Summary Life Cycle Assessment

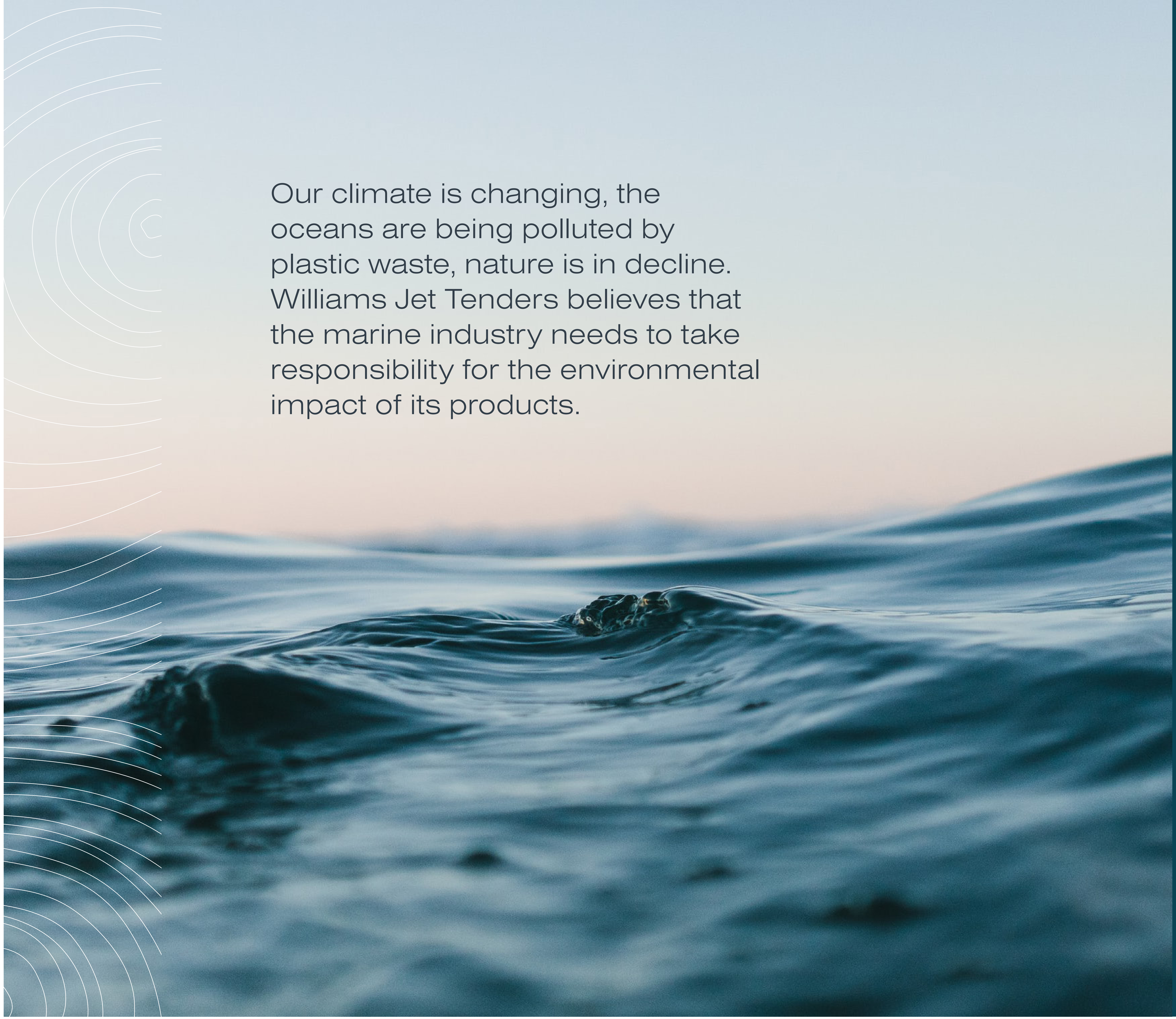
of a TurboJet 325

Williams Jet Tenders is a pilot partner, supporting the development of MarineShift360 life cycle assessment (LCA) tool for the marine industry.

This case study is based on an analysis using the pre-release beta version of MarineShift360. No statements regarding accuracy are made and results may change over time as the development of MarineShift360 continues.

October 2021 (version 2)

WILLIAMS JET TENDERS



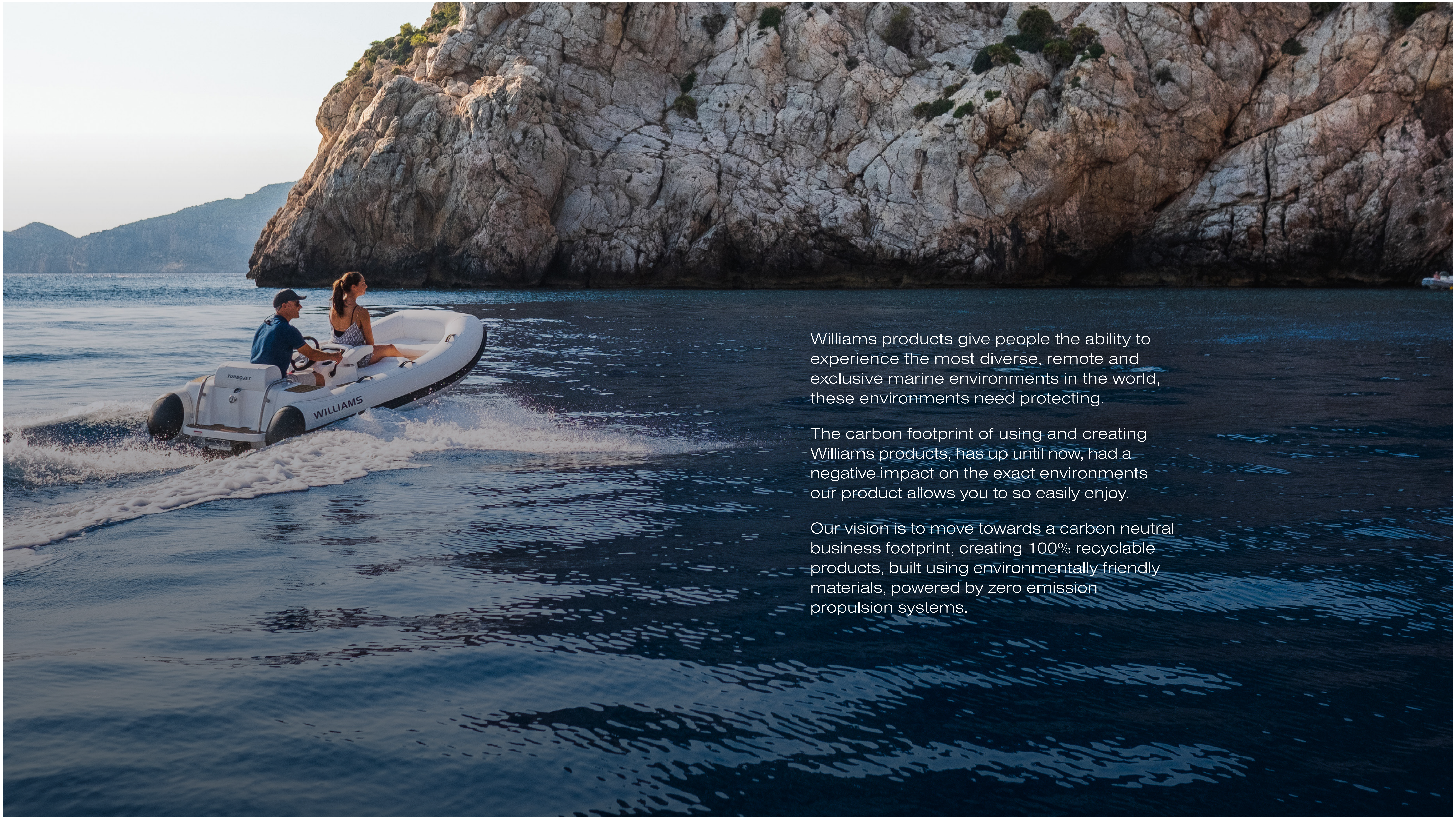
Our climate is changing, the oceans are being polluted by plastic waste, nature is in decline. Williams Jet Tenders believes that the marine industry needs to take responsibility for the environmental impact of its products.

We are just starting out on the journey to transform our business to one which leaves a clean wake. We are committed to doing things the right way. Our quest for perfection in all we do means that there can be no shortcuts. This is why we initiated, in 2021, a detailed environmental assessment of our complete product range – starting with the TurboJet325 – to really understand the complete environmental impacts of our boats.

Until now, such a comprehensive life cycle assessment (LCA) has been out of reach for most within the marine industry due the complexities of LCA and the specialist skills needed to conduct and interpret an analysis.

We were therefore pleased to become a MarineShift360 pilot partner, part of an international collaboration that aims to drive positive, sustainable changes in design and manufacturing in the marine industry. Backed by 11th Hour Racing as Founding Sponsor, MarineShift360 is a purpose-built LCA tool that enables non-LCA experts to evaluate and compare materials and processes, investigate alternatives, and drive innovation to allow informed, environmentally and economically sustainable choices.

By becoming a pilot partner we were able to both kickstart on our own sustainable journey and support the development of a tool to help others within the marine industry.



Williams products give people the ability to experience the most diverse, remote and exclusive marine environments in the world, these environments need protecting.

The carbon footprint of using and creating Williams products, has up until now, had a negative impact on the exact environments our product allows you to so easily enjoy.

Our vision is to move towards a carbon neutral business footprint, creating 100% recyclable products, built using environmentally friendly materials, powered by zero emission propulsion systems.

Goal of the study

To understand the production, use and end-of-life impact of our products using the TurboJet325 – our best selling tender – as the subject of the study.

The TurboJet325, like all Williams Jet Tenders, is moulded and assembled at our facility in Berinsfield, Oxfordshire, UK using raw materials and components sourced from around the world.

Our aim was to use the insights gained from the LCA to inform a broader sustainability strategy as well as a plan that provided tangible short, medium and long term actions to reduce the environmental impact of our products.

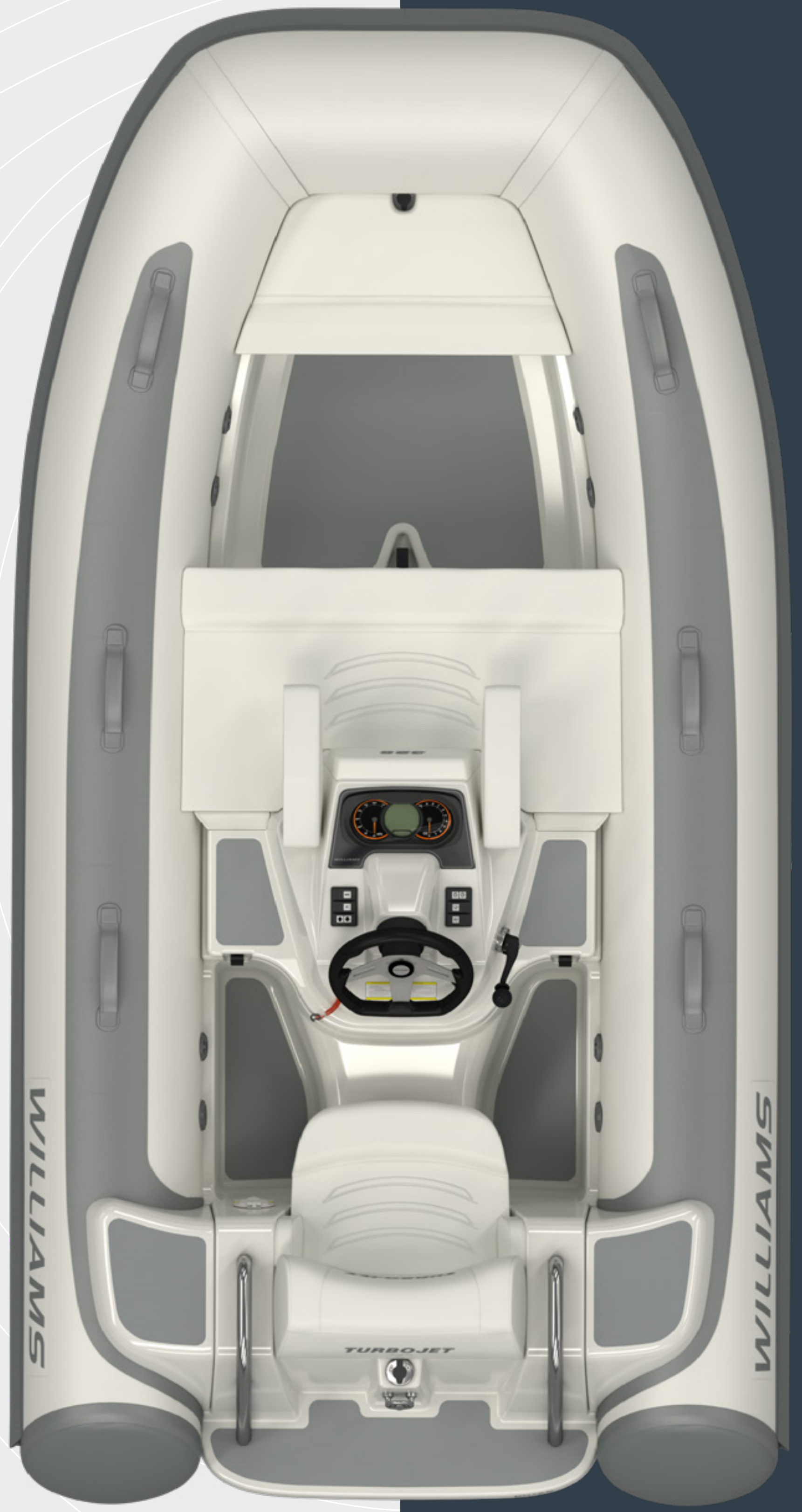
Scope of the study

As this was our first LCA study, we decided to set a wide scope including our complete value chain from cradle to grave.

This necessitated making some assumptions about the embodied impacts in the materials we procured, the impact of certain processes. the usage profile of our boats and their likely end of life. MarineShift360 contains a complete LCA database, tailored to the marine industry, which helped enormously.

We also decided to model a complete product system including the manufacture of each TurboJet325 as well as the tooling and patterns used to produce the moulded parts. However, after realising the small contribution that these made they were omitted from the final analysis[1]. The system boundary therefore included the following discrete assessments:

1. A single pattern produces three tools, each of which is used to produce around 300 boats. So, a single pattern is typically sufficient to produce 900 boats. As the environmental impact of manufacturing the pattern and tooling, when spread across a production run, was immaterial it was considered separately.



- **Composite mouldings** – including hull, deck, helm and engine stringer components
- **Engine** – Rotax ACE 903 90hp petrol engine and driveshaft
- **Fuel tank** – polypropylene injection moulding
- **Pump assembly** – aluminium jet pump and associated fittings
- **Tube** – Hypalon inflatable tube
- **Upholstery** – interior upholstery and associated fittings
- **Ancillary metal fittings** – various fixings, fastenings, cables, steering wheel, brackets and so on
- **Decking** – flexi teak decking
- **Use phase** – Fuel use based on typical lifetime usage profile (10 Year Lifespan)
- **Delivery of completed TurboJet325** – road transportation from production site in Oxfordshire to a typical Mediterranean customer

Each assessment covered, where appropriate, manufacturing processes, consumables used during manufacture, energy use, packaging, upstream transport of materials to the manufacturing site and end-of-life fate for the finished product, packaging and unused production waste materials.

Life cycle assessment methodology

The functional unit used in this case study is one TurboJet325. All input data for the LCA came from staff at Williams Jet Tenders manufacturing plant in Oxfordshire.

MarineShift360 uses an ISO14044-compliant life cycle assessment method using impact factors from the MarineShift360 database.

At the time of our study, the MarineShift360 database contained impact factors generated from EcoInvent 3.6 covering primary materials, utilities, waste processing and transport. To these have been added marine specific processes and materials from a number of industry sources, pilot partner contributions and literature reviews.

Two environmental impact assessment methods were used to calculate five different impacts.

ReCiPe is a method for the life cycle impact assessment first developed in 2008[2]. The primary objective of the ReCiPe method is to transform the long list of life cycle inventory results into a limited number of indicator scores. These indicator scores express the relative severity on an environmental impact category.

Below is a table listing the various impacts used in MarineShift360 as of the date of our study, their corresponding units and impact method:

Impact category	Unit	Impact method
Global warming	kg CO_2 eq.	ReCiPe 2016 v. 1.1
Mineral resources scarcity	kg Cu eq.	ReCiPe 2016 v. 1.1
Marine Eutrophication	kg N eq.	ReCiPe 2016 v. 1.1
Water consumption	m_3	ReCiPe 2016 v. 1.1

2. Source: https://pre-sustainability.com/articles/recipe/

Cumulative Energy Demand represents the total primary energy input for the generation of a product or a process. This includes the direct uses as well as the indirect energy use. It works by summing the different types of energy sources used in the production of a material. These different energy sources are listed in the table below:

Energy source	Unit	Description
Non-renewable resources – fossil	MJ	hard coal, lignite, crude oil, natural gas, coal mining off-gas, peat, pit gas, methane, sulphur
Non-renewable resources – nuclear	MJ	uranium
Non-renewable resources – primary forest	MJ	wood and biomass from primary forests
Renewable resources – biomass	MJ	wood, food products, biomass from agriculture, e.g. straw
Renewable resources – geothermal	MJ	geothermal energy
Renewable resources – solar	MJ	solar energy
Renewable resources – water	MJ	run-of-river hydro power, reservoir hydro power, energy from waves
Renewable resources – wind	MJ	wind energy

In addition, MarineShift360 also reports on three categories of waste; waste materials during production, waste packaging during production and fate of product at end of life.

Summary results

Although MarineShift360 can report against six impact categories, the results here are focused on greenhouse gases and waste – the primary areas of interest for Williams Jet Tenders.

The complete life cycle of a TurboJet325 is estimated to be responsible for just over 9 tonnes of carbon dioxide equivalents (9.12 tCO_2e per boat). As can be seen in Figure 1, the primary impact – based on assumed typical usage patterns – is the use phase (5.60 tCO_2e per boat). This is almost entirely attributable to the consumption of petrol by customers. However, production is also significant (3.17 tCO^2e per boat). End of life is relatively small (0.34 tCO_2e)– from a carbon perspective – but is important in other ways. End of life materials may still have economic value and are relevant to any exploration of circularity and end of life management of boats (a new EU Directive on this is widely anticipated).

Note that the life cycle carbon footprint of the TurboJet325 excluding fuel use by customers is 3.65 tCO_2e (3652 $kgCO_2e$).

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Figure 1: Breakdown of greenhouse gas emissions by life cycle stage for Turbojet325

Calculated by MarineShift360 beta software on 1st September 2021

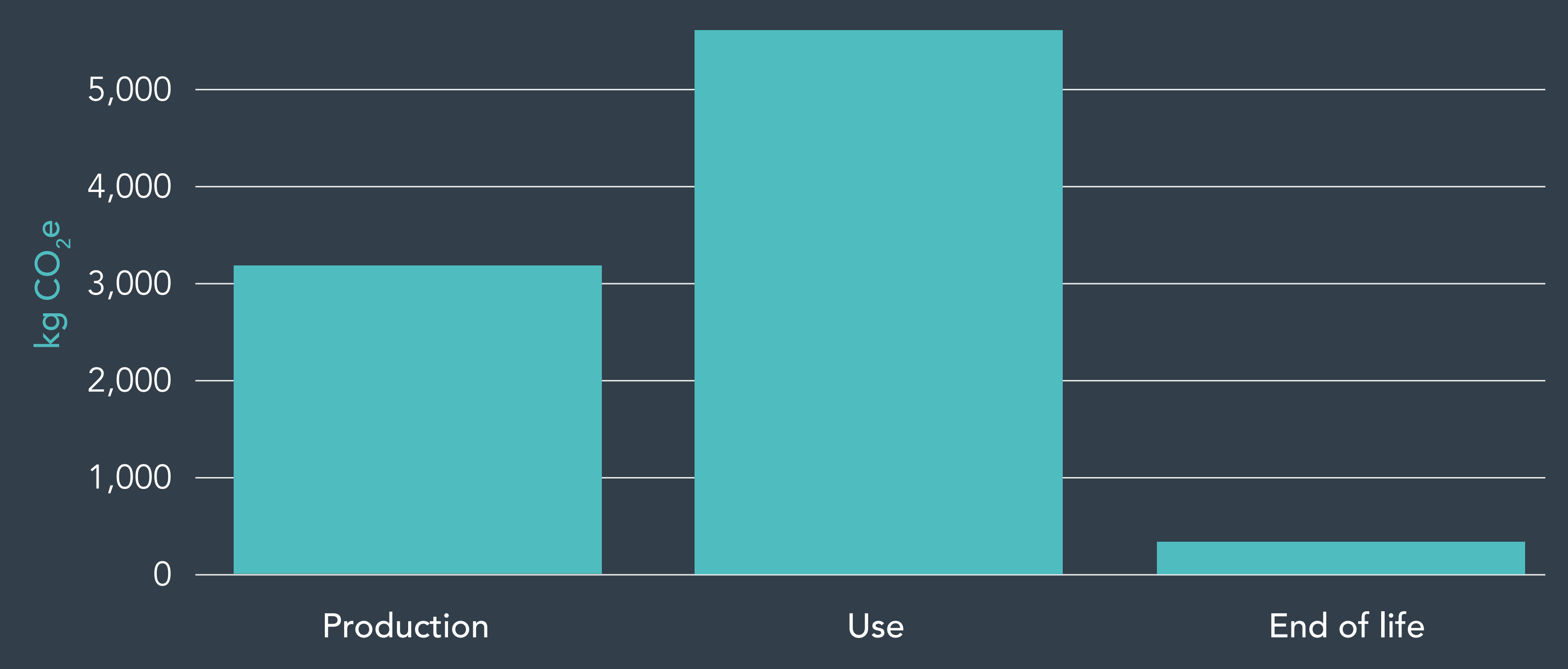
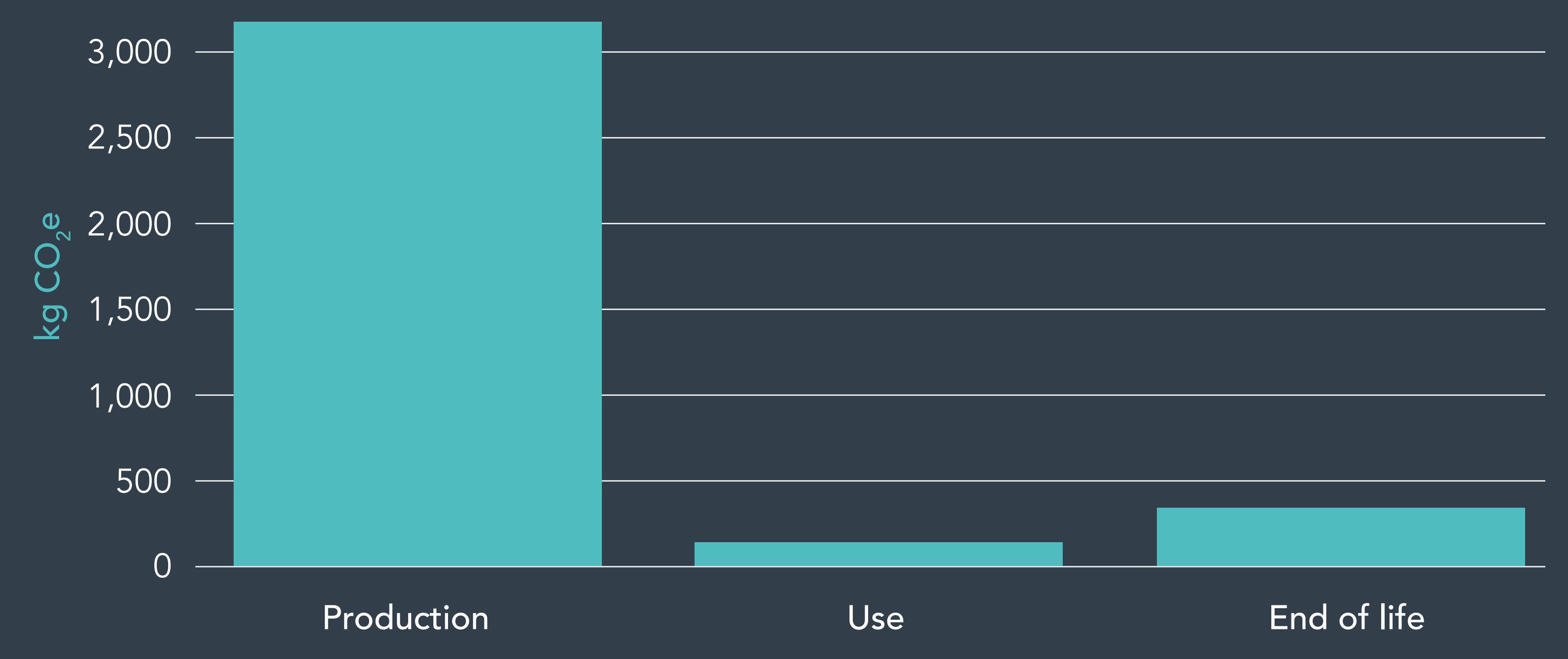


Figure 2: Production, Use and End of Life greenhouse gas with fuel use removed

Calculated by MarineShift360 beta software on 1st September 2021



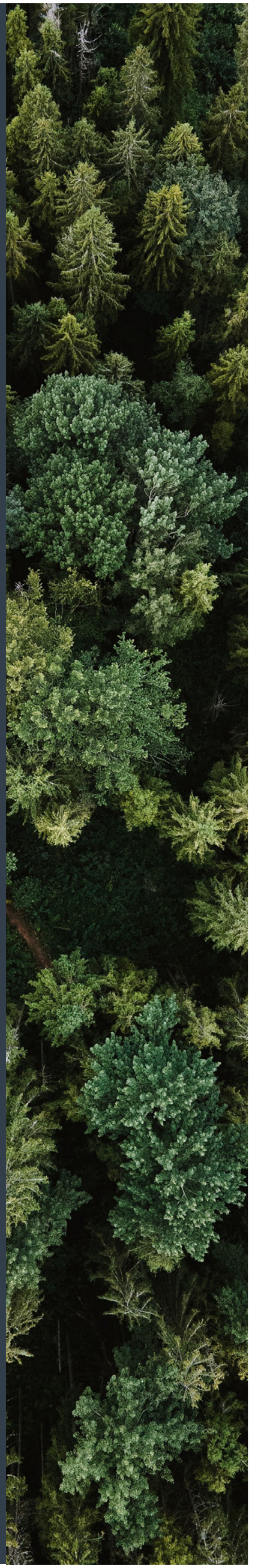
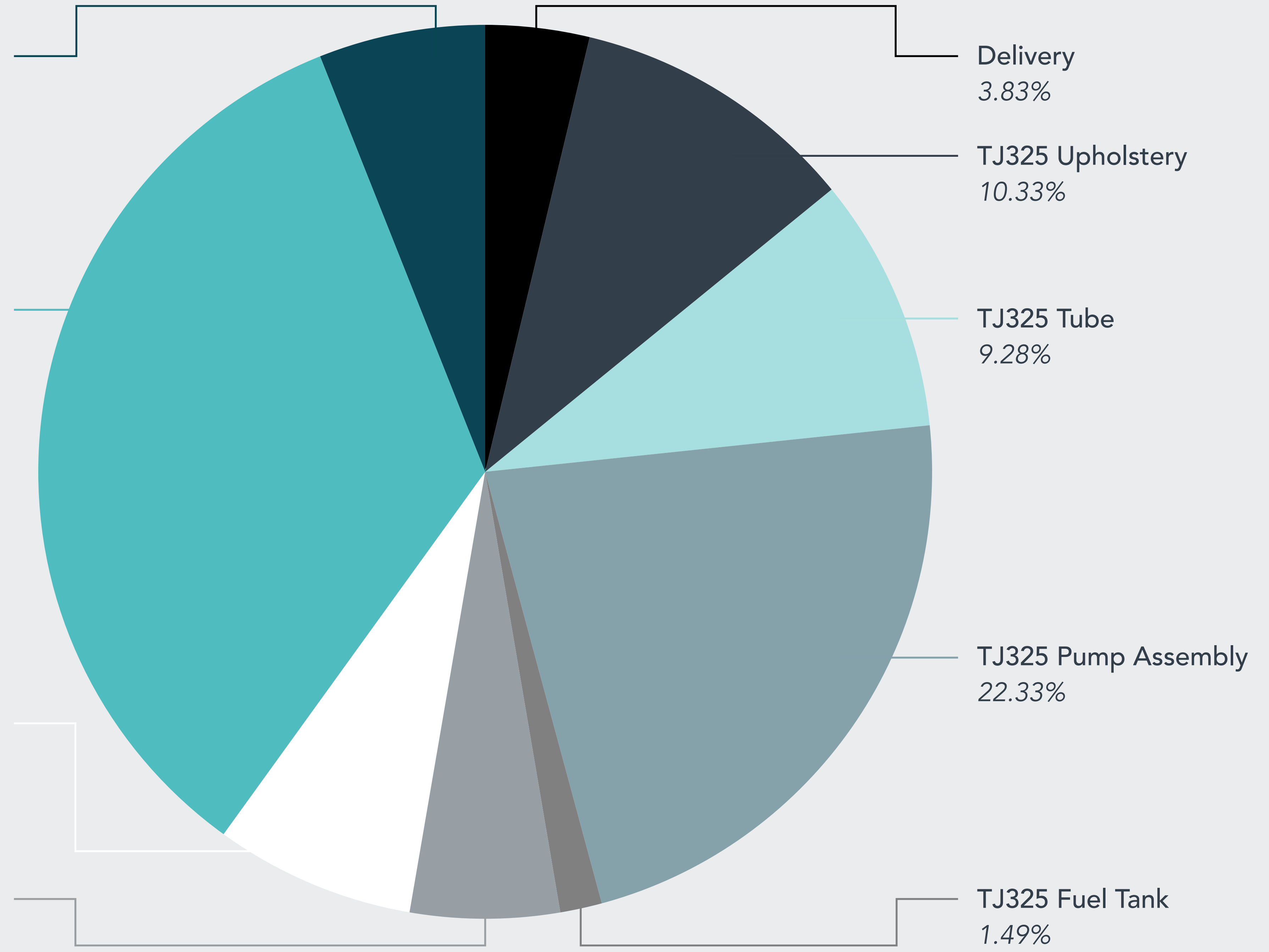


Figure 3: Breakdown of production emission

Calculated by MarineShift360 beta software on 1st September 2021



Just over a third (34.13%) is attributable to the composite mouldings with the cast aluminium jet pump assembly just over one-fifth of the total (22.33%). The tube and upholstery are each about one-tenth of the total (9.28% and 10.33% respectively) with the remainder made up of the engine (7.20%), flexi-teak decking (5.41%), delivery to customer (3.82%), metal fittings (6.00%) and fuel tank (1.49%).

3. The figure for the engine is most likely an under-estimate as it is based on the Ecoinvent average assumptions within MarineShift360. We are currently working with MarineShift360 to increase the range of marine engines that are covered.

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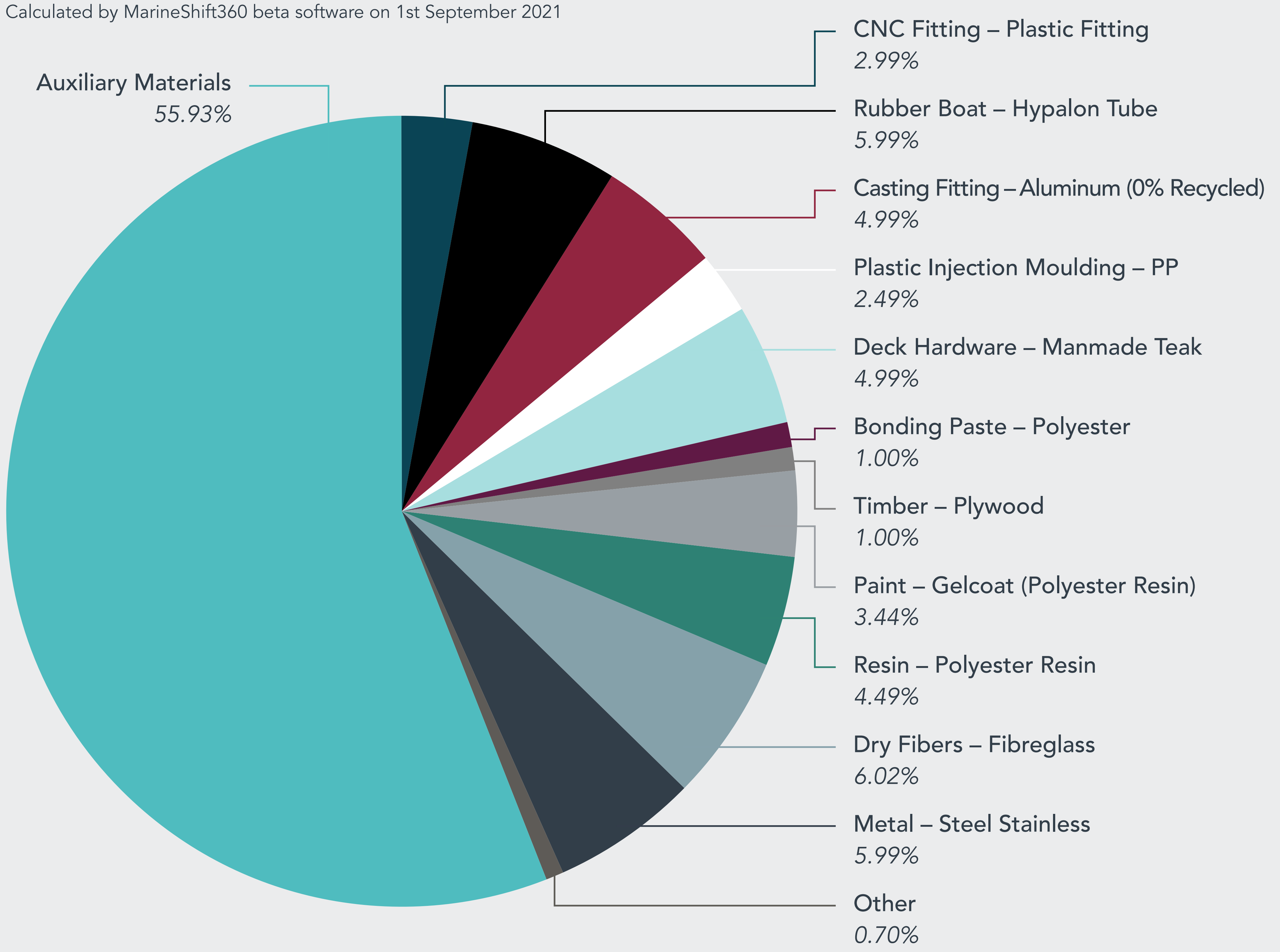
Turning to waste, almost one-quarter (22.16%) of the materials entering the production facility end up somewhere other than in the product. That includes disposable items (such as brushes and gloves – referred to collectively in MarineShift360 as ‘auxiliary materials’), materials surplus to requirements (for example, fibreglass offcuts) and waste from packaging. See Figure 4 for a breakdown, by mass, of waste.

A waste audit is planned to both validate these figures and provide more insight into the possibilities for waste reductions, reuse and recycling.

Figure 4: Breakdown of waste (all purchased items that do not form part of the finished product)

Calculated by MarineShift360 beta software on 1st September 2021



Williams Jet Tenders has a responsibility to instigate and drive change to ensure our environmental impact is dramatically reduced.

This is currently a choice we are making, but external pressure from changing government legislation and shifting consumer demand will soon become the biggest driving factor in the need to adapt our business and industry at large.

Key findings

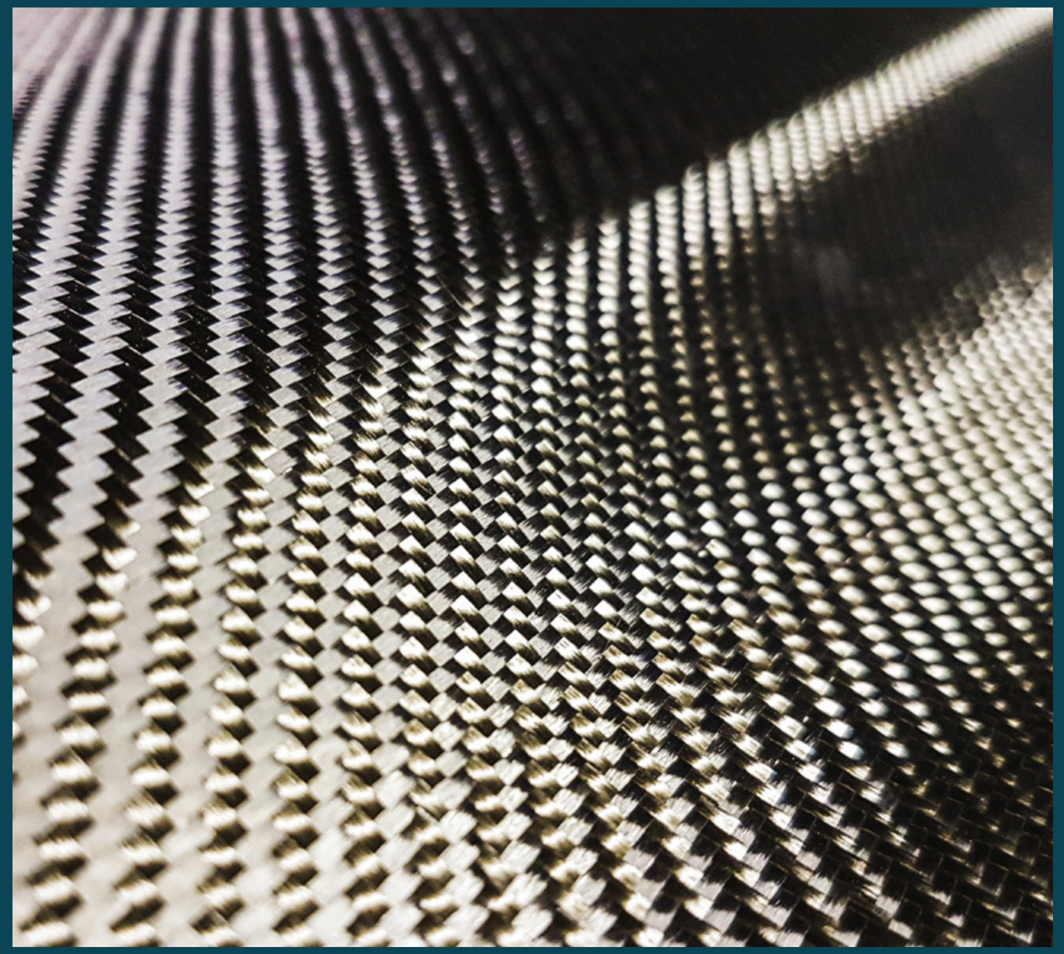
The MarineShift360 LCA study has already informed our thinking around future developments as well as identified some shorter term actions that can be taken to reduce production impacts.

Electrification

Whilst an electric version of the TurboJet325, appeared initially attractive, this would actually increase production emissions (as well as delivering a tender which was heavier, with less range and carrying a significant Green Premium).

Whilst use phase emissions would decrease, significant decarbonation of the electricity grid is required before the additional production emissions are counterbalanced over the boat's lifetime.

Due to the relatively low 'Use' phase of our products compared to 'on-road' vehicles (our petrol tenders accumulate less than 50 engine hours per year on average) we believe that electricification makes little sense for us until the grid is further decarbonised and battery production improved. Meanwhile we are continuing to explore other drivetrain solutions.



Alternative composites

Using MarineShift360, we have already modelled four alternative composite materials, all of which produced interesting results with big savings available if the full business case stacks up.

Challenges related to base material creation and then suitability of use in 'Resin Infused' laminates remain present. Again, further development of these materials is required before they could be considered 'Commercially Viable' in volume small boat manufacturing.

Virgin vs. recycled raw material

The majority of our base components are made from virgin raw materials, there are significant savings we can make by encouraging our supply chain to adopt recycled base materials. The cast aluminum jet pump is one example where a 60% saving can be made by switching to 100% recycled aluminum rather than using only virgin material.

How does this initial LCA case study drive Williams sustainable future?

By adopting the 'LCA' approach to understanding our environmental footprint, we have clear data that can inform our wider strategy, the key focus areas become obvious very quickly.

Just focusing on replacement of the propulsion system and ignoring those areas over which we have the most immediate control – the boats construction and the production systems – is short-sighted.

We are taking a 'Business Wide' approach, this allows us to make significant reductions in our environmental footprint today, whilst waiting for the larger technological breakthroughs that will allow us to reduce the 'USE' phase emissions in the future.

Williams Jet Tenders has a responsibility to instigate and drive change to ensure our environmental impact is dramatically reduced. This is currently a choice we are making, but external pressure from changing government legislation and shifting consumer demand will soon become the biggest driving factor in the need to adapt our business and industry at large.

We have developed a multi-point action plan based on six key ideas.

Just focusing on replacement of the propulsion system and ignoring those areas over which we have the most immediate control – the boats construction and the production systems – is short-sighted.

Reduce Energy Consumption

The creation of energy (Electricity) is one of the largest contributors to global annual CO_2 emissions. A reduction in energy consumption needs to be concentrated not just on the improving the facilities we operate and the production methods we utilise but also consuming less energy during the 'USE' phase of our products. This means focusing on reducing product weight and improving hull efficiency.

Reduce and Re-Use Waste

We produce significant amounts of waste, there is value in not only reducing the creation of waste but also repurposing the waste we do create. We live on a planet with finite resources so must become laser focused on maximizing all raw materials. We aim to become a Zero waste to landfill business by 2025.

Localise the supply chain

Like most manufacturers we utilize a global supply chain. Transport mileage accounts for a significant portion of our annual CO_2 creation. A particular focus will be placed on eliminating all air freight (many times worse than sea freight) consolidating inbound and outbound shipments and sourcing locally where possible.

Champion alternative materials and propulsion systems

Thanks to the MarineShift360 software we can very quickly model alternative options, be that different laminate options (Hemp, Basalt), propulsion systems or moving from virgin to recycled raw materials. As a small tender manufacturer, we don't have the budget to develop our own drive system, so are reliant on wider industry innovation. However, the LCA approach has highlighted the numerous other 'Marginal Gains' we can make that stack up to make a significant reduction in our environmental footprint.

Move towards a 'Circular Design' methodology

The ultimate goal is to move from the traditional model of Make, Use, Dispose towards a circular model of Make, Use, Recover/Recycle/Repurpose. Traditional manufacturing is wasteful, because it focuses exclusively on the end user. The circular economy mindset looks much wider, to consider everyone who extracts, builds, uses, and disposes of things.

Adopt a data driven approach – The Full LCA

We must not take shortcuts to reduce CO_2 in one phase to have a larger impact in a later phase. Taking a 'Data Driven' approach allows the business to avoid costly mistakes both environmentally and financially. MarineShift360 gives us the data required to make smart decisions and focus on the innovations that will make a measurable reduction in our environmental footprint.

We are investigating the option of allowing customers to offset up to 10 years of usage, however further data analysis is required before making this available to purchase.

Thanks to MarineShift360, we have used a mass-based scaling method to calculate our total annual CO_2 emissions (4,662 tCO_2e Cradle to Customer) Individual model analysis will be complete by Q2 2022.

We are now 100% focused on delivering on our longer-term strategy to significantly reduce emissions in the first instance. We plan to publish our annual CO_2 reduction commitments and longer term strategy during 2022.

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Anthesis

We would like to thank Anthesis for their input into developing the Turbojet 325 Case Study and help in developing our wider sustainability strategy.