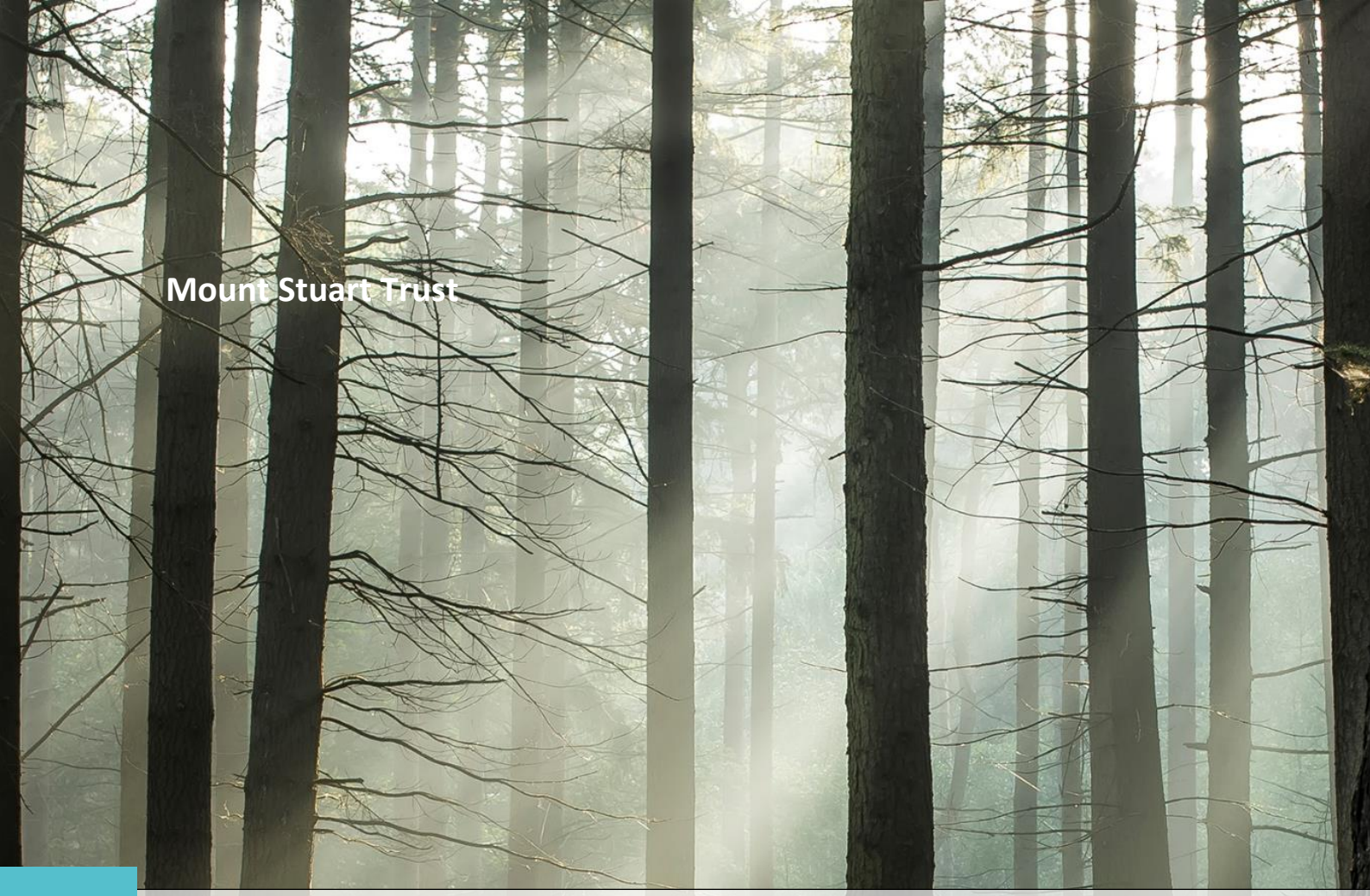

Mount Stuart Trust

Baseline Carbon Assessment of the Mount Stuart Trust

Draft Report v3.0

Date: 03 May 2023

ADAS

ADAS GENERAL NOTES

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EXECUTIVE SUMMARY

This greenhouse gas (GHG) emissions assessment covers several enterprises within the Mount Stuart Trust, referred to as the Trust 'in scope'. These include Mount Stuart House and gardens, a commercial sawmill, several self-catering properties, a hydro-electric facility located off-site and over one hundred sheep managed directly by the Trust. It provides an estimation of the GHG emissions produced in these enterprises in the period January to December 2021.

The total greenhouse gas emissions for the Mount Stuart Trust 'in-scope' in the accounting period were **437.6 t CO_2e**.

The main source of emissions within the Trust 'in scope' was the use of fossil fuels, which accounted for **43.7%** of the total emissions. This is primarily driven by natural gas used for heating Mount Stuart House, some of the self-catering properties, greenhouses and other buildings in the gardens (**24.6%**), followed by white diesel (**9.6%**) and red diesel (**8.4%**).

The second greatest source of emissions within the Trust 'in scope' was grid electricity, accounting for **25.0%** of emissions. There are two ways of calculating emissions from grid electricity: market-based and location-based. The location-based approach is used throughout this report since it more fully reflects the grid electricity used on site and highlights opportunities to reduce this. The market-based approach applies a reduction to grid electricity emissions based on exports of grid electricity from renewables, e.g. the hydro-electric facility. Since the amount of electricity exported is greater than what is consumed on-site, this means emissions from grid electricity are zero. This approach accounts for the fact that Mount Stuart has invested in renewable energy projects but gives limited visibility of on-site grid electricity usage. A more detailed overview of both approaches is presented within the report.

The third greatest source of emissions is the management of sheep by the Trust, accounting for **14.6%** of total emissions. This is mostly due to enteric methane emissions (**12.7%**) which can be reduced to some extent by optimising productivity.

On-site renewable energy emissions include the installed biomass boilers (**5.4%**) and the hydro-electric site (**4.7%**).

A full summary of GHG emissions is provided, including a breakdown by emission category, by enterprise and by scope. High-level information on emission reduction opportunities is provided, covering aspects such as monitoring energy use, reducing energy consumption and improving efficiency, as well as installing renewable energy sources. This is not exhaustive but should allow Mount Stuart Trust to choose which aspects are most relevant and these can be explored further.

This report exclusively accounts for GHG emissions and has not taken into consideration any carbon sequestration that may be occurring on the land managed by the Trust. Information is provided on carbon sequestration including the risks, opportunities and caveats. Finally, information is provided on the gaps and assumptions in this assessment, with recommendations on how to improve these going forward.

The next step should be to repeat this GHG emissions assessment using the most up-to-date activity data, while incorporating carbon storage and sequestration to provide a complete picture of carbon and GHG emissions within the main enterprises of the Mount Stuart Trust.

In the future it may be possible to expand the scope of the assessment or link up with work that is already being done, e.g. by supporting farmer groups to understand and reduce emissions in the wider Mount Stuart system boundary.

CONTENTS

1 INTRODUCTION

1.1 Background

It is widely recognised that the global climate emergency is one of the key sustainability challenges facing society over the next 50 years. Climate talks in Paris resulted in agreement from many governments that urgent action needed to be taken to halt global warming, limiting further temperature rises to 1.5°C. To achieve this, action needs to be taken across all sectors to reduce greenhouse gas (GHG) emissions and enhance carbon removal from the atmosphere. As part of the UK's climate commitments the UK government has enshrined in law that the UK will become 'Net Zero' by 2050. This means that emissions will be reduced by as much as possible, and where emissions cannot be reduced those residual emissions will be balanced by increased carbon removals from the atmosphere.

The Mount Stuart Trust Ltd is responsible for the stewardship of a large area of land and several properties on the Isle of Bute. This comprises Mount Stuart House and associated gardens, policies (ornamental woodland) and buildings, residential properties (95, plus 7 self-catering properties) approximately 1,500 ha of woodland (including both commercial conifers and mixed broadleaved woodland), a sawmill and over 9,900 ha of farmland used to produce beef, sheep and dairy. In addition, there are a number of other commercial interests which are part of the Trust including three golf courses, bowling greens, four lochs, an airstrip and much of the foreshore on Bute; there is also a property portfolio off the island as well as a hydro-electric site.

Mount Stuart consider that it is part of their duty in the stewardship of the site to ensure that it is managed in a sustainable way to ensure that it has a long-term future. Mount Stuart are already investing in a number of activities to reduce the Trust's impact on the environment, such as utilising home-grown biomass (waste arising from the sawmill) to provide heat and power to the house. They are particularly focused on reducing the climate impact of the enterprises managed by the Trust, although also recognise that there is potential to deliver multiple ecosystem services, including biodiversity benefits. However, at the moment they have no real understanding of where their biggest sources of emissions are and therefore where they are best focusing their future investments. Mount Stuart Trust also lack a baseline to compare the impact of any investment in order to demonstrate the benefits.

This report provides a baseline GHG emissions assessment of the Trust, capturing the house, gardens, sawmill, self-catering properties, the hydro-electric site and areas of the farm under direct management by the Trust – referred to as **the Trust 'in scope'**. This will allow Mount Stuart to monitor progress towards their climate goals going forwards, as well as identify the key emission sources. This report also highlights some of the key opportunities to reduce emissions, with additional recommendations to improve the robustness of data collected. There is a brief overview of the role of carbon sequestration in mitigating climate impacts, which is an area to be explored further in the future.

1.2 Site boundary

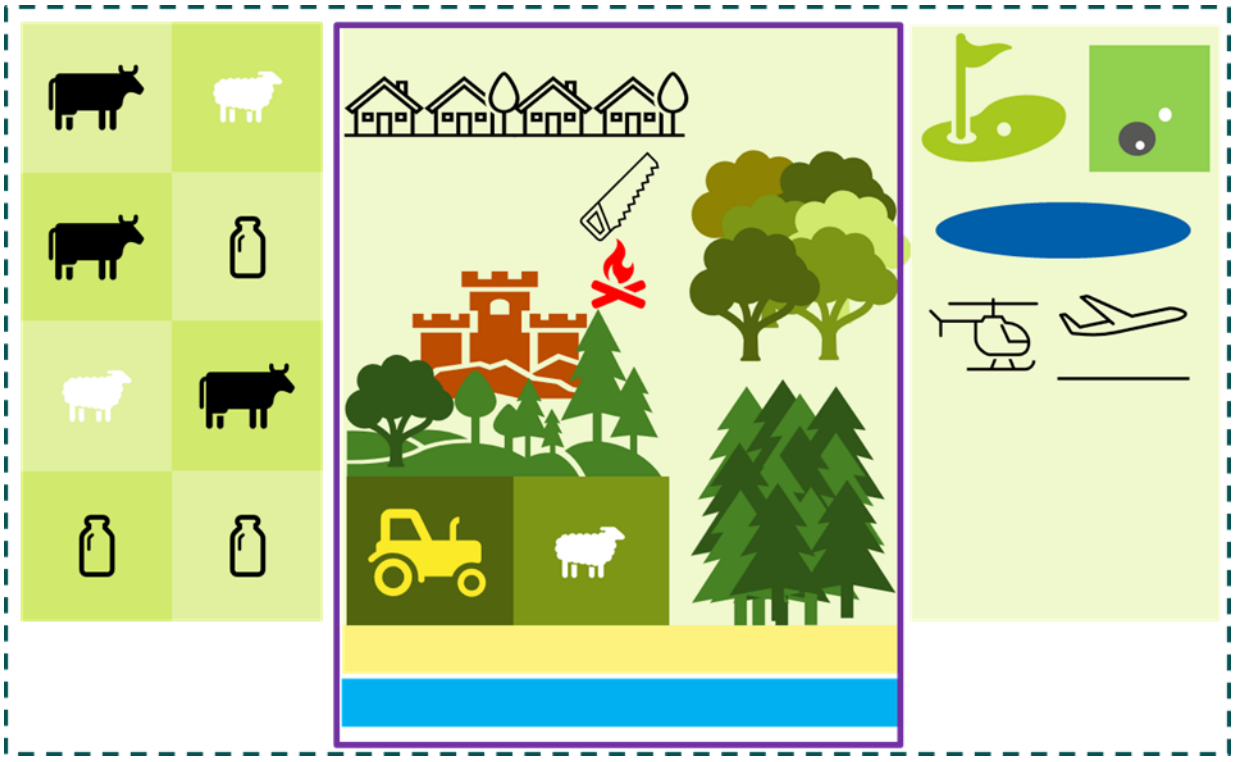
This GHG emissions assessment is for January to December 2021 and aims to capture all emissions within this timeframe across some of the key enterprises managed by the Trust (the Trust 'in scope'). Table 1 provides an overview of these enterprises, showing what was included and excluded in the baseline GHG emissions assessment.

Table 1. Summary of the boundaries of the baseline GHG assessment.

Included in assessment boundary	Excluded from assessment boundary
House	Forestry
Gardens	Agricultural land managed by third parties
Sawmill	Golf courses and bowling greens
Self-catering buildings	Airstrip
Hydro-electric site	Other owned property
Directly managed agricultural land	

For this phase of the project, the house, gardens, sawmill, self-catering buildings, hydro-electric site and the directly managed agriculture land have been included in the assessment (Figure 1). All data provided by the Mount Stuart Trust were allocated to one of these enterprises by the Mount Stuart team. In the results section, emissions are presented for the whole Trust 'in scope', as well as presented per enterprise, per emission source category and per Greenhouse Gas Protocol scope.

Figure 1. Schematic diagram of the enterprises managed by the Trust. Those highlighted in the middle box are included in the baseline GHG emissions assessment.



1.2.1 Greenhouse Gas Protocol Scopes

The Greenhouse Gas Protocol (GHGP) is an organisation that sets a series of standards for GHG emission assessment and accounting. This framework allocates GHG emissions to one of three scopes. Scope 1 includes direct emissions from owned or controlled sources. Scope 2 emissions are indirect emissions from the generation of purchased energy (mainly electricity). Scope 3 includes all indirect emissions (not included in scope 2) that occur upstream and downstream in the value chain.

This GHG emissions assessment includes emissions from all scopes where possible, for those enterprises within the assessment boundary (Table 2). There is potentially a substantial amount of Scope 3 GHG emissions (and carbon sequestration potential) in those enterprises that have been excluded from the assessment boundary – this is discussed more fully in section 6.2.

Table 2. Summary of GHGP scope allocations for the Trust 'in scope'.

Scope	Emission categories included under scope
Scope 1	Fuel used in machinery and on-site processes, livestock emissions, generation of heat from biomass.
Scope 2	Purchased grid electricity.
Scope 3	Embedded emissions in the production and disposal of material inputs, tools and machinery; transport of goods; embedded emissions in the production of electricity, fuel, livestock feed; mains water treatment.

2 METHODOLOGY

This greenhouse gas (GHG) emissions assessment has been carried out in accordance with the "Greenhouse Gas Protocol - Corporate Accounting and Reporting Standard" (GHG Protocol) developed in a partnership of the World Business Council for Sustainable Development (WBCSD) and the World Resource Institute (WRI).

Emissions were calculated by multiplying the activity data (e.g. litres of diesel combusted, tonnes of plastic manufactured, kilometres driven by an HGV) by an emission factor that quantifies the amount of carbon dioxide equivalent (t CO_2e) produced per unit of the activity (e.g. per litre of diesel combusted). Most of the emission factors used in this report are sourced from the Greenhouse Gas Emission Conversion Factors 2021, produced by the UK Government's Department for Business, Energy & Industrial Strategy (BEIS) – now the Department for Energy Strategy and Net Zero. These emission factors are updated annually to reflect updates to calculation methodologies and the reduction in UK grid electricity emissions over time as more renewable sources are connected.

Some emissions are more difficult to calculate since they depend on many factors, including land-use change, livestock management and application of nitrogen fertiliser. To estimate livestock emissions, we used the Intergovernmental Panel on Climate Change (IPCC) 2019 Refinement Tier 2 methodologies and emission factors to calculate an emission factor for sheep managed by the Trust.

The activity data used to calculate GHG emissions were supplied by Mount Stuart via a data collection sheet designed by ADAS.

2.1 Emission factors

Table 3 provides the source of all emission factors used in this assessment, with their date of publication.

Table 3. Sources of emission factors used in the GHG assessment.

Emission category	Emission factor source	Date
Grid electricity (location)	BEIS GHG conversion factors	2021
Grid electricity (market)	AIB European Residual Mixes 2021	2021
Fuel	BEIS GHG conversion factors	2021
Biomass	BEIS GHG conversion factors	2021
Hydroelectricity	IPCC 2015 Annex 3: Technology-specific cost and performance parameters	2015
Materials	BEIS GHG conversion factors	2021
Capital items	BEIS GHG conversion factors (using steel as proxy)	2021
Livestock	ADAS calculated values based on IPCC 2019 refinement Tier 2 methodologies	2019
Transport	BEIS GHG conversion factors	2021
Waste	BEIS GHG conversion factors	2021
Water	BEIS GHG conversion factors	2021

2.2 Data quality and methodology robustness

A baseline assessment is a first step in understanding emissions and plotting a route to reduce them. It is expected that there will be gaps and limitations that can be improved upon in subsequent assessments. Understanding where the main emission sources are and identifying these gaps is a key part of this process.

The reliability of the results of the GHG assessment depend on the quality of the data supplied and the robustness of the methodology applied (Table 4). Further information on how to improve the robustness of the data used in the assessment is available in Section 6.

Table 4. Summary of data quality and methodology robustness for each area of the GHG assessment.

	Data quality	Method robustness
Emissions		
Electricity		
Fuel		
Biomass		
Hydroelectricity		
Materials		
Capital items		
Livestock		
Transport		
Waste		
Water		

Data quality: Green = Complete, accurate data provided. Amber = Some data points have been estimated or calculated. Red = data are absent or based on conservative approximations using data from published sources.

Method robustness: Green = a robust approach with UK-specific emissions factors. Amber = emissions were estimated based on ADAS calculations, global emission factors were used, or the IPCC Tier 1 global methodology was used. Red = large uncertainties as little data provided upon which to build assumptions.

2.3 Scope 2 emissions

Scope 2 emissions includes indirect emissions associated with off-site generation of purchased electricity, heat, steam and cooling. In 2015, the GHG Protocol published its Scope 2 Guidance, an amendment to the Corporate Standard. These guidelines state that any operations in markets providing product or supplier-specific data in the form of contractual instruments shall report scope 2 emissions in two ways: one based on the location-based method, and one based on the market-based method, with each result labelled according to the respective method. This is also termed ‘dual reporting’.

The location-based method reflects the average emissions intensity of grids on which energy consumption occurs, while the market-based method reflects proportional emissions from specific electricity tariffs that companies actively select in the market and is therefore generally regarded as more accurate.

2.3.1 Scope 2 grid-exported renewable electricity

The GHG Protocol Scope 2 Guidance states that companies that export more electricity to the grid than they import "should treat their grid consumption as though it were supplied by their own generation facilities (e.g. as though they were an "on-site" source), with no additional emissions reported in scope 2." This means that, even though the electricity is being exported to the grid and then reimported, for the purposes of GHG protocol compliant accounting it can be treated as though all electricity was supplied on-site. In the case of the Mount Stuart Trust, the hydro-electric facility supplies more electricity than the site uses from the grid, so the market-based grid electricity emission is zero. The location-based grid electricity emission shows what the emissions from grid electricity would be in the absence of the hydro-electric site using a UK average emission factor for grid electricity.

2.4 Avoided emissions

Avoided emissions is a term for emissions that would have occurred but did not due to changes to energy production or land-use. For example, switching to biomass produces less emissions than what would have been produced by using natural gas, and the difference could be calculated as avoided emissions. However, there is no requirement in the Greenhouse Gas Protocol to report avoided emissions, and they cannot be used to offset any actual emissions incurred. Over time, the benefit of switching to renewable energy sources will become evident in reduced emissions associated with energy generation.

3 RESULTS

3.1 Overall emissions summary

Presented below are the overall results of the baseline GHG emissions assessment of the Trust 'in scope', separated into emission sources (Table 5).

Table 5. Summary of GHG emissions from the Trust 'in scope'. Note values are rounded to one decimal place.

Emission source category	Subcategory	GHG emissions (t CO_2e)	Percentage of total (%)
Fuel	Natural gas	107.4	24.6
	White diesel	42.0	9.6
	Red diesel	36.8	8.4
	Petrol	2.6	0.6
	Contractors' fuel	2.6	0.6
Electricity	Grid electricity (location-based)	109.3	25.0
Livestock	Methane	55.6	12.7
	Manure	5.4	1.2
	Feed	2.9	0.7
Renewables	Biomass	23.4	5.4
	Hydroelectric	20.5	4.7
Materials	Plastics	4.8	1.1
	Growing media	7.3	1.7
	Other	0.8	0.7
Capital items	Tools	0.2	0.0
	Machinery	7.3	1.7
Transport	Total	3.9	0.9
Other	Water supply and treatment	2.3	0.5
	Waste	0.2	<0.1
Total GHG emissions (location-based Scope 2)		**437.6**	**100.0**
Grid electricity (market-based)		0.0	
Total GHG emissions (market-based Scope 2)		**328.2**	

The following section presents greenhouse gas emissions from the Trust 'in scope' as determined by the location-based scope 2 approach, split by emission source (Figure 2), enterprise (Figure 3) and GHGP scope (Figure 4). Below each figure is a discussion of the key emission hotspots. Appendix 1 shows the same information but using the market-based scope 2 approach, which accounts for a reduction in accounted grid electricity emissions due to the hydro-electric facility.

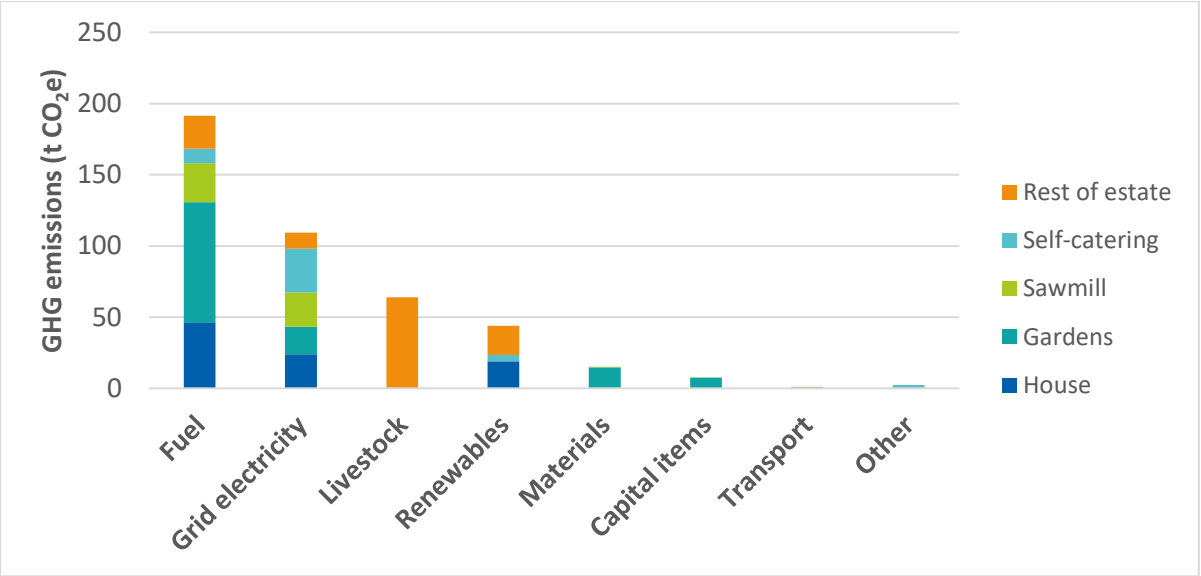


Figure 2. Breakdown of GHG emissions for the Trust 'in scope' split by emission source using the location-based approach.

Fuel use is the main emission source from the Trust 'in scope', accounting for 43.7% of total emissions. This is primarily driven by natural gas use for heating the house, greenhouses, other buildings part of the gardens and some of the self-catering properties (24.6%), followed by white diesel (9.6%) and red diesel (8.4%). A small amount of petrol was used, accounting for 0.6% of emissions, with contractors' fuel use in various projects around the house and gardens making up 0.6%.

Grid electricity was the second greatest emissions source (using the location-based approach), accounting for 25.0% of total emissions with approximately even usage across enterprises.

Only livestock directly managed by the Trust were included in this assessment, and they accounted for 14.6% of the total emissions. Their main contribution is in the form of enteric methane (from digestion) which is naturally produced by all ruminant animals (12.7%), followed by emissions of methane and nitrous oxide from manures (1.2%) and the embedded emissions in the production, harvest, processing and transport of livestock feeds (0.7%).

Renewable energy has some direct and embedded emissions in its production, and although these are lower than if the energy had been supplied by fossil fuels, it still accounts for 10.0% of the total emissions. Of this, 5.4% of total emissions is a result of the biomass boilers installed in the house and the self-catering buildings and 4.7% is from the operation of the hydroelectric facility.

Materials accounted for a small proportion of the overall emissions (3.5%) and largely consists of plastics used in the house (1.1%) and peat-free growing media purchased for the gardens (1.7%). Compost produced on-site contributed another 0.5% to the total GHG emissions.

Capital items, including tools and machinery, accounted for 1.7% of the total emissions. These emissions were estimated using the weight and materials of different capital items. This is the climate impact of manufacturing the products, while the transport and end-of-life emissions are captured in other categories.

Transport of all goods onto the site – fuels, materials and livestock – amounted to 0.9% of the total emissions and included road and ferry transport where applicable.

The other category contains emissions arising from the supply and treatment of water (0.5%) and emissions resulting from the disposal of waste from the site (<0.1%).

3.1.1 Breakdown by enterprise

Figure 6 presents the emissions from the Trust 'in scope' by enterprise. In this baseline assessment, five enterprises were considered.

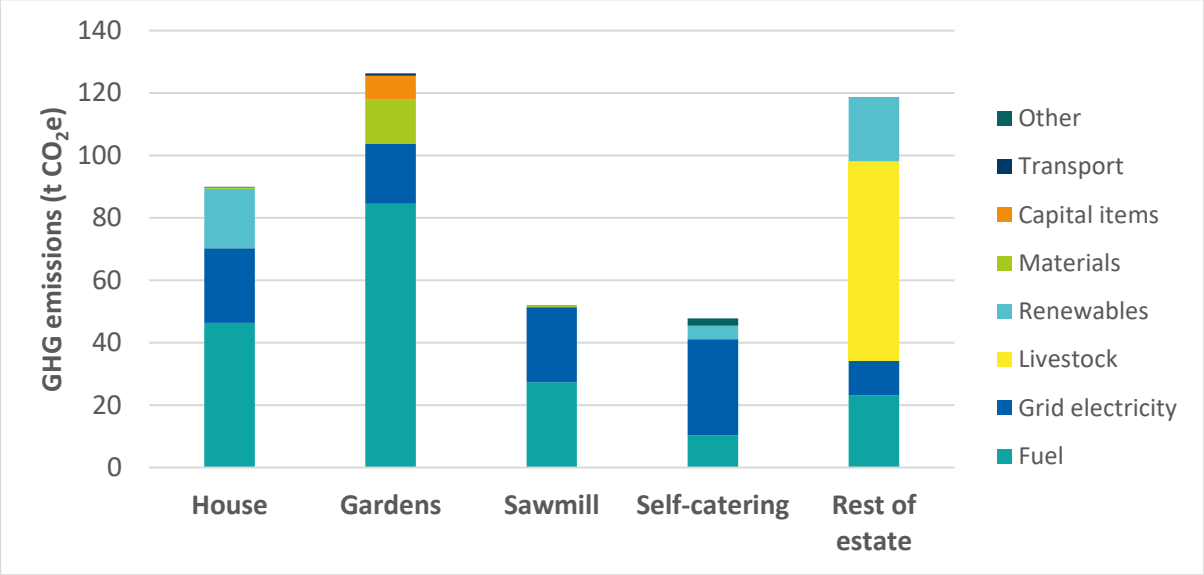


Figure 3. Breakdown of GHG emissions for the Trust 'in scope' split by enterprise using the location-based approach.

GHG emissions in the house are predominantly from heating. Natural gas accounted for 48.6% of the enterprise emissions, with grid electricity accounting for 26.6%. The biomass boiler produced 21.2% of the enterprise emissions, although emissions from biomass are much lower than a comparable amount of heat delivered via natural gas.

In the gardens, fuel dominates the GHG emissions, accounting for 66.9% of the enterprise total. This is primarily driven by natural gas, which is used for heating the greenhouses, the pavilion and other buildings (Table 6). Emissions from grid electricity and materials made up most of the remainder, accounting for 15.2% and 11.4%, respectively.

Table 6. Breakdown of fuel emission sources in the Trust gardens.

Fuel type	Share of total enterprise emissions (%)
Natural gas	43.4
White diesel	4.6
Red diesel	15.6
Petrol	1.9
Contractors' fuel	1.5

Emissions from the sawmill were dominated by fuel use (52.6% of total enterprise emissions) and grid electricity use (46.6%), with a small amount of embedded emissions in materials.

The self-catering buildings main emission source was grid electricity (64.6% of the enterprise total). This includes the electricity used for lighting and appliances, but also for heating in two of the properties. The second greatest emission source was natural gas (18.7%) and biomass (9.2%), both of which are used for heating in the self-catering properties. There is a more detailed discussion of the self-catering heating systems in section 4.4.

Direct and indirect emissions from livestock was the main emission source on the rest of the estate (53.9% of the enterprise total), arising from enteric methane, manure deposition and imported feeds. A more detailed breakdown of livestock emissions is presented in Table 7. Diesel fuel was the second greatest emission source (19.4%) followed by the production of renewable electricity at the hydro-electric site (17.3%).

Table 7. Livestock emissions per kg product and per hectare.

	Units	Value
Total GHG emissions	kg CO_2e	63,908.7
Total quantity product	kg	3,889.5
Total area grazed	ha	354.7
GHG emissions per kg product	**kg CO_2e/kg product**	**16.4**
GHG emissions per hectare	**kg CO_2e/ha**	**180.2**

3.1.2 Breakdown by scope

Figure 7 shows the breakdown of emissions by scope, as defined in the Greenhouse Gas Protocol Corporate Standard. Scope 1 comprises direct fuel use, scope 2 is the grid electricity used by the site (as per the location-based approach; for the breakdown under the market-based approach see Appendix 1) and scope 3 is the upstream and downstream emissions associated with scopes 1 and 2, as well as other emission sources including materials, capital items, livestock, transport, water treatment and waste. A more detailed breakdown of scopes is provided in section 1.2.1.

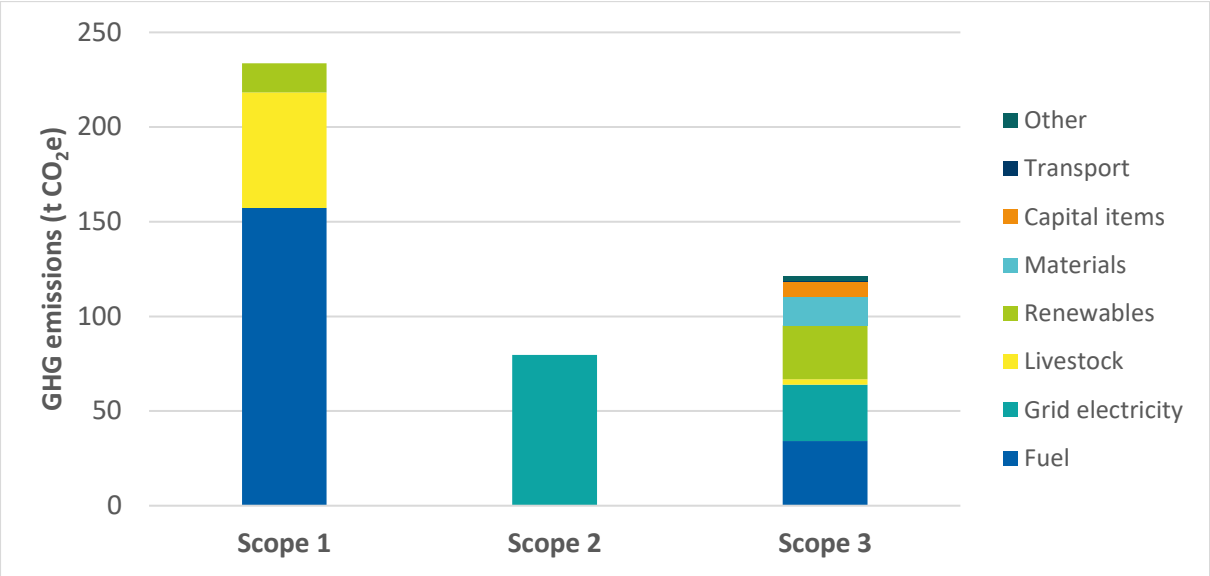


Figure 4. Breakdown of GHG emissions for the Trust 'in scope' split by GHGP scope using the location-based approach.

Scope 1 emissions are mostly made up of direct CO_2 emissions from fuels used by the Trust (67.3% of scope emissions) – mainly natural gas. Direct emissions from livestock, including enteric methane and manure deposition make up another 26.1% of this scope. A further 6.1% of Scope 1 emissions are direct emissions from the use of biomass boilers on the site.

Scope 2 emissions in this assessment is comprised solely of grid electricity.

Scope 3 includes all the upstream and downstream emissions associated with the Trust 'in scope'. The three main sources are fuel (the extraction, refinement and transport of fuels; 28.2% of Scope 3 emissions) grid electricity (fuels used in the generation of grid electricity; 24.4%) and renewables (embedded emissions in the production and operation of renewables; 23.5%). Minor sources within Scope 3 include embedded emissions in livestock feed and those associated with manufacture and disposal of materials and capital items, as well as fuel used in transporting goods.

4 OPPORTUNITIES TO REDUCE GHG EMISSIONS

This section provides a high-level overview of the types of actions Mount Stuart Trust can take to begin to address GHG emissions. The first section provides a high-level overview of actions that can be taken across enterprises to monitor fuel and electricity usage, improve energy efficiency and install additional renewable energy generation. The other sections provide more bespoke analysis and specific recommendations for some of the enterprises at Mount Stuart.

The Energy Saving Trust is an independent organisation that provides advice for consumers and business to reduce the climate impact of energy use – their website contains a lot of information covering many aspects of what is covered here. For many of these approaches, a more bespoke investigation is required which ADAS can facilitate.

4.1 Fuel and Electricity

Fuel was the main source of emissions for the Trust 'in scope', accounting for 43.7% of the total emissions. This is largely driven by natural gas used to heat the house, greenhouses and other buildings in the gardens, and the self-catering buildings.

Using the location-based approach, electricity was the second greatest source of emissions for the Trust 'in scope', accounting for 25.0% of the total emissions. There is a relatively even split of electricity use across all the enterprises assessed, so each one presents an opportunity to reduce electricity usage.

Energy audit

The first step to reducing fuel emissions is to understand what fuel is being used and where. This GHG emissions assessment provides a broad overview, but this should be further investigated by the Mount Stuart team. For example, they could seek to implement a system of recording fuel usage, either manually or using a smart pump, to understand which vehicles and site operations are using disproportionate amounts of diesel and petrol. Smart meters are available that can monitor natural gas usage in real time to identify activities that are disproportionately using natural gas.

As with fuel, the first step is to accurately understand how much electricity is being used and where. Smart meters can help to quantify this for each of the enterprises managed by the Trust. This can then inform an electricity reduction strategy. Monitoring meters as different appliance are switched on and off can help to identify where there are inefficiencies.

Improve efficiency

An energy audit would help highlight machinery that needs upgraded to more efficient models, or processes that could be made more efficient. It is also important to check that all heating systems are performing optimally, without leaks and with good insulation on all aspects of the heating system. Insulation in the house, self-catering buildings, greenhouses and other garden buildings should also be reviewed to ensure that it is as good as it can be within the limitations of the building designs.

Electricity use can be reduced by ensuring that appliances are as energy efficient as possible across all enterprises. This includes the easy wins such as switching to LED light bulbs and replacing small appliances with more energy efficient models (at the end of their lifecycle to avoid unnecessary downstream emissions). Larger appliances incur greater cost, so a considered cost-benefit analysis should be done before making any decisions to replace these. The Energy Saving Trust provide guidance for business looking to reduce energy use.

Renewable heating

Increasing the proportion of renewable heating would provide further opportunities to reduce the emissions associated with heating. The house and self-catering buildings already have some biomass installed, so there is a question of whether this can be expanded to further reduce emissions. Other popular options for renewable heating that could be explored are heat pumps, including air-source heat pumps (ASHP) and ground-source heat pumps (GSHP). The Energy Saving Trust also provide a comprehensive guide for businesses looking to install renewable heating systems, including an overview of each technology and details of funding options available. As part of the RSK Group, ADAS have access to a range of companies with extensive expertise in all aspects of renewable heating projects, including site assessment, planning and installation. Where more information is required, we can engage with these companies as appropriate.

Renewable electricity

There is no on-site renewable electricity generation by the Trust 'in scope', so this presents an opportunity to substantially reduce emissions through the installation of solar panels, wind turbines or biomass with CHP. The Energy Saving Trust provide an overview of the various approaches, including the benefits and drawbacks of each. It is important to consider the cultural and historic nature of the house, which potentially limits the application of some of these technologies. As with renewable heating, ADAS can engage with other RSK Group companies with expertise in renewable electricity projects as appropriate.

4.2 Mount Stuart House

4.2.1 Fuel

Mount Stuart House has installed biomass boilers which will have already reduced natural gas usage associated with heating. Mount Stuart Trust should explore the option of expanding this and/or installing additional renewable heating, e.g. from ground-source heat pumps, with the goal of heating the house with 100% renewable energy sources. The links in section 4.1 will provide a starting point to understand what options are available.

4.2.2 Materials and waste

Materials make up a small proportion of the emissions 'in scope', accounting for 3.5% of the total emissions. Most of the emissions in this category are from paper, plastic, and other materials used in the house café. There was limited resolution on the specific sub-sections of this category – e.g. organic waste versus plastics, which could be improved going forward. Other materials included construction materials such as aggregates and concrete which could vary from year to year but are typically used in long-term projects, so emissions are very low over the lifetime of the materials.

While waste is a small proportion of the site's emissions, it is an important topic to consumers and can be addressed in visible ways, by ensuring robust systems are in place for recycling, minimising unnecessary plastic waste, composting organic waste, etc. Trading in machinery avoids emissions associated with the end-of-life of the equipment.

Comparison of Vegware and stainless-steel cutlery

A brief analysis was done to compare the GHG emissions from using Vegware compostable products versus using typical stainless steel cutlery (which require washing). An emission factor for Vegware products was unavailable so cardboard was used as a proxy, although this may or may not be accurate.

Vegware

The EF for cardboard is 0.82 kg CO_2e/kg (BEIS, 2021). Mount Stuart used 123.6 kg of Vegware products in the baseline assessment year, which, assuming the EF is representative, produced 101.5 kg CO_2e.

Stainless steel cutlery

The primary manufacture of stainless-steel cutlery has an EF of 3.10 kg CO_2e/kg (BEIS, 2021; steel cans). One load of dishes washed by hand, with careful use of hot water, produces 0.36 kg CO_2e, while a full load of a dishwasher produces emissions of 0.47 to 0.60 kg CO_2e depending on the temperature, and includes the embedded emissions of the product manufacture and disposal (Berners-Lee, 2020). Almost all these emissions are in the energy used to heat the water.

Conclusion

Using these figures, Mount Stuart can determine the best approach based on the quantity of cutlery required. In general, it seems that washing stainless steel cutlery is the best approach long-term, since almost two full dishwashers of cutlery could be washed for the same emissions as 1 kg of cardboard and is even more effective where water is heated from renewable sources. It is, however, also important to consider the practical implications of any decision and to bear in mind the restriction of not knowing the Vegware EF.

4.3 Gardens

The gardens at Mount Stuart consist of several heated buildings, including a pavilion, greenhouses, an office and a staff breakroom. Details of these buildings are shown in Table 8.

Table 8. Details of buildings in Mount Stuart gardens.

Building	Estimated area (m^2)
Staff breakroom (bothy)	16
Office	24
Boot room	24
Four greenhouses	208
Pavilion	292

AHDB have prepared a comprehensive guide to minimising energy use in greenhouse production, including monitoring and benchmarking energy usage, improving the efficiency of equipment and installing renewable energy sources. AHDB have also published a report written by ADAS which explores a range of techniques to reduce GHG emissions in protected horticulture. Both reports provide detailed discussion on how biomass can be implemented into greenhouse production systems which would be a favourable option for Mount Stuart, with the opportunity to relocate the greenhouses closer to the house where they can benefit from spare biomass capacity.

It would be useful to measure the natural gas usage in each of these buildings to better understand where the greatest energy requirement is to help prioritise action.

4.4 Self-catering buildings

A brief analysis was done to compare and benchmark the self-catering buildings. There were limited data, but there is an indication that recent work to improve the sustainability of these buildings has led to lower-than-average energy use figures (Table 9).

Table 9. Comparison of energy efficiency of self-catering buildings to average values for "residential/self-catering accommodation" (CIBSE Guide F - Energy efficiency in buildings, 2012).

Section	Area (m^2)	Heating source	Electricity (kWh/m^2)		Natural gas (m^3/m^2)	
			Mount Stuart	Average	Mount Stuart	Average
Kerryniven	103	Natural gas	51.7	54	16.0	240
Nether Stravanan (N)	179	Electricity	153.7	54	0.0	240
Nether Stravanan (S)	267	Electricity	136.1	54	0.0	240
Quien SW (Bannatyne)	153	Biomass	53.3	54	0.0	240
Quien NE (Spence)	162	Biomass	24.0	54	0.0	240
Woodend	283	Biomass	77.7	54	0.0	240
The Kennels	109	Natural gas	24.9	54	19.4	240

The self-catering properties at Mount Stuart have a range of heating systems, including natural gas, electricity and biomass. Both properties using natural gas had lower electricity use per square metre than average, as well as much lower natural gas use per square metre than average. Electricity use at the properties with electric heating was approximately three times higher than the average figures. Properties using biomass were, on average, approximately in line with benchmark figures in terms of electricity use per square metre (Quien NE was lower, Woodend was higher, Quien SW was equal), although it should be noted that data for the two Quien properties were unavailable and so was populated based on figures from Woodend. The difference in electricity usage between the two Quien properties may be due to differences in occupancy levels across the year.

The priorities for the self-catering buildings should be to investigate the current level of insulation, of the building and any hot water tanks, and continue to monitor energy use over time. Mount Stuart should consider replacing the natural gas heating systems with renewable heating systems, such as electricity (coupled with renewable energy generation e.g. solar panels), ground-source heating or biomass. The existing electric heating systems should be connected to renewable energy sources to minimise costs and greenhouse gas emissions associated with grid electricity.

4.5 Livestock

The Mount Stuart Trust manage a farm on moorland near Mount Stuart House, where a growing flock of cheviot ewes are kept to maintain the land and produce food. They also provide indirect benefits to the site in terms of aesthetic value and play a role in landscape management. However, livestock have high levels of emissions, mainly due to enteric fermentation, which produces methane as a by-product of digesting fibrous plant material. High-level figures are provided here for livestock, but these can be explored in more detail in future, including benchmarking against similar livestock systems. The main principles with reducing GHG emissions in a livestock system are:

- Optimise productivity to dilute emissions over a greater quantity of finished product
- Minimise mortality through active health planning
- Optimise concentrate feed use
- Explore use of methane inhibitors

Optimising productivity of a livestock system is one of the most effective ways of reducing emissions. This involves optimising nutrition and management to achieve target growth rates and support target age at first lambing and age at slaughter. Lambing earlier increases lifetime productivity which dilutes emissions over a greater quantity of product while optimising age to slaughter minimises unnecessary time on farm and associated emissions from enteric fermentation, manure and feed.

An element of productivity also considers minimising losses, which active health planning can support with. This involves proactive planning of vaccinations and other preventative treatments, regularly reviewing stock health, identifying and treating problems early, monitoring health related KPIs etc. Over time, it can reduce mortality rates and result in a greater amount of finished product for the same inputs, diluting GHG emissions.

Concentrate feeds were a small part of the livestock emissions but nonetheless should be managed as efficiently as possible. Splitting the stock into batches with different feed requirements, optimising the timing of concentrate feed, and linking feed to body condition can all help reduce excess concentrate feeding.

Finally, methane inhibitors are an emerging market of products that can potentially reduce enteric methane emissions in livestock systems. There are several products in development, all with varying levels of efficacy. It is important to consider that currently they must be incorporated into the ration so are most applicable to periods of the year where the stock are housed.

It is also important to consider livestock's role in providing cultural value to the Trust, producing nutritious food and, where managed accordingly, enhancing biodiversity through habitat creation.

4.6 Other

Staff carbon/sustainability training

One option that could run in parallel to the work being done around the GHG emissions assessment and wider sustainability strategy could be to run a workshop for the Trust's staff. This would serve multiple purposes:

- Raise the profile of the work Mount Stuart is doing and demonstrate their commitment to improving sustainability
- Inform staff and encourage them to engage with the process
- Collect feedback from staff on what is important to them and what changes they would like to see.

ADAS have excellent background in developing and delivering training materials in carbon, greenhouse gas emissions and sustainability as well as hosting workshops for farmer groups, community stakeholders and corporate teams. We would be well positioned to work with the Mount Stuart team to present the findings of the GHG emissions assessment to a broader audience and run a workshop to inform staff how they can play a part in reducing the climate impact of the Trust and collect feedback on what changes they would like to see.

5 CARBON STORAGE AND SEQUESTRATION

In land-based systems, GHG emissions can potentially be partially balanced by carbon sequestration – the removal of carbon from the atmosphere into soils and vegetation where it can be stored long-term. It is therefore important to understand both the total quantity of carbon in these stores (which should be protected) and the annual increase in carbon via sequestration.

Given the extensive land area of the Trust, particularly of woodland and permanent grassland, there is considerable carbon stored on the site. There may also be substantial carbon sequestration, depending on the management of this land.

Note that there are several factors that determine whether carbon sequestration is occurring:

- Permanence: Carbon sequestration is reversible (i.e. stored carbon can be lost as carbon dioxide) so new management practices must be maintained in order to preserve accumulated carbon and stored carbon must be protected.
- Leakage: Changes in management practice that increase soil carbon may result in a decrease in soil carbon elsewhere, e.g. moving manures from one farm to another.
- Saturation: Soil will eventually become saturated, and woodlands and hedgerows will reach maturity, at which point no further carbon sequestration can happen.
- Quantification: It is difficult and expensive to measure soil carbon accurately so proxies and models are used, although actual figures may vary substantially depending on the site.

Future work should seek to assess the carbon stores on Trusts' land and estimate the potential annual carbon sequestration. This can then be balanced against the GHG emissions produced by the Trust to give a full picture of where the Trust currently sits in relation to net zero.

6 IMPROVING ASSESSMENT ROBUSTNESS

6.1 Gaps in existing data

Overall, the data supplied for this baseline assessment was of high quality due to the strong engagement from the Mount Stuart team. However, due to time constraints and lack of data availability in some areas, there are still some gaps and assumptions made. Table 10 provides an overview of these and gives recommendations for how to address going forward.

Table 10. Summary of data gaps and recommendations

Data gap	Recommendation
Data on the heat output of biomass was only available for Mount Stuart House and is not currently being measured in the self-catering properties.	Already plans in place to connect the self-catering biomass to a meter to collect this data.
Several assumptions made on the fuel usage associated with contractors' projects.	This could be collected in more detail during each project undertaken, although it is a small proportion of total emissions so the impact is minimal.
There was limited resolution in terms of the waste streams leaving the house, e.g. no split between plastics and organic waste.	It would be useful to collect information on the total quantity of different types of waste leaving the site – although again the impact on overall emissions is minimal.
Limited resolution on livestock management.	Future reports could explore in more detail the impact of livestock managed by the Trust, capturing information such as housing duration, KPIs, yield information etc.
Several assumptions were made on the transport distances for various materials and products coming on to the site.	Accuracy of transport emissions only really becomes a concern when large volumes of products are transported long distance, which wasn't the case in this baseline assessment.
Assumptions were made surrounding the weight and type of materials used in capital items and therefore the embedded manufacturing emissions.	In general, product suppliers don't publish the GHG emissions associated with the manufacture of their product so this approach provides a reasonable estimate where no other information is available.

6.2 Expanding scope of assessment

For the baseline assessment it was necessary to confine the boundary of the assessment to those enterprises which have the greatest impact on emissions and/or for which data was more easily accessible. Future work should seek to expand the boundary to include all relevant enterprises within the Trust, including all scope 3 emissions. This would include, in addition to the enterprises in the Trust 'in scope':

- Golf courses
- Other buildings

- Leased agricultural land
- Forestry and woodland

Including golf courses and other buildings in the Trust's property portfolio should be relatively straightforward since the main emission sources in these enterprises are likely to electricity and fuel. Including the leased agricultural land and forestry would add additional complexity, but ADAS are experts in undertaking land based GHG emissions assessments. We would be able to work with Mount Stuart to develop an approach that makes the data collection process as easy as possible. These additional enterprises, particularly the leased agricultural land, may be responsible for a substantial share of the emission of the Trust.

7 APPENDIX 1

This section presents the GHG emissions from the Trust 'in scope' using the market-based scope 2 approach, split by emission source (Figure 3), enterprise (Figure 2) and scope (Figure 4). It shows the impact of accounting for a reduction in grid electricity emissions due to the hydro-electric facility. See section 2.3 for more information.

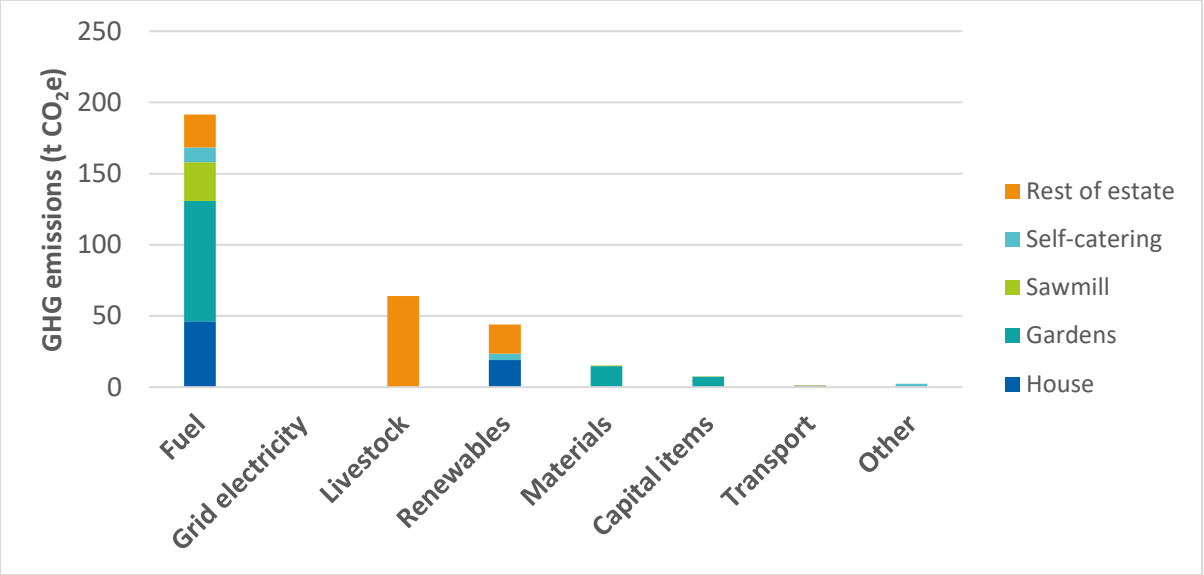


Figure 5. Breakdown of GHG emissions on the Trust 'in scope' split by emission source using the market-based approach.

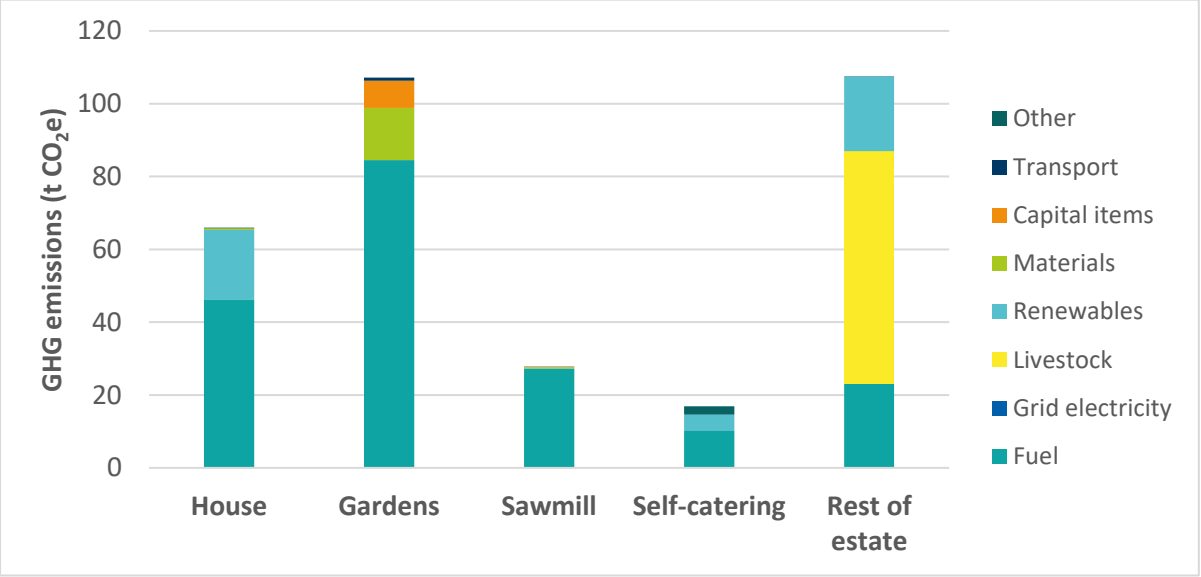


Figure 6. Breakdown of GHG emissions from the Trust 'in scope' split by enterprise using the market-based approach.

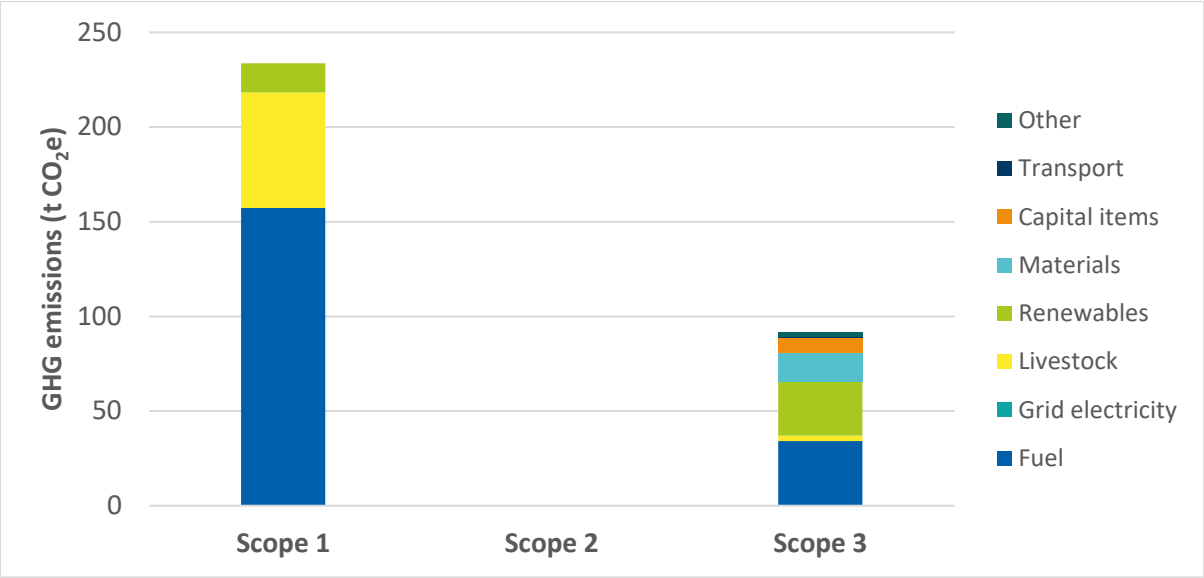


Figure 7. Breakdown of GHG emissions on the Trust 'in scope' split by GHGP scope using the market-based approach.