Final Report

Streamlined Life Cycle Assessment: Pair of Cricket Batting Pads

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1. Background

Cricket is the 2nd largest and potentially the most gear intensive sport but has been generally slow to consider sustainability and environmental issues in gear design and development. Previous research undertaken by The Centre for Sustainable Design ® (CfSD) at University for the Creative Arts (UCA) through PASIC[1] platform identified that sustainability initiatives in cricket focus primarily on the wider impact of climate change on the game overall, venues, facilities, and grounds, largely overlooking the environmental impact of cricket gear and apparel. The findings presented in this report, form part of the UKRI CE-Hub flexible fund's feasibility study on Circular Cricket Gear (CCG) which aims to support the development of potential strategies to maintain the value of products, components, and materials in the economic and social systems of cricket gear, as well as exploring innovation in relation to new materials (TRL2) specifically for cricket gloves, batting pads and balls. The report builds on findings from the Vegan Leather Cricket Gear project (VLCG)[2], which has completed research in the sustainability impacts of cricket gear, primarily focusing on the potential substitution of bovine leather with a plant-based ('vegan') leathers in cricket balls, gloves, and batting pads.[3]

To contribute to an increased understanding of the environmental impact of cricket gear, a non-exhaustive review of existing Lifecycle Assessments (LCA) for cricket gear and the wider sports sector was conducted. Findings from this indicated that while a few LCA's have been conducted for other sports gear (e.g., skiing, tennis, hockey)[4], no LCAs[5] had been completed on any items of cricket gear to date. Due to lack of time and budget, it was decided to complete a streamlined LCA[6] [7] on one item of cricket gear - batting pads - as some knowledge had been built on the product through a disassembly exercise.[8]

The streamlined LCA presented in this report is therefore, a first attempt to assess the environmental impact of cricket batting pads. The LCA results should be taken as indicative (and not definitive) of the potential environmental impacts associated with the

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[1] https://cfsd.org.uk/projects/cricket/

[2] Funding provided for the Vegan Cricket Gear project was provided by UKRI via University for the Creative Arts, AHRC Impact Acceleration Account (IAA).

[3] See report: 'Leather Alternatives for Cricket Gear'. Available at: https://cfsd.org.uk/wp-content/uploads/2023/04/Final-Vegan-leather-alternatives-22-4-23.pdf

[4] Subic, A., Paterson, N. (2006). Life Cycle Assessment and Evaluation of Environmental Impact of Sports Equipment. In: Moritz, E.F., Haake, S. (eds) The Engineering of Sport 6. Springer, New York, NY. https://doi.org/10.1007/978-0-387-45951-6_8

[5] A life cycle assessment is a methodology for assessing environmental impacts associated with all the stages of the life cycle of a product, process, or service.

[6] A streamlined LCA can be defined as a 'strategic' assessment that assists businesses in identifying and focusing in on the main impacts in relation to a product or process. It allows for key issues to be explored in more detail where necessary and provides an agile and cost-effective alternative to full LCA's. Moreover, a streamlined LCA can use a combination of qualitative and quantitative approaches to evaluate impacts and allows the user to "design out" the main impacts of a product through the lifecycle. (Source: https://www.anthesisgroup.com/streamlined-life-cycle-assessment-tools-pdf-guide/)

[7] A streamlined LCA requires a reduced level of data compared to a full LCA and focuses in the main impacts in relation to a product or process.

[8] See: https://cfsd.org.uk/projects/ccg/research/

production, use, and end-of life of a cricket batting pad. The streamlined LCA was conducted using Sustainable Minds (SM)[9], an Eco-concept + Life Cycle Assessment software based on the SM 2013 Impact Assessment Methodology. SM was selected over other LCA software including Simapro and Gabi for its focus on early product design and development, being user friendly and being time and cost efficient.

2. Introduction to the Streamlined LCA

The product assessed in this study is a pair of cricket batting pads manufactured by a well-known brand which can be purchased for approximately £95.00. The sample of the product assessed was provided directly by manufacturer, however, for confidentiality reasons, the brand has been anonymised throughout this report.

The LCA addresses the entire life cycle of a product, this is, from the extraction of raw materials to manufacturing, usage, and end-of-life. The life cycle has been divided into three sections, including the following sub-sections:

1. Production: raw material extraction, processing, manufacturing, and assembly. Transportation is included from suppliers to manufacturing site.
2. Use: transportation to the end user has been included as part of the use phase.
3. End-of-Life: calculations assume that all materials, parts, and components of the product are landfilled and therefore no transport to waste treatment plants and waste treatment has been calculated.

3. Goal and Scope

The goals of the LCA are to:

1. Generate insight into the environmental impact of the cricket batting pads along the value chain to identify opportunities for improvement through circular design principles.
2. The result of the assessment is intended to be used as part of background research within the CCG project.

3.1 Functional Unit

Due to a lack of publicly available data regarding usage and end-of-life of cricket gear, assumptions had to be made to assign the functional unit for the LCA. Therefore, based on player knowledge, the functional unit is based on adult use in recreational cricket for 3 seasons (3 years) from April to September in the UK. For conducting this streamlined LCA, the batting pads are expected to have a lifetime of 3 years where 20 games + 10 indoor nets are played per year. In other words, the number of services delivered by a pair of pads is 60 games + 30 indoor nets across the entire lifespan of the product.[10] However, it is pertinent to highlight that according to Kookaburra, the average use of a

[9] SM2013 claims to be transparent, ISO 14044 compliant – with formulas and data sources, and industry reviewed. SM 2013 uses the Tool for Reduction and Assessment of Chemicals and Other Environmental Impacts (TRACI 2.1), 9 impact categories developed by the U.S. EPA, North American normalization and weighting values developed by the United States Environmental Protection Agency (EPA) and the National Institute for Standards and Technology (NIST) respectively, and process inventory data from credible sources worldwide. Source: http://www.sustainableminds.com/software/methodology

[10] The total number of games and indoor nets has been calculated based on 3 years of usage= 3x 20 games and 3x10 indoor nets.

pair of gloves and pads is 1 year. This could be the case for professional rather recreational players[11] and may not be due degradation of the batting pads but due to other reasons such as a sponsorship requirements. Moreover, the life of the cricket batting pads will vary depending on the number of games the batter plays, the extent of practice and the length of time the batter spends batting, the quality of production and assembly and how they are stored when not in use. A recent survey, conducted with 42 primarily recreational players, indicated that 57% of respondents kept their batting pads for over 8 seasons, while 33% for 3-8 seasons. This indicated that batting pads are potentially kept for longer than originally thought. However, for this study, it was decided to calculate the functional unit based on 3 seasons, as the results from the above survey were not available when the LCA was undertaken. It is also noted that the survey results are based on an older demographic (generally over 55), which perhaps play fewer games at recreational level compared to perhaps younger players playing league cricket that may be participate more intensely e.g. play more games and complete more net practice.[12]

3.2 System Boundaries

The system of the cricket batting pads during its lifetime (3 years) includes the production, distribution, use and disposal. The streamlined LCA excludes the packaging as it assumed that the main environmental impacts are caused by the production and disposal lifecycle stages.

3.3 Geography

The assessment is based on the sole use of the cricket batting pad(s) within the UK. Therefore, CO2 emissions related to transportation of the final product has only been calculated from India to the UK. Nonetheless, assumptions have been made regarding the product's supply chain which are outlined below.

3.4 Assumptions

Due to the lack of access to primary data, assumptions were made regarding some of the materials' specification, their geographical origin, and suppliers used for manufacturing the cricket batting pad(s). In turn, calculations related to transportation, such as distances and mode of transportation were also based on assumptions. For example, the report is based on the Polyurethane leather (PU) used for the exterior component being sourced from China (the world's largest producer of PU). With the mode of transportation being oceanic freighter from China to Northern India where the products are assembled. Calculations were based on selecting one of the ports available on the 'Corgoport'[13] website, after which distance was calculated in nautical miles (nmi) and then converted into kilometres as per requested by the Sustainable Minds software (SM).

[11] https://www.kookaburrasport.co.nz/pad-and-glove-care
[12] See report: Specific Findings from a Survey of Cricket Players related to Cricket Gear and Plant-based/'Vegan' Leather Alternatives. Available at: https://cfsd.org.uk/projects/vlcg/research/
[13] https://www.cogoport.com/blogs/a-guide-to-ocean-freight-from-china-to-india

Additionally, due to a lack of primary or secondary data related to the end-of-life of batting pads, further assumptions were made e.g., all materials ending up in landfill. As mentioned previously, the results do not include transportation incurred from end-of-use to end-of-life.

3.5 Environmental Impact Categories

The environmental impacts and indicators considered in the LCA calculation are:

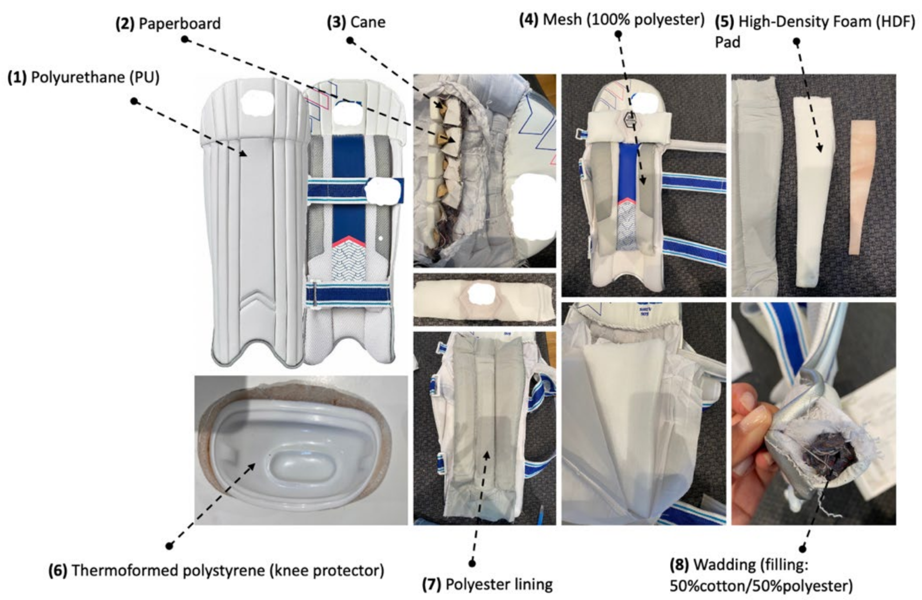
1. Ecological damage: which includes acidification, ecotoxicity, eutrophication, global warming, and ozone depletion.
2. Resource depletion: which include fossil fuel depletion due to most materials used for manufacturing the cricket pad being derived from fossil fuels.
3. Human health damage: include carcinogenic and non-carcinogenic impacts.

4. Life Cycle Inventory

4.1 Materials, production data and technical and functional requirements

The materials and quantities specified in the table below were identified as part of a disassembly exercise where individual materials were extracted (see **Diagram 1** and **Table 1**) and weighed on a kitchen scale that detects mass ranging from 1g to 5kg. Additionally, some of the material specifications were defined based on desk research and expert knowledge e.g., wadding: 50% polyester and 50% cotton.[14] The total weight of the batting pads is 1.728 kg. It is currently unknown whether the manufacturer holds information on the exact material specification for each product part. Assumptions have therefore been made based on similar materials.

Diagram 1: Disassembly of Cricket Batting Pads-Components and Materials



[14] The materials have not been verified by the manufacturer. Therefore, further research is required to certify the list of materials provided in Table 1.

Table 1: Cricket Batting Pads-Components and Materials Specifications

No.	Material	Weight	Technical requirements	Functional requirements
1	Polyurethane (PU) Plastic-based fixings, such a Velcro fastening straps.	277g x2=**554g**	Abrasion resistant/lightweight/flexible	Provides structure to the product and holds all internal protective components.
2	Paperboard (carton)	72gx2=**144g**	Lightweight	protects outer casing from tears due to impact with cane. Increases durability of product, rigidity, cushioning of impact
3	Cane	105gx2=**210g**	Lightweight/impact protection/ integrity of product	Provides structure to the product and user impact protection
4	Mesh (100% polyester)	55gx2=**110g**	Breathable/flexible	
5	High-density-foam (HDF)	169gx2=**338g**	Impact protection/integrity/lightweight/ flexible, energy absorption	Impact protection
6	Thermoformed polystyrene (kneecap)	23gx2=**46g**	Lightweight/impact protection/rigidity	Knee protection from impact
7	Polyester lining	55gx2=**110g**	Breathable/flexibility	Hold protective HDF in place within product/protect HDF
8	Wadding (50% cotton/50% polyester)	108gx2=**216g**	Lightweight/resistant	Protects product and user from tears caused by the inner cane.

4.2 Waste Management

Data related to waste management was not considered for this assessment, as it was assumed that all products are landfilled at end-of-life However, a further LCA could potentially include waste management data by including national or global recycling rates for specific materials if, for example, potential design solutions explored material recovery and recycling.

4.3 Transportation

The selected product is manufactured in Northern India. As indicated earlier, assumptions have been made regarding the origin of the primary materials used for manufacturing. It has been assumed that PU originates from China, as the world's largest producer of PU raw materials and products.[15] While polyester used for the mesh and lining, as well as the high-density foam, polystyrene, cane, paper board and wadding are assumed to be sourced locally and therefore transportation calculations are based on road transportation by truck/multiple land vehicles.[16]

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[15] https://tradingeconomics.com/india/imports/china/plastics

[16] For further background in the environmental impacts of 5 items of cricket equipment and apparel, see report on 'Components, Materials and, and Innovation Opportunities 'for cricket gear, clothing, and apparel. Available at: https://cfsd.org.uk/wp-content/uploads/2022/07/Sustainability_Cricket-Gear_Materials-Final-28-7-22.pdf

4.4 Production

The cricket batting pads are manufactured in Northern India. All raw materials for manufacturing and parts for assembly are therefore transported to this site and then transported, in this instance, to the UK for distribution. The pair of cricket batting pads assessed weigh 1.728Kg when delivered to the end user (excluding any associated packaging).

Due to the lack of available data regarding the manufacturing processes for the selected batting pad(s), manufacturing waste was not accounted for despite identifying, for example, excess seam allowance for the pads. Moreover, the energy used by, for example, the sewing machines used to assemble the product and the energy used for the manufacturing plants also fell outside the scope of this assessment.

4.5 Use

The end user market is based on usage (playing) within the UK. Therefore, the selected batting pads are assumed to be transported by oceanic freight from Northern India to the UK: distances are estimated. During the use (playing) phase, there is no usage of resources, energy, or water and therefore this was excluded from calculations. The batting pads maybe cleaned by (some) players (users) with a damp cloth and dried naturally after use. However, the usage of water used during the use phase is assumed to be minimal and therefore it has been excluded from this assessment.

4.6 End of life

The calculations for the environmental impact assume that the product is not disassembled and therefore, all materials, parts and components are landfilled at end-of-life. This is aligned to prior research undertaken that highlights a gap in data regarding the end-of-life for cricket gear (see PASIC platform)[17]. Furthermore, specifically related to batting pads, no product life-extension strategies have been identified as being applied by producers or distributors.

5. Results

5.1 Hotspot Analysis

The results below show that the total impact of a pair of batting pads is 0.16mPts per year of usage or 0.47mPts across the product's expected lifetime of 3 years. In the Sustainable Minds LCA methodology, the single score indicator (more generally referred to as the 'impact factor'), is expressed in millipoint (mPts). One millipoint is 1/10000th of a point is where 1 point represents the 'annual environmental load of the US (i.e., entire production consumption activities in the economy) divided by the share of one individual.'[18] While the single score indicator is based on US data, we anticipate that this

[17] https://cfsd.org.uk/projects/cricket/

[18] Sustainable Minds LCA methodology aligns to ISO14044 and is intended for use in product development. It is based on TRACI impact categories which allows for compatibility in future studies. For further details on Sustainable Mind's single score system, including normalization and weighting see: http://www.sustainableminds.com/showroom/shared/learn-single-score.html

will not affect the results presented in this report which is based on a use scenario in the UK.

Figure 1 indicates that the highest environmental impact associated with the production of a pair of batting pads is human toxicity (carcinogenic). This is followed by global warming potential associated with the carbon dioxide (CO_2) emissions embedded in the entire lifecycle of the product and fossil fuel depletion due to the raw materials used for the majority of the product's components. **Figure 2** indicates that from a material perspective, the 3 main contributors to the product's total score are the use of high-density foam (HDF), the polyester used for the products lining and polyester used for the mesh.

Figure 1: Environmental impact by category

Sustainable Minds
Design greener products right, from the start

Project: Cricket Batting Pad
Concept: baseline
Methodology: SM 2013

Scorecard

	Reference	
	baseline	This concept is the reference for this project. The reference is a baseline to which other concepts in this project will be compared.
	Image not provided	
Impacts per functional unit	**0.16** mPts per 1 year of use	
Total amount of service delivered	3 x 1 year of use	
Impacts of total service delivered	0.47 mPts	
Assessment level	Estimate	
Greatest impacts		
SBOM input	Polyurethane, flexible foam	
Impact category	Carcinogenics	
Life cycle stage	Manufacturing	
Total impacts by impact category		

Impact category	%
Ecological damage	
Acidification	4.56
Ecotoxicity	5.27
Eutrophication	5.36
Global warming	23.89
Ozone depletion	0.02
Resource depletion	
Fossil fuel depletion	17.73
Human health damage	
Carcinogenics	31.98
Non carcinogenics	2.64
Respiratory effects	2.82
Smog	5.73

Figure 2: Impacts by material

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Project: Cricket Batting Pad
Concept: baseline
Methodology: SM 2013

Impacts by SBOM inputs: Total [mPts/func unit]

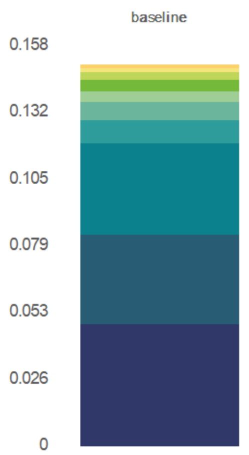
Reference

The first concept created in a project is, by default, the **reference concept**. The reference is the baseline that other concepts in this project will be compared to.

About this results view

This view shows the total impacts in millipoints (mPts) of your product system per functional unit.

You can identify and compare 'hot spots' (materials, manufacturing processes, power, water and other consumables, end of life methods and transportation activities with high scores) with which you can improve the overall environmental performance of your product concept.



Total = 0.16mPts/func unit

Input	mPts/func unit
Material - high density foam HDF	0.0484
Material - mesh	0.0355
Material - Polyester lining	0.0355
Transportation - Freighter, oceanic	9.21×10^{-3}
Process - PU leather : Foaming, expanding, plastics	7.11×10^{-3}
Material - paperboard	4.73×10^{-3}
Process - high density foam HDF: Foaming, expanding, plastics	4.34×10^{-3}
Material - Kneecap	2.98×10^{-3}
Transportation - Freighter, oceanic	1.46×10^{-3}
EOL - PU leather : Landfill, polyurethane	1.28×10^{-3}

5.2 Carbon Footprint by Life cycle Stage and Material

The total carbon footprint of a pair of batting pads is equivalent to 2.60 CO_2 eq. Kg/functional unit. **Figure 3** shows that the main contributor to the product's carbon footprint is the manufacturing phase. Within this phase, as highlighted in **Figure 4**, the main contributor is the production of polyester for the product's lining and mesh, followed by the production of high-density foam (HDF) for the protective padding. The third contributor to the product's carbon footprint is related to transportation. Although as previously mentioned, transportation calculations for this report only consider the transportation of primary materials to manufacturing sites in Northern India and shipment to the warehouses in the UK. Therefore, transportation from warehouses in the UK to retailers and consumers (players) has been excluded.

Figure 3: Impacts by life cycle stage-Carbon footprint

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Project: Cricket Batting Pad
Concept: baseline
Methodology: SM 2013

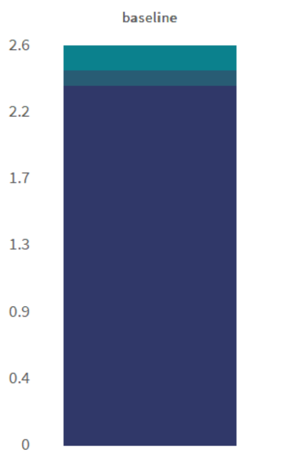
Impacts by life cycle stage: Carbon footprint [CO_2 eq. kg/func unit]

Reference

The first concept created in a project is, by default, the **reference concept**. The reference is the baseline that other concepts in this project will be compared to.

About this results view

This view shows the carbon footprint in kilograms of CO_2 equivalents (CO_2 eq. kgs) of your product system by life cycle stage: manufacturing, use, end of life and transportation. You can identify and compare the life cycle stages with high scores and target them to reduce the overall carbon footprint of your product concept.



Total = 2.6 CO2 eq. kg/func unit

Lifecycle stage	CO2 eq. kg/func unit
Manufacturing	2.36
End of life	0.103
Transportation	0.160

Figure 4: CO2 emissions by material

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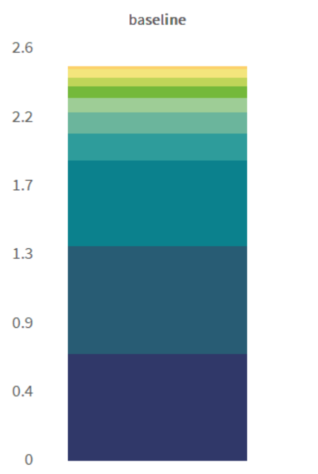
Project: Cricket Batting Pad
Concept: baseline
Methodology: SM 2013

Impacts by SBOM inputs: Total [CO_2 eq. kg/func unit]

Reference



The first concept created in a project is, by default, the **reference concept**. The reference is the baseline that other concepts in this project will be compared to.

About this results view

This view shows the carbon footprint of your product system per functional unit. It actually represents the total quantity of global warming gasses created throughout the life cycle of your product concept. The impact units are in kilograms (kgs) of carbon dioxide (CO_2) equivalent because it accounts for all the gasses that contribute to global warming. Many of these have greater global warming capacity per kg than CO_2.

You can identify and compare 'hot spots' (materials, manufacturing processes, power, water and other consumables, end of life methods and transportation activities with high scores) with which you can reduce the global warming impacts of your product concept.

Total = 2.6 CO2 eq. kg/func unit

Input	CO2 eq. kg/func unit
Material - Polyester lining	0.682
Material - mesh	0.682
Material - high density foam HDF	0.549
Process - PU leather : Foaming, expanding, plastics	0.164
Transportation - Freighter, oceanic	0.132
Process - high density foam HDF: Foaming, expanding, plastics	0.100
Material - paperboard	0.0643
EOL - paperboard : Landfill, packaging cardboard	0.0583
Material - Kneecap	0.0535
Process - mesh : Weaving, bast fibres	0.0215

6. Conclusion

The LCA results presented in this report should be viewed as indicative of the environmental impact of a pair of batting pads, rather than definitive. Several assumptions had to be made due to a lack of primary data, while some calculations have been based on secondary data or industry averages. A primary gap in the report is data related to CO2 emissions associated with the distribution of raw materials to suppliers, manufacturers, warehouses, and the final distribution of the products to retailers and customers (players). Furthermore, the associated impacts related to the infrastructure of manufacturing and retail sites (e.g., electricity, water, etc), and the end-of-life phase of the product for which transportation has also been excluded.

Nonetheless, the results offer an initial overview of the main areas of environmental concern related to the lifecycle of cricket batting pads. Not surprisingly, the highest impact is related to the manufacturing stage, as most of the materials used to produce the batting pads are from virgin non-renewable sources. The LCA also indicates that the use of polyester for the lining and mesh are the highest contributors to the product's overall carbon footprint, despite only representing 220g of the total weight of the batting pads (1.728 Kg). Furthermore, the study indicates that the use of high-density foam (HDF) represents the highest environmental impact in relation to human health damage (due to its carcinogenic properties). Based on these findings, the following recommendations are made below.

7. Recommendations

7.1 To conduct a further streamlined LCA that considers a higher functional unit based on the preliminary results of a survey conducted with cricket players/users, which indicated that cricket gear, specifically cricket batting pads and gloves are kept for over 8 seasons by 38% out of 42 respondents.[19]

7.2 To focus on strategies to extend the life of the product so that the average use of cricket batting pads can be extended beyond 3 years, or faulty parts/components or damaged materials can be replaced. In turn, this could potentially lower the overall environmental impact of the product.

7.3 To consider material substitution of HDF, PE and polyester used for the textile lining and mesh with sustainable material alternatives (e.g., recycled, or biobased materials) as these represent the primary contributors to the product's overall carbon footprint.

7.4 Focus on strategies to extend the life of the high-density foam (HDF) used for the internal protective padding through reuse, repair, or refurbishment. As the results show, this material/component is the highest contributor to the product's overall environmental impact and third of the carbon footprint.

7.5 Explore potential cost implications of potential changes highlighted in 7.1, 7.2 and 7.3.

8. Next Steps

Further research is required to understand the impact associated with pre-consumer waste, which has not been considered for this report. As the preliminary findings from the product disassembly exercise highlighted, there is significant waste associated with the production of the batting pad(s), primarily related to the use of the PU leather and other textiles.[20] Moreover, using the results presented in this report as a baseline for the

[19] https://cfsd.org.uk/wp-content/uploads/2023/04/Final_Players_Vegan_Cricket_Gear-27-04-23.pdf

[20] An example of future considerations for addressing the impact of pre-consumer waste is the potential implementation of zero-waste pattern cutting. For example, see: Katarina Winand, 'Concept Development for Sustainable and Resource-saving Fashion Design', in *Sustainable Innovation 2023*. https://cfsd.org.uk/events/sustainable-innovation-2023/programme/

environmental impact of batting pads, a next step is to conduct further streamlined LCA's on different product scenarios to evaluate if the recommendations presented above in effect, lead to a reduction in the product's environmental impact.