



Esken Renewables

Carbon and Sustainability Report

For Esken Limited

Document Control

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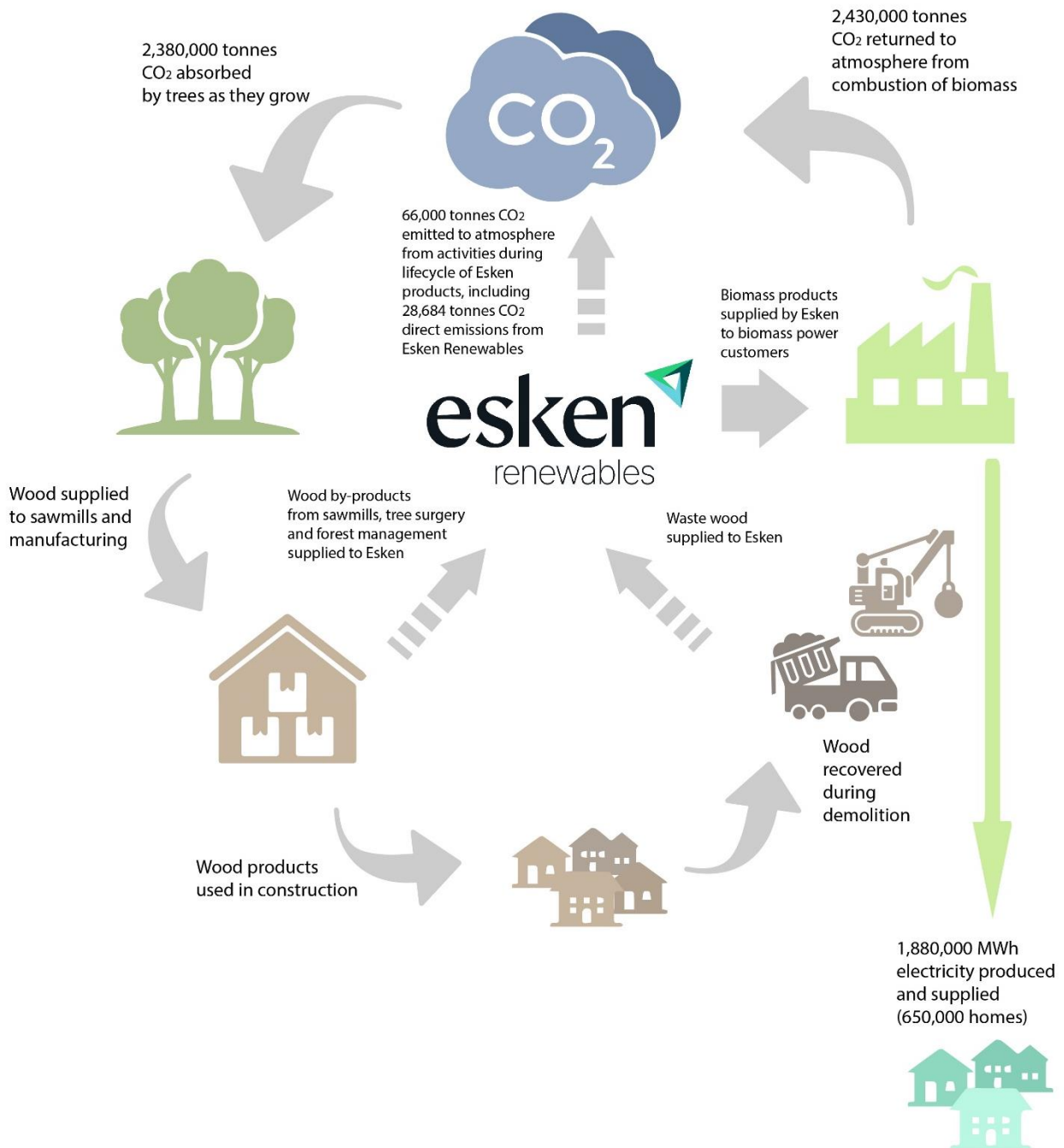
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Executive Summary

Esken Renewables provide sustainable biomass fuel products, primarily for use in power stations generating energy. The primary biomass streams that feed the Esken Renewables business are waste wood and forestry by-products such as sawmill offcuts, branch and bark materials, wood from tree surgery, and wood from forest management. The GHG lifecycle of Esken Renewables biomass products is illustrated below.



Avoiding GHG Emissions

By treating 1.1m tonnes of waste wood that would otherwise be sent to landfill, Esken Renewables and its supply chain partners and customers, enable the avoidance of 630,000 tonnes of GHG emissions per year from landfilling waste wood.

By supplying a total of 1.4m tonnes of waste wood and forestry by-products for energy generation, Esken Renewables enables its supply chain partners and customers to save 714,000 tonnes of GHG emissions per year from gas-fired electricity generation.

In total the GHG savings from avoiding landfilling of waste wood and gas-fired electricity generation total around 1.344MTCO₂e in FY22.

Esken Renewables Emissions

Esken Renewables activities currently lead to the release of GHG emissions, primarily related to emissions from the Company's fleet of haulage vehicles, as well as diesel-fired machinery at Esken's nationwide processing sites.

Esken Renewables Company GHG emissions total around 29,000 tonnes per annum, around 95% of which are related to diesel fuel consumption in Esken Renewables' haulage vehicles and machinery and third-party haulage vehicles.

Esken Renewables plan to tackle these emissions in the future through the use of biofuels in site machinery, which could reduce emissions by up to 13% in the near future. Future electrification of site plant and the introduction of zero emission haulage vehicles in the next decade will further reduce this.

Decarbonising Esken Renewables' Customers Energy Generation

By supplying renewable biomass products to supply chain customers and partners, Esken Renewables enables the production of low carbon energy for use by homes and businesses.

GHG emissions from Esken Renewables' customers equates to around 2.4 MTCO₂e per year, the vast majority of which is balanced by CO₂ absorbed by the biomass during its growth cycle, ensuring the energy generated has low carbon intensity over its lifecycle.

The residual carbon intensity of electricity exported by Esken Renewables' customers is around 65 gCO₂e/kWh, which is around 6 times lower than natural gas power generation.

In FY22 Esken Renewables supplied over 1.1 million tonnes of waste wood to biomass power customers, that would have otherwise been sent to landfill and saved around 630,000 tonnes of additional GHG emissions to atmosphere from landfill methane gas.

Esken Renewables' customers in FY22 used the total of 1,474,000 tonnes of biomass supplied by Esken to generate an estimated 1,880,000 MWh of electricity, which is sufficient to power around 650,000 homes. If this electricity were to be generated using natural gas power stations, the resulting fossil GHG emissions would be around 714,000 tonnes.

The power plants also export heat to consumers which replaces heat and offsets emissions generated by fossil fuel heat sources such as natural gas. Esken Renewables themselves use some waste heat from a biomass customer for waste drying at the Widnes site, saving up to 12,000 tonnes of CO₂ per year, equivalent to over 40% of Esken's own GHG footprint.

Supporting Small Businesses

In addition to providing substantial volumes of wood products to customers operating large-scale biomass power plants, Esken Renewables also provide products to a wide range of small businesses including small-scale biomass CHP operators, fruit and vegetable growers, poultry farms and plant nurseries where they generate low carbon energy to reduce their own carbon footprints.

Future Outlook

In the future, it is anticipated that Esken Renewables' customers will be able to upgrade their power plants to include carbon capture and storage, potentially creating carbon negative power stations and significantly contributing to the UK's efforts of achieving net zero carbon by 2050.

1 Introduction

1.1 Setting of Report

Stobart Energy is the UK's leading supplier of commercial biomass, used for generating energy in a number of UK biomass plants. A combination of waste wood and forestry by-products biomass are supplied, both of which benefit from being considered renewable energy resources.

It is understood that Stobart Energy are currently undertaking a rebranding, and will in the future be referred to as Esken Renewables.

Esken Limited are keen to understand the carbon emissions and wider environmental credentials of Stobart Energy's operations, and identify how the process of biomass fuel production and use compares in carbon and general environmental terms to other forms of energy generation.

Logika have been commissioned on behalf of Esken Limited to assess and compare the carbon accounting of Stobart Energy's biomass operations. The findings of this report will be used to provide technical third party support to feed into the key sustainability messages as part of the proposed rebranding. For the purpose of this report, Stobart Energy is hereafter referred to as Esken Renewables.

1.2 Carbon and Climate

Climate change (sometimes also referred to as Global Warming) describes the change in the global climate caused by the release of greenhouse gasses¹ (GHGs) which act to trap heat within the earth's atmosphere. Climate change includes changes (both globally and regionally) of temperature, rainfall, frequency of storms, and sea level.

GHGs include emissions that occur naturally, for example due to release of methane from peat bogs as well as from human activity, for example due to the combustion of fossil fuels. The primary GHG is Carbon Dioxide (CO₂) which accounts for over 90% of all GHG emissions.

Key sources of human induced GHG include the combustion of hydrocarbon-based fuels (e.g. petrol, diesel, kerosene) in motorised transport, combustion of coal, gas, and oil for the generation of electricity, combustion of gas and oil for heating, and from industrial processes, for example the production of cement, steel, and glass.

¹ GHGs are atmospheric emissions defined as having an effect on global climate and include carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF₆), and nitrogen trifluoride (NF₃).

To simplify the measurement of GHG it has become normal practice to present them in a common unit called Carbon Dioxide Equivalent (CO₂e). This takes into account that some GHGs result in greater warming than others.

For example, 1kg of methane which is a GHG has the same effect on climate as 28-36kg of CO₂. To convert methane to CO₂e it is therefore multiplied by a factor between 28 and 36. CO₂ on the other hand is multiplied by 1.

Climate change is a global issue, and is therefore the subject of an international response. To meet this challenge members of the United Nations signed the United Nations Framework Convention on Climate Change (UNFCCC) in 1992 whose objective is to stabilise global climate change.

Members of the UNFCCC meet regularly to agree and ratify international treaties to meet this objective, the most recent and significant of which has been the Paris Agreement signed in 2016. This seeks to limit global climate change to less than a 2 degrees Celsius increase by the end of this century, with an ambition for this to be no more than 1.5 degrees.

To keep global temperature rise below 2 degrees, scientists have calculated that net global emissions² of GHG need to fall to zero by the 2080s, and to meet a 1.5-degree objective to be net zero by 2050. It is the responsibility of individual country states to set national policy that contribute to these global goals, reflecting each country's historic responsibilities and level of economic development. In other words, developed countries like the UK are expected to cut their GHG emissions faster and deeper than developing countries. Through the Climate Change Act the UK has therefore set a legally binding target to reduce its GHG emissions to net zero by 2050.

The Government recognises a key role for biomass in the transition to net zero by 2050 and sets out the need to switch from fossil fuel energy production to low carbon energy production (including biomass) in its recently published Industrial Decarbonisation Strategy³. The Government have also pledged to publish a Bioenergy Strategy in 2022, which would provide a more detailed plan for the use of biomass fuels in the transition to a net zero economy.

Through the application of Carbon Capture and Storage (CCS), it is also possible that in the future, biomass power plants can become net carbon negative (i.e. permanently remove CO₂ from the atmosphere) which would cement the role of biomass in long term energy generation.

² Net emissions reflect that there are both sources of emissions, for example combustion of fuels that add emissions to the atmosphere and carbon sinks, for example trees, that reduce GHG emissions in the atmosphere. The balance between the two are net emissions

³ Department for Business, Energy and Industrial Strategy (2021) Industrial Decarbonisation Strategy

2 Greenhouse Gas Footprint

2.1 Background

As a biomass fuel supplier, Esken Renewables facilitates the production of green energy (electricity and heat) in its customers' power plants using sustainable biomass fuels.

Esken Renewables has two main UK supply chains for biomass fuels:

- **Waste wood:** wood products that have reached the end of their useful lifetime and have become a waste material, such as wood recovered from building deconstruction, wood from landscaping and gardening projects, and wood from domestic recycling centres.
- **Wood by-products:** these are by-products from the wood products industry, such as bark and branch material and offcuts from sawmills producing commercial wood products, wood from tree surgery, wood from highway and railway clearance and maintenance, and forestry management.

Each of these wood sources can be considered to be part of a sustainable carbon lifecycle, which is explained in the sections below.

2.1.1 Waste Wood

Esken Renewables receives waste wood from suppliers in the UK for conversion into wood chips for use in customers' biomass power plants.

When wood products used in construction come to the end of their useful life, they become a waste product. In most cases, due to the quality of these waste products it is not possible to prolong the life of all waste wood by reuse or recycling (e.g. recycled panel boards or landscape surfaces) and it is necessary to treat or dispose of this wood. Biomass energy is the best solution for this wood to recover energy, as the most likely alternative would be disposal in landfill which has no substantive secondary benefits.

Disposal of waste wood in landfill would also lead to emissions of methane during decomposition of the wood, which is a very potent GHG responsible for considerable global warming. Further discussion on methane emissions is provided in Section 3.2.

The carbon cycle associated with the waste-wood supply chain is related to the fact that CO₂ emissions from the combustion of the waste wood are broadly equal to the CO₂ that was absorbed from the atmosphere by the trees during their growth cycle. Wood products serve a primary lifetime as building materials, furniture etc. before they become a waste and are utilised for energy production. The production of energy from waste wood therefore provides a secondary benefit at the end of the primary lifetime of the wood.

2.1.2 Wood By-products

Esken Renewables also work with a wide range of suppliers to source sustainable wood by-products for conversion into wood chips for use in customers' biomass power plants. Esken Renewables also work proactively in forestry management, providing advice on effective tree thinning to maximise the growth potential of a woodland plantation.

As part of the life of a sustainable forest, wood is routinely cropped and used for the manufacture of wood products such as sawn wood, flooring, doors, fencing, furniture, panel boards and MDF, or felled in order to make space for effective tree growth and create a healthy woodland. The process of cropping the trees and making the wood products results in a supply of wood by-products, which if left unused would simply biodegrade and release much of its stored carbon to the atmosphere.

By using these wood by-products for the production of biomass wood fuels for energy generation, the carbon is still returned to the atmosphere, but a useful commodity is produced (electricity and heat) which reduces the need for energy from fossil fuel combustion and ultimately results in lower overall GHG emissions to the atmosphere.

There are some emissions associated with fuels consumed by machinery used to crop the trees and transport and process the wood by-products into wood chips, but these emissions are relatively small. Furthermore, Esken Renewables is proactively exploring initiatives to reduce and eventually eliminate these emissions in the future through the use of biofuels, and the conversion of diesel-powered processing equipment to electric-powered versions as discussed in Section 4.

2.2 Scope of Esken Renewables GHG Footprint

2.2.1 Esken Renewables Corporate GHG Footprint

In reporting GHG emissions associated with a Company's activities, the best practice approach is to follow the GHG Protocol⁴, which is the agreed international standard for GHG emissions reporting.

The GHG protocol divides all GHG emissions into three categories, referred to as Scopes, which are defined as follows:

- **Scope 1 GHG Emissions:** these are emissions directly related to a Company's activity such as fuels used by Company owned vehicles and assets.
- **Scope 2 GHG Emissions:** these are emissions released by third parties in the generation of energy (i.e. electricity or heat) purchased by the reporting Company.
- **Scope 3 GHG Emissions:** these are indirect emissions related to the Company's customers and supply chain.

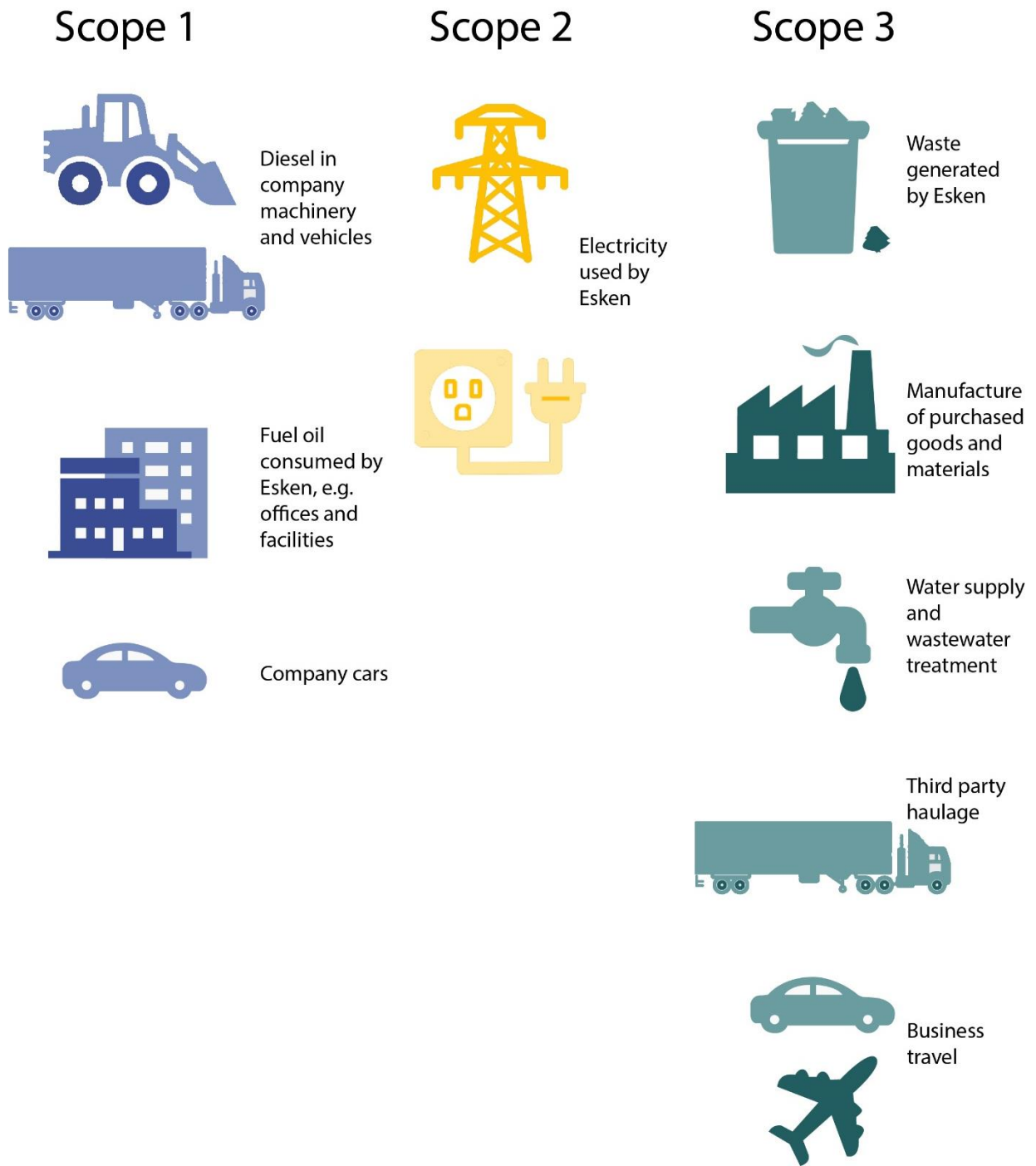
In relation to Esken Renewables, the Scope 1, 2 and 3 emissions associated with the business, which form the Company's carbon reporting envelope, are summarised in Table 2-1 and Figure 2-1.

⁴ <https://ghgprotocol.org/>

Table 2-1 Esken Renewables Scope 1, 2 and 3 GHG Emissions

GHG Emissions Scope	Associated Activities
Scope 1	<ul style="list-style-type: none"> • Diesel fuel consumed in Esken’s vehicle fleet for collection of wood by-products and waste wood from suppliers, and delivery of processed wood chips to customers. • Diesel fuel consumed by plant and machinery in Esken-owned processing facilities such as Tilbury and other facilities. • Fuel oil used for heating and hot water in offices and welfare facilities owned or leased by Esken Renewables. • Emissions from Esken Renewables’ company cars.
Scope 2	<ul style="list-style-type: none"> • Electricity purchased by Esken Renewables and used on all Esken owned or leased offices and facilities.
Scope 3	<ul style="list-style-type: none"> • Emissions from the mining, processing, and manufacture of goods and raw materials consumed by Esken Renewables (e.g. tyres and batteries for fleet vehicles, oils and lubricants for plant and fleet). • Emissions from water supply and wastewater treatment for water used in all Esken Renewables owned and leased offices and facilities. • Emissions from business travel by land, air, and sea. • Emissions associated with the treatment or disposal of waste generated by Esken Renewables. • Emissions associated with haulage of wood to Esken facilities or from Esken to customers by third party hauliers.

Figure 2-1 Esken Renewables Scope 1, 2 and 3 GHG Emissions



It should also be noted that for some Scope 3 emissions such as recycling of ferrous metals, although there may be GHG emissions associated with the recycling process, these emissions would be much lower than those associated with the production of new ferrous metal products, and this is therefore a potential benefit in terms of overall GHG emissions. This is further discussed in Section 3.3.

2.2.2 Wider Scope 3 Emissions

It is also important to acknowledge that there are other wider Scope 3 GHG impacts associated with Esken Renewables’ activities, which affect the overall carbon intensity (i.e. lifecycle carbon emissions) associated with Esken customers’ biomass power plants, which are set out in Table 2-2. These additional Scope 3 emissions, which are all important to the overall carbon lifecycle are further described in Section 2.4.

Table 2-2 Esken Renewables Wider Scope 3 GHG Emissions

Scope 3 GHG Emissions Activity	Description
Combustion of wood chip in biomass power plants	Downstream of Esken Renewables, the combustion of biomass wood products in biomass power plants results in the release of GHG emissions to atmosphere.
Sequestration of atmospheric carbon dioxide by trees	Upstream of Esken Renewables, the trees which form the biomass supplied by Esken (both wood by-products and waste wood) removed carbon dioxide from the atmosphere during their growth cycle. This constitutes a negative GHG emission (i.e. a GHG removal) which balances with the GHG emissions from combustion of the wood chip in biomass power plants.
Emissions from tree felling/forest management, transport, and processing of wood by-products	Upstream emissions released, predominantly due to diesel and electricity consumption in vehicles and machinery associated with felling, forest management, and the transport and processing of wood products before distribution of the by-products to Esken Renewables. This applies to the wood by-products stream.
Emissions from waste sorting, processing and transport associated with waste wood	Upstream emissions associated with the transport, sorting and separation, and processing of waste wood by Esken Renewables waste wood suppliers. This applies to the waste wood stream.

The major Scope 3 source is emissions (predominantly CO₂) from combustion of the biomass wood chip products in Esken customers’ biomass power plants. Although these emissions contribute to global warming, the carbon emitted was removed from the atmosphere by the trees which provide the source of the wood, and therefore a carbon cycle is created.

Where wood is sourced from sustainable forestry and tree plantations are replaced as they are cropped, then this creates a close-to net zero carbon lifecycle, with carbon emitted by combustion of wood near to equalling the carbon removed from the atmosphere by the trees as they grow. The only additional emissions are therefore associated with felling or forest management, transport, and processing of wood chips (for the wood by-products part of the business) as well as waste processing and transport emissions (for the waste wood part of the business). This carbon lifecycle is explained further in relation to Esken Renewables' business in Section 2.3.3.

2.3 Quantification of Esken Renewables GHG Footprint

2.3.1 Esken Renewables Corporate GHG Footprint

The key components of Esken Renewables' GHG footprint are described in Section 2.1 and Table 2-1, and principally relate to the use of fuels in the Company's fleet of vehicles and machinery.

A summary of the annual GHG footprint for Esken Renewables is provided in Table 2-3.

This footprint matches the footprint provided for Company reporting, with the addition of emissions from third party hauliers. Technical details of the inputs to these calculations are provided in Appendix A1.

The predominant source of emissions is diesel fuel use in Esken Renewables' fleet of haulage vehicles and site plant, together with third party haulage vehicles, which make up around 95% of the total annual GHG footprint.

Esken Renewables are committed to working to reduce these emissions over the coming years and further details of measures to reduce these emissions is discussed in Section 4.

Table 2-3 Esken Renewables GHG Footprint (FY22 March 2021 - February 2022)

GHG Emissions Scope	Activity	Annual GHG Emissions (TCO ₂ e)	Scope Total	% of Total
Scope 1	Diesel fuel used in Esken Renewables haulage fleet	11,828	15,604	54.4 %
	Diesel fuel used in Esken Renewables site plant and machinery	3,726		
	Domestic heating oil used at Esken sites	2		
	Esken company cars	48		
Scope 2	Electricity consumption	1,106	1,106	3.9%
Scope 3	Esken business travel (land, sea, and air)	41	11,975	41.7 %
	Water supply and treatment	8		
	Goods consumed by Esken Renewables (e.g. tyres, batteries)	72		
	Treatment and disposal of waste generated by Esken Renewables	112		
	Third party haulage of Esken Renewables biomass fuels	11,741		
TOTAL ANNUAL GHG EMISSIONS		28,684 TCO₂e		

2.3.2 Wider Scope 3 Emissions

It is also important to acknowledge that there are other wider Scope 3 GHG impacts associated with Esken Renewables’ activities, which affect the overall carbon intensity (i.e. lifecycle carbon emissions) associated with Esken customers’ biomass power plants. These additional Scope 3 emissions are described in Table 2-4.

This is based on FY22 data. Technical details of the inputs to these GHG calculations are provided in Appendix A1.

Table 2-4 Esken Renewables Wider Scope 3 GHG Emissions

Scope 3 GHG Emissions Activity	Annual GHG Emissions (TCO ₂ e)	Emissions per Tonne of Biomass (kgCO ₂ e/T)
Combustion of wood chip in biomass power plants	2,433,313	1,651
Sequestration of atmospheric carbon dioxide by trees	-2,378,124	-1,613
Emissions from tree felling/forest management, transport, and processing of wood by-products	12,909	39.8
Emissions from waste wood transport, sorting and separation, and processing	24,476	21.3
Esken Renewables Emissions (Table 2-3)	28,684	19.5
TOTAL EMISSIONS	121,258	82.3

The data in Table 2-4 demonstrates that the largest contributor to GHG emissions is emissions from the combustion of biomass by Esken customers. However, the majority of these emissions are balanced out by carbon dioxide absorbed from the atmosphere by the trees which form the source of the biomass. The residual GHG emissions are 121,258 tonnes per annum.

2.3.3 Electricity Generation

Biomass power plants, such as those operated by Esken Renewables’ customers, provide a constant, reliable electricity supply to power homes and businesses, without which electricity would need to be generated by other means, including natural gas power stations.

The lifecycle GHG emissions from biomass power stations are very low (see Table 2-5) due to the removal of carbon from the atmosphere by the trees that constitute the wood used during their growth cycle.

Esken Renewables provided 1,474,000 tonnes of biomass fuel to customers’ power plants in FY22. This was used to generate an estimated 1,880,000 MWh of electricity.

If this amount of electricity were to be generated by natural gas power stations, it would result in the emissions of approximately 714,000 tonnes of fossil CO₂e to the atmosphere.

Ofgem estimate that average UK household electricity consumption is 2,900 kWh/year. On this basis, the electricity generated by Esken Renewables’ customers is enough to power approximately 650,000 homes.

2.3.4 Heat for Waste Drying

Esken Renewables require heat for drying of wood chips (principally those sourced from wood by-products) before distribution to customers. Currently, drying facilities at Widnes and Clacton-on-Sea operate using low carbon heat from the nearby biomass power plant and therefore avoids the combustion of fossil fuels to heat the drying processes. For example, at the Widnes site, Esken Renewables currently use 7MW of heat from the biomass plant for wood drying. This alone saves up to 12,000 tonnes of GHG emissions per year from the use of natural gas heat for wood drying, which is equivalent to over 40% of Esken Renewables' GHG footprint (as set out in Table 2-3) and a considerable saving.

A portion of the wood dried at Widnes (and at a similar third party site at Clacton-on-Sea) is supplied to a range of small business end users, which are discussed further in Section 5.1.

2.4 Esken Renewables Carbon Lifecycle Analysis

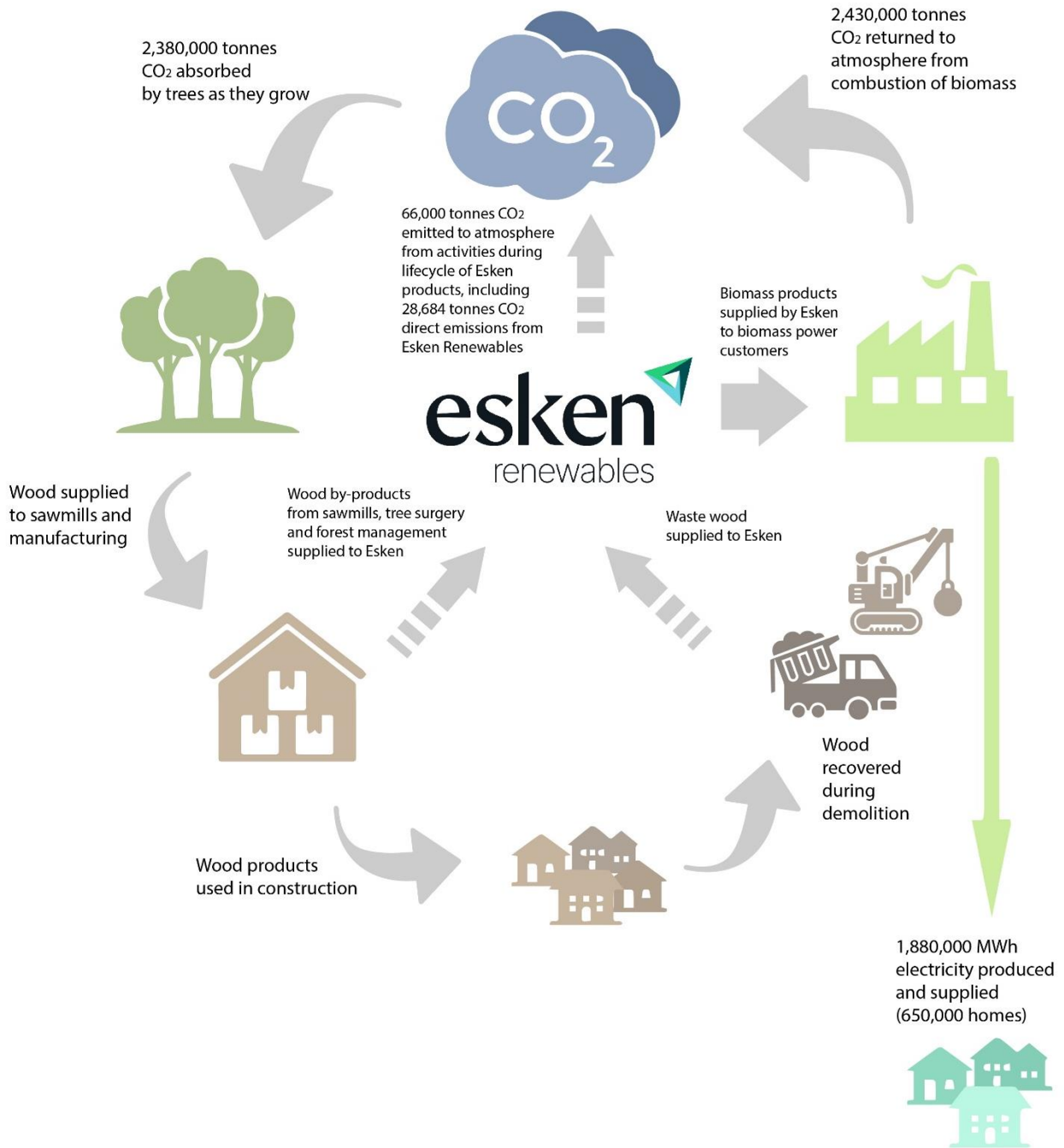
2.4.1 Lifecycle GHG Emissions

In carbon accounting, it is accepted that energy generated from the combustion of biomass is a low carbon energy source.

The rationale for this in GHG accounting has been explained in Section 2.1, in that the release of these emissions is simply returning carbon to atmosphere that was absorbed by the biomass feedstock during its growth cycle.

The carbon lifecycle of Esken Renewables' biomass products taking account of the analysis and discussion provided in Sections 2.1, 2.2 and 2.3 is illustrated visually in Figure 2-2.

Figure 2-2 Esken Renewables Biomass Products Carbon Lifecycle



2.4.2 Biomass Power Carbon Intensity

An analysis of the lifecycle GHG intensity of electricity generated by a range of electricity generation types is provided in Table 2-5. The lifecycle emissions for biomass take account of major emissions within the supply chain, and for biomass and energy from waste include carbon sequestered by the biomass (or biomass portion) of the fuel consumed.

Table 2-5 Comparison of GHG Emissions for Electricity Generation

Energy Source	Lifecycle GHG Intensity (gCO ₂ e/kWh)	Reference
Natural Gas (CCGT)	380	
Wind	0	Department of Business Energy and Industrial Strategy Fuel Mix Disclosure Data 2020/2021 ⁵
Solar	0	
Energy from Waste (EfW)	459	Tolvik Consulting UK EfW Statistics 2020 ⁶
Esken Renewables Biomass	65	

The data in Table 2-5 shows that compared to other sources of electricity generation, on a lifecycle emissions basis, it is clear that biomass electricity has low carbon intensity (i.e. is a low carbon energy source).

It is also important to note that the analysis in Table 2-5 is for electricity production only. Biomass power stations also produce heat which can be used by commercial customers or as part of district heat networks. Although this is also the case for energy from waste, it is not applicable to wind and solar where heat is either not produced or routinely able to be usefully harnessed.

The use of waste heat ultimately further reduces the overall GHG intensity of energy generated, which is discussed further in Section 3.1.

⁵ BEIS, Fuel Mix Disclosure Data Table 01/04/2020 - 31/03/2021. Available: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1007752/fuel-mix-disclosure-data-2020-2021.pdf

⁶ Tolvik Consulting, UK Energy from Waste Statistics - 2020. Available: https://www.tolvik.com/wp-content/uploads/2021/05/Tolvik-UK-EfW-Statistics-2020-Report_Published-May-2021.pdf

In the future, installation of carbon capture and storage onto biomass power plants has the potential to lead to biomass power plants having substantially lower GHG emissions, and potentially net negative lifecycle emissions, as is discussed further in Section 4.3. This will also be the case for EfW although it is unlikely that EfW will be able to achieve net negative emissions.

3 Greenhouse Gas Benefits

The generation of energy from biomass, and treatment of waste wood by energy recovery has a number of indirect GHG benefits. These indirect benefits are savings in GHG emissions that would otherwise be emitted elsewhere.

3.1 Heat Production

As discussed in Section 2.3.3 biomass power plants, such as those operated by Esken Renewables' customers, provide a constant, reliable electricity supply to power homes and businesses, without which electricity would need to be generated by other means, including natural gas power stations.

In addition, as discussed in Section 2.3.4, heat produced by these power plants can be used by local consumers to offset the use of natural gas or heating oil.

The precise amount of heat export and usage from Esken's customers power plants is not known, but as is discussed in Section 2.3.4 at the Widnes site alone, Esken Renewables currently use 7MW of heat from the biomass plant for wood drying, saving up to 12,000 tonnes of GHG emissions per year from use of natural gas heat. This represents only a tiny portion of the total potential heat supply of Esken Renewable's customers, which have the potential to save many more thousands of tonnes of fossil GHG emissions from gas and oil combustion.

It is likely that heat from Esken's customers is well utilised, or can be utilised in the future as connection options become available, and this will further lower the carbon intensity of energy produced by these power plants.

3.2 Avoiding Landfill

Esken Renewables processes waste wood that either by its constituency (e.g. MDF) or contamination with treatments and coatings (e.g. Grade C waste wood) cannot be reused or recycled, and therefore use for biomass energy represents the best fate of this material as an alternative to landfill.

When wood (and other biodegradable material) is landfilled, it breaks down anaerobically (without oxygen) and releases a mixture of carbon dioxide and methane gas. Some of this gas is captured and used for energy, but much of it is released to the atmosphere.

Methane is a very potent GHG, which has a much greater global warming potential than carbon dioxide (released when biomass is combusted). The Global Warming Potential (GWP) of methane is between 28-36 times higher than CO₂. This means for every tonne of methane released, the atmospheric warming effect is equivalent to 28-36 tonnes of CO₂.

Esken Renewables received, processed, and supplied over 1,100,000 tonnes of waste biomass in FY22 that would otherwise be landfilled, saving up to 630,000 tonnes of GHG emissions from landfill methane emissions.

3.3 Recovered Materials

In processing waste wood for provision to customers, Esken Renewables recovers a large volume of ferrous and non-ferrous metals and other materials which can be recycled and reprocessed into useful products, saving GHG emissions associated with the manufacture and transport of new products.

The recovery of metals provides significant benefits in this regard as the production of steel and metal alloys are very energy intensive and result in substantial GHG emissions (for example from coking coal used in blast furnaces for steel manufacture). Recovery and recycling of metals by Esken Renewables therefore provides a positive benefit for offsetting GHG emissions from the mining and production of new metal products.

In addition, the biomass power plants operated by Esken Renewables' customers produce two key by-products, bottom ash and air pollution control residue, both of which can be processed into aggregate products for use in the construction industry. These by-products replace aggregate products produced from newly quarried stone which saves GHG emissions associated with the quarrying and processing of such aggregates, and positively contributes to a circular economy.

4 Future Greenhouse Gas Outlook

4.1 Reducing Esken Renewables Scope 1 GHG Emissions

4.1.1 Replacement of Diesel with Biofuels

Esken Renewables are in the process of assessing a biofuel trial to replace diesel fuel used in plant and machinery at a number of the Company's processing sites.

Although vehicles and machines operating on biofuel have similar exhaust pipe CO₂ emissions to those operating on fossil diesel, biofuel emissions are net zero due to carbon removed from the atmosphere during the growth of crops used to produce the biofuel, in exactly the same way as the biomass fuel supplied by Esken Renewables.

Esken Renewables estimate that, if successful, a biofuel rollout for their on-site machines and plant would save close to 3,500 tonnes of CO₂e per annum, equivalent to around 13% of the Company's GHG footprint (as shown in Table 2-3).

4.1.2 Processing Plant Electrification

Although biofuel provides a good interim step, the longer-term solution to reducing Esken Renewables' fuel bill and associated GHG emissions is to replace all diesel-powered vehicles and plant with electrically powered plant and machinery. As UK electricity generation decarbonises with the increase in wind, solar, nuclear and biomass, with a reduction in gas and oil power, this would allow Esken Renewables' processing facilities to operate with zero GHG emissions.

4.1.3 Heavy Goods Vehicle Fleet

At present, there is no plan to extend the biofuel trial to the haulage vehicle fleet, however this may become a viable option in the future.

In the longer term, the UK Government has pledged to cease the sales of non-zero emission Heavy Goods Vehicles (HGVs) by 2035⁷ as part of the Department for Transport's transport decarbonisation plan⁸. It is therefore expected that following the next round of fleet renewal, expected in 2024/2025, that the Esken Renewables vehicle fleet may be all or partially upgraded to zero emission vehicles.

⁷ For vehicles less than 26 tonnes. For vehicles greater than 26 tonnes, the date for ending sales of non-zero emission variants is 2040.

⁸ Department for Transport (2021) Decarbonising Transport: A Better, Greener Britain

4.2 Reducing Esken Renewables Scope 2 and 3 GHG Emissions

4.2.1 Electricity Consumption

As the UK decarbonises its electricity generation through increasing wind, solar, nuclear, and of course biomass, together with battery storage, and decommissioning the use of gas and oil, as has been the case for coal power in recent years, the electricity consumed by Esken Renewables would transition towards net zero.

It is understood that Esken Renewables are currently converting to LED lighting on all sites, which is currently 70% to 80% complete. Lights are sensor controlled, and as part of company policy staff are advised of standard good practice of turning off products when not in use. Furthermore, when historic portacabins come to the end of their life, opportunities exist to switch to more energy efficient units which would improve heating efficiency.

4.2.2 Materials and Waste

Efforts to decarbonise the UK economy are reflected worldwide, with most nations party to the Paris Agreement having committed to economic decarbonisation by around 2050 or a few years later.

This means that the carbon intensity of goods and materials purchased and used by Esken Renewables would decarbonise in the future.

In addition, efforts to decarbonise the waste sector would also result in a reduction in emissions associated with the treatment or disposal of waste generated by Esken Renewables, as waste minimisation measures reduce overall waste volumes, waste reuse and recycling rates increase, and energy from waste facilities install CCS.

4.3 Reducing Wider Scope 3 GHG Emissions

4.3.1 Biomass Energy with Carbon Capture and Storage (BECCS)

The UK Government have set out how the use of biomass energy is likely to be prolonged in the future by the application of carbon capture and storage systems onto biomass power stations.

The systems work by passing the combustion gasses through a series of processes which remove CO₂ from the airstream. The residual gas is released to atmosphere and the captured CO₂ is stored, with the potential for either permanent storage in CO₂ reservoirs, or for reuse in industries such as the drinks industry or for the production of green fuels known as Power to Liquid fuels.

The application of BECCS would mean a large proportion of the circa 2.4 million tonnes of CO₂e emitted from Esken Renewables customers (see Table 2-4) per year can potentially be captured and stored, permanently removing it from the atmosphere.

This would provide a significant climate change benefit and would reduce the energy intensity of biomass power to a negative value (i.e. for each MWh of energy produced, more carbon is removed from the atmosphere than is released).

5 Wider Sustainability Aspects

Beyond the GHG benefits described in Section 3, Esken Renewables business also offers some wider sustainability benefits and opportunities.

5.1 Supporting Small Businesses

In addition to biomass products supplied to larger power-generating customers, Esken Renewables also provide biomass products to a wide range of small business end users. Esken products are used by these businesses to lower their own carbon emissions, progress towards net zero operations, and improve the sustainability of their businesses.

These products are sourced from the wood by-products side of the business, including sawmill dust, and forest management arisings, and are processed and dried at Widnes or Third Party facilities and supplied to small business customers for a range of users.

Some examples of small businesses provided with biomass products by Esken Renewables are provided in Table 5-1 below and illustrated in Figure 5-1.

Table 5-1 Esken Renewables Small Business End Users

End User Activity	Description
Small-Scale Combined Heat and Power Plants	A portion of biomass products produced by Esken Renewables is supplied to owners of small-scale biomass Combined Heat and Power (CHP) plants, to generate low carbon heat and electricity for local heat networks or commercial businesses.
Intensive Poultry Farming	Rearing of chickens requires poultry sheds to be maintained at a fixed temperature range to comply with welfare regulations. In winter months and when the birds are juvenile and very small, this requires poultry sheds to be continuously heated. Esken Renewables supply a number of poultry farms with wood chips for biomass boilers to provide low carbon heat to poultry sheds that would otherwise employ gas or fuel oil for the generation of heat, thus lowering these farms’ carbon footprint.
Fruit and Vegetable Growing	A number of Esken Renewables’ smaller customers grow fruit and vegetables to supply to UK food retailers. Biomass processed and dried at Widnes and Clacton is supplied by Esken for use in biomass boilers to provide low carbon heat to greenhouses for food growing. Without biomass heat, these customers would use natural gas or fuel oil for heat, greatly increasing their own carbon footprint.
Nursery Plant Growing	Esken Renewables also supply to a small business growing nursery plants for garden centres. Biomass processed and dried at Widnes and Clacton is supplied to provide low carbon heat to greenhouses at the nursery used to grow and propagate plants.
Animal Housing	Esken Renewables supply dried sawmill dust and shavings to a third party (AWJ) who supply it to market as animal bedding. The products supplied, once used, will then have potential to be further utilised, for example to generate energy in an anaerobic digestion facility.

Figure 5-1 Esken Renewables Small Business End Users



5.2 Other Sustainability Aspects

As part of discussions with Esken, in addition to carbon reductions (covered in Section 4) the potential for wider sustainability benefits to be harnessed by Esken Renewables has been considered, within both current and future operations. However, ultimately these are relatively limited, as the focus of operations is understandably on biofuel manufacturing and carbon reduction.

For example, as part of the forestry management operations, the potential exists to provide biodiversity enhancement through the felling and retention of some dead wood, to create additional habitats. It could be argued that through the decomposition of dead wood carbon is released to the atmosphere, which in terms of carbon accounting would be against the principle of reducing CO₂ emissions. However, ultimately this would be a very slow release and, in the intervening period, would support the growth of other plants which by their nature would have carbon benefits. In terms of carbon quantification the decomposition of these relatively small quantities of dead wood would be negligible.

Over and above carbon accounting, the felling and retention of some trees would nominally reduce wood supply for processing, and therefore may not be a desired approach commercially. However, should there be marginal areas of the woodland plantations which are not forested, there may be the potential to plant wildflowers and contribute positively to the natural environment.

It is also understood that there are existing ponds located at the current processing sites, which capture and treat surface water prior to discharge. Depending on their current condition, there is the potential to enhance the biodiversity of these features and increase habitat diversity. If tanks and significant below ground pipework are present on some sites, consideration could be given to retrofitting above ground features such as ponds and swales, to increase the sustainability value of all sites.

The potential to provide future sustainability elements may in part be led by the potential electrification of machinery (as set out in Section 4.1.2). This would require the construction of buildings to house this machinery. In turn this could enable:

- Rainwater could be captured within tanks fitted to external facades, or below ground features, for use for internal washdown or external damping.
- Photo Voltaic panels (PVs) could be fitted to the building roofs. With machinery housed internally, external dust would be less of concern in terms of their impact on the PV panels.
- The sustainability of materials used in construction should be considered, reducing the carbon footprint where feasible.

6 Conclusion

Esken Renewables provide sustainable biomass fuel products, primarily for use in power stations generating energy.

Avoiding GHG Emissions

By treating 1.1m tonnes of waste wood that would otherwise be sent to landfill, Esken Renewables and its supply chain partners and customers enable the avoidance of 630,000 tonnes of GHG emissions per year from landfilling waste wood.

By supplying a total of 1.4m tonnes of waste wood and forestry by-products for energy generation, Esken Renewables enables its supply chain partners and customers to save 714,000 tonnes of GHG emissions per year from gas-fired electricity generation.

In total the GHG savings from avoiding landfilling of waste wood and gas-fired electricity generation total around 1.344MTCO₂e in FY22.

6.1 Esken Renewables Direct Emissions

Esken Renewables corporate GHG emissions total around 29,000 tonnes per annum, around 95% of which are related to diesel fuel consumption in Esken Renewables' haulage vehicles and machinery and third party haulage vehicles.

Esken Renewables plan to tackle these emissions in the future through the use of biofuels in site machinery, which could reduce emissions by up to 13% in the near future. Future electrification of site plant and introduction of zero emission haulage vehicles by Esken Renewables and third parties in the next decade will further reduce this.

6.2 Decarbonising Esken Renewables' Customers Energy Generation

GHG emissions from Esken Renewables' customers equates to around 2.4 MTCO₂e per year, the vast majority of which is balanced by CO₂ absorbed by the biomass during its growth cycle, ensuring the energy generated has low carbon intensity over its lifecycle.

The residual carbon intensity of electricity exported by Esken Renewables' customers is around 59 gCO₂e/kWh, which is over 6 times lower than natural gas.

In FY22 Esken Renewables supplied over 1.1 million tonnes of waste wood to biomass power customers, that would have otherwise been sent to landfill and saved around 630,000 tonnes of additional GHG emissions to atmosphere from landfill methane gas.

Esken Renewables' customers in FY22 used the total 1,474,000 tonnes of biomass supplied by Esken to generate an estimated 1,880,000 MWh of electricity, which is sufficient to power around 650,000 homes. If this electricity were to be generated using natural gas power stations, the resulting fossil GHG emissions would be around 714,000 tonnes.

The power plants also export heat to consumers which replaces heat and offsets emissions generated by fossil fuel heat sources such as natural gas. Esken Renewables themselves use some

waste heat from a biomass customer for waste drying at the Widnes site, saving up to 12,000 tonnes of CO₂ per year, equivalent to over 40% of Esken's own GHG footprint.

6.3 Supporting Small Businesses

In addition to providing substantial volumes of wood products to customers operating large-scale biomass power plants, Esken Renewables also provide products to a wide range of small businesses including small-scale biomass CHP operators, fruit and vegetable growers, poultry farms and plant nurseries where they generate low carbon energy to reduce their own carbon footprints.

6.4 Future Benefits

In the future, it is anticipated that Esken Renewables' customers will be able to upgrade their power plants to include carbon capture and storage, potentially creating carbon negative power stations and significantly contributing to the UK's efforts to achieve net zero carbon by 2050.

7 Glossary

Acronym	Explanation
BECCS	Biomass Energy with Carbon Capture and Storage
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CHP	Combined Heat and Power
CO₂	Carbon Dioxide
CO₂e	Carbon Dioxide Equivalent
gCO₂e/kWh	Grams of Carbon Dioxide Equivalent per Kilowatt Hour of Electricity Generated
GHG	Greenhouse Gas
GWP	Global Warming Potential
HGV	Heavy Goods Vehicle
kWh	Kilowatt Hour
LED	Light Emitting Diode
MSW	Municipal Solid Waste
MW	Mega Watt
MWh	Mega Watt per Hour
NCV	Net Calorific Value
PV	Photovoltaic Panel
UNFCCC	United Nations Framework Convention on Climate Change

8 Appendices

A1 Carbon Footprint Technical Appendix

A1.1 Introduction

This Appendix provides all the technical data and assumptions used in the calculation of the GHG emissions and energy outputs related to the Esken Renewables business and supply chain.

A1.2 Esken Company GHG Footprint

Esken Renewables produce an annual GHG footprint for corporate reporting as part of the Task Force on Climate-Related Financial Disclosures (TCFD). The TCFD footprint covers emissions from the main activities associated with the Esken Renewables business, and provides the basis of the core GHG footprint set out in Table 2-3.

All input data have been provided by Esken Renewables. Data on fuel usage, electricity, water consumption, and purchased goods are all obtained from invoices for the purchase of the relevant commodities. Where necessary, such as for materials purchased, assumptions have been made by Esken Renewables to convert the materials from unit numbers to mass in tonnage, based on estimates of commodity weight etc.

Other inputs such as company car mileage and business mileage have been obtained from company expense claims.

All GHG emissions factors used in the footprint have been obtained by Esken Renewables from factors for company reporting published by the Department of Business Energy and Industrial Strategy (BEIS)⁹.

A summary of the Esken Renewables company GHG footprint is provided in Table A1-1.

⁹ BEIS (2021) Greenhouse gas reporting: conversion factors 2021:
<https://www.gov.uk/government/publications/greenhouse-gas-reporting-conversion-factors-2021>

Table A1-1 Esken Renewables Corporate GHG Footprint FY22

Emissions Source	Metric	FY22 Consumption	GHG Factor (kgCO ₂ e /metric unit)	GHG Emissions (TCO ₂ e)	Rounded GHG Emissions by Source as Presented in Table 2-3 (TCO ₂ e)
Scope 1 Emissions					
Diesel in Haulage Fleet	Litres	4,707,837	2.51233	11,828	11,828
Diesel in Site Plant and Machinery	Litres	1,483,258	2.51233	3,726	3,726
Heating Oil	Litres	753	2.51233	2	2
Diesel in Company Cars	Litres	19,011	2.51233	48	48
Scope 2 Emissions					
Electricity Consumption	kWh	5,206,997	0.21233	1,106	1,106
Scope 3 Emissions					
Business Travel (Diesel Car)	miles	161,326	0.25678	41.4	41
Water Supply	m ³	33,235	0.149	5.0	8
Wastewater Treatment	m ³	12,432	0.272	3.4	
Purchased Goods - Lubricating Oil	Tonnes	5.82	1,401	8.1	
Purchased Goods - Hydraulic Oil	Tonnes	8.65	1,401	12.1	
Purchased Goods - Engine Oil	Tonnes	1.38	1,401	1.9	72
Purchased Goods - Batteries	Tonnes	0.11	12,119.2	1.3	
Purchased Goods - Tyres	Tonnes	14.57	3,335.6	48.6	

Waste - General	Tonnes	960.4	21.294	20.5	
Waste - Hydraulic Oil	Tonnes	1.82	21.294	0.04	
Waste – Engine Oil	Tonnes	0.24	21.294	0.005	
Waste - Batteries	Tonnes	0.1	21.294	0.002	112
Waste - Tyres	Tonnes	11.21	21.294	0.24	
Waste - Ferrous Metals	Tonnes	3836.6	21.294	81.7	
Waste - Non-Ferrous Metals	Tonnes	458.0	21.294	9.75	
TOTAL GHG Emissions (TCO₂e)				16,943	

A1.2.1 Third Party Haulage

In addition to the GHG emissions reported by Esken Renewables as part of TCFD disclosure, there are additional emissions associated with third party haulage of Esken biomass. All the emissions from haulage of biomass using Esken Renewables’ own fleet of vehicles is captured in the Scope 1 fuel consumption emissions in Table A1-1.

The emissions from third party hauliers are considered to be Scope 3 emissions associated with Esken Renewables’ business. If for example Esken Renewables outsourced all haulage to third parties then all the emissions under Scope 1 for the haulage fleet would be captured as Scope 3 emissions.

Esken Renewables have provided data on the tonnages of biomass product hauled by third parties. Third party haulage comprised around 50% of the total tonnage hauled in FY22.

The haul routes operated by third parties vary substantially, and so an estimate of average single trip haul distance has been made. The distance estimated results in total GHG emissions from third party haulage being similar to the total GHG emissions from Esken Renewable’s haulage fleet. Given Esken fleet and third parties hauled a similar tonnage of products in FY22, this is considered indicative that the assumed third party average haulage distance is appropriate.

GHG emissions for third party haulage are then calculated using GHG emissions factors for road freight from BEIS⁹, based on the tonnage of material hauled and the average distance. The BEIS GHG factor used in the calculation is relevant to emissions from 100% laden articulated HGVs between 7.5 and 33 tonnes in laden weight.

The calculation of GHG emissions from third party haulage is presented in Table A1-2.

Table A1-2 GHG Emissions from Third Party Haulage

Tonnage Hauled by Third Parties (FY22)	Average Distance Hauled (km)	GHG Factor (kgCO ₂ e/tonne.km)	GHG Emissions (TCO ₂ e)
892,395	180	0.07309	11,741

A1.3 Wider Scope 3 Emissions

In addition to the company GHG footprint (including third party haulage) described above, there are some wider Scope 3 emissions which are relevant to the overall lifecycle carbon emissions associated with the use of Esken Renewables’ biomass products for energy generation. These wider Scope 3 emissions are described in Section 2.2.2.

A1.3.1 Biomass Power Production and Carbon Sequestration

GHG emissions associated with the combustion of biomass in the power plants operated by Esken Renewables’ customers has been calculated based on the tonnages of waste wood and wood by-products supplied by Esken Renewables in the 2021-2022 financial year (FY22).

In order to calculate the carbon within the biomass, and subsequently the emissions resulting from combustion and the amount of CO₂ sequestered by the trees which supply the biomass, a series of variables must be estimated, including the average carbon content by mass, net calorific value (NCV) of the biomass, and production and release of nitrous oxide (N₂O) and methane (CH₄) during biomass combustion.

The release of small quantities of N₂O and CH₄ during combustion are important as these emissions have a very high Global Warming Potential relative to carbon dioxide, and therefore it is robust to acknowledge their contribution to the overall GHG emissions balance.

All data on carbon content, NCV, and N₂O and CH₄ emissions have all been based on analysis by Defra¹⁰ and the IPCC^{11,12}.

The key inputs into the calculation of emissions from biomass combustion are provided below in Table A1-3.

¹⁰ Defra (2014) Energy recovery for residual waste. A carbon based modelling approach.

¹¹ IPCC (2006) IPCC Guidelines for National Greenhouse Gas Inventories Volume 2, Chapter 2 Stationary Combustion.

¹² IPCC (2014) AR5 Synthesis Report: Climate Change 2014.

Table A1-3 Key Inputs to Biomass Power Plant GHG Emissions

Parameter	Value	Metric	Comments
Carbon Content of Biomass Fuel	44	% by mass	Based on Defra ¹⁰ data.
Net Calorific Value of Biomass Fuel	18	MJ/kg	Energy content of biomass in megajoules per kilogram of biomass
Nitrous Oxide (N₂O) Emissions from Biomass Combustion	0.004	g/MJ	Grams of N ₂ O produced for each megajoule of biomass consumed
Methane (CH₄) Emissions from Biomass Combustion	0.03	g/MJ	Grams of CH ₄ produced for each megajoule of biomass consumed
GWP of N₂O	310	CO ₂ e	In accordance with IPCC AR5 ¹² .
GWP of CH₄	28	CO ₂ e	

The data in Table A1-3 can be used in conjunction with biomass tonnages provided by Esken Renewables, to estimate the stored carbon in the biomass (i.e. carbon sequestered from the atmosphere by trees during the growth cycle) and subsequent release of emissions to the atmosphere in biomass power plants.

The calculation of GHG emissions from the biomass combustion is provided in Table A1-4 below.

Table A1-4 Calculation of Biomass Power Emissions

Parameter	Value			Metric	Comments
	Waste Biomass	By-Product Biomass	Total		
Biomass Throughput	1,149,447	324,597	1,474,044	Tonnes	Provided by Esken Renewables for FY22
Total Carbon in Biomass Fuel	505,757	142,823	648,576	Tonnes C	Waste throughput x carbon content by mass
Total Carbon Dioxide Sequestered by Biomass	1,854,441	523,683	2,378,124	Tonnes CO ₂	Carbon content / molecular mass of C (12) x molecular mass of CO ₂ (44)

Total Carbon Dioxide Emitted by Biomass Combustion	1,854,441	523,683	2,378,124	Tonnes CO ₂	This is equal to the mass of carbon dioxide sequestered by the trees.
Total Energy Input of Biomass Fuel	20,690,046	5,842,747	26,532,793	GJ	Biomass throughput x NCV in Table A1-3
Total N₂O Emitted by Biomass Combustion	25,656	7,245	32,901	Tonnes CO ₂ e	NCV x N ₂ O emissions (in g/MJ) x N ₂ O GWP in Table A1-3 x biomass throughput
Total CH₄ Emitted by Biomass Combustion	17,380	4,908	22,288	Tonnes CO ₂ e	NCV x CH ₄ emissions (in g/MJ) x CH ₄ GWP in Table A1-3 x biomass throughput
Total GHG Emitted by Biomass Combustion	1,897,476	535,836	2,433,313	Tonnes CO ₂ e	Total of CO ₂ + N ₂ O + CH ₄ emissions

A1.3.2 Upstream Wood By-product Emissions and Waste Wood Processing Emissions

The final elements of the wider Scope 3 GHG footprint are emissions associated with upstream activities associated with Esken Renewables’ suppliers.

These emissions arise on the wood by-product side in relation to tree felling and forest management, wood transport, sawmills, and other supply chain emissions.

On the waste wood side, emissions are associated with sorting, separation, processing and transport of the waste before it is received by Esken Renewables.

It is not appropriate to include emissions associated with wood products manufacture or use for the waste wood business as any GHG emissions associated with this primary lifetime of the materials is not additional to Esken Renewables.

Emissions from tree felling, forest management, and upstream processing and transport of wood by-products has been estimated based on published analysis by the Department of Sustainable

Resources Management at the State University of New York¹³. This research estimates a GHG emission of 39.77 kgCO₂e/tonne of biomass for wood by-products.

Emissions from processing, sorting, separation and transport of waste wood biomass has been estimated using BEIS GHG emissions factors⁹ for closed loop waste wood recycling, of 21.294 kgCO₂e/tonne of waste wood.

The calculation of these upstream Scope 3 emissions is presented in Table A1-5.

Table A1-5 Upstream Scope 3 Emissions Calculation

Product Stream	Annual Tonnage (T/annum)	GHG Emissions Factor (kgCO ₂ e/tonne)	Total Annual GHG Emissions (TCO ₂ e)
Wood By-products	324,597	39.77	12,909
Waste Wood	1,149,447	21.294	24,476

A1.4 Biomass Energy Outputs

In order to calculate the potential GHG benefits of energy generated by Esken customers using biomass products supplied by Esken Renewables, an estimate of the electricity generated by Esken customers has been carried out.

A summary of the calculation of electricity generated using Esken biomass products is provided in Table A1-6.

¹³ Weyrens, J.P.; Therasme, O.; Germain, R.H. Quantifying the Life Cycle Greenhouse Gas Emissions of a Mechanized Shelterwood Harvest Producing Both Sawtimber and Woodchips. *Forests* 2022, 13, 70. <https://doi.org/10.3390/f13010070>

Table A1-6 Calculation of Electrical Energy Outputs

Parameter	Value			Metric	Comments
	Waste Biomass	By-Product Biomass	Total		
Energy Input	20,690,046	5,842,747	26,532,793	GJ	NCV (Table A1-3) x Throughput (Table A1-4)
	5,747,235	1,622,985	7,370,220	MWh	Energy input in GJ x 0.27778
Electrical efficiency of biomass plant	30	30	30	%	Assumption based on typical plant efficiencies.
Gross electrical output	1,724,171	486,896	2,211,066	MWh	Energy Input x fraction of electrical efficiency (0.3)
Parasitic electrical load of biomass plant¹⁴	15	15	15	%	Percentage of total electricity generated. Assumption based on typical large scale biomass plants.
Parasitic electricity consumption	258,626	73,034	331,660	MWh	Gross electrical output x fraction of parasitic electrical load (0.15)
Total exported electricity	1,465,545	413,861	1,879,406	MWh	Gross electrical output minus parasitic electrical consumption.

The electricity exported by Esken Renewables’ customers is provided to homes and businesses in the local area to each biomass plant. Ofgem analysis¹⁵ estimates that the average UK household

¹⁴ Parasitic load is the electricity used by the plant in order to operate. This energy has been discounted from the exported electricity values.

¹⁵ Ofgem Typical Domestic Consumption Values for gas and electricity:
https://www.ofgem.gov.uk/sites/default/files/docs/2020/01/tdcvs_2020_decision_letter_0.pdf

consumes 2,900 kWh (2.9 MWh) of electricity each year. On this basis, the 1,879,406 MWh of electricity generated by Esken Renewables' customers is sufficient to power 648,071 UK households.

A1.5 Biomass Power Carbon Intensity

In order to compare biomass power to other forms of power generation, as presented in Table 2-5 of this report, a carbon intensity calculation has been carried out for power produced by Esken biomass products. The carbon intensity is the net amount of carbon emitted in order to generate each unit of electricity.

The carbon intensity calculation combines the data in Tables A1-2, A1-3, A1-5, and A1-6, as presented in Table A1-7.

Table A1-7 Calculation of Biomass Lifecycle Carbon Intensity

Parameter	Value	Metric	Comments
Total GHG Emitted by Biomass Combustion	2,433,313	TCO ₂ e	See Table A1-3
Total Carbon Dioxide Sequestered by Biomass	-2,378,124	TCO ₂ e	See Table A1-3
Upstream GHG Emissions for Wood By-products	12,909	TCO ₂ e	See Table A1-5
Upstream GHG Emissions for Waste Wood	24,476	TCO ₂ e	See Table A1-5
Esken Renewables Scope 1-3 GHG Emissions	28,684	TCO ₂ e	Total from Table A1-1 and Table A1-2
Total GHG Emissions	121,258	TCO ₂ e	Sum of emissions in this table
Total Electricity Generated	1,879,406	MWh	See Table A1-6
Carbon Intensity of Biomass Electricity	65	gCO ₂ e/kWh	Total emissions / total electricity x 1000

The lifecycle carbon intensity of the electricity generated by Esken Renewables' customers is 65 gCO₂e/kWh, which is low compared to other forms of energy generation as set out in Table 2-5 of this report.

A1.6 Landfill Emissions

As discussed in Section 3.2, waste wood processed and supplied by Esken Renewables would otherwise have to be treated or disposed by alternative means, such as landfill.

A landfill gas calculation has been undertaken to estimate the amount of methane that might result if the waste wood supplied by Esken Renewables was instead sent to landfill. The inputs to the calculation are provided in Table A1-8.

Table A1-8 Inputs to Landfill Emissions Calculation

Parameter	Value	Metric	Comments
Proportion of Waste Wood that is Decomposable Degradable Organic Carbon (DDOC)¹⁶	12.5	%	
Landfill Gas CO₂ Content	50	%	
Landfill Gas CH₄ Content	50	%	Assumptions consistent with Defra’s modelling of GHG emissions from landfill ¹⁷ .
Landfill Gas Recovery Efficiency	75	%	
Proportion of Released CH₄ Oxidised in Landfill Cap	10	%	
Proportion of Captured CH₄ Leaked through Gas Engines	1.5	%	
GWP of CH₄	28	TCO ₂ e/T	Consistent with lower value in IPCC AR5 ¹⁸ for GWP ¹⁰⁰ of CH ₄

The input data provided in Table A1-8 have been used to calculate the resultant landfill methane releases as set out in Table A1-9.

¹⁶ Decomposable Degradable Organic Carbon (DDOC) content is the proportion of the wood by mass that will anaerobically break down in landfill to form landfill gas (a mixture of CO₂ and CH₄).

¹⁷ Defra (2014) Energy recovery for residual waste. A carbon based modelling approach.

¹⁸ IPCC (2014) AR5 Synthesis Report: Climate Change 2014

Table A1-9 Calculation of Landfill Emissions

Parameter	Value	Metric	Comments
Waste Biomass Throughput	1,149,447	Tonnes/yr	See Table A1-4
Proportion of Waste Wood that is Decomposable Degradable Organic Carbon (DDOC)¹⁹	143,681	Tonnes C	12.5% of waste biomass throughput
Total CH₄ in Landfill Gas	95,787	Tonnes	DDOC / molecular mass of C (12) x % CH ₄ in landfill gas (50%) x molecular mass of CH ₄ (16) / 1000 (see
Captured CH₄	71,840	Tonnes	75% of total CH ₄ in landfill gas
Uncaptured CH₄	23,947	Tonnes	25% of total CH ₄ in landfill gas
Uncaptured CH₄ Oxidised in Landfill Cap	2,395	Tonnes	10% of Uncaptured CH ₄
Captured CH₄ Leakage through Gas Engines	1,078	Tonnes	1.5% of Captured CH ₄
Total CH₄ Released	22,630	Tonnes	Uncaptured CH ₄ + Captured CH ₄ leaked through gas engines - uncaptured CH ₄ oxidised in landfill cap
Total GHG Emissions	633,633	Tonnes CO ₂ e	Total CH ₄ released x GWP for CH ₄ (see Table A1-8)

It is estimated that if the waste wood supplied by Esken Renewables were to be sent to landfill, additional GHG emissions of 633,633 tonnes per annum would occur. These emissions are essentially prevented by the use of waste wood biomass in power plants.

¹⁹ Decomposable Degradable Organic Carbon (DDOC) content is the proportion of the wood by mass that will anaerobically break down in landfill to form landfill gas (a mixture of CO₂ and CH₄).

A1.7 Lifecycle Emissions by Wood Product

A1.7.1 Waste Wood Carbon Lifecycle

Waste wood received, processed and supplied by Esken Renewables totalled over 1.1 million tonnes in FY22. This biomass was consumed by Esken's customers to produce around 1,465,000 MWh of low carbon electricity, enough to power 505,000 homes.

The wood by-products carbon lifecycle is illustrated visually in Figure A1-1.

A1.7.2 Wood By-Products Carbon Lifecycle

Wood by-products derived, received, processed and supplied by Esken Renewables totalled nearly 325,000 tonnes in FY22. This biomass was consumed by Esken's customers to produce around 415,000 MWh of low carbon electricity, enough to power 145,000 homes.

The wood by-products carbon lifecycle is illustrated visually in Figure A1-2.

Figure A1-1 Waste Wood Carbon Lifecycle

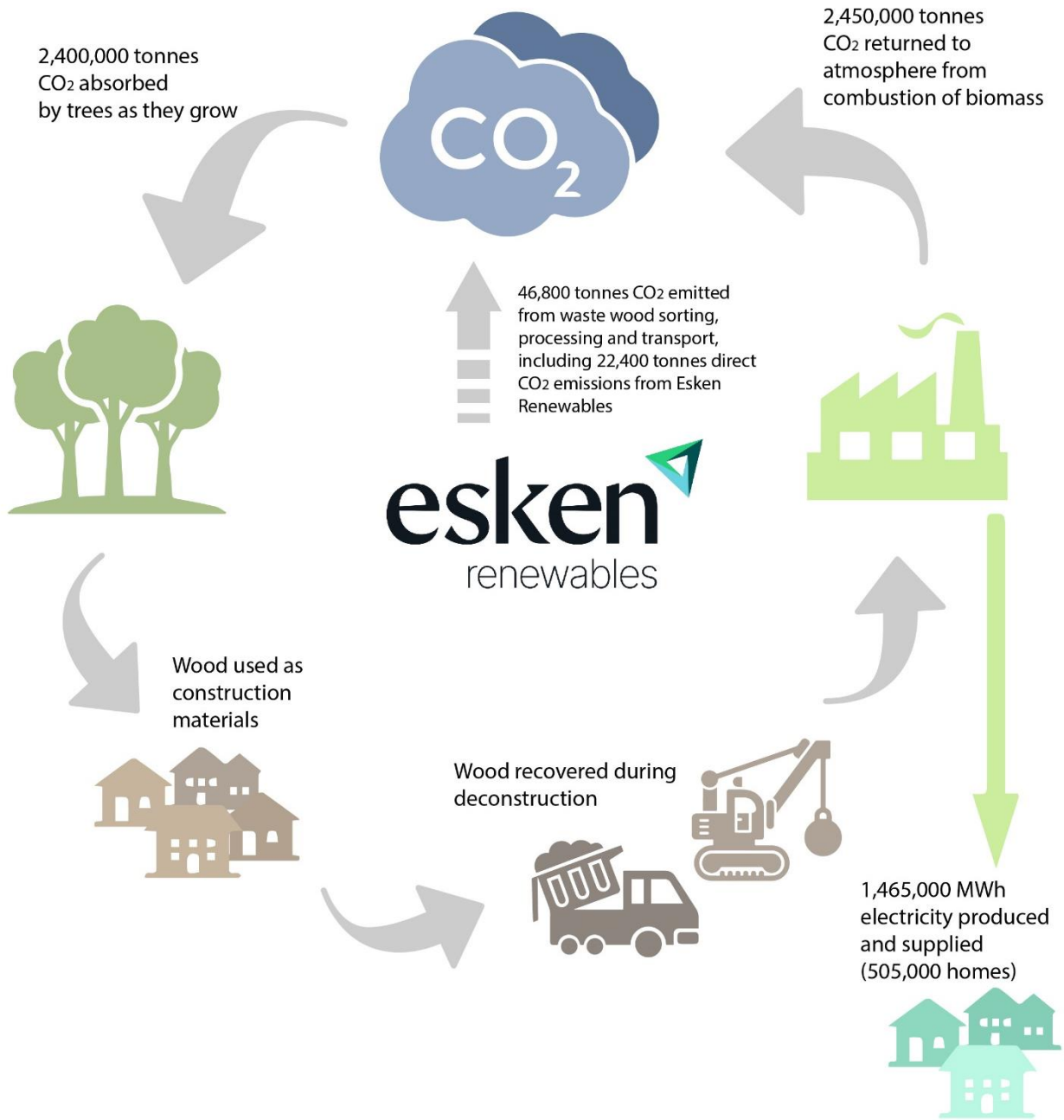


Figure A1-2 Wood By-products Carbon Lifecycle

