



Eco-design Practices Report: Pela case

Analysis of Pela case's eco-design practices and recommendations for the future

Introduction

Pela is a Canadian based company founded in 2011 by Jeremy Lang, that aims to provide an alternative to the common petroleum-based plastic phone cases. They identified the issue that over a billion phone cases are sold every year, and often made in excess. Thus significant amounts are disposed as they no longer fit the current phone models(Pela, 2021b; Sarath et al., 2015). Premature disposal of conventional phone cases arises as they tend to easily break or wear prior to replacing a phone(Hasnain Saeed et al., 2019; Bridgens et al., 2015; Lilley et al., 2016). Moreover, rapid changes in trends mean that consumers regularly change their cases for aesthetic reasons; reduced demand can lead to disposal of entire collections. Pela's solution was to create a 100% compostable phone case which they claim is 0% waste due to the use of carbon offesets. They have also developed several other "everyday products" such as sunglasses, AirPod cases, smartwatch bands, zero waste screen protectors, cardholders and phone grips(Pela, 2021b). These products plastic items that are frequently disposed of before the end of their useful life; the resulting negative environmental impacts(Bridgens et al., 2015). Considering this, it is evident Pella provide a potentially valuable alternative to conventional plastic.

Goal and Scope

The eco-design strategies employed by Pela throughout the product's life cycle will be analysed using application of lifecycle thinking and the LiDs wheel; the resulting relative examination allowed for solutions and their possible barriers and drivers to be evaluated. The report focuses on the primary product sold by Pela, the phone cases, and also analyses the impact of using the brand's website.

Evolution of eco-design within the industry

Definition:

Eco-design is an approach that seeks to minimise environmental impacts throughout the product's life cycle whilst not compromising performance, quality and cost(van Weenen, 1995; Pigosso et al., 2013; Sakao, 2007). Eco-design is closely associated with 'Sustainable Product innovation'; however, this report distinguishes between eco-design and sustainable design. Sustainable design can be defined as a more holistic approach that closely considers impacts

regarding society, such as, equity and empowerment, something that eco-design may only touch on(Bhamra, 2004; van Weenen, 1995).

The eco-design process is applied from the beginning of the product development phase, and can include environmental, ergonomic, aesthetic, and economic factors; maintenance, quality and safety requirements; drawings and documentation. Manufacturer's often link environmental considerations with cost increase. However, design improvements and reductions in economic cost can be achieved by increasing productivity and reducing material usage(Romli et al., 2015).

Pioneers and history:

The term ecological design was coined by Van der Ryn and Cowan (1996). However, eco-design concepts emerged in the 1800s, in the wake of the Industrial revolution. For example, Chapman recognised early connections between emergent cultures of excessive materialism and environmental deterioration(Chapman, 2005).

Papanek (1995) highlighted the issue that many materials used in design were environmentally harmful. From this, much eco-design revolved around eco-efficiency and zero emissions which assumes a linear economy. Criticism of this one-way flow of materials, from 'Cradle-to-Grave', included the recycling of many products; having not been specifically intended to be recycled, many undergo a reduction in quality. Moreover, zero waste or emissions is argued to be virtually unreachable(Braungart et al., 2007). Gradually the focus moved to a circular economy as the concept of eco-effectiveness and cradle-to-cradle design presented an alternative, whereby materials maintain their status as a resource with added value through subsequent life cycles(Braungart et al., 2007).

During the Industrial Revolution increased mechanisation of manufacturing lead to a throwaway society as production began to exceed demand(Ashby, 2013). Purchasing began to be driven by aesthetics (cosmetic obsolescence) rather than functionality(Lilley et al., 2016; Bridgens, B. et al., 2019). Additionally, planned obsolescence emerged within the technology industry(Bridgens, B. et al., 2019). Shortened lifespans meant it predicting which mobile phones would sell was challenging; hence phone cases are often produced in excess. With the resulting excess of non-biodegradable waste, this rapid consumerism, driven by increased consumption, has resulted in negative global environmental, social, and economic consequences(Sarath et al., 2015).

Pela was the pioneer of the first 100% compostable phone case. In the years following, other brands have developed biodegradable and bioplastic cases. There are also cases made from cork,

recycled plastic, leather, rubber, and bamboo (Table 1). Fashion eco-design pioneers are relevant pioneers as phone cases are both a functional technology protector and a fashion accessory. The founder of Pela has cited Patagonia as a pioneer of significant influence (Grow Ensemble, 2020). Patagonia is an outdoor clothing company, founded in 1972, with a focus on helping the environment (Rattalino, 2018; Reinhardt et al., 2010). They became established as leaders in naturally enterprising-eco-design of business products through creative thinking and product design (Beard and Hartmann, 1997). Since 2002, around 1,500 members, including Pela, have joined Patagonia in donating at least 1% of their sales (Patagonia, 2021). Further more Organic Basics (2021) are one of the first fashion brands to implement sustainable design into their website, and raise awareness of the environmental impact of internet use.

Methodology

The report will extract information from various sources: Pela's website, their competitors' websites, reviews, reports, and scholarly literature from the field of eco-design.

A systematic exploration of the Pela website allowed the range of products, and pages with key information regarding their sustainability strategies to be identified. Reviews and comparisons from tech reviewers provided indications of the competitors. These were sampled from sources other than Pela, to mitigate brand bias; brand websites were used to confirm the information from the review sites (Table 1). The University of Leeds Library database and Google scholar were used to identify key literature regarding eco-design's evolution, and studies looking at eco-design issues of phone-cases, and medium-short life plastic products.

From the LiDS wheel (Figure 1), four stages that would be most impactful to Pela were selected. The Inventory Matrix for Lifecycle Assessment informed the selection of these stages (Table 2). The environmental impact of using the digital website was evaluated using the Digital Wholegrain (2021) online calculator.

Analysis of Eco-practices

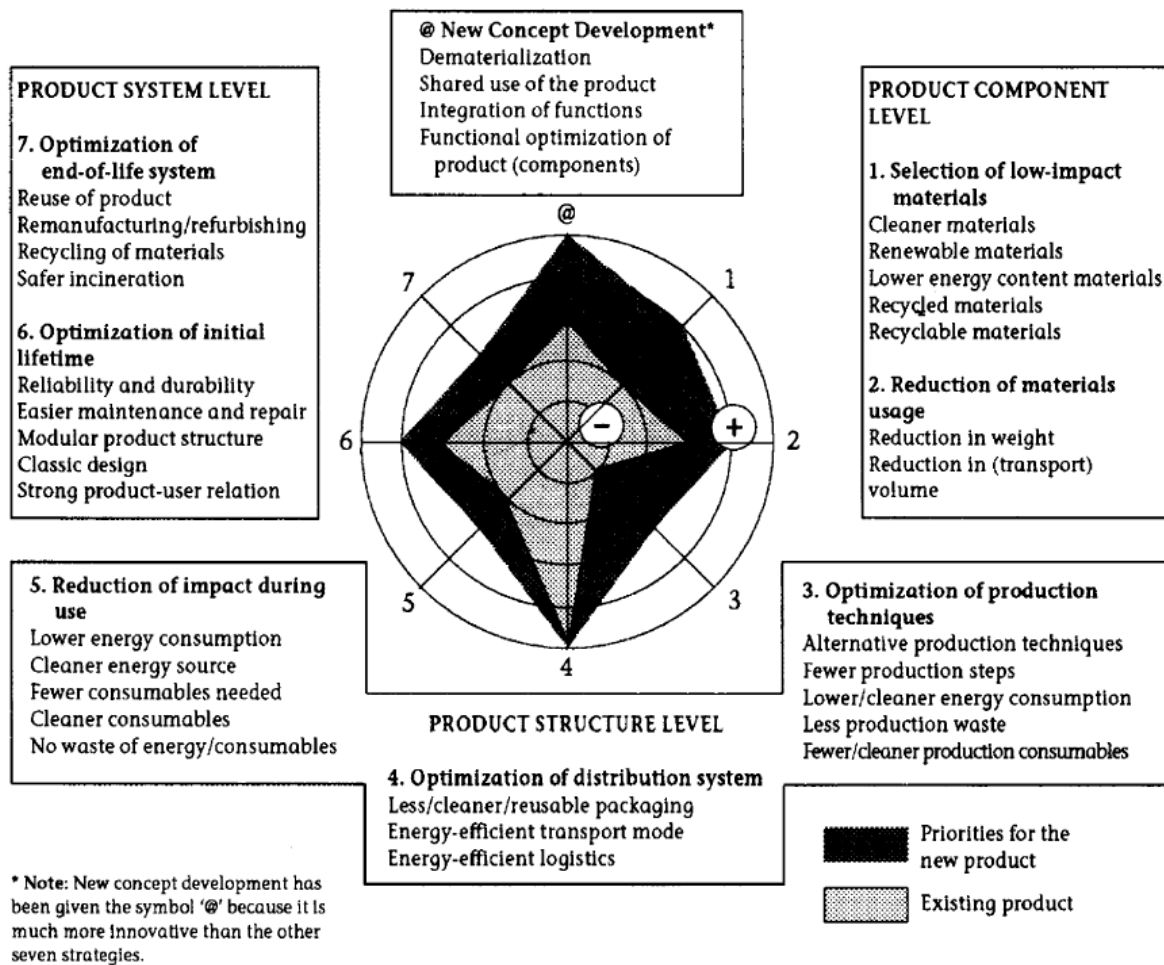


Figure 1: Lids cycle (van Hemel and Cramer, 2002)

Stage 1) selection of low impact materials

Whilst the flax used would otherwise be a waste product, growing flax still consumes a considerable amount of nonrenewable fuel (Dissanayake et al., 2009). Other companies such as 'A Good Company', 'Tech21', 'Najture', 'Reveal', 'mmore' and 'Nimble' make a conscious effort to source sustainably grown raw materials (Table 1). A barrier may present if materials have to come from further afield due to a lack of more local growers. This would increase the economic cost and emissions from transportation which already accounts for 46% of Pelas carbon footprint (Greenstep Solutions Inc and Ecobase Solutions Inc, 2019). Therefore more sustainable production practices should be balanced with the need for local suppliers.

The biopolymer, Flaxstic is the core material in Pela case's manufacturing and is made by OMD using a bioplastic elastomer, Terratek® Flex GDH-B1. Terratek Flex, created and supplied by the Green Dot Bioplastics located in Kansas, is a pioneer in its category, meeting the U.S. and E.U. composting standards ASTM D6400 and EN 13432(Pela, 2020). The energy used to produce this material is 4.21 Mj/kg and it is packaged in plastic before transport(Green Dot Bioplastics, 2021). Working with the supplier to source recycled plastic or plastic free containers, and ensure the production process uses renewable energy, would lower the impact, but likely increase the manufacturing cost.

Currently, only 40% of the resources used in manufacturing are renewable. Pela (2021a) believe Flaxstic is the most effective eco-designed material for phone cases. However, considering other materials such as, wheat straw used by 'wave cases', or cork used by 'tech21', 'EcoQuote', and 'KWMobile'(Table1), may give more flexibility in developing the desired 100% renewable and biodegradable material. Overall, the main barriers to selecting low-impact materials would be a likely increase in cost or a significant investment needed for further research and development.

Stage 3) Optimisation of production techniques

Currently to produce the raw materials the bioplastic elastomer uses 50% less nonrenewable energy than conventional plastic cases. This could be further reduced by working with the Chinese manufacturer that produces most of Pela's cases learn and plan to implement a renewable energy source or more efficient machines that consume less energy.

Government regulations could be a key external stimuli for manufacturers to adopt renewable energy resources; this should be considered for future decisions The product up the location manufacturers(van Hemel and Cramer, 2002). Moving some manufacturing to British Columbia lowered carbon emissions as most the energy produced comes from renewable hydroelectric sources thanks to several government targets to drastically reduce the production of emissions (Government of, 2021). While China has pledged to carbon neutrality by 2060 the government drive is greater in Canada who have pledged that zero emissions by 2050(Odi_Global, 2021; Service Canada, 2020).

Stage 5)Reduction of impact during use(website).

Although the phone cases themselves have little to no impact during their use other then the very occasionally needing to be wiped clean, the Pella website produces 60% more CO2 than

average(Digital Wholegrain, 2021). Through exploration of the website it was found that information was not always easy to navigate and fractions of information regarding the same topic would be found in multiple different pages. The website of Organic Basics, an eco-fashion brand is designed to be low impact. Pela may benefit from replicating some of Organic basics strategies. For example: organising and prioritizing content, ensure images only load on user request; reducing the number of videos; compressing data; only loading the essential programming scripts, cookies and frameworks; reducing the amount of light emitted by the screen; and actively reporting the impact of the users browser behavior(Organic Basics, 2021). However, the appearance and content of the websites may be limited, which may negatively impact the user experience for something which does not necessarily have clear environmental benefits to the consumer, hence presenting a barrier(van Hemel and Cramer, 2002).

Stage 7) Optimisation of end-of-life system

Pela utilises eco-design strategies that may result in product's end-of-life (EoL) becoming a profitable business opportunity(Romli et al., 2015). Old Pela cases can also be returned through the 360 program, to be upcycled into a new product or composted appropriately, converting them into nutrients. However only 5% of palace customers used this service(Greenstep Solutions Inc and Ecobase Solutions Inc, 2019). Although the return is free it still takes additional effort for the customer, decreasing the likelihood they will return it, as environmental benefit is the only real driver. Hence, providing an incentive to return old phone cases and packaging would increase the likelihood that customers will return their cases and continued to purchase replacement products from Pela. Although an incentive may present a commercial disadvantage it may be necessary to stay competitive as numerous other eco-phone cases have adopted a similar system and provide an incentive such as a discounted replacement case(Table1).

Conventional plastic cases a can also be sent to Pela to be upcycled into a new Pela product, or is recycled appropriately. However the value of the material is reduced through the recycling process and likely involves further transportation of the products. The inhouse upcycling approach is more ideal. Thus further development and research into how this can be more consistently achieved is recommended. Ocean75 has launched a variety of cases from recycled plastics. Recycled plastic is also being used as an inner case by some brands to provide additional protection alongside the biodegradable material(Table1). This is a key driver as the protective

abilities of the case are key because repairing damaged phone will result in more cost, energy and resource expense for the consumer and the environment.

Pela along with most other eco-phone brands packages their products in recyclable or compostable plastic free packaging. An solution may be to request people send the packaging back with their old phone case rather than automatically providing an additional envelope to return the cases. A barrier to this solution may be that people will forget where their old packaging is, not want to store it for a long time, or without thinking throw the packaging away. Therefore an alternative solution would be to request the return of the packaging immediately after receiving the product with clear instructions to flatten the packaging will minimise the use of space. The impact of transportation of returns is also a barrier, especially as pela ships their products globally: the transport alone is likely to have significant negative environmental effects. Hence ultimately there would be benefit in exploring partnerships with companies who can process the packaging into another product to limit the distance the packaging needs travel, or setup more streamlined distribution centers within the countries they ship to (Greenstep Solutions Inc and Ecobase Solutions Inc, 2019) this.

Conclusion

Overall Pela is one of the more impactful brands that product eco-cases and has a wider range of choice than its competitors. This report has highlighted a number of aspects that Pela has executed well and suggested solutions for aspects which could be improved. Notably some suggestions to the services website have been outlined. Furthermore incentives for more people to return the phone cases to be upcycled would be beneficial. As Pela continues to expand its product range they should consider alternative renewable materials to flax. Finally through my exploration of colours websites and various reviews it can be concluded that Pela would hugely benefit from the information being much clearer and more easily accessible or identifiable. The resulting increase in apparent transparency better connect Pela with their consumers and create more trust. Furthermore transparency is a powerful incentive for sustainability to be carefully considered across all the supply chains used by pela.

References:

Ashby, M.F. 2013. *Materials and the environment: eco-informed material choice, second edition*. 2nd ed. ed. Waltham, Mass: Butterworth-Heinemann.

Bag Borrow or Steal. 2021. *Rent Designer Handbags*. [Online]. [Accessed 29 May 21]. Available from: <https://www.bagborroworsteal.com/>

Beard, C. and Hartmann, R. 1997. Naturally enterprising - eco-design, creative thinking and the greening of business products. *European business review*. **97**(5).

Bhamra, T.A. 2004. Ecodesign: The search for new strategies in product development. *Proceedings of the Institution of Mechanical Engineers. Part B, Journal of engineering manufacture*. **218**(5), pp.557-569.

Braungart, M., McDonough, W. and Bollinger, A. 2007. Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design. *Journal of cleaner production*. **15**(13), pp.1337-1348.

Bridgens, B., Lilley, D., Smalley, G. and Balasundaram, K. 2015. Ageing gracefully to increase product longevity. In: Cooper, T., et al., eds. *PLATE: Product Lifetimes and the Environment*. Nottingham Trent University: CADBE, pp.28-35.

Bridgens, B., Hobson, K., Lilley, D., Lee, J., Scott, J.L. and Wilson, G.T. 2019. Closing the Loop on E-waste: A Multidisciplinary Perspective. *Journal of industrial ecology*. **23**(1), pp.169-181.

Chapman, J. 2005. *Emotionally durable design : objects, experiences and empathy*. London ;: Earthscan.

Digital Wholegrain. 2021. *Website Carbon Calculator*. [Online]. [Accessed 22 May 2021]. Available from: <https://www.websitecarbon.com/website/uk-pelacase-com/>

Dissanayake, N.P.J., Summerscales, J., Grove, S.M. and Singh, M.M. 2009. Energy Use in the Production of Flax Fiber for the Reinforcement of Composites. *Journal of natural fibers*. **6**(4), pp.331-346.

Government of, B.C. 2021. *Energy Efficiency - Province of British Columbia*. [Online]. [Accessed 29 May 2021]. Available from: <https://www2.gov.bc.ca/gov/content/industry/electricity-alternative-energy/energy-efficiency-conservation>

Green Dot Bioplastics, L.L.C. 2021. Terratek® Flex Technical Datasheet. [Online]. Available from: https://www.greendotbioplastics.com/images/pdf/GDH-B1FA_datasheet_8-22-16.pdf

Greenstep Solutions Inc and Ecobase Solutions Inc. 2019. Pela Case Life Cycle Analysis. [Online]. Available from: https://cdn.shopify.com/s/files/1/0078/1032/files/Pela_Case_LCA_2019.pdf?v=1587587786

Grow Ensemble. 2020. The Social Entrepreneurship & Innovation Podcast. #82 - *How Sustainable Product Design Creates a Circular Economy with Jeremy Lang, Founder of Pela*. [Podcast]. Available from: <https://growensemble.com/pela-case-jeremy-lang/>

Hasnain Saeed, M., Shah, S.A.R., Arshad, H., Waqar, A., Imam, M.A.H., Sadiq, A.N., Hafeez, S., Mansoor, J. and Waseem, M. 2019. Sustainable Silicon Waste Material Utilization for Road Construction: An Application of Modified Binder for Marshall Stability Analysis. *Applied sciences*. **9**(9), p1803.

Lilley, D., Smalley, G., Bridgens, B., Wilson, G.T. and Balasundaram, K. 2016. Cosmetic obsolescence? User perceptions of new and artificially aged materials. *Materials & design*. **101**, pp.355-365.

Odi_Global. 2021. *Five expert views on China's pledge to become carbon neutral by 2060*. [Online]. [Accessed 29 May 2021]. Available from: <https://odi.org/en/insights/five-expert-views-on-chinas-pledge-to-become-carbon-neutral-by-2060/>

Organic Basics. 2021. *The Low Impact Website | Organic Basics*. [Online]. [Accessed 29 May 2021]. Available from: <https://lowimpact.organicbasics.com>

Papanek, V.J. 1995. *The green imperative : ecology and ethics in design and architecture*. London: Thames and Hudson.

Patagonia. 2021. *1% for the Planet - Patagonia*. [Online]. Available from: <https://eu.patagonia.com/gb/en/one-percent-for-the-planet.html>

Pela, C. 2020. *What are your Pela cases made out of?* [Online]. Available from: <https://help.pelacase.com/article/ul7do0af3k-what-are-your-pela-cases-made-out-of>

Pela, C. 2021a. *Pela Versus The Competition | Pela Case*. [Online]. Available from: <https://pelacase.com/blogs/news/pela-versus-the-competition>

Pela, C. 2021b. *Phone Cases: Compostable & Eco-Friendly Phone Cases | Pela Case*. [Online]. [Accessed 29 May 2021]. Available from: <https://uk.pelacase.com/>

Pela Case. 2021a. *best seller cases*. [online]. [Accessed 30 May 2021]. Available from: <https://uk.pelacase.com/>

Pela Case. 2021b. *Pela logo*. [online]. [Accessed 30 May 2021]. Available from: <https://uk.pelacase.com/>

Pigozzo, D.C.A., Rozenfeld, H. and McAlloone, T.C. 2013. Ecodesign maturity model: a management framework to support ecodesign implementation into manufacturing companies. *Journal of cleaner production*. **59**, pp.160-173.

Rattalino, F. 2018. Circular advantage anyone? Sustainability-driven innovation and circularity at Patagonia, Inc. *Thunderbird International Business Review*. **60**(5), pp.747-755.

Reinhardt, F.L., Casadesus-Masanell, R. and Kim, H. 2010. Patagonia. *Harvard Business School Strategy Unit Case*. (711-020).

Romli, A., Prickett, P., Setchi, R. and Soe, S. 2015. Integrated eco-design decision-making for sustainable product development. *International journal of production research*. **53**(2), pp.549-571.

Sakao, T. 2007. A QFD-centred design methodology for environmentally conscious product design. *International journal of production research*. **45**(18-19), pp.4143-4162.

Sarath, P., Bonda, S., Mohanty, S. and Nayak, S.K. 2015. Mobile phone waste management and recycling: Views and trends. *Waste management (Elmsford)*. **46**, pp.536-545.

Service Canada. 2020. *Net-Zero Emissions by 2050 - Canada.ca*. [Online]. [Accessed 29 May 2021]. Available from: <https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html>

Van der Ryn, S. and Cowan, S. 1996. *Ecological design*. Washington, D.C: Island Press.

van Hemel, C. and Cramer, J. 2002. Barriers and stimuli for ecodesign in SMEs. *Journal of cleaner production*. **10**(5), pp.439-453.

van Weenen, J.C. 1995. Towards sustainable product development. *Journal of cleaner production*. **3**(1), pp.95-100.

Appendix

Table 1: Overview of research findings for competitors

Brand	End of life & waste	Primary Materials	Products	comments	source
Pela	Biodegradable Return to be recycled into another Pelacase recyclable packaging	Flaxstic® compostable bioplastic elastomer and flax straw materials Plastic free cardboard packaging	Phone cases, AirPods cases, Glasses, Card wallet, Apple Watch, Vine Bands	range of phone models available range of designs (artist series) 5% of sales go to environmental charities Relatively good protection but sides could be tighter certified as biodegradable by European standards relatively more expensive Certified B Corporation (80.3)	www.beeco.green www.techradar.com www.sustainablejungle.com https://ecofreak.com www.gq-magazine.co.uk www.bestproducts.com
Eplanita	Biodegradable commercially compostable recyclable packaging	Wheat straw and recyclable TPU 100% recycled paper, minimalistic packaging	Phone cases Apple watch bands Baby hair brush set Kitchen sponges / brushes	Great shock absorbance Reasonable price Very durable Gets easily dirty Relatively thick Limited selection of phone models	www.beeco.green www.eplanita.com
Najture	Biodegradable Compostable return old case, and they recycle it and give a 15% discount on a new Najture eco-friendly case compostable packaging	Plant-based starches from several sustainably harvested plant Plastic Free packaging.	iPhone cases	Great grip have a reforestation partnership aim implement blockchain technology into operations by 2022 to help get 100% traceability for raw materials	www.beeco.green www.najture.com
A good company	Biodegradable/compostible Return to be recycled into another case and get €5 Climate positive measure taken to offset carbon recyclable packaging	Linseed / Flax Recycled Nylon Brass, Sanitizer, Cork, Humanium Metal, Wheat Straw, Organic Cotton, Recycled Polyester, Sugarcane, Recycled Cardboard, Cornstarch, Recycled Plastic, Bamboo, Meadow Grass, Soy Ink, Recycled Cotton, Tencel, RPET (Recycled PET), Stainless Steel, Aluminium , Glue, Water-based Colors, Clay, Glass, Linseed / Flax, Stone Paper packaging 100% pure Stone Paper and ink based from soy	phone cases Mobile Cases Pens Creatives Non disposables Stationery Personal Care Posters	Recommends other sustainable brands e.g. clothing brands Vast array of products Detailed material lists and manufacturing info, all of which meet a level of sustainability 4% to A Good Foundation Climate neutral shipping Appear very transparent Certified B Corporation (82.2)	www.sustainablejungle.com www.gq-magazine.co.uk agood.com

Wilma	Biodegradable (compostable cases) recyclable packaging	corn-based bioplastic plastic free recycled cardboard packaging is printed with soy ink. Sustainably sourced Jute/burlap packaging 100% recycled cardboard	Phone Cases AirPods ipad Bags	Various plain and eco inspired designs Eco-friendly packaging wanted to intertwine fashion with sustainability color fades came in plastic from amazon	ecofashionbywilma.com/ www.sustainablejungle.com/ https://ecofreek.com/
Tech21	Biodegradable Recyclable (return old cases) 100% recyclable packaging Not biodegradable	sustainable composite materials including take 21 and wood filler recycled excess and returned Tech21 cases	Phone cases phone cover, Ipad cases, Macbook cases, Phone Accessories, AirPod Cases, Apple Watch, Shields, iPod Touch Case	very aesthetic designs customised option easily gets dirty sometimes flakes Limited choice for eco-friendly cases (only iphones) only phone cases are eco-designed	www.beeco.green https://uk.tech21.com/ www.bestproducts.com
Reveal	Biodegradable	Sustainably harvested Cork Inner TPU cover	Phone cases	Great grip and good protection Plastic inside	www.beeco.green https://revealshop.com/ www.sustainablejungle.com/ https://ecofreek.com/
mmore	Compostable, Biodegradable, part biodegradable, part recyclable recyclable packaging	Wheat straw, Flax, PLA bioplastic, Organic Coffee beans, Recyclable TPU plastic sustainable wood and a natural coating, Recyclable TPU plastic 100% Plastic Free packaging.		Good grip Coffee case smells of coffee Coffee and wood particularly lack protection ability Wide range of phone models Good grip	www.beeco.green https://www.etsy.com www.techradar.com www.gq-magazine.co.uk
popsicase	Not biodegradable and unsustainable to rely on plastic waste long term Project CeroCO offsets carbon footprint and shipping emissions Incentive to share shipping with price reduction for second phone biodegradable. Compostable recyclable packaging	Recycled plastic and aluminum (from abandoned fishing nets and scrap aluminum) Plant based biopolymer (corn, cassava, sugar cane or beet) Plastic free recycled packaging	Phone cases iPhone Posidonia Seed POPSICASE	Great protection (thick case) Selfie stick design is useful but flimsy Iphone cases only	www.beeco.green https://popsicase.com/ www.techradar.com www.gq-magazine.co.uk
Nimble	Nimble provides you a label to send in plastic to be safely and responsibly recycled. biodegradable/ recyclable packaging	Recycled Polycarbonate 100% recycled plastic bottles (Recycled PET) Materials from renewable resources and existing waste streams (e.g. recycled plastics and aluminum, organic hemp) Plastic free packaging Water based dyes: no harmful inks or dyes	Disc Case, Bottle Case, Portable Chargers, Wireless Chargers, Wall Chargers & Adapters, USB-C Cables	durable fabric exterior built-in card holder 1% of annual profits to environmental nonprofits 5% of proceeds go to ocean charities only work with suppliers who share values on sustainable materials, environmental impact, and workers' rights, Certified B Corporation (80.3)	www.sustainablejungle.com/ www.bestproducts.com https://www.gonimble.com/

iMakeTheCase	Biodegradable	bamboo	Phone cases	Customisable with laser engraver Poor shock absorption Bamboo can't be grown worldwide e.g. not in UK Nice designs	www.beeco.green www.gq-magazine.co.uk imakethecase.com/
Wild case	Biodegradable compostable recyclable packaging	bamboo straw and PBAT bioplastic plastic free, cardboard envelope, Kraft paper, packaging with a little envelope of seeds for the bees	Phone cases AirPod cases Finger loop	5% each sale goes to Ocean Cleanup affordable	www.sustainablejungle www.gq-magazine.co.uk www.wildcase.co/
WAVE CASE LIMITED	biodegradable recyclable packaging	Wheat straw 100% plastic free recycled packaging Stainless steel	Phone cases AirPod cases Bottle	7 vibrant colours main phone brands available only	www.beeco.green www.techradar.com www.wavecase.co.uk/
Kalibri	Biodegradable 100% recyclable packaging	Wheat straw, recyclable TPU wood leather Cardboard packaging	Phone cases Phone cases device stands Phone cases wallets	Easy to clean, but attracts dirt Only three main phone brands Previously used plastic packaging No plastic inner cover Less shock absorbing Elegant Limited info on sustainable sourcing	www.beeco.green http://www.kalibri.de/ https://ecofreek
EcoQuote	Partially Biodegradable recyclable packaging	Products are predominantly made with Bamboo or cork other materials they use include terracotta, sugarcane bagasse, coconut and pineapple, jute, and other natural plant fibers. Recycled PC or TPU handmade bamboo packaging	Phone case, Device, holders and sleeves, wallet/purse, bags, travel and outdoor, home and living, survewear,	blank canvas to doodle your own designs or just enjoy natural texture shipped from Kuala Lumpur unresponsive to faults being reported great grip limited phone models available call for more use of cork in fashion	www.sustainablejungle www.ecoquote.com
KWMobile	Partially Biodegradable have plastic inner case non-recyclable packaging	Wood (e.g. bamboo, walnut, rosewood, or cork) plastic packaging		Limited information on the lifecycle – just a statement that it is eco-friendly Shipped globally from China – transport emissions Could be thicker iPhone only	www.beeco.green www.kwmobile.de/
Ocean75	can return old case to ocean75 who make a new case from it recyclable packaging	Recycled plastic recycled cardboard packaging with no plastic window	iPhone phone cases	Limited protection Not biodegradable 5% of the price is donated to a ocean conservation charity	www.beeco.green www.carphonewarehouse/ocean-75

Table 2: Inventory matrix for lifecycle assessment.

	Input of material	Energy Use	Waste and emissions
	<p>compared to a conventional plastic phone case pillowcases produce: 33% lower Water consumption</p>		<p>Compared to a conventional plastic phone case pillowcases produce: 76% lower waste production; 26% lower carbon emissions. Overall transport accounts for 46% of Pela's carbon footprint.</p>
Production of Materials	<p>Terratek® Flex GDH-B1 Flaxstic®: Bioplastic elastomer and flax straw materials - flax fiber, flax shive, wheat starch resin, thermoplastic polyurethane (TPU) synthetic silicone rubber Packaging is FSC certified and recycled paper Distribution involves plastic</p>	<p>Terratek® Flex GDH-B1 uses 4.21 Mj/kg Uses 50% less non-renewable energy than plastic Growing flax consumes a considerable amount of fossil fuel Machines are used to till, sow, water, harvest, bale flax straw Thermoforming: processing of the raw materials for input into the manufacturing</p>	<p>Zero waste-uses waste byproduct as a raw material greenhouse gas emissions during transportation of materials from farm to bioplastic manufacturer</p>
Manufacturing	<p>The bioplastic elastomer (40% made from renewable resources but other 50% non-renewable resources)</p>	<p>Injection moulding: Heating bioplastic elastomer in an extruder at approximately 300° F the consumes energy Injection mold facility & engraving facility operate on electricity majority of cases are produced in China with nonrenewable power sources minority of cases are produced in British Columbia where the majority of power produced is from renewable hydroelectric sources</p>	<p>Cardboard packaging GHG emissions electrically powered machinery Greenhouse gas emissions from transportation from bioplastic manufacturer to the product manufacturer and then to the distribution centre.</p>

Distribution	a plastic- lined 250 pound fibre drum to package and ship Bioresin to company cardboard packaging for Individual cases	Trucks transport flax straw from the field to factory/manufacturer (Pela) Pela ships directly to consumers worldwide Air transport of online orders from the international and domestic market Amazon transportation i.e trucks, warehouses	Greenhouse gas emissions from transportation from the distribution center to the customer or retailer.
Product use	No maintenance for product usage Only degrades if composted, but replacement sent by pela if does start degrading Shock proof case protects glass screen reducing resources needed to place the screen.	Negligible for phone case Website use, contains blogs and much info. A website carbon calculator indicated that Palace website produced 60% more carbon dioxide than the average website tested but did indicate that the website seems to be running on sustainable energy (figure 1)	Negligible
End of life	50% are composted: becoming enrichment to the soil. 5% are shipped to pela to be recycled via the closed loop Pela cycle initiative 45% of Pela cases do end up in landfill if disposed of incorrectly	No energy required to compost the case, Energy is required to recycle the packaging (e.g. small transport component to recycling center) Cases returned to Pela require shipping energy	Cardboard packaging should be recycled Broken/old Pela cases can be recycled into a new case Zero waste- Can be composted or returned to Pela for recycling when broken Methane and other GHG emissions during composting
	(Greenstep Solutions Inc and Ecobase Solutions Inc, 2019; Pela, 2021b; Dissanayake et al., 2009; Green Dot Bioplastics, 2021; Digital Wholegrain, 2021)		

@new concept development

Currently there are a number of systems whereby the old case can be returned to the eco-phone case manufacturer to be upcycled into another product (Table 1). A significant barrier is that it relies on customers willingness to return the item.

If however a person paid to rent the case for two years for a slightly cheaper fee, they would be obliged to return it so it can then be upcycled by pela.

A potential barrier for this would be whether customers would accept this new approach to protecting their phone (van Hemel and Cramer, 2002).

Although no subsystem has been employed for phone cases that have been renting or borrowing systems for other non-technological accessories such as bags (Bag Borrow or Steal, 2021).

The function of the phone case could also be integrated by including a cardholder in the case, similar to the nimble phone case.

This would be preferable to the completely separate cardholder that Pela currently offer as it would use less materials.