NPD4CE Research Report

Design for Upcycling and Circular Economy

by Joe Shade

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This research report will investigate how to design new products (namely a desktop/bookshelf speaker) to better fit circular business models and promote upcycling within the design industry.

Key terms:

Upcycling: recycling in such a way that the resulting product is of higher value than the original item (Mariam-Webster, n.d.) as opposed to downcycling where the recycled material or object is turned into something of lesser value. In Cradle to Cradle, the authors give an interesting case study: "Aluminium is another valuable but constantly downcycled material. The typical soda can consists of two kinds of aluminium: the walls are composed of aluminium, manganese alloy with some magnesium, plus coatings and paint, while the harder top is aluminium magnesium alloy. In conventional recycling these materials are melted together, resulting in a weaker-and less useful-product." (McDonough & Braungart, 2019).

Circular Economy: The European parliament defines the circular economy as "a model of production and consumption, which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible". (Circular economy: Definition, importance and benefits: News: European parliament 2023). Circular business models fit inside this framework.

1. Secondary Research

1.1 Circular Business Models

One of the key factors slowing the adoption of sustainable design practices is corporate inertia: a general ignorance of circular business models (Shade & Hatch, 2023). Companies, especially larger ones, are slow to make the vast changes which are necessary to adopt sustainable design practices. We will need to pitch at a company-wide scale and not at the product level. For real, tangible change to be made, the products we design need to clearly fit into a circular business model.

For this reason, we will need to become educated on and design around specific circular business models.

(Bakker et al., 2020) argues that there a five discrete circular business models:

- The Classic Long-life Model: Where high-quality products, that are built to last, are sold at a premium.
- The Hybrid Model: Where profits are generated from repeat sale of consumables such as toner cartridges.
- The Gap Exploiter Model: businesses that fulfil a gap in the market, usually by offering services such as repair or maintenance but can also be extended to include upcycling.
- The Access Model: Making money by providing access to a product, for example car leasing or tool rental.
- The Performance Model: The performance model is similar to the access model but the consumer is not paying for access to the product but for the service itself. For example, a business may have an agreement to fulfil a local library's printing needs, the responsibility is on the provider to carry out all repairs and maintenance.

1.2 Product Category Lifecycle

Another key consideration is product category lifecycle which describes what stage of development a product is in. (Bakker et al., 2020) suggests that there are four stages:

- Introduction: This stage of product development / adoption is chaotic, competitors race to acquire market share and products quickly become outdated as the technology progresses. Durability is a lesser concern as products become obsolete.
- Growth: In the growth stage this rapid development begins to slow but design priorities stay constant.
- Maturity: In the maturity stage the market is less turbulent and rapid technological development has slowed drastically. Businesses look for ways to differentiate their products often through cosmetic changes. Durability becomes a great concern to businesses as a long-life product enables value-adding services and another source of revenue.
- Decline: Finally, in the decline stage development has all but ceased and priorities are shifted to an even greater focus on durability, dis- and reassembly and ease of repair. Cost reduction is often considered at this stage in the product category lifecycle or alternatively, high-end alternatives are often brought to market.

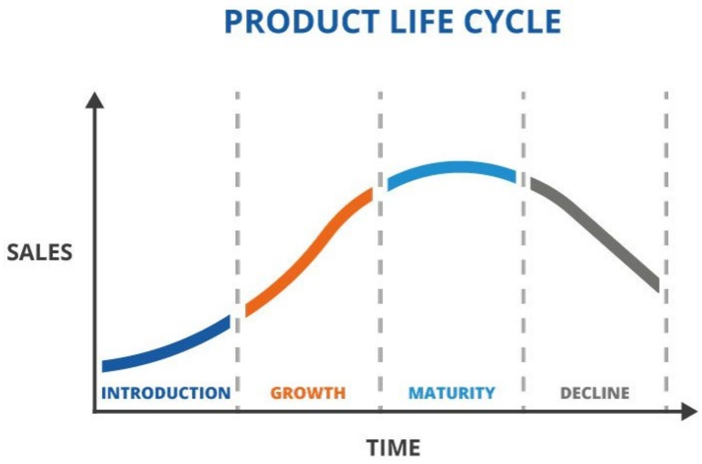

Figure 1, TWI Global, Product Life Cycle Categories, n.d.

https://www.twi-global.com/CachedImage.axd?ImageName=Product-Life-Cycle-Diagram.jpg&ImageWidth=800&ImageHeight=611&ImageVersionID=107543&ImageModified=20210621110712

Desktop speakers fall within the decline category due to diminishing sales figures. Information on direct sales figures is inaccessible to the general public and is usually kept internally for business purposes. So, Google search data has been used as a substitute as it reflects the public interest.

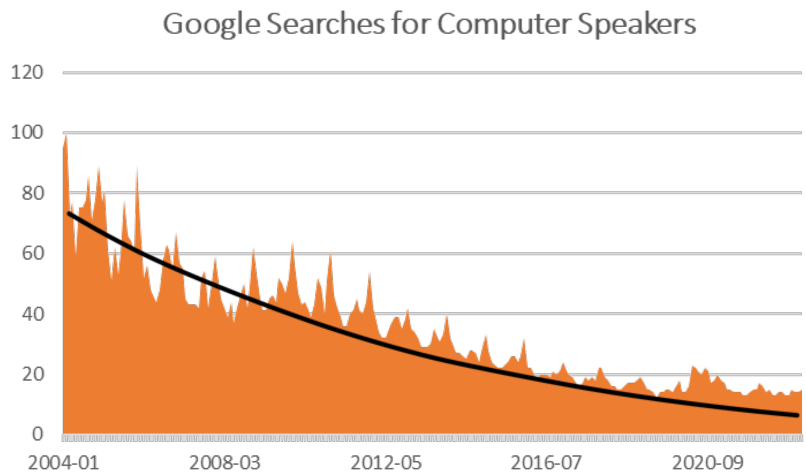

Figure 2, Joseph Shade, Google Searches for Computer Speakers, 2023

1.3 Design Priorities

From this information design priorities can be established. Bakker et al (2019) suggests these four traits should be pursued for product in the decline stage:

- Design for Product Durability
- Design for Standardisation and compatibility
- Design for Ease of Maintenance and Repair
- Design for Dis- and Reassembly

There are a few considerations that Bakker et al suggest which are less applicable to the declining product category but are of secondary interest. These include:

- Design for Product Attachment and Trust
- Design for Upgradability and Adaptability

The above design priorities can be achieved by following a set of guidelines that have been developed alongside this project:

1.3.1 Product Durability

Products can be made more durable with computer simulation and real-life testing. Computer simulation can be used to identify weak points in the design which can then be reinforced, this is an iterative process by eliminating weak points and adding reinforcing features where required a more durable product can be created.

Real life testing is also a valuable tool. Impact testing, drops from height and multi-axis shock testing can simulate common mishaps. Inspiration could be drawn from the rigorous testing and standards met by motorcycle helmets which have to endure extreme conditions in the event of a crash, including surface abrasion, fire and multiple harsh impacts (Snell helmets certification, n.d.). Other conditions can be recreated such as Salt spray and intense humidity / temperatures although, these are less relevant for the indoor use of a desktop or bookshelf speaker. It is important to properly define the products target market, as products designed for moderate climates do not cope well in high humidity, hot temperatures or arid and cold environments, often leading to premature failure. McDonough & Braungart (2019) warns of the detriments of a universal approach calling it "the attack of one-size-fits-all" and suggests the best designs are those that have an "energetic and material engagement with place".

By designing for ease of maintenance products can also be made more durable as preventative measures can be taken to increase service life and parts nearing failure can be identified and replaced.

User observation can be a useful tool as well, products are often used in unintended ways and either by either embracing these use cases or by making proper use more discoverable and the product is less likely to be mistreated.

Avoid cheap fasteners and fixings. Cheap nuts, bolts and screws are easier to strip, have shorter duty cycles and make for less durable products (Which screw where? n.d.). Snap hooks are also problematic as they often break when released or are bent past their elastic potential and no longer function as intended. In a similar light, it is important to eliminate perishable components where possible, such as O-Rings and rubber grommets that harden and become brittle over time.

How to improve product durability:

- Utilise computer simulation.
- Carry out real-life testing and user observations.
- Make your product discoverable.
- Design for the appropriate use case, climate, and environmental conditions.
- Avoid cheap fasteners, snap hooks and perishable components.

1.3.2 Standardisation and Compatibility

By following current standards, setting them when absent and implementing them properly service life can be increased.

Standardisation across generations of products and within product lines can also be achieved. The GoPro family of action cameras is an example of a highly standardised system (Whitted, 2019), with mounts being compatible between cameras and product generations.

These standards for desktop speakers have been identified through secondary research and stakeholder interviews:

- USB-C charging
- AUX 3.5mm and 6.5mm Jacks
- Bluetooth compatibility

Standardisation of interfaces and features is also important, Norman (2021) praises the merits of just noticeable differences which iterate on an existing design. These changes mean the product is still discoverable, the user may already be familiar with desktop speakers and reinventing the wheel in terms of product interaction and user interface may be a source of enormous frustration rather than novelty. Similarly, project stakeholder Abby Hatch describes timeless design as a simple elegant solution where the features are predictable, without gimmicks (Shade & Hatch, 2023).

How to design for standardisation:

- Follow Industry standards and set them when absent.
- Ensure compatibility between product generations and product lines.
- Keep features and interfaces consistent.

1.3.3 Ease of Maintenance and Repair

Ease of maintenance and repair is essential in prolonging the service life of a product. One of the key ways to make repair and maintenance easier is by reducing the barriers to entry. Removing the need for specialist knowledge or tools can make the repair process less intimidating and more approachable.

Avoiding the use of uncommon screw types such as TORX, Polydrive and Bristol heads in favour of commonplace alternatives can work to this effect. All fasteners should be reversible. One-way connections such as pressure fittings, snap hooks and security screws should be avoided.

Where possible utilise all available space for Printed Circuit Boards (PCBs) and avoid unnecessarily component-dense boards, this will allow better access to components for repair. Similarly, it is important to consider the ergonomics of repair and try to avoid awkward placement of connectors and fasteners. The placement of these features can be verified by observing the user attempting a repair. Unnatural angles will shortly be uncovered.

Modular design can also be incorporated to eliminate the need for specialist tools, a PCB can be split up into individual daughter boards that then mount on a central motherboard through a pin header.

Diagnostic features can also be added to quickly identify failures. For example, probe points and LEDs can be used to establish if a particular part is getting power or for more complex issues an I2C port could be used to read data directly off a communication bus (Valdez & Becker, 2015).

Knowledge should be made accessible through detailed maintenance guides and operating instructions. If possible, it is advisable to include this information on the product itself through markings and diagrams.

It is worth noting maintenance could be explored as a source of revenue for circular business models: 3D files for printing could be sold on a pay-per-print basis.

How to design for maintenance and repair:

- Avoid the use of one-way fixings.
- Eliminate the need for specialist tools.
- Utilise all available space when designing PCBs.
- Build in diagnostic tools.
- Make repair/maintenance guides accessible.

1.3.4 Dis- and Reassembly

Design for dis- and reassembly incorporates many of the factors discussed earlier. Again, one of the key issues is the need for specialist tools and knowledge, which can be vastly reduced. For example, by designing products as highly modular systems, PCB-level components can be removed without the need for a soldering iron.

Avoiding the use of one-way fasteners remains a priority as the use of these features inhibits reassembly. Considering the ergonomics of disassembly is important, as awkward angles add to the frustration of disassembling a product.

Similarly, avoiding the use of small easily stripped screws and buying higher quality connectors and fasteners can greatly increase the duty cycle of these components, extend the product service life and make the disassembly process much easier.

Herman-Miller have adopted a design rule that sub-assemblies should be removable within 30 seconds (Bakker et al, 2019). By considering disassembly in the design process quick and easy dis/reassembly can be achieved.

Design for dis- and reassembly

- Utilise modular design.
- Removing the need for specialist tools and knowledge.
- Avoid the use of small easily stripped screws.
- Eliminate one-way fasteners.
- Use high-quality fasteners and fixings.
- Consider dis/reassembly in the design process.

1.3.5 Product Attachment and Trust

In his book, Emotionally Durable Design, Chapman (2015) shares that “90 per cent of computers still function when people get rid of them”, going on to suggest that people throw working products away due to a failed relationship between the product and user. He explains that products need to change as the user’s identity evolves. Chapman (2015) believes people consume to satisfy their ego needs: status, respect and recognition (Block, 2011) which are insatiable and that to continue to satisfy these needs, products need to be changed and made new again.

There is also a recurring idea of the fetishisation of new products. Chapman talks about the deflowering gaze of familiarity and suggests that knowing all there is to know about a product makes it loses its magic and appeal. These issues could be rectified through customisation and modularity.

Bridgens et al (2019) suggests an alternative mode of consumption in that products could be designed to age and value "instilled through a surface patina that tells the story of the object". Similarly, Stahel (2008) discusses the teddy bear factor where a "rich narrative history is developed through the bear, elevating its often-worn out physical body to an irreplaceable plateau" (Chapman, 2015). Graceful ageing can add value to products and strengthen relationships with the user through these effects.

Another way to imbue deep emotional connection is honest materials, those that reflect the process of making, these allow for a deeper emotional connection as the user can empathise with the product, almost seeing it as a tortured form. Ingold (2013) gives the example of making a willow basket. He describes the "recalcitrant nature" of the material and how it had to be wrangled into submission. Only once he finished did he realise that this very resistance was what held the basket together. He argues that the hylomorphic theory of matter (Peramatzis, 2018) is not true and that form, matter, and the process of making cannot be separated. All objects have an element of this tortured visage. Although, showcasing this further could promote a stronger bond between user and product.

Ritual is an important component of the emotional connection. These are rich sensory experiences that are frequently repeated and often have a cultural component, for example, boiling a kettle. Imagine the sound of water rushing into the kettle as you fill it, the weight steadily increasing and then the sharp click of flicking the switch, followed by the roar of the water as it starts to boil - almost every sense is being stimulated. Repeat this every day and the experience becomes wholly integral to your routine. Then there is the cultural element of talking over a hot beverage and extending hospitality to your guests which reaches further into your psyche reinforcing the user-product relationship.

Chapman (2015) warns of "experience impoverished" design, he compares the intimate experience of laying down vinyl to the cold and anonymous experience of playing a CD. The difference between the two? Sensory feedback. Hummels (1999) describes the process of laying down vinyl: "I cautiously removed the precious record from its cover… [and] with the no-static brush removed the barely visible dust particles" before placing the arm gently down then "a soft tick, a cracking noise, and a few seconds later the beautiful voice of Mathilde Santing filled the room". This, compared to the "stream-lined efficiency" (Chapman, 2015) of a CD player, is a much greater interactive experience, all owing to tactile and audio-visual feedback which can easily be adopted into a design.

How to achieve emotional attachment and trust:

- Renew products through customisation and modularity.
- Utilise the teddy-bear factor and graceful ageing.
- Use honest materials.
- Incorporate interactive experiences through tactile, audio-visual feedback and ritual.

1.3.6 Upgradability

Modularity and standardisation are key factors in upgradability. In highly modular designs upgrades can be plug-and-play solutions, this is enabled through the proper application of standards which ensure widespread compatibility.

Planning for future use cases and scenarios is an important tool when designing for upgradability. By keeping options open and not designing yourself into a corner radical design changes can be made throughout the product's lifecycle. For example, by adding connectors to flash new/updated firmware software features can be added at a later date or compatibility with a new standard/component can be added.

How to design for Upgradability:

- Design for future use cases.
- Focus on modularity.

2. Primary Research

2.1 Product Analysis

In order to establish a datum for any new design to be measured against an existing product has been reverse engineered and analysed, namely the Sony SRS XB-23 Speaker.

The Sony SRS-XB23 (fig. 3) is an IP67-rated, portable Bluetooth speaker with 12 hours of battery life and USB-C charging (Sony, n.d.).

The product makes impressive use of a strict power and space budget: The PCB is incredibly dense and well-designed although it does have some obvious shortcomings. The reliance on SMD components makes hand repair extremely difficult for the average consumer. Similarly, there is a daughterboard for the Bluetooth antenna, which is soldered directly onto the motherboard, where it could have easily been a modular component. There is also no disassembly or maintenance guides available from the manufacturer.

Figure 3, Sony, SRS XB-23 Speaker, n.d. https://www.sony.co.uk/image/b236ba45a56c3edbd19777ddce726722?fmt=png-alpha&wid=600

Interestingly, the Sony SRS-XB23 uses USB-C for charging, which has become a standard in consumer electronics, but the USB-C standard has not been utilised to its full extent. The USB-C port only carries power and cannot be used to update the speaker's firmware or connect devices to the speaker.

As mentioned earlier, the speaker makes excellent use of its strict power budget. In operation the speaker uses less than one watt and yet produces an impressive sound. This is partly due to its use of passive radiators. These are passively driven diaphragms that amplify the low-end frequencies produced by the mid-range drivers to produce a stronger bass effect.

Unfortunately, the speaker does have some more drawbacks, it makes heavy use of glue to secure seals and rubber trim in place. Although it is easy enough to remove these parts despite the glue, it still compromises the end-of-life (EOL) potential of the speaker. Similarly, the EOL disassembly of the speaker is complicated by mixtures of different materials. McDonough & Braungart (2019) would describe these as "monstrous hybrids" which cannot be properly recycled, only downcycled into a lesser-value material.

The Sony SRS-XB23 is a very impressive piece of engineering, and it is hard not to appreciate the striking sound quality and incredible power efficiency in such a small package, but this is tainted by questionable design choices and a negligent environmental stance. The product is representative of the consumer electronics industry as a whole and is an excellent point of reference to compare against.

2.1.1 Eco Audit

For this reason, an Eco-audit of the product has been completed. It assumes the following:

- Transport from Shenzen to Felixstowe by ocean freight.
- Transport from Felixstowe to Coventry by 6-axle truck.
- Transport from Coventry to Leicester by light goods vehicle.
- 1 hour of use daily.
- A service life of five years.

These figures will be kept constant in any future comparison.

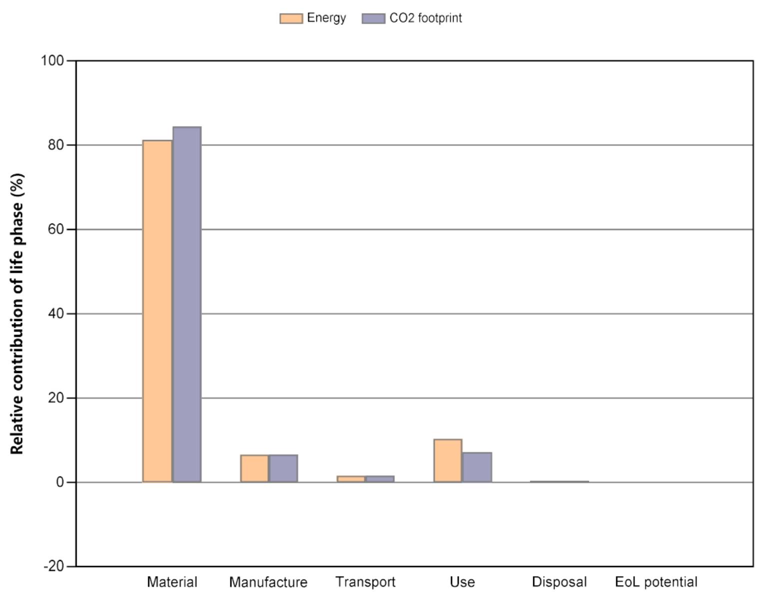

Figure 4, Joseph Shade, Eco-audit summary graph, 2023

Most of the energy usage and carbon footprint is in the material of the speaker owing to its high embodied energy making up 81.2% of the energy consumption and 84.5% of the CO2 footprint. Use makes up a surprisingly small amount of the carbon footprint due to the speaker's outstanding efficiency. Use makes up only 10% of energy usage and 7% of the CO2 footprint. Manufacture and transport have a much lesser share of the total carbon emissions and energy use but total almost a kilogram (0.798 grams) of carbon dioxide emissions.

Clearly, materials make up the biggest environmental burden, which could perhaps be alleviated through upcycling and environmentally considerate material choices.

Phase	Energy (MJ)	Energy (%)	CO2 footprint (kg)	CO2 footprint (%)
Material	107	81.2	8.2	84.5
Manufacture	8.71	6.6	0.634	6.5
Transport	2.28	1.7	0.164	1.7
Use	13.7	10.4	0.694	7.1
Disposal	0.13	0.1	0.00907	0.1
Total (for first life)	**132**	**100**	**9.71**	**100**
End of life potential	0		0	

Figure 5, Joseph Shade, Eco-audit Summary table, 2023

2.1.2 Disassembly

The product was hard to dissemble due to small easily stripped screws, several of which had to be drilled out. Additionally, there were several snap hooks that had to be bent up to release sub-assemblies. These snap hooks are a prime example of a one-way fastener. Although it is possible to resecure the snap hooks, they can never return to their original shape, they lose strength, and each further deformation brings the feature closer to failure.

Figure 6, Joseph Shade, Broken snap hook, 2023

Although Sony had done the right thing in using reversible connectors to wire the speaker drivers, they chose to use surface mount device (SMD) sockets rather than thru-hole which are much more robust. This is likely due to the extreme space constraints. However, this has had a detrimental effect on the product’s longevity as the connector failed the first time it was removed, coming completely off the board.

Figure 7, Joseph Shade, Broken SMD mount connector, 2023

2.2 Stakeholder interviews

Stakeholder interviews have been carried out to ensure relevance to industry and to gather new perspectives.

2.2.1 Nick Rowan

The first person interviewed was Nick Rowan, Senior Lecturer in product design at De Montfort University, who has an extensive background in audio.

Rowan quickly raised the issue of properly defining a target market. Some of the ideas that were being developed were geared towards an enthusiastic audience. For example, a modular audio-amp circuit would allow the user to drastically change the sound profile of the speaker.

Rowan pointed out a glaring flaw in upcycled products, that they are inherently compromised in their function and they will never be as good as a product designed with fewer environmental constraints. This, he argued, would make any attempt to target the audiophile market futile.

Instead, he suggested, leaning into the upcycled status of the product and using that to promote a narrative that would drive interest.

Interestingly, Rowan did not like the idea of a detachable fascia panel. This would allow the user to customise the product and re-invigorate the product-user relationship. He partially disagrees with Chapman’s theory that products are thrown away due to a failed relationship and a waning interest. Rowan argues that there are two classes of products, perpetual and disposable. Fashion is disposable and consumed for ego needs whereas, tools and products that offer utility are perpetual. He suggests speakers belong to the perpetual class and therefore, emotionally resilient design should not be a factor.

Rowan also talked of technical issues with a modular audio-amp circuit, using pin-headers to attach the circuit to the mainboard could add noise and interference but he also suggested that this could be a feature and it may appeal to audiophiles who like to tinker. He suggested an alternative where the speaker changes shape to influence the sound, giving the case study of Birmingham symphony hall which has an acoustic canopy that can be raised or lowered to change the acoustics of the hall (Fraser, n.d.). Although, these features may only appeal to the enthusiast.

2.2.2 Abby Hatch

The second interview was with Abby Hatch, a sustainable design engineer, who has rich experience in sustainable furniture design.

Hatch disagreed with Rowan on the detachable fascia panel and thought it could be a value-adding feature, she particularly liked the idea of changing between different materials to give a different feel to the product and suggested it might help with consumer engagement. However, she also warned of gimmicks, which is something Nick Rowan echoed. Abby suggested going for a timeless design, where the features and main elements are simple and consistent between different versions / fascia panels.

Another key issue highlighted by Abby Hatch was that sustainable designs often fail as they are perceived as being too expensive, largely owing less exploitative supply chains and better-quality components that are built to last. Again, it is important to sell this aspect of the product in order to overcome this image.

2.2.3 Sebastian Ward

The final interview was with Sebastian Ward, a design engineer at MIXX Ltd - a company that specialises in “design, development and manufacturing of products that use wireless audio” (Mixx Audio, n.d.).

Ward reinforced the need to differentiate from other products. He asks why someone would prefer an upcycled speaker over a conventionally designed one - it needs to be desirable. He suggests antiques as a source of inspiration, linking back to the idea of graceful ageing and a surface patina that adds value to the product.

Ward was also interested in the idea of the detachable fascia panel and suggested that it could be taken further by allowing users to 3D print their own designs. He was very vocal on modularity, suggesting that the drivers could be swapped out as the user pleased or even entire sections removed to change the speaker from a bookshelf speaker to a portable solution. Likewise, connectivity could be a modular feature, allowing the user to add functionality as required. Although, he did stress that there would need to be significant education on how this feature works and the benefits it offered.

The final point he was passionate about was the ease of use and how pivotal it is for the success of a product.

3. Synthesis of the Research

This research report has explored what circular economy is and why it is essential to product design. Bakker et al. highlight the core tenets of design which should be followed, including circular design models and design priorities. Studies and research conducted by Norman (2021), Shade & Hatch

(2023), Valdez & Becker (2015) and Chapman (2015) give evidence that supports each of these elements, and proves their importance even in very recent years. For products in a decline phase, it is vital to pay attention to each element, including standardisation, ease of repair, serviceability and product attachment. Stakeholder research further confirmed the importance of these core focuses and helped to refine and offer new perspectives on ways to extend the life of the product in order to reduce waste and increase the potential lifetime and overall value of the product for a consumer. This research has been invaluable in determining the direction of the project, as explored below.

4. Implication of the Research

In terms of the Bakker et al. (2020) circular design models, desk speakers fit best into the classic long-life model as they do not have any consumable components. There is also a case for the performance model where perhaps speakers could be included as part of an audio system. However, desktop speakers do not satisfy the scale normally associated with the business model. In light of this, I will design my speaker to follow the classic long life model as Bakker proposes.

The design will prioritise the traits that best apply to the declining product lifecycle category. These are:

- Design for Standardisation and compatibility
- Design for Ease of Maintenance and Repair
- Design for Dis- and Reassembly

Ease of maintenance and repair and design for dis- and reassembly go hand in hand and will be achieved through a sympathetic approach to disassembly and repair; avoiding common frustrations such as awkward angles, one-way fasteners and the need for specialist tools. This is covered in greater depth above.

Standardisation and compatibility is a key issue and will be achieved by adopting industry standards where possible and where possible and establishing them when they are absent.

Primary research will shape the design, on-going feedback from stakeholders will continue to influence the products direction throughout development.

Stakeholder research has dramatically altered the direction of the product. Following suggestions from Nick Rowan, the target audience will be altered. The product will focus much more heavily on the benefits of upcycling in terms of marketing rather than relying on a high-quality product that can reach the pinnacle of audio. Advice from Abby Hatch has further prompted this move towards highlighting the importance of upcycling when it comes to marketing, to overcome issues of price and quality which can be an obstacle to selling the product.

Following the interviews, the customisable fascia panels will become a less prominent feature, although the idea of easy replacement and disassembly will be pursued.

As a result of conversation with Sebastian Ward, the modularity of the speaker will be much further explored. For example, it will include a quick replacement system for input and output ports and potentially discrete sections that can be removed to form their own speaker unit.

5. Design Brief

The speaker will be: easy to dis- and reassemble, pleasant to listen to yet not audiophile grade and be highly modular. The target market will be the eco-conscious consumer based in a maritime climate. It will not use one-way fastening features, strongly avoid the use of uncommon fixings and be as durable as possible.

6. Product Design Specification Table

Design Requirement	Specification Metric:	Quantitative Value:
Easy to dis- / reassemble	Sub-assembly assembly time	>30s
Pleasant to listen to	User Feedback	-
Highly Modular	Proper Implementation of Standards and widespread compatibility	-
Durable	-	-
Eliminate one-way fasteners	Number of one-way fasteners	0

7. Initial Ideas

Two initial concepts have been highlighted as deserving of further exploration.

Concept one utilises a 2-stroke engine barrel as a speaker housing.

Figure 8, Joseph Shade, Ferrofluid speaker concept, 2023

In this design, the exhaust port of the barrel is opened and closed with a servo motor. This manipulation would allow dynamic adjustment of the frequency response of the speaker, this was based on Rowan's suggestion of changing the shape of the speaker. Ferrofluid (a magnetic suspension in a fluid, most commonly oil) is used to visualise the audio input of the speaker and promote an upcycling narrative, reusing both the engine components and fluids of a vehicle.

Concept two uses found objects to create a speaker tower. Each speaker forms its own discrete unit which can then be removed from the instalment and used as a portable audio solution.

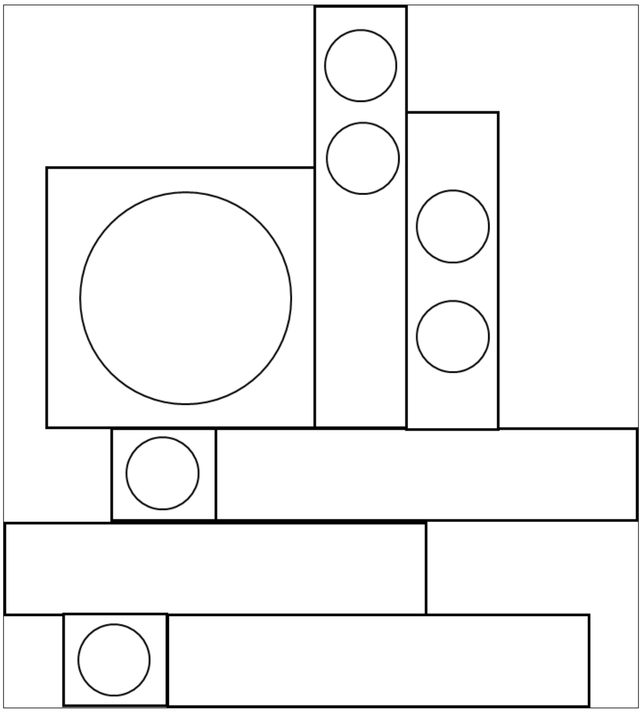

Figure 9, Joseph Shade, Speaker tower concept, 2023

These units would be connected by a central controller / distribution board which connects the speakers to power and handles the audio input and controls.

This solution could produce better audio as it allows different drivers to be used for each part of the audio frequency spectrum.

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