensive option than other financing methods discussed prior, and for the majority of agreements the company does not own the asset. Pros to leasing include tax deductible rental payments, no upfront CAPEX required freeing up cash flow for other investment, and in some cases, maintenance is undertaken by the lessor [10].

6.6. Renewable Heat Incentive

The non-domestic Renewable Heat Incentive (RHI) is a government scheme that enables a business to take advantage of financial incentives to encourage the use of renewable heat for businesses, the public sector, and non-profit organisations [11]. The RHI is a source of income from a green investment and will reduce the payback period for the capital investment of renewable heat sources. RHI payments are available for the following technologies:

- ASHP (air to water only)
- GSHP
- Biomass Boilers (wood fuelled)
- Solar Thermal Panels providing hot water
- Biomass Pellet Stoves with integrated boilers providing space heating

6.7. ECM Financing & Savings

In finance there are a number of key indicators to look out for when deciding on an investment, from the initial cost of the project to the operation and maintenance. In business it is common to analyse a number of financial decision indicators (FDIs) depending on the requirements of the company. Whether, the main interest is to make a quick profit within a few years, or to simply break even over a 10-year period on the basis that other needs are met (such as a reduction in emissions). This section aims to provide a comprehensive analysis of the energy conservation measures (ECMs) and their related financial factors.

Table 3 aims to provide average figures for payback period, return on investment, and internal rate of return to provide a comparison between each of the ECMs. For this report, CAPEX and O&M costs have not been calculated as there are too many factors to consider meaning no accurate figures can be calculated, in order to get an idea of costs it is advised that Greenbridge Renewables contact providers to ask for a full feasibility study to be completed.

ECM	Payback [yrs]	ROI [10 Years]	IRR	Environmental & Financial Benefits
Lighting & Controls	1.3	579.6%	80.4%	- Reduced energy demand
IR Heating	2.2	286.3%	47.1%	- Low-energy, efficient heating alternative - No emissions if combined with a renewable energy source
Fabric Retrofit	2.5	219.0%	40.7%	- Improved thermal efficiency - Reduced energy demand
EnMS	5.7	177.0%	26.2%	- Improved understanding of energy spend - Reduce energy consumption through identification of SEUs
Biomass Boiler	6.2	20.5%	10.2%	- Low-carbon heating source - Eligible for RHI
ASHP	6.9	22.8%	12.2%	- Efficient heating alternative - No emissions if combined with a renewable energy source - Eligible for RHI
Solar PV Array	16.0	-30.13%	5.0%	- 100% renewable electricity

Table 3. Typical Financial Analysis of ECMs

7. Implementation

Developing an implementation strategy is important for any business wishing to reduce their carbon footprint, it ensures the principles and reasons behind the project are not forgotten. Referring back to section 2 - Project Scope at this stage will reinforce the key drivers for the project and also ensure that targets set during this stage are implemented into the strategic implementation plan. There is no one solution for reaching net zero carbon emissions and it will be a combination of a number of scenarios, this section aims to help with the selection of which energy conservation measures (ECMs) to prioritise.

7.1. Zero Carbon Project Priorities

The UK Green Building Council (UKGBC) is an organisation that looks at ways to improve the sustainability of the built environment. In 2019, they released a report[4] in an attempt to define what is meant by a net zero carbon building in the UK. The report outlines a framework for achieving net zero, Fig7 shows a simplified hierarchy of that framework and demonstrates the priorities when undertaking a net zero carbon project. The hierarchy shows that fabric efficiency and energy efficiency should be prioritised over all other measures, this will reduce the energy demand and consumption before considering more costly solutions, such as renewable energy technology.

"Investing in energy efficiency and demand reduction is the most cost-effective way to minimise the new infrastructure that will be required to achieve a zero-carbon energy system." – UKBGC, 2019 [12]

[4] The report is part of a global project working in conjunction with the World Green Building Council (WGBC), the project is named 'Advancing Net Zero' and aims to encourage the commitment of 100% net zero carbon buildings by 2050 [19].

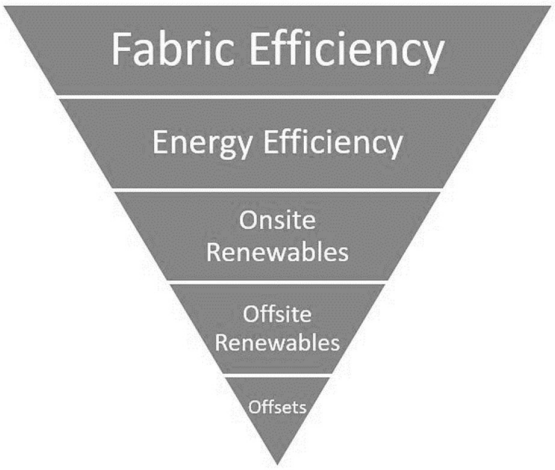

Fig7. Net zero carbon hierarchy, proposed by UKGBC, 2019

7.2. Strategic Implementation

When deciding on a strategic implementation plan for an energy and carbon reduction project it is important to consider a number of factors based on the requirements of a company. It is the responsibility of the company to decide on which ECMs are implemented and when; However, a proposed strategy for Greenbridge Renewables (displayed as a flow chart in 8) has been developed based on a number of factors including:

- Energy efficiency
- Demand reduction
- Financial Benefits
- Net zero carbon hierarchy

Each of the factors listed above are equally important to consider when undertaking a carbon reduction and mitigation project. The strategy proposed below in Fig8, should be used as guidance for influencing a future sustainability strategy at Greenbridge Renewables.

Strategic Implementation Plan (SIP)

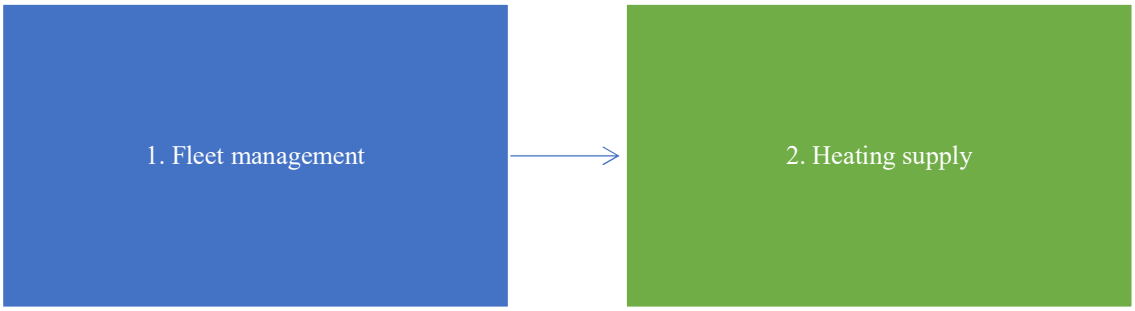

Fig8. Strategic implementation flow chart

Fleet management – It is recommended that the company records each month the millage driven per vehicle and its diesel consumption to better understand the effects its practices have on its overall carbon footprint and start implementing ways to reduce it.

Heating Supply – At present, the current heating system installed in both of the dwellings where operations take place is gas-powered. Through the installation of an electric-powered heating system, the emissions from the combustion of gas can be avoided.

8. Futureproofing

Safeguarding the longevity of a carbon reduction and mitigation project is just as important as the implementation stage. It is important that Greenbridge Renewables continue to achieve their sustainable goals and targets for the foreseeable future. This section focusses on futureproofing the achievements set out by this adventurous project and identifies ways to guarantee that initial targets set are fully met with the addition of new targets. Through setting and achieving sustainable targets, the business will continue to save money, and stay in control of energy use for any developments or changes made to the business. Information discussed in this section is designed to improve the transparency of business activities and to improve robustness of the proposed strategy.

8.1. Master Plan Integration

In order for a company to progress and grow as a business, master plans are developed to construct a comprehensive plan of action for future investments and changes. It is important to integrate the carbon reduction & mitigation strategy into the current master plan to build and extend on the existing sustainability plans. Through master plan integration, dissemination of the proposed strategy can be disseminated to all relevant stakeholders, whereby details can be discussed and agreed upon. It is suggested that information from this document be considered when updating the company master plan (ecology strategy), and is highly advised to incorporate zero-carbon design and thinking into all ventures, now and in the future.

Greenbridge Renewables are considering the implementation of a hybrid or electric fleet since 99.06% of their footprint if diesel use. The complete elimination of diesel vehicles will be hard at the moment due to the current state of the technology and infrastructure. The company requires transporting heavy loads all around the country, meaning the current range of electric cars, the time they take to charge and the unavailability of charging point an issue. The use of hybrid vehicles could reduce the carbon footprint 25% and is a possibility the company has in mind for when the current leases of their vehicles finishes.

8.2. Reporting

In order to maintain a net zero carbon status, a minimum level of reporting is required by the company. Both M&V and PDCA (see section 8.3 and 8.4 respectively) include reporting as a major part of the process, demonstrating just how important it is. Regular reporting will provide stakeholders with transparent information on the status on the business's energy use and carbon emissions, providing clear, transparent information is a positive trait that demonstrates leadership and responsibility to stakeholders, visitors and the wider public. Reporting should be made publicly accessible and should consider the following principles taken from the GHG Protocol [4]:

- **Relevance** – To ensure the details of the report appropriately reflect the emissions and goals of the company and enables stakeholders to make relevant decisions based on information reported.
- **Completeness –** To define the project boundaries and guarantee all relevant data is accounted and reported on. Disclose and justify any omissions.
- **Consistency –** Choose a method and stick to it. Certify transparently any changes in data, methodology, scopes, boundaries, or any other relevant factors in the time series.
- **Transparency –** Disclose all relevant information including data sources, assumptions, and references methodologies.

- **Accuracy –** To enable the quantification of precise, quality data and to eliminate uncertainties wherever possible. Accuracy of data will provide decision-makers with reasonable assurance to the integrity of the proposed report.

8.3. Measurement & Verification (M&V)

Measurement and verification (M&V) is a process that cannot be ignored during an energy and carbon reduction project and is generally considered once contractual terms between the client and ECM suppliers have been agreed. The performance of energy conservation measures (ECMs) needs to be measured and verified to identify accurate project costs and savings, specific technological requirements, and the risk allocation between the client and supplier [14].

M&V is the process of reliably measuring the performance of an ECM to determine actual savings [14]

ECM savings cannot be directly quantified since it is the reduction in energy use compared to baseline data determined by the company, thus savings are calculated by comparing measured energy data before and after ECM implementation, making sure to consider certain factors (e.g. inflation, and the cost of energy). M&V considers the following steps [14]:

- Sub-meter installation and maintenance
- Data collection and monitoring
- Analysis of measured data to determine a series of estimated outputs
- Reporting of emissions to improve transparency
- Quality assurance, and third-party verification of reports

An M&V plan should be developed following the agreement and completion of carbon reduction & mitigation strategy. There are three main M&V methods that can be used and are listed below [15]:

1. **Retrofit Isolation** – measures the energy consumption before and after ECM implementation to determine savings specific to systems where the ECM was applied.

2. **Whole-Facility** – uses measured energy data of an entire facility to determine savings using baseline energy use against post installation energy use. Data can be taken from utility bills and/or sub-meter data.

3. **Calibrated Simulation** – this approach determines savings through the use of computer simulation tool to create a model of energy use and demand of the whole site.

8.4. Continuous Improvement

It is imperative that Greenbridge Renewables continue to work on their environmental issues to uphold a positive reputation to both stakeholders and their supply chain. A way to achieve this is through a continuous improvement (CI) framework. There are a number of CI frameworks/programs that can be implemented, however, the recommended method for this project is the Plan-Do-Check-Act (PDCA)[5] Cycle as adopted by ISO 50001.

[5] For more information on PDCA in the context of energy & carbon management, see ISO 50001 [5] where the standard outlines how the PDCA approach is adopted to achieve a continuous improvement plan.

ISO 50001

ISO 50001 is an international standard based on the CI framework, PDCA, and outlines the requirements for an energy management system (EnMS). Achieving ISO 50001 certification improves the ability of a company to manage their energy use through regular audits, data collection & analysis, and frequent reporting. Development of an EnMS includes the implementation of an energy policy, objectives, energy targets, and a strategic implementation plan (SIP) to consider a company's energy efficiency, energy use, and energy consumption [5]. Effective implementation of this standard provides a systematic approach to improve how energy is managed, leading to a greater understanding of energy costs and carbon emissions.

8.5. Other Environmental Impacts

Increasingly companies are reporting and reducing the impact their operations[6] are having on the environment, however, eliminating all carbon emissions and achieving true carbon neutrality requires a company to consider a holistic approach to carbon management, this is achieved by considering emissions throughout their supply chains, otherwise known as scope 3 emissions [16]. In addition to scope 3 emissions, environmental impacts from water and waste are also something to consider when reporting on a company's emissions.

Scope 3 Emissions

Considering emissions generated on behalf of the company across the supply chain is significantly overlooked worldwide. There is currently little understanding on the scale and magnitude of emissions generated through a company's value chain, and greater collaboration between suppliers and customers is needed to account for these widely omitted emissions [16]. Scope 3 emissions can account for up to 85% of a company's total carbon footprint [16], and multinational grocery manufacturing company, Kraft Foods, found that value chain emissions accounted for more than 90% of the company's total emissions [17].

The World Resources Institute (WRI) & World Business Council for Sustainable Developments (WBCSD), developers of the global standardised frameworks (GHG Protocols) to measure and manage greenhouse gas (GHG) emissions, have a number of resources available for guiding commercial businesses on their entire value chain (scope 3) emissions. Studies have shown that companies undertaking corporate value chain and product GHG inventories[7] have seen a positive return on investment (ROI) [17]. In addition to this, measuring scope 3 emissions can provide a company with a more complete understanding on their impact on the environment, identify resource and energy risks in the supply chain, and educate & engage employees and customers with accurate emissions data.

Greenbridge Renewables relies on their supply chain to operate as an efficient business and is vital in upholding the current operations of business activities. Scope 3 emissions that could be considered by Greenbridge Renewables include the production and distribution of the equipment they install (such as solar panels and batteries), and waste produced during the distribution and installation of the equipment. The production line behind goods, and their transportation is not always clear, but the company could start small, looking at where they buy their products and how the products are transported around the world.

[6] A Company's own environmental impact is usually considered as Scopes 1 & 2 emissions, whereas scope 3 emissions are generally excluded from reports and carbon reduction plans. For more information on emissions scopes and boundaries, refer to section 2.4

[7] Greenhouse Gas (GHG) Inventories refers to the development of whole life carbon footprints as seen in this report, and is simply the process of measuring and reporting on carbon emissions, whether they are considered to be scope 1, 2, or 3 emissions.

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