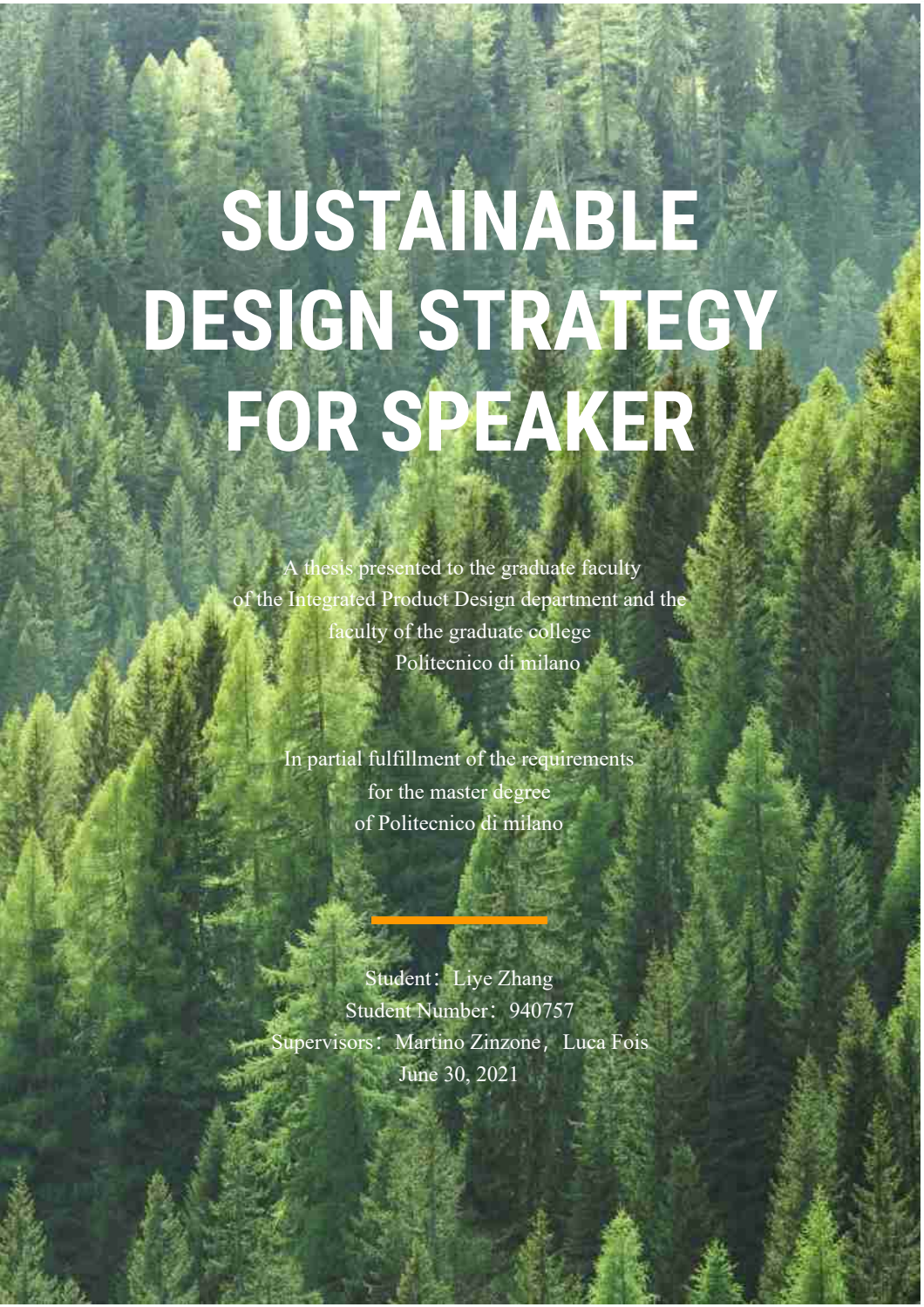

SUSTAINABLE DESIGN STRATEGY FOR SPEAKER

A thesis presented to the graduate faculty
of the Integrated Product Design department and the
faculty of the graduate college
Politecnico di milano

In partial fulfillment of the requirements
for the master degree
of Politecnico di milano

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Student Number：940757
Supervisors：Martino Zinzone，Luca Fois
June 30, 2021

We want sustainability everywhere in all our activities and reflect our culture. Therefore, we are reimagining how we use materials, manufacturing, distribution, and recycling to improve harmful emissions and social influences.

INDEX

BACKGROUND I RESEARCH I ANALYSIS I CONCLUSION

ABSTRACT

Nowadays, too much waste from electronic consumer products is harmful to the environment. As a product company, implementing sustainable development, re-improve product systems, and reducing environmental pollution is essential. This thesis takes the sustainable design research of audio products as an example. First, Setting up questionnaires and literature research on consumers' attitudes towards sustainability, and then through interviews to understand different views on sustainable design from designers and managers in the company. Moreover, conclude suggestions for the development of products in this field. Finally searching for cases analysis for each problem and then took the JBL Pro brand as an example through LCA(Life Cycle Assessment) and ICS tools to analyze and improve their current production system to make it more sustainable. After that, we are learning how to attract consumers to participate in purchasing sustainable products and, for the company, how to build a more sustainable production system and solve existing problems. However, due to the limitations of data resources, the actual business blueprint should be more comprehensive. Overall, the results show that for JBL Pro, sustainable development can be implemented in three areas,01) Social design: Produce more valuable products and better impact users, 02) Circular design: build a product circulation system using recyclable materials. Realize the recycling of materials and reduce the impact of landfills on the environment. 03) Eco design: Create design guidelines, such as modular design, easy maintenance, life extension, to guide the product design process.

Keywords: Sustainable Design Research, Life Cycle Assessment, Jbl Pro, Social Design, Circular Design, Eco Design.

01 MOTIVATION

In the field of industrial design, sustainable design has increasingly become a significant trend. We should all take responsibility based on protecting the environment and awakening people's environmental awareness, shaping product culture, and even setting company goals. Because sustainable design can alleviate environmental problems, it is more beneficial to its development and consumer impressions. However, if we pay attention to the existing ecological pollution problems, we will find that the reality is horrible. According to investigations, pollution is the most significant environmental cause of disease and premature death in the world today. Infections caused by pollution caused an estimated 9 million premature deaths in 2015, accounting for 16% of all deaths worldwide, three times more deaths than AIDS, tuberculosis, malaria combined, and more deaths than all wars and other forms of violence. 15 times more. In the worst-hit countries, pollution-related diseases cause more than a quarter of deaths[1].

Fig 1. Current Production Pullution

[1] *Philip J Landrigan, Richard Fuller, Nereus J R Acosta ect , The Lancet Commission on pollution and health,The Lancet,Volume 391, Issue 10119, 2018,Pages 462-512, ISSN 0140-6736.*

In order to respond to this global trend, we should pay more attention to sustainable development in product design and industrial production. Of course, it will also bring certain benefits to enterprises and companies and the environmental impact. According to Porter Novelli/Cone's 2019 Gen Z Purpose Study[2]. 90% of Gen Z people believe that companies must solve social and environmental problems.

	2017	2019
Share their postive opinion about a company that is doing good	77%	85%
Buy a product with a social or enviornmental benefit	90%	84%
Volunteer for a case they care about	87%	83%
Refuse to buy from a company that is doing harm	76%	77%
Research if a company is helping or hunrting sciety and the envirnment	69%	77%
Share social or envirnmental information with their their social network	77%	77%

Fig 2. Gen Z Purpose Study

Furthermore, 77% of people will research to understand whether the company is honest when it takes a stand on the issue, and when the company supports environmental causes, 92% of consumers have a more favorable impression of the company.

[2] *2019 Gen Z Purpose Study.*

Of course, since the 1990s, people's attention has shifted to product design with less environmental impact[3]. Since then, to reduce the adverse impact on the environment, people have paid more attention to the product life cycle concept. Throughout the entire life cycle, from conception to end-of-life, products meet sustainability requirements. Therefore, modifying product design and selecting the best material combination to reduce pollution and waste in the entire process is a universal method to achieve sustainability[4].

In their early work, Fiksel et al[5]. proposed sustainability indicators for evaluating environmental, social, and economic considerations. However, to achieve better sustainable development, the four phases of the life cycle need to be integrated-before production, manufacturing, after use, and end of use. Moreover, by adding the concept of 6R, the closed-loop flow can be better.

With the rise of the consumer electronics industry nowadays, products from design to final production to user use to end of life also need to go through the series mentioned above. In this process, a lot of waste and pollution will inevitably occur. Therefore, for these enterprises, whether environmental society at the consumer level, sustainable design will be the eternal direction.

[3] *C. Vezzoli, E. Manzini, Design for Environmental Sustainability, Springer, London,*
[4] *J. Fiksel, Achieving Eco-Efficiency through Design for Environment, Total Quality Environmental Management, John Wiley & Sons, Inc. (1996)*
[5] *J. Fiksel, J. McDaniel, D. Spitzley, Measuring product sustainability, Journal of Sustainable Product Design. (1998) 7-16.*

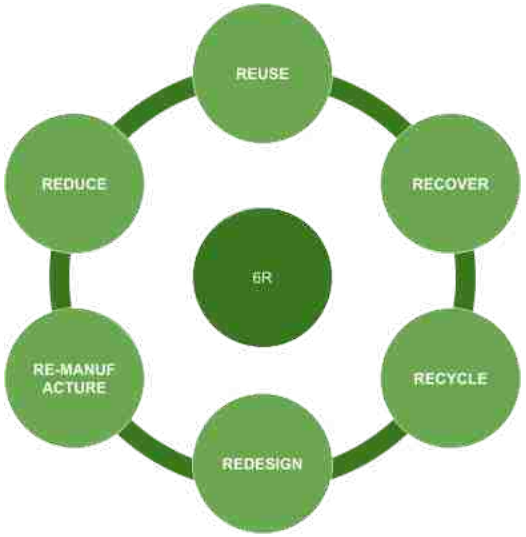


Fig. 3 6R concept[6]

[6] *Yan, J., & Feng, C. (2014). Sustainable design-oriented product modularity combined with 6R concept: A case study of rotor laboratory bench. Clean Technologies and Environmental Policy, 16(1),*

BACKGROUND I RESEARCH I ANALYSIS I CONCLUSION

02 RESEARCH OBJECTIVES

WHY

As mentioned in "motivation," from the company's long-term development, consumer attitudes, and environmental protection, we are responsible for exploring more sustainable product design, discovering environmentally friendly design methods[7], and proposing to the target company and product Sustainable product design.

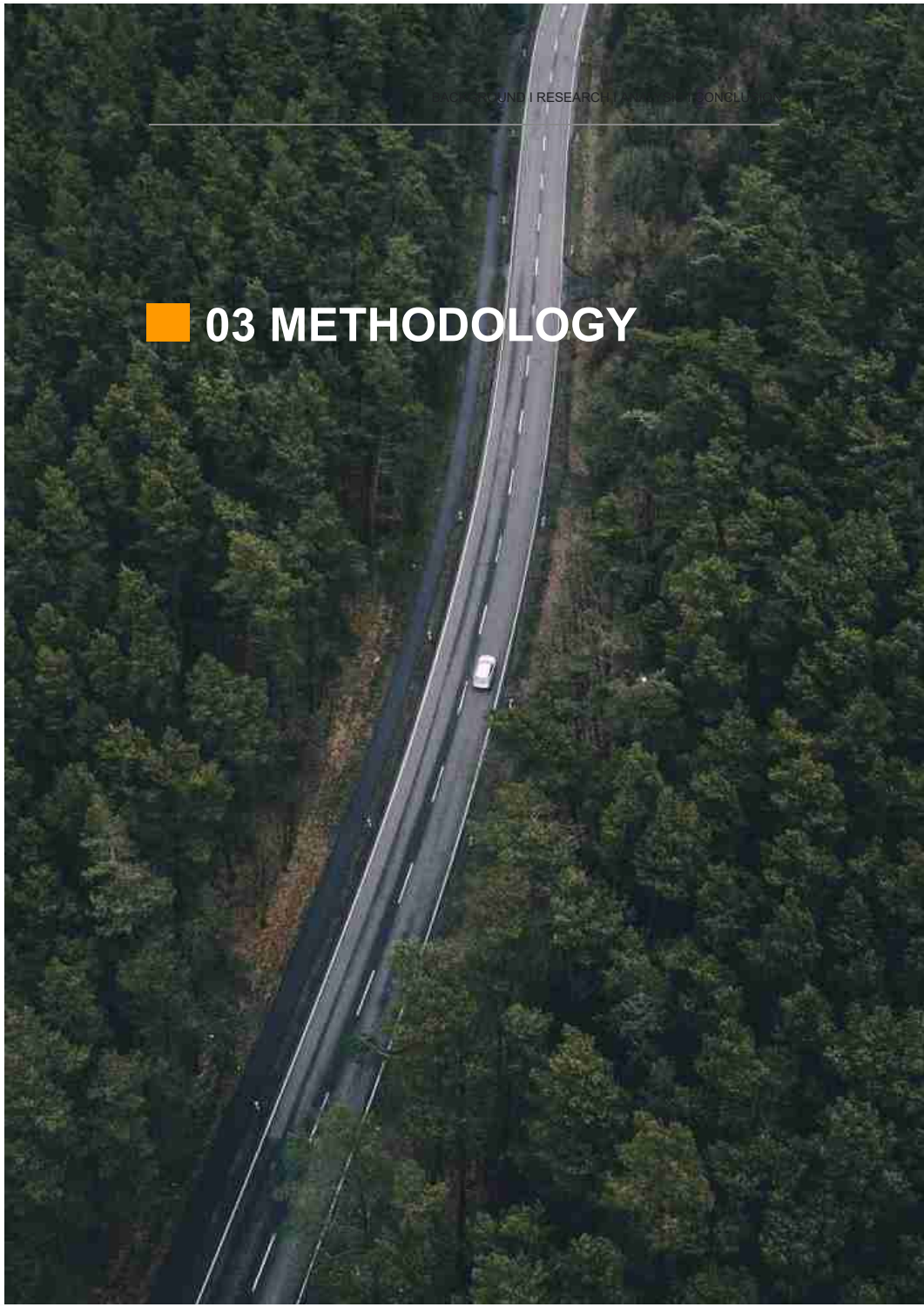
WHAT

Starting from the background, analyze the pain points and opportunities of the existing target company, do a large number of case studies to summarize the methodology, and finally apply these methods and establish the final strategy according to the characteristics and culture of the target company.

HOW

This paper will select and analyze existing consumer electronics companies that have formulated sustainable design directions. Collect data about their products and the entire sustainable system, compare their previous differences, explain the advantages of these data and be reasonable. Finally, demonstrate how they work and establish a sustainable strategic[8] plan for the target company's best product design.

[7] Harbin hongtian ruida science & tech seeks patent for energy-saving environmentally-friendly design method for hydrogen sulfide dry-method sulfuric acid device. (2019, Sep 16). *Global IP News.*
[8] Small-Warner, K. (2018). A review of sustainable business models and strategic sustainable development. *Journal of Business Models, 6*(2), 84.



03 METHODOLOGY

3.1 Methodology Description

In the research of this thesis, adopt quantitative analysis and qualitative analysis methods[9]. Moreover, investigate the following questions:

- *What is the Recycling rate of electronic products?*
- *What is the environmental impact of non-recyclable electronic products?*
- *What are the most commonly used materials used in the electronics industry? Their destructive power to the environment?*
- *Consumers' attitude towards recycling purchased electronic products such as audio? How to deal with it?*
- *What are the essential aspects consumers pay attention to when buying electronic products (audio)?*
- *Currently existing circular references for consumer electronics products?*
- *What are the attitudes and opinions of product designers and company managers on sustainable development?*
- *New materials and choices for electronic products (audio)?*

[9] *Shavrini, M. (1996). Research design: Qualitative and quantitative approaches. Harvard Educational Review, 66(4), 885-886.*

These problems need to collect the specific pollution sources of existing products to the environment, such as the most severe environmental pollution materials and the adverse chain reactions caused by these pollutants. In addition, from the perspectives of corporate designers and managers on the sustainable cycle of product design, it needs to explain this in the form of interviews and understand the attitude of product designers through their answers.

In this research, the goal is to solve a practical problem, which aims at the sustainable development of the target industry and products. Choose the above method because the designers and managers of top companies in the target industry have much knowledge about the industry. With significant influence, they are directly responsible for the output of the product. At the same time, quantitative surveys are more convincing. The data directly reflect the existing problems and how we will avoid them.

Nevertheless, in product design, this is a method that needs to be continuously proven. For example, whether the theory finally output by this method is valid or not needs to be proven. In the entire methodology, there are ethical considerations from the perspective of global human development, what we are concerned about is not just how to better use a product, but thinking about whether they pose a threat to the environment and whether our human production and feedback can balance energy conservation. Finally, in this quantitative and qualitative research, the validity criterion comes from the accuracy and authority of the data.

3.2 Description Of Method Selection

QUANTITATIVE

Questionnaires & Literature Research

The target is May 19, 2021 solstice May 26 on the network of consumers. Consumers are those who have bought a series of audio products. Participants have five minutes to fill out a survey anonymously, and 200 customers responded. Since not all surveys finished, 180 survey results are included in the analysis. The survey includes ten questions from the consumers' perspective; respondents must use the prescribed form to answer. Another approach is to query data on the web, which is obtained from literature sites such as ProQuest or corporate reports and big data sites such as Engage for Good.

QUALITATIVE

Interview & Case Study

In this paper's qualitative research, to better understand the possibility of sustainable development in sound design, a semi-structured interview[10] was conducted with three designers and three management members from the main target groups of Harman Caton. All the designers interviewed have been working in the sound design industry for four years or more. Survey participants used to select target industries and product outputs. The interviews took place in Harman Caton's design department office and lasted about 20 minutes. Record the answers by taking notes, and film the interview with agreement.

[10] Carruthers, J. (1990). A rationale for the use of semi-structured interviews. *Journal of Educational Administration, 28*(1)

ANALYSIS METHOD

After collecting the data, it needs to process and analyze the obtained data. In quantitative research, the analysis will be based on numbers, and the collected data will be prepared before the analysis. Of course, in this step, we will check the missing data and eliminate abnormalities—numerical value. Then use the statistical software to analyze the data.
For the qualitative analysis part, the key themes and ideas will be classified based on language, images, and observations, and each topic will be analyzed to deepen the understanding of the participants' opinions.

DISCOVER OPPORTUNITIES

With the support of research and theory, discover points that can be explored, find existing content that can be applied or create new opportunities.

GUIDELINES CREATION

Build a complete reference system for the sustainable development of electronic products, and mark the innovation points and possibilities.

04 RESEARCH

4.1 quantitative research

As the analysis in the research objectives, in this first part, we will use quantitative analysis to analyze the psychological state of users[11]. Because users play a significant role in fundamental research and design, they are the product users. The entire life cycle of the product is closely related to them. So when we discuss sustainable design, we need to consider the user's view of this field.

In this part, we will use questionnaires and literature surveys to understand users' views on sustainable design, their primary considerations when purchasing electronic products, and their sources of purchase motivation. In addition, the user's environmental awareness is also an aspect I want to understand, which will also affect their handling of the product when life is exhausted. These questions and answers will be recorded through questionnaires, and then the statistical analysis will be performed through graphs.

[11] FNI co ltd files korean patent application for method for obtaining psychological state data of user to assess psychological state thereof and user terminal server and psychological assessment kit using the same. (2020, Mar 02).

4.11 survey

The first part is about the questionnaire part. Users from China and Europe answered this questionnaire. There are about 200 response samples. There are nine questions in the problem sets, which are about their views and discussions on sustainability. Specifically, we will gradually analyze the results and analysis process of each problem.

The first question is about the purchase rate of audio products. In this research, we found that 86% of people have purchased experience. It proves that the consumption of electronic products is very high now, which is also true for user needs. It means that electronic products are becoming more and more popular with everyone, and we also need to pay attention to the design of this product.

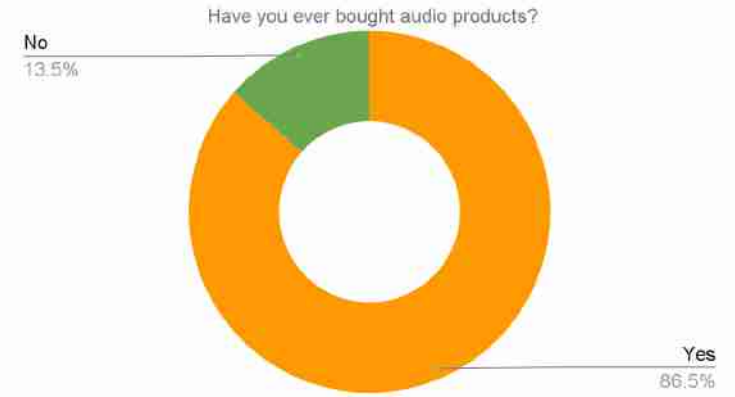


Fig. 4 Question one

In the second question, when purchasing electronic consumer products, whether the recycling of the product has been considered. Surprisingly, almost 90% of users have not considered this. So what is the root of this problem? Is it because everyone is not aware of recycling? Alternatively, is it because the company's recycling mechanism is not perfect, or is it due to other factors. In response to this, we will look into the source of this problem through a literature survey[12].

Fig. 5 Question Two

[12] Kara, S., Ibbotson, S., & Kayis, B. (2014). Sustainable product development in practice: An international survey: IMS. *Journal of Manufacturing Technology Management, 25*(6), 848-872.

The next question is about how users deal with electronic products that are no longer in use. People's first option is to pile it up at home. Alternatively, it is transferred again at a low price, and some users choose to throw it into the trash can. Only almost 10% of users will choose the brand's official channels for recycling. So the disposal method adopted by most users means that these products will eventually be treated as landfills, which means that it is a big problem for the environment. The lower recovery rate[13] also shows that it may be caused by the company's lack of recovery channels or insufficient improvement. In response to this, We will also look for the answer to this question during the interview.

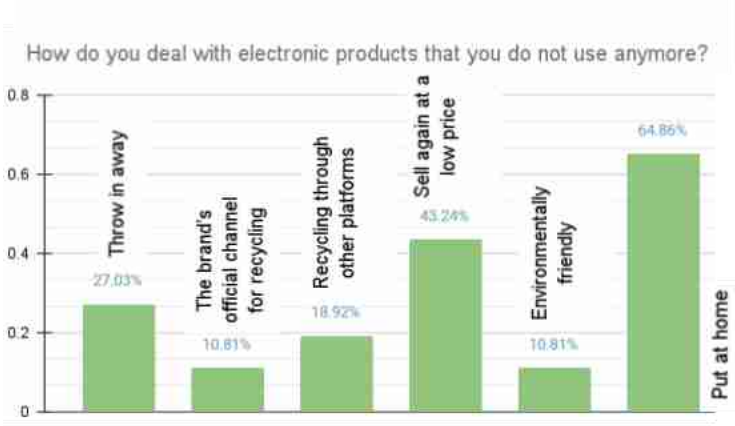


Fig. 6 Question Three

[13] Bishal, B., Junya, Y., & Sakai Shin-ichi. (2021). Comparison of end-of-life vehicle material flows for reuse, material recycling, and energy recovery between japan and the european union. *The Journal of Material Cycles and Waste Management, 23*(2), 644-663.

When it comes to people's environmental pollution from discarded electronic consumer products, most people think we must make changes. However, 30% of people think it has little to do with our lives. Because there are no restrictions on age groups in the current questionnaire target groups, so in response to this, we will also use literature surveys to find more specific data to discuss people of different ages and this sustainable view. Moreover, after realizing that we have to make changes, will people take action? Or how many people would be willing to take action?

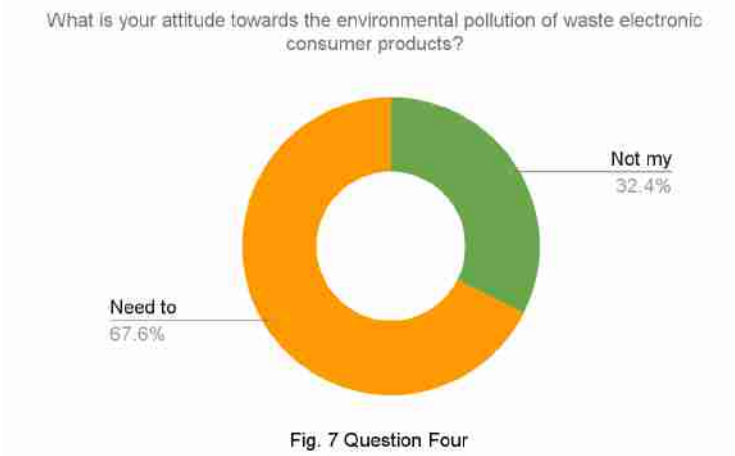


Fig. 7 Question Four

Regarding the factors that users will prioritize when buying audio products, the results show that price and appearance are the first considerations for users. It means that we should learn how to control our costs to reduce the price of products in our production process. Moreover, to improve the quality of products, this is the most reliable and effective way for the company to create. Of course, the brand is also a factor that users first consider to select the most representative brands in the industry in subsequent interviews as this research and analysis objectives.

At the same time, we assumed what factors people would consider when buying a sustainable product. However, similar to the previous problem, most people will still prioritize price and appearance, so this means. Sustainable design does not affect people's purchase intentions or measurement standards when buying. Then this is verified again. Reducing product costs and improving product quality and aesthetics are very helpful for product sales and marketing, even for sustainable product design.

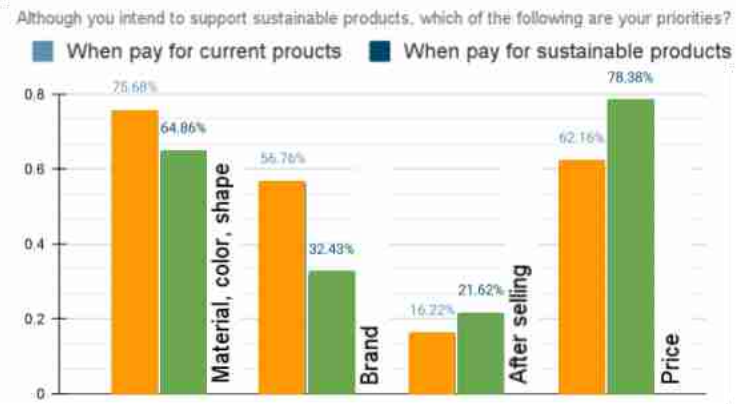


Fig. 8 Question Five

In this question, we discussed people's views and understanding of sustainability. These answers are evenly distributed. Many people think that

sustainability is about environmental protection or the use of renewable materials, and a large number of people think that it is a social responsibility. Of course, this is only about the popularization of sustainable knowledge. We think collecting these answers will also help our research.

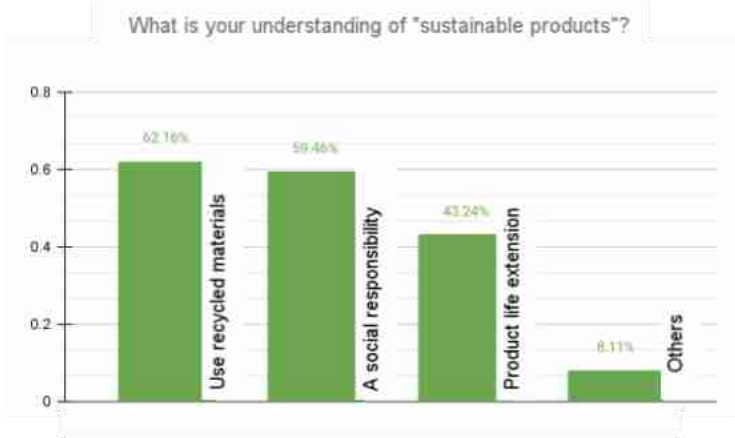


Fig. 9 Question Six

This question is about the motivation that users may have to buy sustainable products. In these answers, we found that our interests and protecting the environment accounted for the majority. Of course, some of them will still choose sustainable products based on style design. That means. Most people will support an excellent sustainable product. Let them know that this will bring benefits to the environment. When it brings value to environmental protection, it may be in their interests.

Fig. 10 Question Seven

Last question. We discussed the connection between users and the target company. Specifically, when the company involves negative news about environmental protection, its user groups will essentially stop consuming its products. It will be a massive blow to the company's operations, so for a company, they must ensure that their sustainable development blueprint is long-term and effective.

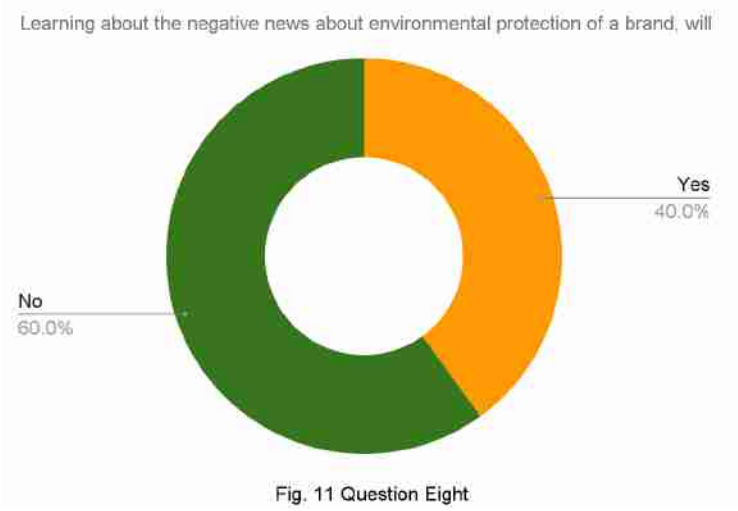


Fig. 11 Question Eight

Conclusion:
Through this questionnaire survey, We got some beneficial conclusions. We know from it, for a company. When designing and producing sustainable products, what are the most important factors? How does the company promote sustainable design and engage users in it, and how to achieve continuous sustainable design. The following three points are the summary of this questionnaire.

01 A large proportion of electronic audio is purchased, and price and appearance are essential elements, so quality improvement[14] and lower product prices are essential.

02 Nowadays, people are not very aware of product recycling, but people have an enthusiasm for environmental protection, so companies should be responsible for leading people sustainably.
03 For the company's development, sustainability and environmental protection will bring them more under the premise of ensuring the quality of styles and products.

In addition, some issues need to be further studied, such as the perception of different groups of people on sustainability. Furthermore, will they take action? Or are people willing to take action? Furthermore, deeper explorations, such as people's desire to buy, environmental awareness, and the proportion of group participation, influence each other for this part. In the next chapter, we will find the answer by employing a literature data survey.

[14] Mättö, T. (2019). Innovation through implementation of a quality improvement method: A finnish public-sector case. *TQM Journal, 31*(6), 987-1002.

4.12 Literature Research

Through literature research, We have found specific answers to the following questions. For example, for a new product, how users will learn about it. Furthermore, what factors will specifically affect users' willingness to consume[15]? For example, who cares more about environmental change and climate change in different age groups. In addition, what kind of people are more willing to act for our environment? In addition, through literature research, We also found out about users' purchase intentions and their attitudes towards environmental protection. And the relationship between user participation, ecological literacy, and consumer perception of effectiveness. Finally, there are user considerations for deeper levels and details.

Fig. 12 Social Media

[15] Morse, G. W. (2012). *Factors influencing the willingness to pay user fees*. St. Louis: Federal Reserve Bank of St Louis.

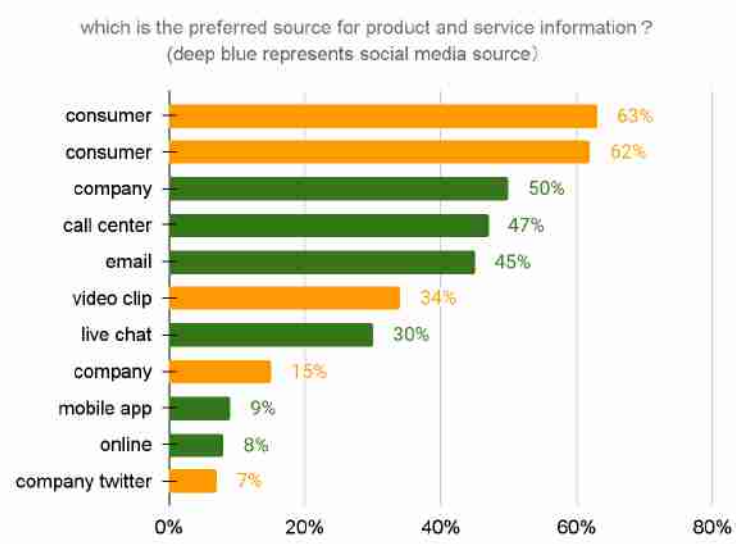


Fig. 13 How Users Know Products Information

First, we found more than 40% of users. It is through social software to know new products or new brands[16]. In social software, we use it every day. Similar to Twitter and Instagram has become a tool that we use very daily. How to explain the relationship between this social software and users and the newly pushed products? One example is when 78% of people comment on a brand on Twitter. They cannot wait to get a reply within an hour. So for these huge workloads and people's urgency for obtaining this information. 28% of these market agents have encountered great difficulties. When they need to solve a series of problems for this social software, social software is still people's source of information and products. So when we discuss social software,

[16] Redefine Marketing Group(08-15-2019),How Social Media Impacts A Brand: The Stats.

there are still plenty of opportunities, and of course, there are also many challenges for companies and brands[17].

So specifically, we have discussed that social media plays an important role when people or consumers explore and discover and share information. Specifically, what channels are used on this kind of social media? People who discover or read this information find out through research. On social media, users are more willing to read online reviews of products. Because almost 3/5 people are willing to comment on the products or services they buy, user reviews and product ratings are the most popular sources of product information for social media users. In summary, if a company wants to build a similar new brand or launch a blueprint for sustainable design on some brands and expand its influence, it can also be through social media. Do some work about brand promotion to attract more users.

The second point is that during our questionnaire process, through our sample response samples, we know that price and quality are the most critical factors for people to consider. Based on this, we have done more in-depth documentary research through more specific, More detailed data and found that the price far exceeds all other options. So, this means that if we want to develop a new product or a sustainable product, then controlling the cost and controlling its price has become a particularly important factor[18].

[17] *Nielsen(Digital 10-14-2011), How Social Media Impacts Brand Marketing.*
[18] Usman, Osly and Aryani, Yenni(December 31, 2019). , The Effect of Brand Ambassador, Brand Image, Product Quality, and Price on Purchase.

Fig.14 What Effects Purchase Intention

The third point is about people's concern about climate change and the environment[19]. We have done a more detailed investigation through the literature in three different age groups: 18 to 34 years old, 35 to 54 years old, and more than 55.

In this data analysis, we found that no matter what kind of people they are, they have the most straightforward understanding of such issues as world warming, for this kind of global warming or climate change threats to their personal lives. People care the least. Of course, the most obvious thing we found is that those young people are the 18 to 34-year-old group in every factor. Compared to the other two groups. We are more concerned about and concerned about our climate change and environmental issues.

[19] Shi, J., Visschers, V. H. M., & Siegrist, M. (2015). Public perception of climate change: The importance of knowledge and cultural worldviews. *Risk Analysis, 35*(12), 2183-2201.

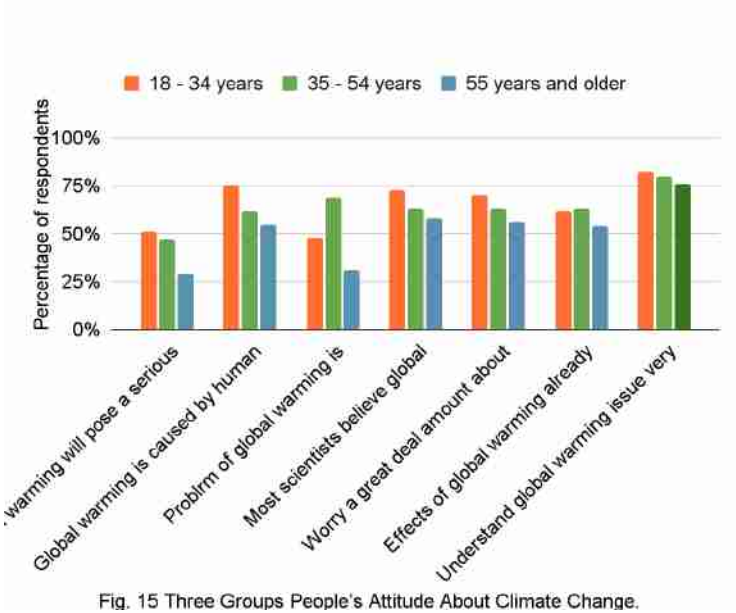


Fig. 15 Three Groups People's Attitude About Climate Change.

Another study[20] found that although young people are more concerned about and concerned about our global changes. Nevertheless, the elderly are more willing to take some actions to reduce our unnecessary travel by plane. Alternatively, planting vegetables and trees, things that can contribute to the global environment. Although this may be different from the lifestyles of the young and the elderly, it also shows that the elderly are still more willing to take actual actions[21].

[20] Statista(May 2018), Concerns About Climate Change In The United States Between 2015 And 2018
[21] Andrea D. Steffen(May 25, 2020),Who Cares About Climate Change? The 55+ Age Group Cares Most.

The final results show that whether they are young or old, they have their advantages. For example, young people have richer and faster access to information, so they are more concerned about global environmental changes. On the other hand, because of their different lifestyles, the elderly also do things beneficial to the global environment in many ways. So we believe in the promotion of sustainable design products, whether young or old. Both will be welcomed in different ways.

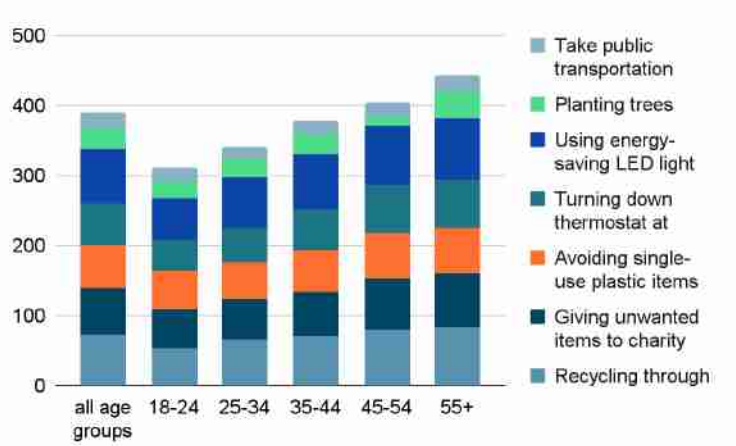


Fig. 16 Different Groups People's Willing To Aake Action For Climate Change

The fourth study is about the relationship between the following factors[22]. First of all, for each factor, we want to make some specific explanations. User's willingness to pay. It means whether users are willing to spend their money on products or sustainable products. Second. Consumers' perceived effectiveness, he meant. The user's confidence in their value or the goal they want to achieve can be achieved. Third, the lack of environmental concern. It means how much people care about the environment. Fourth. Consumer

[22] Shuqin Wei, Tyson Ang, Vivien E. Jancenelle,Willingness to pay more for green products: The interplay of consumer characteristics and customer participation,Journal of Retailing and Consumer Services,Volume 45,2018,Pages 230-238,ISSN 0969-6989.

participation level. Specifically, this is the participation of the majority group or the participation of the minority group. The last one. Ecological literacy. He means people's understanding of our environment and living body. And the awareness of environmental issues.

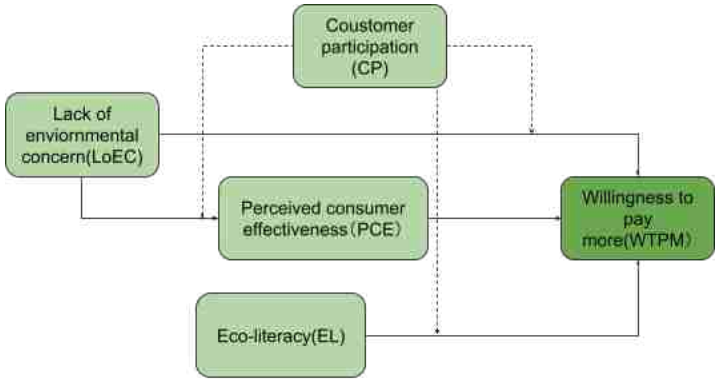


Fig. 17 Relation Between Different Factors

According to literature research. The first. The higher the negative attitude of users towards environmental protection. The less likely they are to spend money on green products. It shows that they are not willing to protect the environment. They are less likely to pay attention to sustainable design and sustainable products. Because the number of humans is too large, we need to consider this point, even if their willingness to buy will not be decisive.

Second, the prerequisites are the same. Assuming that customers still have a higher negative attitude towards protecting the environment, they will not feel that their actions will affect solving environmental problems. Furthermore, even if more users participate in this activity, it will not make them feel that their actions will significantly impact solving environmental problems. Furthermore, we found that more participation and participation of more users will not effectively increase consumers' purchasing intentions. Even if they think their actions will have an impact on solving environmental problems. It

means that the factor that affects people's desire to buy will not be the number of participants. Furthermore, it depends more on their awareness of protecting the environment.

So for the company and promoting the sustainability of the product, at the same time, we must do our best to tell users the importance of protecting the environment and awaken their positive attitude towards protecting the environment[23]. So it is not just relying on traditional marketing methods. but create a more significant flow of more participants.

The third point. It is about the relationship between people's desire to buy and their ecological literacy. We found out. Users have a more profound and more precise understanding of environmental issues. With more understanding of environmentally friendly products, they will be more willing to buy green products.

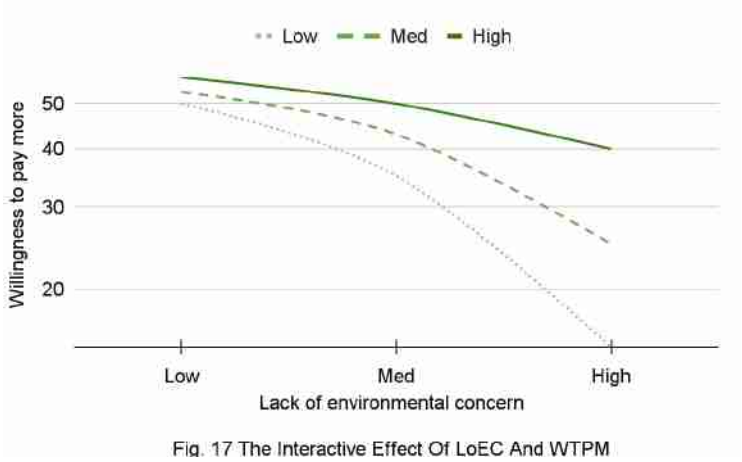


Fig. 17 The Interactive Effect Of LoEC And WTPM

[23] Muhammad, S. K., Saengon, P., Amr Mohammed, N. A., Chongcharoen, D., & Farrukh, M. (2020). Consumer green behaviour: An approach towards environmental sustainability. *Sustainable Development, 28*(5), 1168-1180.

To sum up, through this part of the research, we found. Increasing people's awareness of protecting the environment and improving people's understanding of environmental issues will lead them to believe that their actions will solve environmental issues. At the same time, for companies and products, consumers like them are also more critical. Willing to spend money to buy products.

Fourth, the literature research in this part explores the user's consideration of green products[24]. In our questionnaire process, we considered the user's considerations when purchasing products and sustainable products. So, at a deeper level, in addition to price and quality. Through this kind of research, we found that from other aspects, users will have some considerations, such as environmental aspects, economic aspects, credibility aspects, and product performance aspects. The following table can be seen very clearly, so for innovation and creation of actual products and green products. In addition to quality and price, we should explore and use these four aspects as a basis.

[24] Paraschos Maniatis, Investigating factors influencing consumer decision-making while choosing green products, Journal of Cleaner Production, Volume 132, 2016, Pages 215-228, ISSN 0959-6526

No.	Customer behaviors	Indicators influencing the customer behaviors (factor variables)
01	Environmental consciousness	• Knowledge of environmental solutions • Knowledge of ecological (green) labeling • Knowledge of environmental benefits • Knowledge of economic benefits • Commitment to environmental
02	Green appearance consciousness	• Knowledge of environmental issues • Commitment to health benefits • Consciousness of presence of ecological labels • Consciousness of presence of environmental certification
03	Reliability consciousness	• Consciousness of presence of recyclable packaging • Consciousness of opportunity for cost reduction • Consciousness of presence of non-polluting ingredients
04	Economic consciousness	• Knowledge of environmental issues • Commitment to wastage reduction • Commitment to cost reduction

Fig. 18 Indicators influencing the customer behaviors

4.2 qualitative research

In the quantitative analysis and research, we discussed consumer attitudes towards sustainable design and how commercial companies can better promote their sustainable products and make them accept sustainable products. So in qualitative analysis, we will be more inclined to implement sustainable design from the perspective of the company or the designer's perspective.
This part is qualitatively analyzed. We will explore in two directions. First of all, we will conduct interviews and surveys on companies engaged in electronic consumer products, especially audio products. So this time, we chose Harman Kardon. Harman Kardon is an exceptionally famous audio product company globally, and its audio products cover consumer audio and professional audio. They have a design department in Shenzhen, China. it is fortunate enough to meet the designers here. We selected five or six designers and some managers. We conducted in-depth interviews with them.
In the other part, we will use case analysis[25] to select audio products and other sustainable design product companies as examples. Explore how they built the entire circulatory system. Furthermore, how they did it step by step. Implement sustainable design. Furthermore, look for the answers to the questions one by one so that the questions correspond to the cases.

[25] McDonnell, M. (2002). Making a case for the case study method. *Social Education, 66*(1), 68. Retrieved from

4.21 Interview

The first part of the interview is the interview with the designer. We set up Five to six questions for each designer. Learned about Changes that affect the design in the past ten years from these questions. Furthermore, now as designers, their choice of materials and sustainable design.

The second part of the interview is for managers, from a macro perspective. We want to know what they think about sustainable design from their perspective.

REESE QUINCY- Director / Design Center / Marketing

-harman kardon meeting room/06/01/2021

-The director of Harman Kardon's design department. Usually responsible for the operation of the department. He had several years of designer experience before and then moved to department management.

Liye:
In your opinion, what has changed in audio product design in the past five or ten years?
Quincy:
The change of size, the improvement of technology, the change of materials, and even improved sound quality are the significant changes of audio products in recent years.

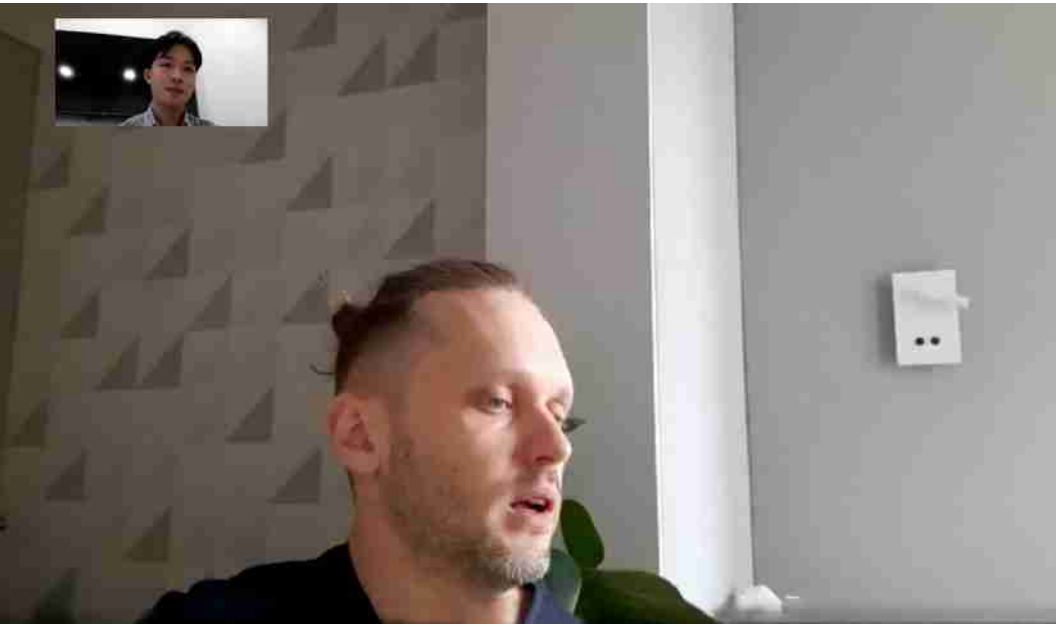
Liye:
Did you join any sustainable audio design work before? If so, could you please talk about that?
Quincy:
I participated in related work. For example, we chose the more environmentally friendly materials used in our products, we found a suitable material on the market and then communicated with suppliers to apply the material in our products.

Liye:
Can you introduce your current design gates, and what aspects will you consider, or what do you think if we put some new sustainable guidelines in your gates if you design in a sustainable direction?
Quincy:
I think there are two directions. The first product appearance design and application of materials is entirely separate. We first discussed the applications of the materials after the design of product appearance. Another is in the present gates with the goal of sustainability. At the same time, we are delighted with the current design process, but I hope we can have more time in the early exploration stage. Materials such as JBL now them do some research and application of the most popular materials used in our products, and of course, this is according to the feedback of market data. We create the new products but also for the feedback from the market, not when we are a generation of product sales, market feedback, we will try to iterate new products, So JBL Consumer's product iteration is fast, but I do not think it is a waste, it is market demand. For another example, we may consider reducing the variety of package sizes. It may be an excellent way to design fewer size categories to package more products of different sizes.

Liye:

When we talk about climate change, what do you think about anything that we can do as a company? For example, did you notice if there are some energy waste situations in our working environment?
Quincy:
We can do it from sustainability eco-friendly footprint less, such as material selection, we can do it for climate change. For the current work environment, we have an automatic power system to turn off to save energy, but we can probably do more, such as making carpets with recyclable materials, reducing the use of paper, reusing 3D printed materials, and so on.

Liye:
What direction do you think the development of electronic consumer products will be in the future?
Quincy:
A few things are the future trends, such as smaller size, easier to use, long service life, more intelligent sensor interaction technology.



Alex- Director/Industrial Design/Marketing

-Online interview /06/01/2021

-Harman Kardon and the director of JBL. Mainly responsible for project promotion. As well as guidance and decision-making for design work.

Liye:
In your opinion , what has changed in audio product design in the past five or ten years?
Alex:
We design from the user's perspective to bring a better and newer personal experience to users. So our goal is to create user-friendly products. These are the things we have been doing for years. Furthermore, different products apply different FABRIC, even including the exploration of metal materials and production technology. Nevertheless, we have many pain points on the

packaging right now because we have companies and factories worldwide, and we need to think about how to make lighter packaging.

Liye:
In your opinion, What would be the most critical strategy In sound design exploration?
Alex:
Seek opportunities based on market needs, knowing what customers want, and designing for tomorrow, means predicting trends through market analysis, and we should always be ready to do so.

Liye:
When we talk about climate change, what do you think about anything that we can do as a company? For example, did you notice if there are some energy waste situations in our working environment?
Alex:
I found the waste of paper, and of course, we work in a more personal way, but through this epidemic, we found that some of the best ways of working are more environmentally friendly, as our online meetings, so we can create more digital space and preserve some of the best ways, and this is a new opportunity for us.

Totom - Senior Designer, Marketing/ JBL Pro

-harman kardon meeting room/06/04/2021

-He has been engaged in sound design for more than ten years. he is very familiar with the changes in sound design. Furthermore, he has a wealth of professional audio design experience. He is an excellent designer.

Liye:
How has sound design changed in the last ten years?
Totom:
at present, in the technology that a speaker is challenging to improve the performance of, for example, compared with our technology of mobile phone product update more slowly, but in the past decade, we from the field, the single market transformation became a more diversified market, we pay more

attention to the change of the market, at the same time to improve our performance. In terms of design, we have gone from organic to more straightforward, cleaner looking, which is also influenced by social changes, and we have become more diverse in terms of materials.02 Material:

Liye:
As far as I know, our current material selection comes from the case reference of the previous generation of products on the one hand and the case reference of suppliers on the other hand. What do you think of this way now? Do you think this approach is a limitation for new experimentation with materials? Or is it a safe way?
Totom:
I think the PP ABS we are using now is a relatively stable and primary material that has been verified for many years.I think that the innovation of the material simultaneously breaks through the limitations in one of two ways. First, we have an application but only 5%, from the perspective of the acoustic appearance and innovation, but for the DaTiLiang application, some problems appeared in the late. Another way is to base material to add a new element. This is our way of using 95%, Because it is less risky, and the new elements that we put in tend to directly improve the performance of something while maintaining the performance of the original material, but maybe it can be recyclable. The recovery rate is twice that of the original material.

Liye:
Compared with consumers, we pay more attention to product quality, which means different service life. What do you think of the service life of current products?Is it possible to extend it further?In what ways?
Totom:
I hope to continue to improve the service life of our products in two ways. One is to extend the service life of the product itself, another kind of promotion materials recovery, of course, much room to continue to ascend, because now products or there are some problems such as deformation wear off paint and so on some questions appearance, Perhaps this can be changed by improving the performance of products in the future.

Liye:
Is there any recovery system for PRO products now?
Totom:
Currently, there is no product recycling system, but we allow 5% recycled material to be added to the product shell material.

Liye:
What do you think about the use of recyclable materials for internal parts while ensuring quality?
Totom:
Because we are a commercial company, the premise to implement this mechanism must be to meet functional requirements and customer requirements. To do this, we also need to consider two aspects. One is the short-term costs such as product cost, on the other hand, it is a long-term cost, such as the way environmental protection may increase our pay taxes (which can be the reference for the development of the car. The government levied higher taxes on high-emission car companies.)

Liye:
Forecast the development of audio in the next ten years?
Totom:
I think the future will be smaller, lighter, and more innovative, and I think more imaginative includes modular design, the application of recyclable composite materials, and the combination with the latest technology. In addition, for professional audio, I think the connection and interaction with other products will be closer, through the way of network and data, to meet more needs of customers.

JIA YANYANG- Industrial Designer / JBL Pro

-harman kardon meeting room/05/20/2021

-Representatives of outstanding young designers who have unique views on design and are mainly responsible for the design of JBL pro products

Liye:
In your opinion, what has changed in audio product design in the past five or ten years?
Yangyang:
I have started to do some research on new materials and environmentally friendly packaging design in recent years. From the past to the present, I think our design is based on market demand and feedback from product managers. I think the annual update is a marketing method for sellers to improve selling

points for consumer products. So it pushes us to iterate rapidly on new and more attractive products.

Liye:
Could you describe how you select materials for a product now? And what is your priority consideration?
Yangyang:
PRO products are products from traditional industries. We will choose PP, ABS, and other materials when choosing materials. We will refer to fish suppliers for different sources of materials, who will start to add new elements to materials, such as carbon fiber in plastic, to increase hardness and performance. For them, performance is the first consideration. For me, the performance of the product material is also the first consideration.

Liye:
As an audio product designer, did you join any sustainable audio design work before? If so, could you please talk about that?
Yangyang:
At present, we have done some sustainable design in our exploration. For example, we will apply the same parts in different products to reduce molds, such as LOGO handles and footpads, etc. In addition, we will try to reduce the number of parts to simplify the products.

Liye:
If not,can you introduce your current design gates in a simple way and from what aspects will you consider or what do you think if we put some new sustainable guidelines in your gates if you design in a sustainable direction?
Yangyang:
At present, we have five steps for a product from concept to mass production, the Gate0 manager is planning, and their requirements, the release of new product requirements, the spread of the concept in Gate 1, the implementation of the concept in Gate 2, Gate3 to do some verification, such as engineering verification, Gate4 to prepare for mass production, Gate 5 is

officially in mass production. So for designers, there is the most opportunity to add some sustainability considerations on their own between Gate1 and Gate2, and for managers, they can put forward requirements and visions for sustainability in Gate0.

Liye:
What do you think is the possibility of sustainable design in audio product design in the future? Could you please predict the future trends or the implementation?
Yangyang:
For the PRO group, I think it will be combined with new technologies in the future, or add new interactive methods, such as audio control by APP. For after-sales maintenance, it may be improved. Many existing parts will be directly replaced in case of damage and time consuming, and it may be possible to consider recycling after reuse.

Hoyean, Kim - Industrial Designer / JBL Pro

-harman kardon meeting room/06/12/2021

-Engaged in sound design for one or two years. There are other designer experiences before. He has his own unique ideas for sustainable design and is an excellent Korean designer.

Liye:
In your opinion, what has changed in audio product design in the past five or ten years?
Kim:
At JBL Pro, we have changed the choice of materials from wood at the beginning to plastic, such as PP and ABS, and we pay more attention to the consideration of wall thickness and create more surface treatment.

Liye:
Could you describe how you select materials for a product now? Furthermore, what is your priority consideration?
Kim:
At present, especially when we do iterative products, we generally follow the previous cases. For example, some of us need to use the original materials, but recently we have considered some new materials, such as the mixed material of plastic and glass. The most important thing is that we are more passive in selecting materials because our material selection comes from the supplier. They give us their samples, and we choose from them, but as far as I am concerned about the quality of sustainable materials, the big problem is that we do not have a supplier to make these sustainable materials without their reference, so for me, quality is the most essential factor to consider.

Liye:
As an audio product designer, did you join any sustainable audio design work before? If so, could you please talk about that?
Kim:
I have been engaged in audio design for two years, during which I have designed replaceable handles and logos. Therefore, I think this can be regarded as a sustainable direction for future PRO products.

Liye:
What do you think is the possibility of sustainable design in audio product design in the future? Could you please predict the future trends or the implementation?
Kim:
There are two directions for future development. The first direction is the change of materials, just like the change from wood to plastic. In addition, prolonging the service life of products is another direction.

Gianni -Director/Industrial Design/Marketing

-harman kardon meeting room/06/01/2021

-Responsible for the production of Harman Kardon products and instructing junior designers. He is a very important figure in the Harman Kardon department.

Liye:
Introduce the process of selecting materials.How can we find new material?
Gianni:
Our selection of materials is based on design language, user needs, and company branding to create maximum value to meet market demand. Our material suppliers are single and fixed, and they will produce the required materials based on cost considerations.

Liye:
Have you done any design related to sustainability? Or material exploration?
Gianni:
Yes, we have done sustainable product design and packaging design, some of which are conceptual design.

Liye:
Is there any recycling system for the product? Do you think it is necessary to join the recycling system?
Gianni:
There is no circulation system, but we have some design points, such as making the product design easier to assemble and disassemble. You can see many Harman Kardon product disassembly tutorial videos on YouTube, which can also satisfy users' curiosity. Creating a circulatory system is a long-term goal, and it is premised on controlling costs and meeting user needs.

Liye:
Predict the development of audio design in the next ten years?
Gianni: The future must be technology-driven design.

Questions:	Answers:
01 Changes in sound design in the past ten years	Materials improvement / open market / design simplify / Technology improvement / Production exploration
02 Current material selection methods and future directions	Option1 : safe way - Basic materials plus new elements – 95% Option 2 : new way - Full use of new materials – 5%
03 Now the sustainable design applications	Mold sharing / modular design / Reduced number of parts
04 Current product development process and possible opportunities	Gate 0 – Gate 5（Gate1 to gate 2 have the opportunity for innovating）
05 Views on the service life of the product	Extend product life / Improve material recovery rate / Over packaging
06 Views on the recycling system	No any recycling system
07 Prospects for future sound design	Lightweight / Intelligent / Miniaturization / Material innovation

Fig. 19 Conclusion About Interviews

4.22 Case study

In this chapter, there are some case analysis. Solve the problems we want to know. Previously, through questionnaire interviews and literature searches. WE have understood many aspects of the problem. There is also a certain degree of research and understanding of sustainable design.So if it is valid for a company, how to implement sustainable design for specific products? So we use case analysis. Ways to respond to problems and find cases. Come and explore these contents. There are four main issues to be explored.

First, how do sustainable materials apply in the current sustainable sound design?

Second. What parts of the product have been changed by sustainable design, and how they have changed.

Thirdly, apart from sound design, any other unique design that covers sustainable design can be used as a reference.

Fourth, is there a better visual sustainable design diagram? The last question is how the concept of product design is mapped on the product?

Fig. 19 Genelec Speaker

Question 1: How to use recyclable materials in the current sound sustainable design?

In response to the first question, based on our previous questionnaire survey, we found that users have very high requirements for the quality of products, whether they are ordinary products or sustainable products. At the same time, we learned from our interview. Quality is always the most important safeguard. In the current audio design, is there any company that has applied sustainable design in product design? Because during the interview, we discussed the application of materials. For example, in the previous interview, there is a way to change the material's performance by adding composite elements based on the existing material. However, this is only used to improve the product's performance, so for sustainability, Would it help again? So we chose the brand Genelec[26]. This brand is the most famous professional audio brand globally that focuses on the quality of the product. It is the pursuit of countless artists and musicians. So how do they do sustainable design? In their information, we found their actions on sustainable design. At the beginning of their company's establishment, they had a long-term plan for sustainable design. They have made good plans in

[26] *genelec,Sustainability Roadmap(2019).*

different aspects, whether product design and packaging design, their factory environment, and their product transportation process, for their team culture. They all made their contributions to the products and sustainable design.

product & packing	factory & environment	transportation	team culture
• Smaller packages introduced for the 8040 model • Carbon-oxide footprint study undertaken for all mainstream products • Genelec ISS-system introduced to decrease product total power consumption • Introduction of our first Natural Composite Enclosure with the M Series • Improvements to product power efficiency with new technology including Class D amplifiers and Switched Mode Power Supplies (SMPS) in main audio monitors	• Regular reporting of factory waste and recycling materials introduced • Regular auditing of environmental issues introduced • Factory heating system is changed from oil to bio-fuels • Factory heating energy savings implemented with ventilation inverters • Further development of Genelec factory waste collection system; improved collection of energy waste • Agreement reached to buy all electricity from renewable energy resources to reduce CO2 emissions	• Development project is introduced to **reduce packing materials** and **harmful emissions** during transportation • **Pallet deliveries optimised** by reducing the return of heavy packing materials • **Plan formulated with the logistics team** to move towards a recycling economy	• Adoption of company web-meetings to **reduce staff travel** • Sustainability aspects now included in the new personnel initiation program • **Staff supported in cycling to work** by through the provision of a proper shelter for bicycles and by organising motivational competitions • Improved video conference system introduced to **reduce staff travel** between Iisalmi and Helsinki

Fig. 20 Road Map Of Genelec

First, we analyze how they do sustainable design from these different aspects. In their company. From the four aspects just mentioned above. We found it in their sustainable Roadmap. Found the corresponding point. Or the design principle. For example, they have their guidelines for packaging and product design. Have their design strategy, for example. They will use

modular product design methods[27] that can be modeled. Furthermore, use smaller packaging. Alternatively, simplify the installation of the product in their factory environment. They will also use, for example, solar energy or other natural energy sources to replace non-renewable energy sources in order to achieve sustainability. Sustainable. At the same time, these actions make a considerable contribution to reducing carbon emissions. In terms of transportation, They minimize the use of materials in product packaging. Furthermore, reduce harmful gas emissions during transportation. For their team culture, they will consider more ways to use online meetings to reduce unnecessarily. Business trips also encourage employees to ride bikes instead. Take the car and other means of transportation in these areas. This company has taken practical actions in order to achieve more sustainable development. If we pay attention to their material application, we will find that their materials are mainly divided into two parts[28]: the materials used in the shell and packaging design, and the shell part mainly uses two materials, aluminum and MDF. Here are specific explanations for the two materials of the shell: its low density and stiffness produce lighter enclosures with thinner walls than is possible with other materials. It also functions as an excellent EMC shield for the amplifier. Each year about 94% of the aluminum used in our enclosures is recycled, with the three primary sources being beverage cans, old automobile parts, and scrap from the production of new aluminum parts and components.MDF is a traditional enclosure material and also very good for making loudspeakers. MDF is an engineered wood product formed by breaking down hardwood or softwood residuals into wood fibers, combining them with wax and a resin binder, and forming panels by applying high temperature and pressure. The environmental impact of MDF has greatly improved over the years, and today many MDF boards are made from a variety of materials: however, Genelec currently uses MDF made from wood. In their packaging material application, they mainly use wood and composite board materials and only use a small amount of plastic, and they will prompt users to properly keep the packaging after they open the product to prevent

[27] Gao, H., & Zhang, Y. (2020). *Application of modular design method in product design*. Piscataway: The Institute of Electrical and Electronics Engineers, Inc. (IEEE).
[28] *genelec,Recycling and Materials(2019).*

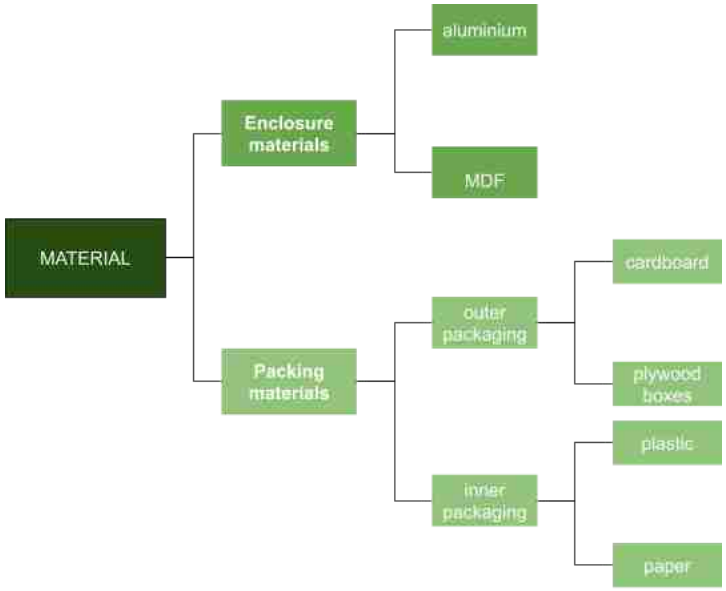


Fig. 21 Materials Of Genelec

being caught when they need it again. In addition, the packaging can be reused when transporting the product. So, in summary, in the product design of this brand, they use many recyclable materials to ensure that the materials will not pollute the environment when they are no longer easily landfilled. Instead, putting it back into the factory for reuse.

In summary, more and more companies are pursuing new-looking materials and various composite materials[29] for the audio industry. However, when we are studying this brand, they only use ordinary aluminum, but their value and status. But it is the highest, so we need to reflect on whether we blindly explore new composite materials while ignoring that the simplest materials can achieve the same effect? Of course, this also depends on the internal

[29] CLASING, M. (1970). Fiber-reinforced materials. I - theory, state of development, and tendencies in fiber production (fiber reinforced materials technology, reviewing basic principles, existing technologies and future trends, various composite materials characteristics, etc). *Verein Deutscher Ingenieure Zeitschrift, 112*(19), 1333-1335.

core technology support, but this can remind us no matter what. We should have confidence in the company because we can always find it. Materials that can be recycled as long as we work hard.

Question 2: What parts of the product have been changed by sustainable design, and how has it been improved?

This question is about the composition of specific products, which parts can use recyclable materials[30]. In response to this problem, we turned to Logitech as a case study. They are very well-known for their work on sustainable design. We found them when searching for information. However, recycled materials use plastic instead of metal, most of the plastic used in their products.

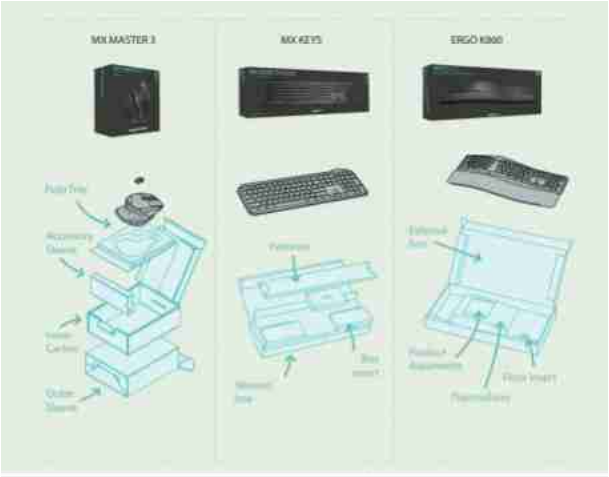


Fig. 22 Products Of Logitech

Furthermore, it is recyclable plastic[31], so take one of their keyboards as an example. 80% of a keyboard is made of this kind of recyclable plastic, and

[30] Keskisaari, A., & Kärki, T. (2017). Raw material potential of recyclable materials for fiber composites: A review study. *The Journal of Material Cycles and Waste Management, 19*(3), 1136-1143.
[31] *Logitech(2020),Sustainability Report Fy20.*

only 20% of the parts require new materials. Including their audio design, almost all the parts inside the shell part are made of recyclable plastic. In addition, almost 90% of their mice use this kind of recyclable plastic.

Specifically, their company has formed its system in terms of sustainable design. For example, they have a sustainable design process. In their sustainable process. There are four steps. From their exploration to the proposal of the concept. To the improvement of the product to the final realization. The pollution will become smaller and smaller. They will try to make their goals and environmental influences visible during the design process.

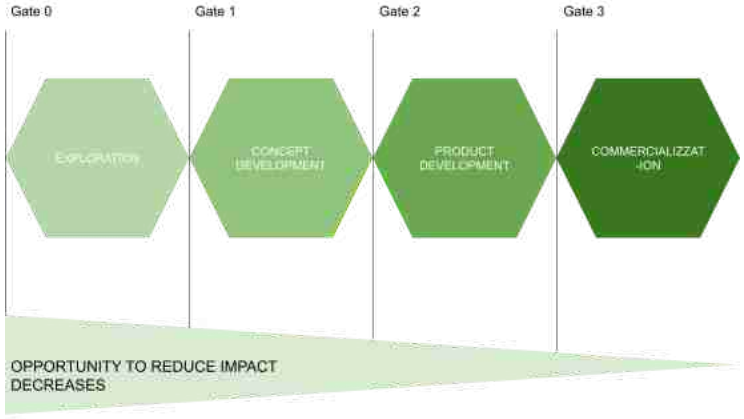


Fig. 23 Sustainability Is Tracked At Project Gates

Therefore, through their sustainable design, changes can be found. They are taking packaging design as an example. This chart is a good illustration of sustainable design guidance—consumption in product packaging, weight, and carbon footprint. Furthermore, the recovery rate has been significantly improved.

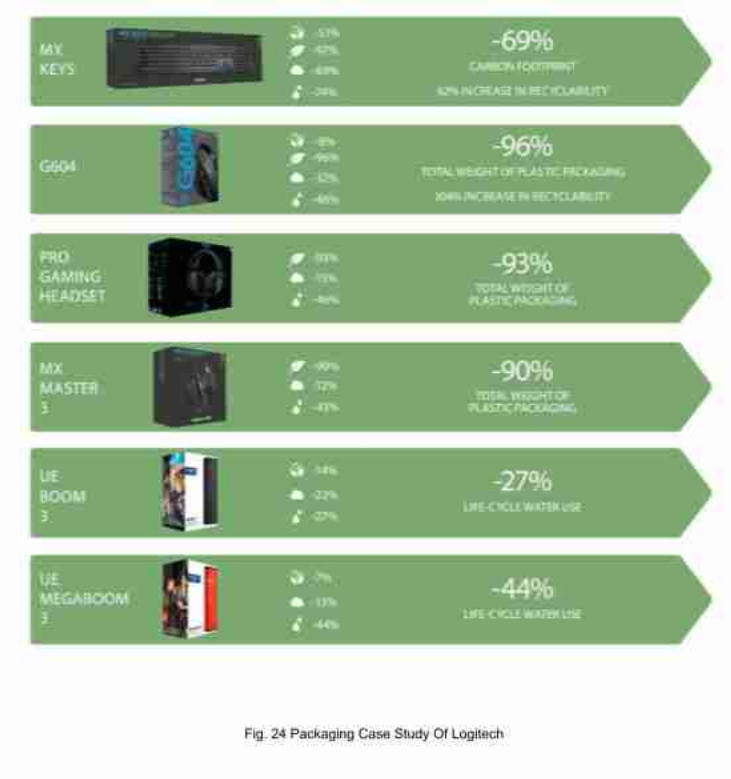


Fig. 24 Packaging Case Study Of Logitech

In summary, compared to traditional people's perceptions, metal materials are easier to recycle. At the same time, plastics are not easy to recycle in people's impressions, but with the advancement of science and technology, more and more materials can be recycled and recycled. Reuse, so when the company carries out sustainable material innovation[32], it can boldly break through the inherent thinking, innovate and use more materials. Because some brand companies have their specific products, if they need to propose a sustainable design, they still need to follow the original design process and even the application of materials. and so. Maybe they can improve on existing materials, whether they use plastic or metal.

[32] Arsenault, P. J. (2014). Recycled material innovations: Designing with sustainable natural fiber insulating products. *Architectural Record, 202*(3), 159-161.

Third question: What is the cycle diagram in sustainable design?

We chose Kvadrat[33] as a case because their products are made of recyclable materials, and even their different brands and different products will directly use recycled sources as a way of publicity to inform users of which recycled materials these products are derived from, such as Really. This material is recycled textiles. After collection, filtration, and reprocessing, new materials are finally produced. Through the following table, we can talk about the entire process.

In conclusion, no matter what it is. Previously, We found out about the recycling of metals and plastics and even this fiber textile. The general principle is the same. They are all re-entered into production through various procedures such as collecting unusable products, re-sorting and reprocessing. So for the company. At least there is no need to think that this will be a highly complex workload. Because the principles are the same, although sustainable design will be a challenge for the company, we already have many good cases to encourage us to recycle materials.

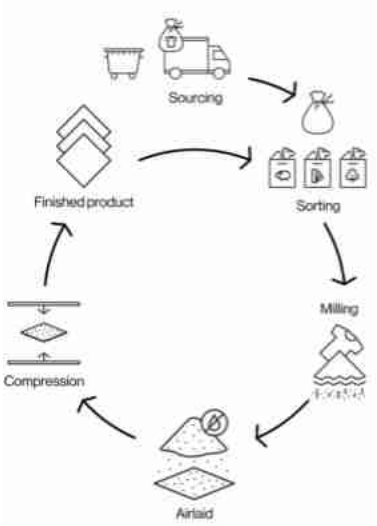


Fig. 25 Circular Design Of Kavadrat

[33] *kvadrat(2021),Really circular processing.*

Fig. 26 Kartell

Question 4: How is the concept of sustainable design reflected on the product?

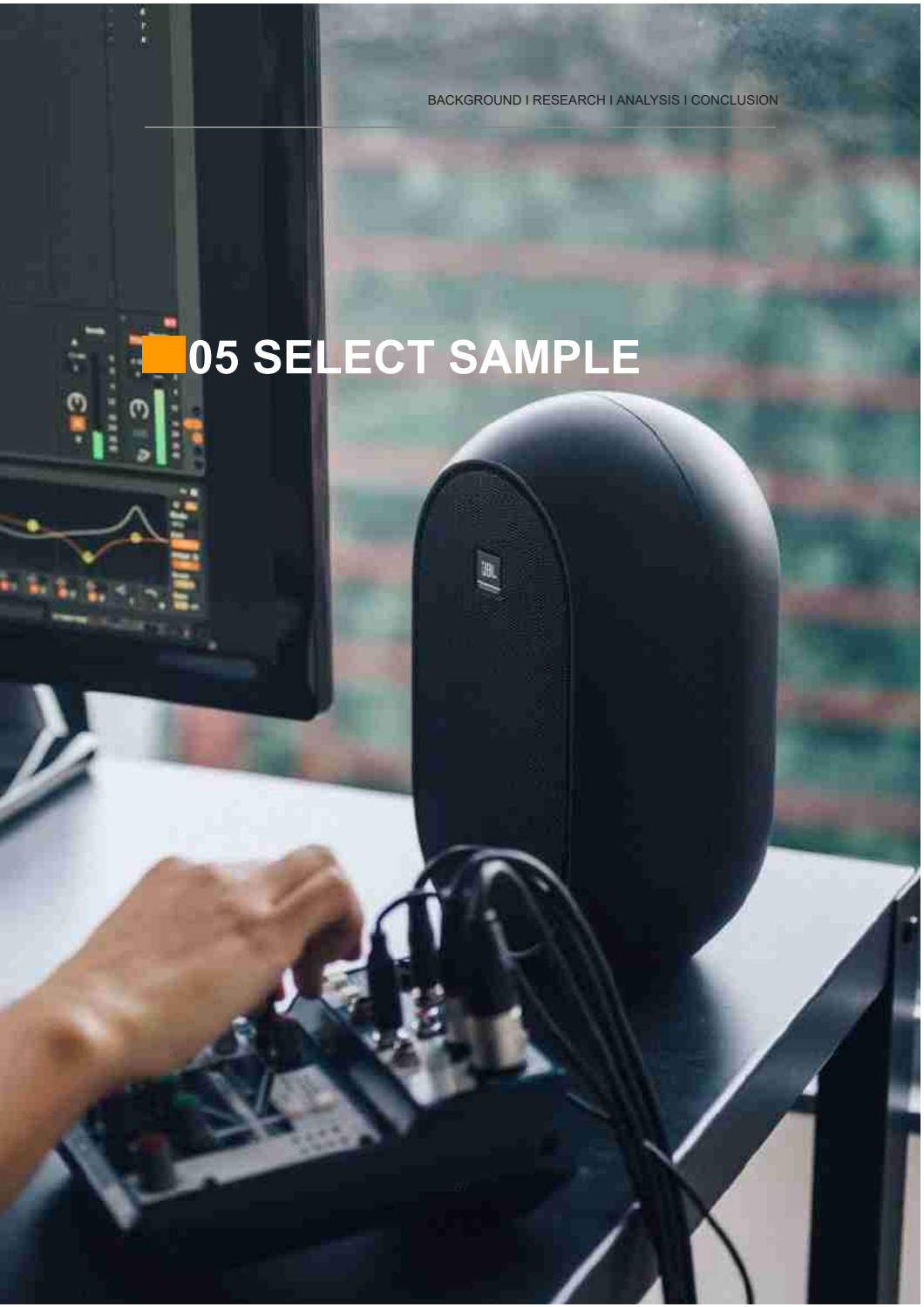
How do we gain the trust of users by adding value to products? This question is based on previous research. First, we found that users' motivation to purchase products is largely derived from conformity with their value. Secondly, Their awareness of protecting the environment increases when they buy sustainable products, so our products are no longer just simple but have their value, so the case I chose is Kartell[34].

Kartell loves the planet is the industrial manifesto with which Kartell intends to emphasize its commitment to sustainability and environmental friendliness. Passion for excellence, which has guided Kartell's every move from the outset, has led the company to focus on environmental responsibility and good sustainability practices.

A Kartell product is a timeless product produced with the utmost respect for the environment and destined - on completion of its function - to occupy museum spaces and join collectors' assets. Kartell's vocation is to create value: not simple objects, but pieces that can contribute towards building a cultural project, not objects that risk being cast aside when no longer used but instead become treasured memories.

In summary, for the company's products. how to position the product, how to define a new value for the product to attract users, and make users generate trust is essential.

[34] kartll(2021),Kartell loves the planet



05 SELECT SAMPLE

BACKGROUND I RESEARCH I ANALYSIS I CONCLUSION

At this point, we have collected all the survey data. From the perspective of users and companies, we know their views on sustainable design. We find that sustainable design is a huge potential opportunity in the audio industry[35].

Because very few companies are beginning to engage in sustainable design, so for sustainable design, they have a lot of innovation and application possibilities

[35] Global audio IC and audio amplifiers industry 2016 market report; launched via MarketResearchReports.com. (2016, Apr 29).

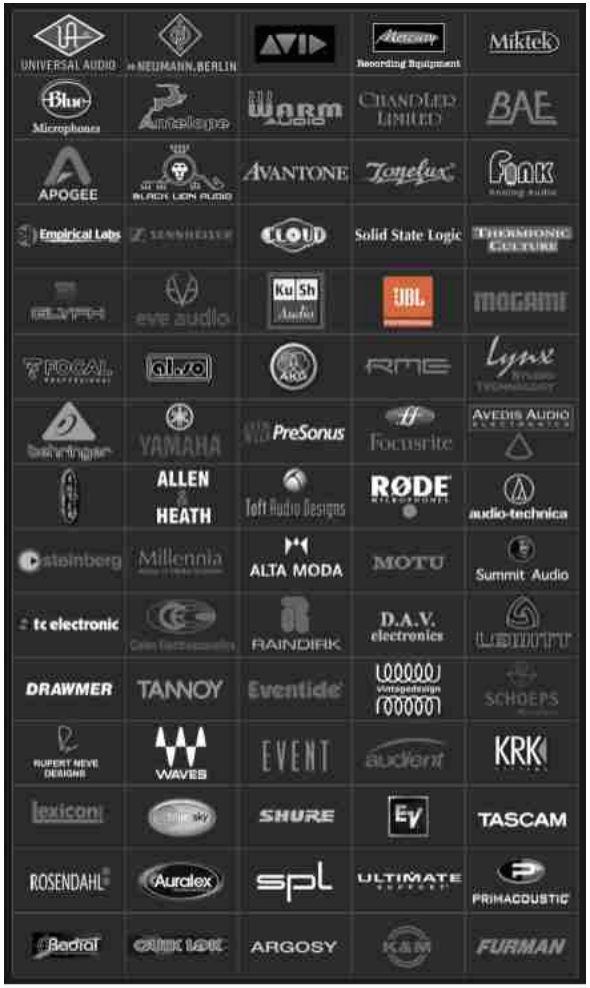


Fig. 27 Speaker Brands

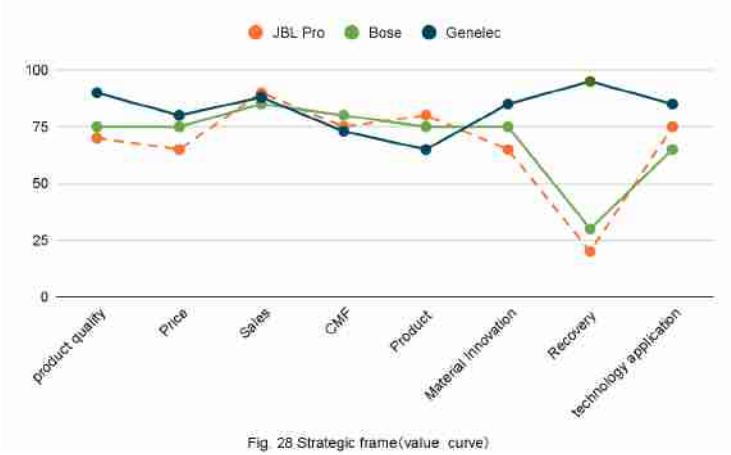


Fig. 28 Strategic frame(value curve)

Let us take a look at the following table in the current audio brand. Only one company applies sustainable design. So for other companies. Should also join the team of sustainable design. So among many brands, we chose JBL[36]. Because its popularity is very high, and its brand influence is excellent not only in Europe but in Asia and the whole world, the scope is favored by young people. We also have the opportunity to meet the designers of GBL.

In previous interviews, we also learned that their brand currently does not have a sustainable design system. Although there are some related attempts, there is a lack of a complete system to carry out sustainable design indeed, so for us. We want to use them as an example. Make a vision of sustainable design in the audio industry.

[36] Harman claims 19 red dot product design awards for design innovation. (2014, Apr 16).

06 ANALYSIS CURRENT SYSTEM

BACKGROUND I RESEARCH I ANALYSIS I CONCLUSION

For the case selected for this analysis-JBL Pro. In order to better analyze the current system. We will use two tools, LCA and ICS, for analysis. LCA is a tool for analyzing the entire product life cycle and can help analyze the impact on the environment during the entire product life cycle. ICS is another sustainable design tool that can help analyze the defects and deficiencies of current products and systems. The following content is a specific analysis.

Fig. 29 Life Circular Accessment

LCA[37]

LCA is a factual analysis of the sustainability of the product's entire life cycle. That is to analyze each part of the product life cycle. For example, extracting materials from the environment, producing the product, the stage of use, and what happens after the product is no longer used. These four aspects will affect the environment in different forms. Using LCA, we can evaluate the impact of our products or services on the environment from the beginning to the end. LCA has many benefits. Analyzing LCA results can help us improve product development, strategic planning, and even policy regulations. Consumers can also learn about the sustainability of products through LCA. The company's purchasing department can also learn which suppliers have the most sustainable products and methods. Finally, product designers can explore how their design affects the sustainability of the product.

[37] Piya, K., Low Jonathan, S. C., & Seeram, R. (2020). Life cycle environmental and economic assessment of industrial symbiosis networks: A review of the past decade of models and computational methods through a multi-level analysis lens. *The International Journal of Life Cycle Assessment, 25*(9), 1660-1679.

The four steps of LCA:

01 We need to define a goal and scope. LCA models the life cycle of a product service or system. Modeling is a simplified process. So the goal and scope describe the essential options. These choices are generally subjective. For example, in this paper, LCA will conduct an LCA evaluation of the current JBL Pro products.

02 In LCA analysis, we can view all environmental inputs and outputs related to products or services. Environmental input means that what is taken out of the environment is put into the product's life cycle[38]. Generally refers to the use of raw materials and energy. Environmental output means that the contents of the product life cycle discharged into the environment include pollutants and discharged waste.

03 Through LCA, the conclusions we draw can help us make decisions because we have classified the environmental impact. It can then be evaluated based on the most critical factors for the company and translated into environmental themes, such as global warming or climate change.

Through LCA, we can create a circular strategy. He will create value for the economy, society, and enterprises while minimizing resource use and environmental impact through reuse and recycling. In contrast, life cycle assessment is a powerful and science-based tool that can be passed to measure the impact of products on the environment. The following is an analysis of JBL Pro products. It is the current LCA analysis chart of their products.

[38] Rahul, L. M., Saravanan, N., & Venugopal, S. (2018). *Life cycle assement (LCA) to improve the product environmental benefits*. Stansted: FISITA (UK) Limited.

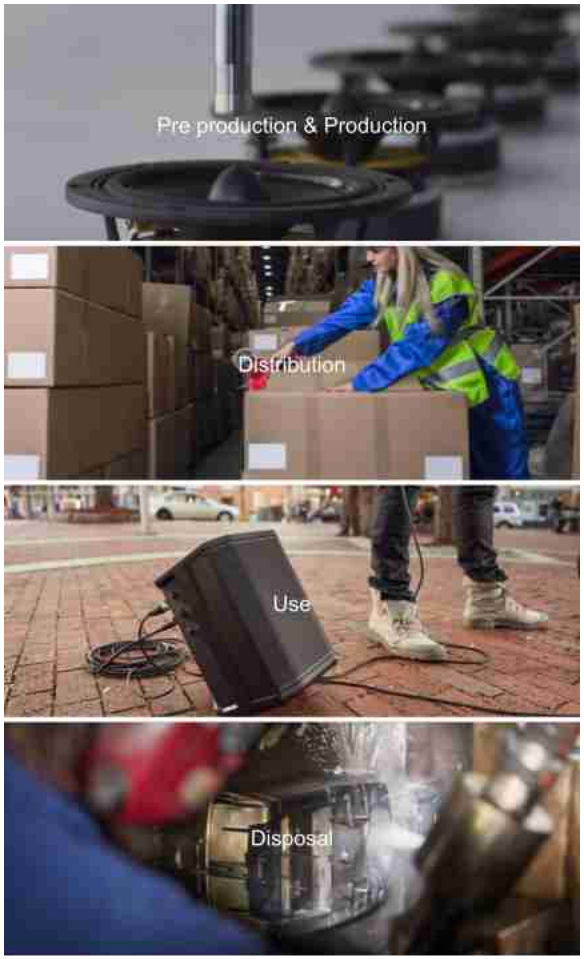


Fig. 30 Four Processes Of LCA

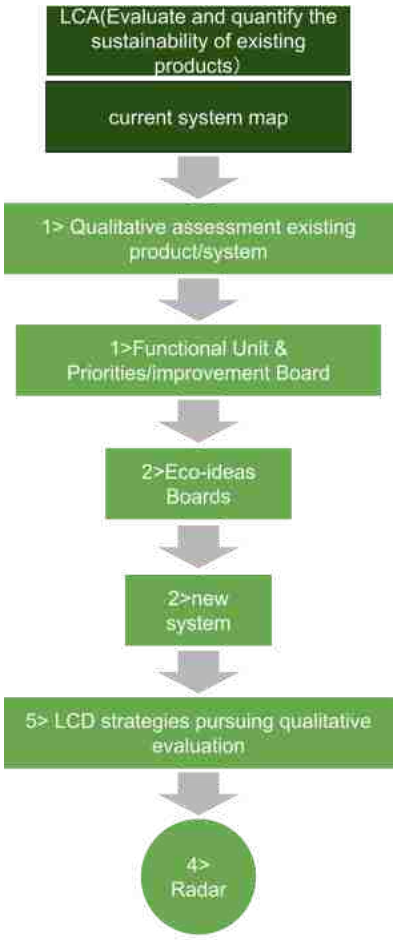


Fig. 31 Steps Of Exploration

ICS[39] is composed of the following tools:

1> qualitative assessment of existing product/system
a set of qualitative checklists for each of the six life cycle design strategies (see next page) is given to help achieve the existing/reference product/system (to be redesigned). For each criterion, it is possible to define the relative priority: high=h: medium=m: low= l: no-n.

2 functional unit & priorities/improvement board
it defines the functional unit and reported in a table both the environmental priorities for each of the LCD
strategies: high; medium; low; no. as well as the level of improvement/worsening of the designed concept/product compared with the existing/reference product): radical improvement, incremental improvement, no change, worse

3> eco-ideas boards

There are six eco-ideas boards, one for each of the environmental design

[39] Lens(2021),Ics Tool.

strategies, used to facilitate the generation and collection of sustainable ideas. Each board is composed of a series of guidelines and indicators to identify environmental priorities. Digital post-its are available to write the sustainable ideas generated.

4> radar
The best ideas generated are selected and positioned close to the corresponding strategy on the radar. Thus, when a concept/product has been designed and evaluated concerning the level of LCD strategies pursued (see below), automatically, it is possible to see the improvements obtained compared to the existing product on the radar.

5> LCD strategies pursuing qualitative evaluation
When a new concept/product has been designed, a set of checklists are given to evaluate the pursuing grade of the life cycle design strategies, assigning a level of improvement: radical, incremental, no improvement; worse.

6.1 Qualitative Current System

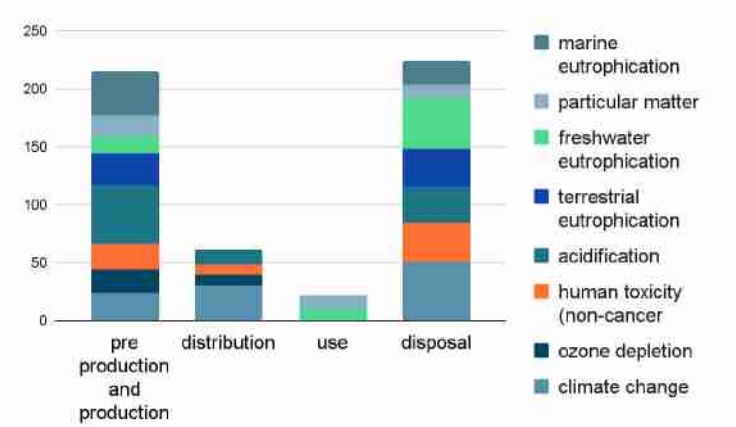


Fig. 32 LCA Of Target Brand(2020)

Through the diagram analysis, we found that the output to the environment is extensive before the production and the production stage, including the final processing stage of the product[40], which is mainly the emission of pollution, for example, in terms of environmental input. Today's products rely on the input of many industrial raw materials, which means that a large amount of non-renewable energy is consumed, including oil and trees. The current product's raw materials come from plastic and wood. Moreover, the demand for raw materials in the production and processing stages is enormous. Furthermore, the consumption of such resources will indirectly bring about environmental impacts. In the distribution and use phase, The product has less impact on the environment because JBL Pro's products are at the top level in the industry, so the quality of the products is guaranteed. For users, it is very safe during use. However, after use, the treatment of the product has

[40] Harman Kardon 2020 report.

not been effectively resolved, so it will still cause a certain amount of pollution to the environment in the end. For example, when non-degradable materials[41] are applied to JBL Pro products, when they can no longer be used, they will cause some pollution to the environment after being buried or incinerated, such as harmful gas emissions and soil pollution.

In summary, it is possible for company departments and designers to re-explore the product's pre-production stage and final processing stage. For example, the company's purchasing department can understand which suppliers have more sustainable materials and production methods. Product designers can also explore how their designs can lead to better sustainability. For example, how the product can be recycled to the greatest extent.

[41] Zaaba, N. F., & Ismail, H. (2019). Thermoplastic/Natural filler composites: A short review. *Journal of Physical Science, 30*, 81-99.

6.2 system Visualization

After analysis based on LCA and interviews with managers and designers of JBL Pro department, we built a simple system map[42] to analyze the entire life system of JBL Pro, from pre-production and production to product distribution and user use to the final product processing. The following is the entire system diagram.

The life system of the product is roughly like this. After the company receives feedback from the market, they will look for suppliers when they confirm the product plan to design the latest products according to needs. They are production plants, material suppliers, and some other sub-suppliers because some particular parts may need to be supplied.

After finding the corresponding supplier, We need to spend a lot of work time to contact them. Furthermore, guide them until they go to joint production. Finally, the product is produced through the factory. After products are produced, they are put into the market through the company. Furthermore, the user purchases the product in the market. For users, if part of the product encounters a situation that needs to be repaired. Some of the company's repair centers can help with repairs. Nevertheless, when the product can no longer be used in the final stage, it is wholly damaged, or the user does not want to use it anymore. The current way of disposal is to return to nature through garbage collection and finally landfill.

It is the entire system diagram now. So how to make improvements to modern systems. We learned about another sustainable design tool (DIS). We will use DIS to analyze improvement opportunities.

[42] Hansen, A. (2001). Managing new products: Using the MAP system to accelerate growth. *The Journal of Product Innovation Management, 18*(4), 279-281.

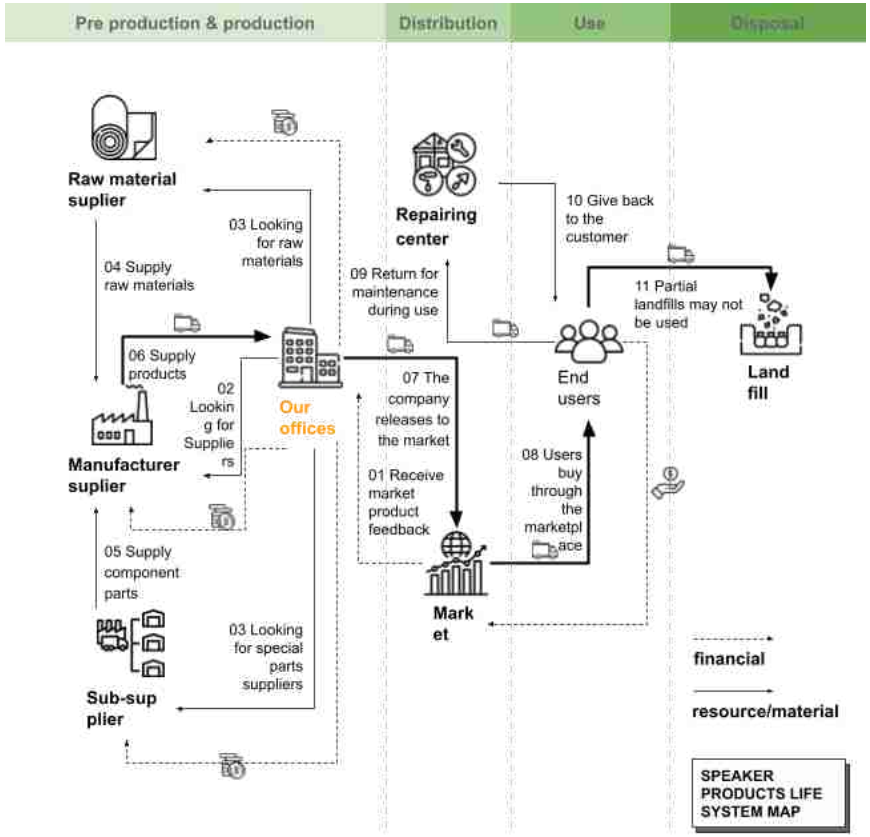


Fig. 33 Current Product System

Based on our previous analysis of existing JBL Pro products using LCA tools. We made the LCA analysis chart and the system map. Moreover, we also summarized the current deficiencies in the four product stages. In order to evaluate the current system, we used DIS as a tool to explore innovations. DIS is a product life cycle designing tool. It is a qualitative tool used to determine the design process from the earliest stages of product development. It is a tool for sustainable conceptual design. It will consist of four parts: First. A qualitative assessment checklist for existing products. Second. Evaluate the priority of the design. Third, the Ecological ideas table. That is from the numerous guides. Find the most familiar and most suitable idea for this system. Fourth. Three evaluation criteria of simplified normality and depth were used to evaluate the new concept. Fifth, it is about the qualitative assessment checklist of the strategic radar. That is the improved concept of visual evaluation.
And so. In this chapter, we will start with a qualitative assessment of existing products. Find the problem and innovate the idea through the guide. Then visualize the new system by creating a new system. Finally, through re-evaluation and strategic radar to detect the results of the new system. Moreover, compared with the original system.

First, The qualitative evaluation of products will be carried out from six aspects: USE EXTENSION/INTENSIFICATION, MATERIAL CONSUMPTION REDUCTION, ENERGY CONSUMPTION REDUCTION, MATERIAL LIFE EXTENSION, TOXICITY REDUCTION, RESOURCE CONSERVATION/BIOCOMPATIBILITY[43].

The following is the specific checklist corresponding to each part. It is based on subjective judgments and objective facts to answer every question.

[43] Boss, J. H., Shajrawi, I., Aunullah, J., & Mendes, D. G. (1995). Relativity of biocompatibility a critique of the concept of biocompatibility. *Israel Journal of Medical Sciences, 31*(4), 203-209.

CHECKLIST

USE EXTENSION/INTENSIFICATION

1. IS THE PRODUCT/SYSTEM A DISPOSABLE ONE (USED ONLY ONE TIME, EXCLUDING CONSUMABLES)?
1. no, Our products can be used many times until the end of life

2. IS THE PRODUCT/SYSTEM WITH A SHORT LIFE-SPAN (EXCLUDING CONSUMABLES)?
2. yes, Some of our products have a long life, but some of our products have a short life

3. ARE DISPOSABLE PACKAGING USED?
3. yes, A lot of disposable plastic packaging and corrugated packaging

4. DOES THE PRODUCT/SYSTEM OR SOME OF ITS SOME PARTS, TEND TO WEAR OUT EASILY?
4. yes, Especially the part that is in contact with the ground or the part that needs to be stressed

5. IS THE PRODUCT/SYSTEM DIFFICULT TO BE MAINTAINED, REPAIRED AND/OR UPGRADED?
5. yes

6. DOES THE PRODUCT/SYSTEM TEND TO BE TECHNOLOGICALLY OBSOLETE?
6. no, It's almost always the latest technology
7. DOES THE PRODUCT/SYSTEM TEND TO BE CULTURALLY/AESTHETICALLY OBSOLETE?
7. no, As the industry leader, our products have a high aesthetic

8. DOES THE PRODUCT/SYSTEM REMAIN UNUSED FOR LONG PERIODS?
8. no, Our products are used frequently

9. IS THE PRODUCT/SYSTEM INDIVIDUALLY USED, WHEN IT COULD BE SHARED IN SOME OF ITS PARTS?
9. yes, Some of our components are modular in design

MATERIAL CONSUMPTION REDUCTION

CHECKLIST
1. IS THE PRODUCT/SYSTEM CONSUMING A HIGH QUANTITY OF NATURAL RESOURCES OR ABSORBING A HIGH QUANTITY OF CONSUMABLES?
1. consuming high quantities of consumables. Most of it consumes industrial raw materials.

2. IS THE PRODUCT/SYSTEM HIGHLY MATERIAL-INTENSIVE (OVERSIZED)?
2.yes, We have a lot of high-value components that need to be assembled by hand

3. IS THE PACKAGING HIGHLY MATERIAL-INTENSIVE (OVERSIZED)?
3.no, the packaging is just the traditional way

4. ARE THERE CONSIDERABLE SCRAPS AND/OR REFUSES?
4.yes, We will produce some waste products in the production

ENERGY CONSUMPTION REDUCTION

CHECKLIST
1. IS THE PRODUCT/SYSTEM CONSUMING A HIGH QUANTITY OF ENERGY?
1. Yes, there will be energy consumption during the production phase

2. IS THE PRODUCT/SYSTEM USING LOW EFFICIENT TECHNOLOGY?
2. some of them, Most of the technology is efficient assembly line machines, but some of the work is manual

3. IS THE PRODUCT/SYSTEM UNABLE TO ADAPT ENERGY CONSUMPTION TO DIFFERENT TYPES OF USE?
3.yes

4. IS THE PRODUCT/SYSTEM USING LOW EFFICIENT INSULATION TECHNOLOGY?
4. no

5. IS THERE ANY EXCESSIVE TRANSPORTATION OF THE PRODUCT/SYSTEM?
5. Yes, we often have to ship goods across borders

MATERIAL LIFE EXTENSION

CHECKLIST
1. DOES SOME/ALL PRE-PRODUCTION AND/OR PRODUCTION WASTE END UP IN LANDFILLS?
1. Most of the pre-production waste and almost all of the post-production waste goes to landfills

2. DOES SOME/ALL WASTE PRODUCED IN USE END UP IN LANDFILLS?
2.no, In the process of using the product, it will lose electricity and will not produce other waste products

3. DOES THE PRODUCT/SYSTEM PRODUCE HIGH QUANTITIES OF LANDFILL WASTE AT THE END OF SERVICE LIFE?
3. yes, Much plastic and metal waste is generated because there is no recycling system for products

4. DOES SOME/ALL PACKAGINGS END UP IN A LANDFILL?

4. Some of the packaging will be retained for storage and used for other purposes, and most will go to landfills.

TOXICITY REDUCTION

CHECKLIST

1. DOES THE PRE-PRODUCTION AND/OR PRODUCTION PROCESSES RELEASES TOXIC AND/OR HARMFUL SUBSTANCES FOR THE WORKERS?

1. During production, some of our processes may produce harmful substances

2. ARE THERE TOXIC AND/OR HARMFUL RELEASES BY THE PRODUCT/SYSTEM MEANS OF TRANSPORT?

2. We will use air and land transportation, which will produce harmful gases

3. ARE PACKAGING RELEASING ANY TOXIC AND/OR HARMFUL SUBSTANCES?

3. Plastic packaging can be difficult to degrade, and waste in nature can be harmful

4. DOES THE PRODUCT/SYSTEM RELEASES TOXIC AND/OR HARMFUL SUBSTANCES FOR THE USER?

4.It is safe for customers

5. DOES THE PRODUCT/SYSTEM RELEASES TOXIC AND/OR HARMFUL SUBSTANCES WHEN DISPOSED OF?

5. Yes, almost all plastic is hard to break down after being buried, and it also produces harmful gases if burned

RESOURCE CONSERVATION/BIOCOMPATIBILITY

CHECKLIST

1. IS ANY/ALL OF THE ENERGY CONSUMED IN USE PRODUCED FROM EXHAUSTING AND/OR NON-RENEWABLE ENERGY RESOURCES (E.G. FOSSIL FUELS)?

1.The wood and cloth we use comes from nature and is renewable, but the plastic we use comes from petroleum sources and is not renewable

2. IS THE PRODUCT/SYSTEM PRODUCED WITH EXHAUSTING AND/OR NONRENEWABLE MATERIALS?

2. Yes, we use a lot of P.P. and ABS, and they are not renewable

3. DOES THE PRODUCT/SYSTEM USE ANY/ONLY DEPLETING AND/OR NON-RENEWABLE MATERIALS IN THE PACKAGING?

3. Most of the packaging material comes from wood, while a small portion of the plastic is made of non-renewable materials

4. IS THE PRODUCT/SYSTEM POTENTIALLY COMPOSTABLE PRODUCED BY ANY/SOME NON-BIODEGRADABLE MATERIALS?

4. yes.

After answering all the checklists, we found that many points are not well done in the current system, and they need to be resolved urgently. Especially the three strategic levels of use extension and material life extension, and resource conservation. They get a higher priority, so we will set these three parts as the highest priority to solve. Energy consumption reduction and TOXICITY REDUCTION will be used as intermediate levels priority. The saving of materials will be the most important thing.

The following figure shows the prioritization of the six strategies[44]. This sorting can better help create new systems. It can help us understand which part I need to focus on and what problems I need to focus on. Therefore, it is evident that the service life of products and the service life of materials have

[44] Coit, D. W. (2000). *System reliability prediction prioritization strategy* Piscataway, NJ: Institute of Electrical and Electronics Engineers, Inc.

been improved. Furthermore, reduce energy consumption. It is a problem we should solve first.

STRATEGY	EXISTING SYSTEM/PRODUCT
	PRIORITY
USE EXTENSION	H
MATERIAL CONSUMPTION REDUCTION	L
ENERGY CONSUMPTION REDUCTION	M
MATERIAL LIFE EXTENTION	H
TOXICITY REDUCTION	M
RESOURCES CONSERVATION	H

Fig. 34 Priority Of Factors

7.1 Eco-ideas Boards

Based on the analysis in the previous chapter, we know what strategic level we will need to prioritize solving the problems in the current system. According to the second part of the Dis tool, we will use eco ideas boards to create our ideas. The logic of this tool remains the same as before. From these six strategic levels, each part of the corresponding guidelines. As our reference. Furthermore, we choose the most suitable company and product needs of the target. Furthermore, sum up the corresponding idea. As shown in the following sections, it is a description and summary of each section:

USE EXTENSION

design for reliability
- reduce the number of parts
- simplify the product as much as possible
- avoid weak connections

facilitate up-grading and adaptation
- plan and simplify the replacement of hardware parts to favour up-grading
- plan and simplify the replacement of software parts to favour up-grading
- design modular and reconfigurable products, able to suit different places and situations
- design adaptable and/or multi-functional products allowing adaptation to users development (both physical and cultural)
- design products for on-site up-grade or adaptation
- provide manuals and tools to enable the user to up-grade/adapt the products

facilitate maintenance
- facilitate the replacement of easy to wear-out parts
- facilitate the access to parts to simplify cleaning, avoiding slots and narrow holes
- design products so that maintenance could be made with easy available tools
- design systems for diagnostic and/or auto-diagnostic regarding the maintenance of parts
- facilitate on-site product/parts maintenance
- provide manuals and tools to enable user to carry-out maintenance procedures
- design to reduce maintenance operations/procedures

facilitate/enable re-use
- facilitate the access and the removal of parts and components that can be reused
- design modular and interchangeable parts and components
- design/use standard parts and components
- improve the resistance of easy to wear-out or easy to damage parts
- foresee the re-use of auxiliary parts

- design packaging that can be reused
- design for second use

facilitate/enable remanufacturing
- facilitate the removal and replacement of easy to wear-out parts
- design structural parts that can be easily separated from external/visible parts
- facilitate the access to parts to be re-manufactured
- foresee adequate tolerance/dimensioning at weak points
- use material overabundance in places more subject to deterioration
- oversize the amount of material used on surfaces that tend to rapidly deteriorate (finishing/coating materials)

intensify use
- design multifunctional products with common components that can be replaced
- design products with integrated functions
- design product-services system for shared use
- design products for collective use

IDEA:
Modular design can be used to facilitate the replacement of parts that are easy to wear. For some other important parts, it can also be designed to be replaceable. More multifunctional integrated products can be designed, and their common parts can be replaced.

MATERIAL REDUCTION

minimise the material content of the product
- dematerialise the product or some of its parts digitalise the product or some of its parts
- miniaturise
- avoid over-dimensioning
- reduce the thicknesses of components
- use ribbed structures to improve structures stiffness avoid parts or components that are not strictly functional

minimise scraps and waste
- prefer production processes that minimize scraps and waste

minimise or avoid packaging
- avoid packaging
- use material only where it is strictly necessary
- design the packaging as a part (to become a part) of the product itself

minimise material consumption during product use
- Design for the most efficient use of the materials. needed for product

functioning
- design for the most efficient use of the materials, needed for product maintenance
- adopt upgradeable digital support systems
- design systems allowing different materials consumption modes according to different functioning conditions/needs
- use sensors to adjust the material consumption according to the functioning conditions/needs
- set out the product default status to the minimum material consumption conditions
- enable/facilitate the users in saving materials when using the product
- enable/facilitate the users in saving materials when doing maintenance

IDEA:
Digitize parts of the product (such as control systems) and design the packaging as part of the product itself.

ENERGY REDUCTION

minimise energy consumption during product use
- design product-service system for shared/collective use
- design for energy consumption efficiency
- design systems allowing different energy consumption modes according to different functioning conditions/need
- use sensors to adjust the material consumption according to the functioning conditions/needs
- incorporate automatic switch-off mechanisms into the product
- define the default working conditions as to consume as less energy as possible
- design systems that can benefit from the passive use of energies
- adopt energy transformation systems with high efficiency
- use most efficient engines
- design/adopt most efficient systems of energy transmission use materials and components with high insulating capacity
- design for local-focused resources providing
- design for optimised insulating shapes
- deign local-focused insulating systems
- minimize the weight of the products to be transported
- design energy recovery systems

- enable/facilitate users in energy savings for functioning enable/facilitate users n energy savings for maintenance

minimize energy consumption in transportation
- design compact products,favouring high density stokking/storage
- design condensed products or semifinished products
- design on-site assemblable products
- reduce product weight
- reduce packaging weight
- optimise logistics

minimize energy consumption in pre-production and production
- prefer materials with low energy consumption in pre-production
- prefer processing technologies with low energy consumption

IDEA
Design products that can be assembled on site to reduce product and packaging weight.

MATERIAL LIFE EXTENSION

adopt a cascade approach
- foresee and facilitate the recycling of materials within components with lower mechanical requirements
- foresee and facilitate the recycling of materials within components with lower aesthetic/formal requirements
- foresee and facilitate the energy recovery (from materials)throughout combustion

select materials with most efficient recycling technologies
- select materials that more easily recover (after recycling)the original performance characteristics
- adopt ribbed structures (or similar)to improve the stiffness of polymers (avoiding the use of reinforcing fibres)
- prefer thermoplastic polymers instead of thermosetting
- avoid composite materials (if necessary,choose those with most efficient recycling technologies)
- avoid the use of fireproof additives by choosing thermoplastics that resist to high temperatures

facilitate collection and transportation of disposed products

- design products considering the existing(third parties)recycling systems
- minimise (products)dimensions and foresee easy stocking of disposed products
- design products able and easy to be compressed when disposed
- inform user about how to dispose the product or its parts
- minimise(products and materials)weight

identify materials

- codify materials according to identify their type
- add info on material age,recyclings processes occurred and additives used
- indicate presence of toxic residues and contaminant materials
- apply the identification codes in visible places
- use standard identification systems,especially when open loop recycling may occur

minimise the number of non-compatible materials and/or facilitate their separation

- integrate functions so to minimise the quantity of materials and components to be used
- use a one single material within a product or part(mono-material strategy)
- use the same materials,but processed with different technologies in sandwich structures use compatible materials (that could be recycled together)within the product or sub-assembly use joints made of the same(or compatible)material with that of the parts to be connected
- facilitate the separation of non-compatible materials for recycling

facilitate cleaning

- avoid unnecessary surface finishing
- avoid the use of contaminant materials
- facilitate the removal of contaminant materials
- use surface treatments compatible with the(treated)material
- avoid adhesives.if needed prefer those which are compatible with the material to be recycled
- prefer internal polymers dying,rather than surface painting
- avoid contaminating printing processes
- avoid product/parts codification/signing made of additional un-compatible materials
- avoid codification processes made after the components manufacturing
- sign/codify components directly in moulding processes
- codify polymers using laser

facilitate composting
facilitate combustion

IDEA:

Design a product recovery system, and tell users how to deal with the product, if the products or components or sandwich structure is used in a single material, or use can be compatible with the material to help with recycling, avoid using glue, if you need to use, choice and recycle material compatible.

TOXICITY REDUCTION

select materials without or with the lowest toxicity/harmfulness potential

- avoid the use of toxic and harmful materials in products
- if used, minimize the risk of toxic and harmful materials avoid the use of additives causing toxic and harmful emissions
- avoid toxic and harmful finishing materials
- design products that do not depend on toxic and harmful consumables
- minimise the dispersion of toxic and harmful residues (during products' use)

select energy sources without or with the lowest toxicity and harmfulness potential

- select energy resources that minimise toxic/harmful emissions during pre-production and production
- select energy resources that minimise toxic/harmful emissions during distribution
- select energy resources that minimise toxic/harmful emissions during (product) use
- select energy resources that minimise toxic/harmful in end-of-life treatments

IDEA

Choose materials that reduce pollution to the environment after they are discarded

RESOURCES CONSERVATION

select renewable and/or bio-compatible materials

use renewable materials
void materials coming from exhausting resources use materials deriving from

other production processes use components made of parts, coming from disposed products use recycled materials (individually) or combined with new materials use biodegradable materials

select renewable and/or bio-compatible energy resources
select renewable energy resources
adopt a cascade approach
select energy resources with the highest secondary order efficiency
select local energy resources

IDEA
Use renewable materials, recycle production waste, use the combination of recycled materials K and new materials, use biodegradable materials, and choose local energy sources as far as possible

7.2 System Visualization

Based on the creation of Eco idea boards. We got many ideas. The most important one is establishing the recycling system[45], so we redesigned the entire product system. As shown in the figure below, this is the redesigned system diagram. Moreover, we emphatically marked the corresponding Guidelines, that is, in addition to the entire recycling system, how to do better for each stakeholder to achieve better sustainable development. First of all, from the original way that the office had to connect with many suppliers, the office had to connect with one product supplier. The rest of the selection of materials, factories, and sub-suppliers are all connected by a product supplier. The benefit of changing this business model is that we have more energy to focus on product design and management.

In this way, although we did not reduce costs, we improved efficiency and saved time. Moreover, we only need to receive feedback on the product from a product supplier.

Furthermore, through them to control the quality of products. As a product supplier and receiving financial support from our office, they also have the responsibility to make the entire system work, for example. When the requirement is to make a sustainable product, Product players need to find materials suitable for sustainable design based on our requirements. After finding the right material supplier, connect with them and cooperate. In this way, the entire recycling system is set up. When they get the relevant materials from the material supplier, they combine the supply of some other sub-suppliers. Put into production Put into the factory for production, put the product into the market after production, and distribute it to users. When the user is using it, in some cases, repairs may be required, so the previous repair center is still needed to help with repairs. However, when the user cannot use the product, it means that the product's service life has ended.

[45] Gregory, J., Fredholm, S., & Kirchain, R. (2008). *A Methodology For Evaluating And Comparing Recycling Systems: A Case Study Of Electronics Recycling Systems* Minerals, Metals and Materials Society/AIME, 184 Thorn Hill Road, Warrendale, PA, 15086-7528, USA.

Users can easily recycle. Because the product uses recyclable materials, most materials can be passed through the recycling material company. It is recycled, returned to the product supplier, and returned to the factory for reuse after the product supplier. Furthermore, a small part of the materials that cannot be recycled will be disposed of by burying because the materials we use are buried and have the most negligible impact on the environment, making it more environmentally friendly than the previous method.

For each stakeholder, we have some corresponding requirements and guidelines.

For example, for our office, as designers, we should try our best to design products that can be assembled on-site so that the packaging volume of products can be reduced. The packaging can be designed as part of the product to improve the utilization rate of the product. In addition, part of the product can be made electronically, such as his control system. Or we can design a multifunctional product. Reduce the variety of products. Finally, we need to tell the user how to deal with the product. When they need to be repaired, or when they need to be recycled.

For suppliers, They need to innovate how materials are used, such as combining sustainable materials with new materials, so that on the one hand, they can help the recycling of materials, and on the other hand, they can help strengthen the performance of materials.
For manufacturing suppliers, they should try to use local energy and use renewable materials. And biodegradable materials. They should also recycle and reuse the waste from production.

For the marketing department, They need to strengthen their interaction with users through social media. For example, we can tell the user the recycling information and the recycling method in different ways. Thus, help improve their environmental awareness. In addition, Users can also learn more about product feedback through them. Through this connection, the user's desire to buy can be increased. It is a must for a commercial company.

BACKGROUND I RESEARCH I ANALYSIS I CONCLUSION

The product is designed to be modular for users, which can help them quickly replace some wearable parts to extend the product's service life.
For the repair center, some essential parts are designed to be easily replaced. Therefore, it can help them improve maintenance efficiency and increase the user's service satisfaction with the product.
For the recycle material company, our products use a single material. It can help them recycle better. Because it reduces their disassembly and assembly steps, in addition, our products rarely use this way of gluing together and can also help them effectively disassemble and recycle.
For landfills, we have very few parts that cannot be recycled. Moreover, the selected materials are the least polluting to the environment, so this tiny part of the materials used in the land field is also sustainable.

To sum up, This is a new system created with the help of sustainable tools, and the guidelines for each stakeholder have been added. From the design part to the social level, there is also a design strategy. Different factors are considered in these aspects. Then this rebuilt system. In what ways has it improved? We will pass the following evaluation to visualize specific changes.

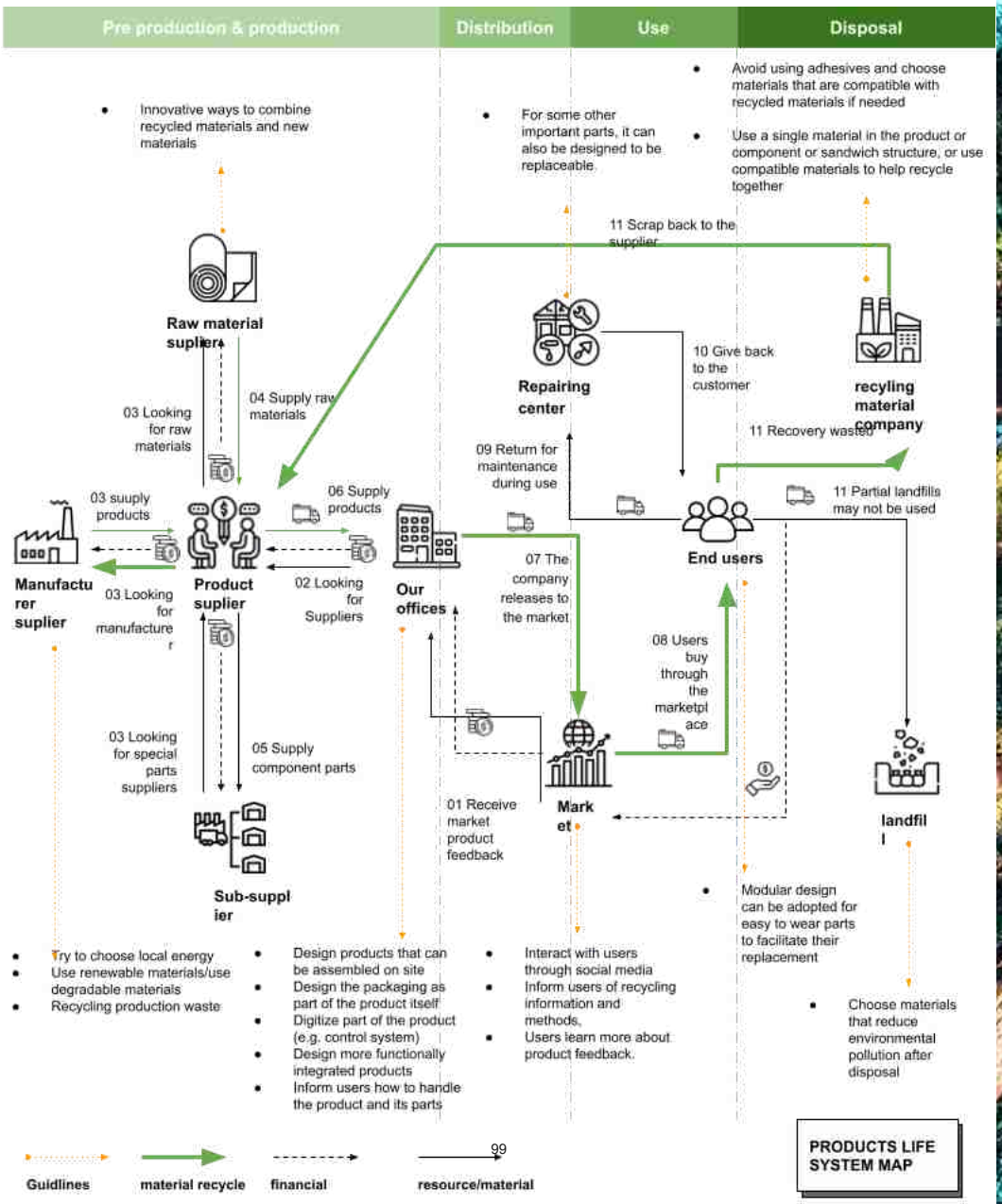
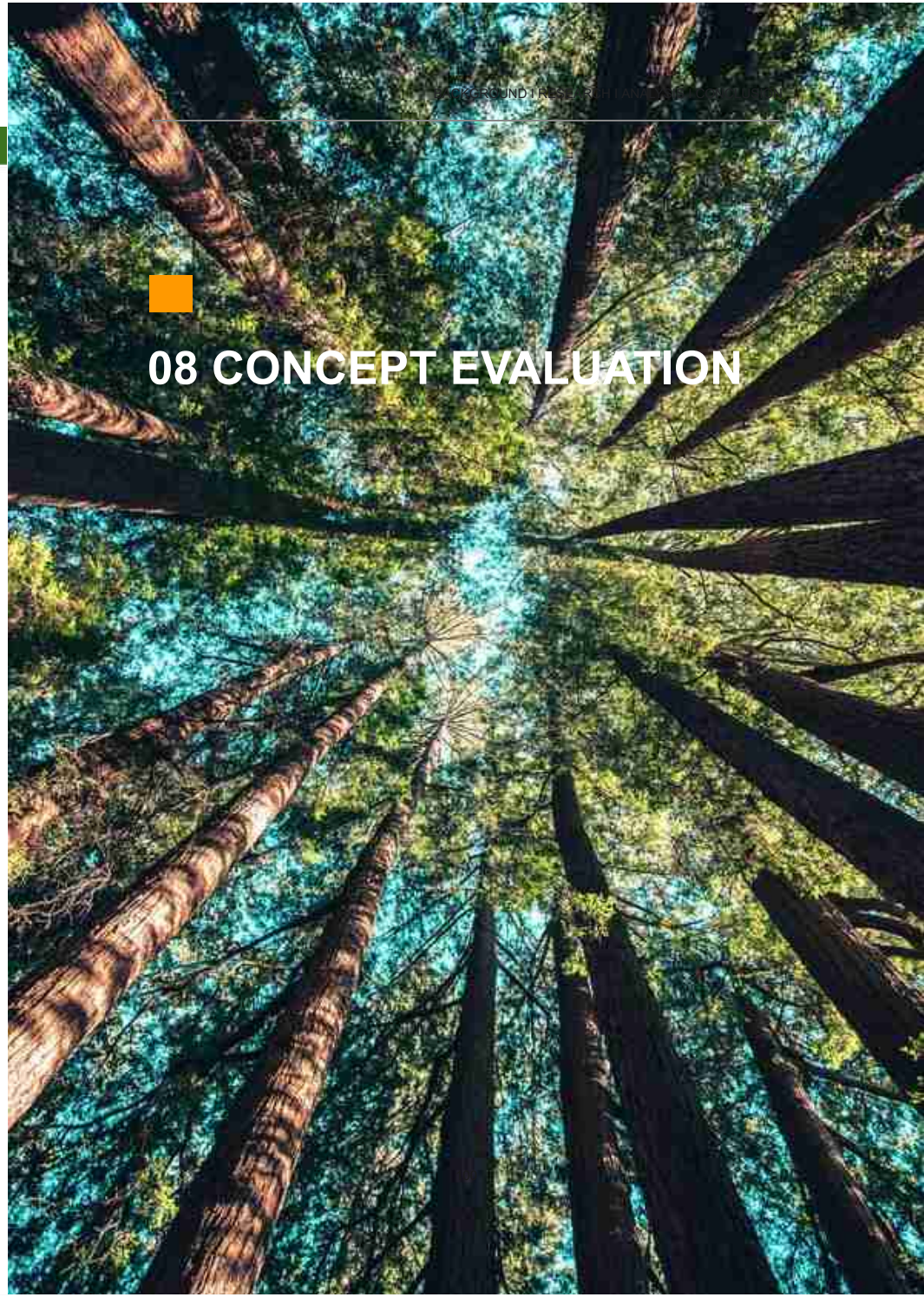


Fig. 35 Redesign System Map



08 CONCEPT EVALUATION

This chapter is about the evaluation of the concept system. In the previous analysis, we found ideas through six aspects and finally created a new system, so in the evaluation part, we will also score from the six parts one-to-one. Through this scoring and statistics, In the end, it can be calculated automatically. Improve the situation for different parts.

The following six parts use extensions. Material consumption reduction. Energy consumption reduction. Use life extension. They are reducing energy resources—toxic and harmful reduction. The six parts of resource conservation are scored. Each part has different questions, and these questions need to be answered. The answer options are: Yes, it has been improved, or it has been partially improved. Or no improvement. Alternatively, there is no application.

For each part of the answer, the number of answers and their proportion will be summarized and finally passed. The method of automatic calculation got the final answer.

Use extension / Intensification

Deep Evaluation

DESIGNING AN APPROPRIATE LIFE SPAN	YES	PARTIALLY	NO	NOT APPLICABLE
1> Are all life span identical for all product pieces?		●		
2> Has the life span of the parts been planned for replacement after a determined time of use?			●	
3> Do the materials used match the performance required by the life span of the product?		●		
4> How have been avoided the use of permanent materials for temporary functions?			●	
TOTAL ANSWERS	0	2	2	
PERCENTAGE(TOTAL/REPLIESX100)		50%	50%	

DESIGNING ARELIABILITY	YES	PARTIALLY	NO	NOT APPLICABLE
1> Have the number of parts been minimized?		●		
2> Has the product been simplified as much as possible?		●		
3> Have weak connections been avoided?		●		
TOTAL ANSWERS	0	3	2	
PERCENTAGE(TOTAL/REPLIESX100)		100%	50%	

DESIGNING AN APPROPRIATE LIFE SPAN	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has on place replacing,updating software parts been simplified?			●	
2> Has on place replacing, updating hardware parts been simplified?			●	
3> Has the product been designed modularly and is it reconfigurable to suit different surroundings?	●			
4> Has the product been designed to be reconfiqurable and/or multifunctional to suit the evolution ofindividual usage?		●		
5> Has on place product upgrading and adaptability been simplified?			●	
6> Are equipment and quide books issued with the product to facilitate upgrading and adaptability?		●		
TOTAL ANSWERS	1	2	3	
PERCENTAGE(TOTAL/REPLIESX100)	17%	33%	50%	

FACILITATING MAINTENANCE	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has the replacement of the part necessary to change been facilitated by simplifying accessibility andremoval activity?		●		
2> Has the accessibility to parts for cleaning been simplified by avoiding slots and narrow holes?		●		
3> as the product been designed modularly and is it reconfigurable to suit different surroundings?			●	
4> Is the product predisposed to use easily available equipment (or are these issued with it)?	●			
5> Have diagnostics/auto diagnostics systems been predisposed to maintain parts?				●
6> Has maintenance been facilitated on the place of usage?		●		
TOTAL ANSWERS	2	3	1	
PERCENTAGE(TOTAL/REPLIESX100)	33%	50%	17%	

SIMPLIFYING REPAIR	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has the substitution of more damaged parts been predicted?		●		
2> Have the components been designed to standards?	●			
3> Have automatic damage cause identification systems been predicted?				●
4> Has on site product repair been simplified?		●		
5> Have tools, materials, quide books been issued for eventual repairs?		●		
TOTAL ANSWERS	1	3	0	
PERCENTAGE(TOTAL/REPLIESX100)	25%	75%	0%	

SIMPLIFYING RE-USE	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has the resistance of parts subject to more wear and tear been improved?	●			
2> Has accessibility and the removal of reusable parts been predicted?		●		
3> Have reusable auxiliary parts been predicted?		●		
4> Have standardized components and parts been designed?		●		
5>Have interchangeable and modular parts been projected?		●		
6> Is it possible to refill or re-use the packaging?			●	
7> Has the product been designed for any secondary usage?			●	
TOTAL ANSWERS	1	4	2	
PERCENTAGE(TOTAL/REPLIESX100)	14%	57%	29%	

INTENSIFYING USAGE	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has the product/service been desiqned for a shared usaqe?				●
2> Has the product been desiqned multifunctional with interchanqeable shared components?		●		
3> Has the product been desiqned for integrated functions?		●		
4> Has the product been or its parts desiqned for on demand production?		●		
5> Has the product been or its parts desiqned for on supply production?	●			
TOTAL ANSWERS	1	3	0	
PERCENTAGE(TOTAL/REPLIESX100)	25%	75%	0%	

Material consumption reduction — Deep Evaluation

MINIMIZING THE PAACKEGING	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has packeging been avoided?				●
2> Has material obly benn used where it is effectively useful?		●		
3> Has the packeging been designed as part of the product?		●		
TOTAL ANSWERS	0	2	0	
PERCENTAGE(TOTAL/REPLIESX100)	0%	100%	50%	

DESIGNING ARELIABILITY	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has the consumption of stationery materials and packaging been reduced?		●		
2> Has information technology been used in the design,modelling and prototyping stages?	●			
3> Has information technology been used in the filing,writtrn communication and presentation stages?	●			
TOTAL ANSWERS	2	1	0	
PERCENTAGE(TOTAL/REPLIESX100)	67%	33%	0%	

Energy consumption reduction — Deep Evaluation

MINIMIZING TRANSPORTATION AND STORAGE CONSUMPTIONS	YES	PARTIALLY	NO	NOT APPLICABLE
1> Have the logistics been optimised?		●		
2> Has the product been designed to be compact within high density storage?			●	
3> Has a concentrated product been designed?			●	
4> Has the product been designed to be compact within high density storage?			●	
5> Has the product been lightened?	●			
6> Has transfer activity been avoided managing it by remote control?	●			
7> Have local resources been used?	●			
TOTAL ANSWERS	3	1	3	
PERCENTAGE(TOTAL/REPLIESX100)	43%	14%	43%	

Material life extension — Deep Evaluation

SIMPLIFYING COLLECTION AND TRANSPORTATION AFTER USAGE	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has the product been designed considering the existing recycling system?				●
2> Has weight been minimized optimally?		●		
3> Has obstruction been minimised and is the dismissed product easy to stack?	●			
4> Has the object been designed to be compressed during disposal?		●		
5> Does the user receive information regarding the type of disposal required for the product?	●			
TOTAL ANSWERS	2	2	0	
PERCENTAGE(TOTAL/REPLIESX100)	50%	50%	100%	

SIMPLIFYING CLEANING	YES	PARTIALLY	NO	NOT APPLICABLE
1> Have unnecessary surface treatments been avoided?		●		
2> Have contaminants difficult to remove been avoided?		●		
3> Has the removal of contaminants been simplified?		●		
4> Have surface treatments compatible with underlying materials been used?	●			
5> Have adhesives been avoided? If not have they been selected to be compatible with the recyclable materials		●		
6> Has colouring polymers during the production been preferred over painting them?	●			
7> Have contaminating printing processes been avoided?	●			
8> Have materials used to mark and code been avoided?			●	
9> Have signs and codes been marked during manufacture?			●	
10> Have the polymers been marked by laser?				●
TOTAL ANSWERS	0	3	2	
PERCENTAGE(TOTAL/REPLIESX100)		100%	50%	

MINIMIZING THE NUMBER OF INCOMPATIBLE MATERIALS	YES	PARTIALLY	NO	NOT APPLICABLE
1> Have functions been integrated to minimise the usage of materials and components?	●			
2> Is the product or one of its parts formed from only one material?	●			
3> Have homogeneous materials been used in joinable structures?				●
4> Have compatible materials been used within the product or its parts?		●		
5> Have the joints been made of materials compatible with those with which they join?		●		
TOTAL ANSWERS	2	2	0	
PERCENTAGE(TOTAL/REPLIESX100)	50%	50%	100%	

Reducing energy resources toxicity and harmfulness — Deep Evaluation

REDUCING ENERGY RESOURCES TOXICITY AND HARMFULNESS	YES	PARTIALLY	NO	NOT APPLICABLE
1> Have sources of energy that minimise harmful emissions of ore-production and production been chosen ?		●		
2> Have sources of energy that minimise harmful emissions of distribution been chosen?		●		
3> Have sources of energy that minimise harmful emissions during use been chosen?	●			
4> Have sources of energy that minimize rubbish and debris been chosen?	●			
TOTAL ANSWERS	2	2	0	
PERCENTAGE(TOTAL/REPLIESX100)	50%	50%	0%	

Resources conservation — Deep Evaluation

OPTIMIZING BIOCOMPATIBILITY AND CONSERVATION OF MATERIALS	YES	PARTIALLY	NO	NOT APPLICABLE
1> Have renewable materials been used?		●		
2> Has the usage of exhausting materials been avoided?		●		
3>Have discarded materials originating from other production processes been used?	●			
4> Have materials originating from dismissed products been used?			●	
5> Have recycled materials been used (individually or combined with virgin materials)?	●			
6> Have biodegradable materials been used?		●		
TOTAL ANSWERS	2	3	1	
PERCENTAGE(TOTAL/REPLIESX100)	33%	50%	17%	

OPTIMIZING BIOCOMPATIABILITY AND CONSERVATION OF ENERGETIC	YES	PARTIALLY	NO	NOT APPLICABLE
1> Has renewable energy been used?		●		
2> Has a cascade approach been adopted?				●
3> Have hiQh efficient second order energy fonts been chosen?				●
TOTAL ANSWERS	0	1	0	
PERCENTAGE(TOTAL/REPLIESX100)	0%	100%	0%	

STRATEGY	EXISTING SYSTEM/PRODUCT	CONCEPT
	PRIORITY	IMPROVEMENT
USE EXTENSION	H	52.5%
MATERIAL CONSUMPTION REDUCTION	L	66.7%
ENERGY CONSUMPTION REDUCTION	M	12.6%
MATERIAL LIFE EXTENTION	H	76.1%
TOXICITY REDUCTION	M	33.2%
RESOURCES CONSERVATION	H	61.2%

Fig. 36 Improvement Datas

After analyzing all the evaluations, we got specific data. The scoring mechanism helps to improve a particular part and a combination of the previous evaluation of the importance of that part. Based on the combination and calculation between the two, the final data is obtained. From the above table, we can know: Life material life extension is the most improved, and energy reduction is the least. Material life extension has increased by 60% on the original basis. On the other hand, the reduction of material consumption has increased by 66.7% on the original basis.

BACKGROUND I RESEARCH I ANALYSIS I CONCLUSION

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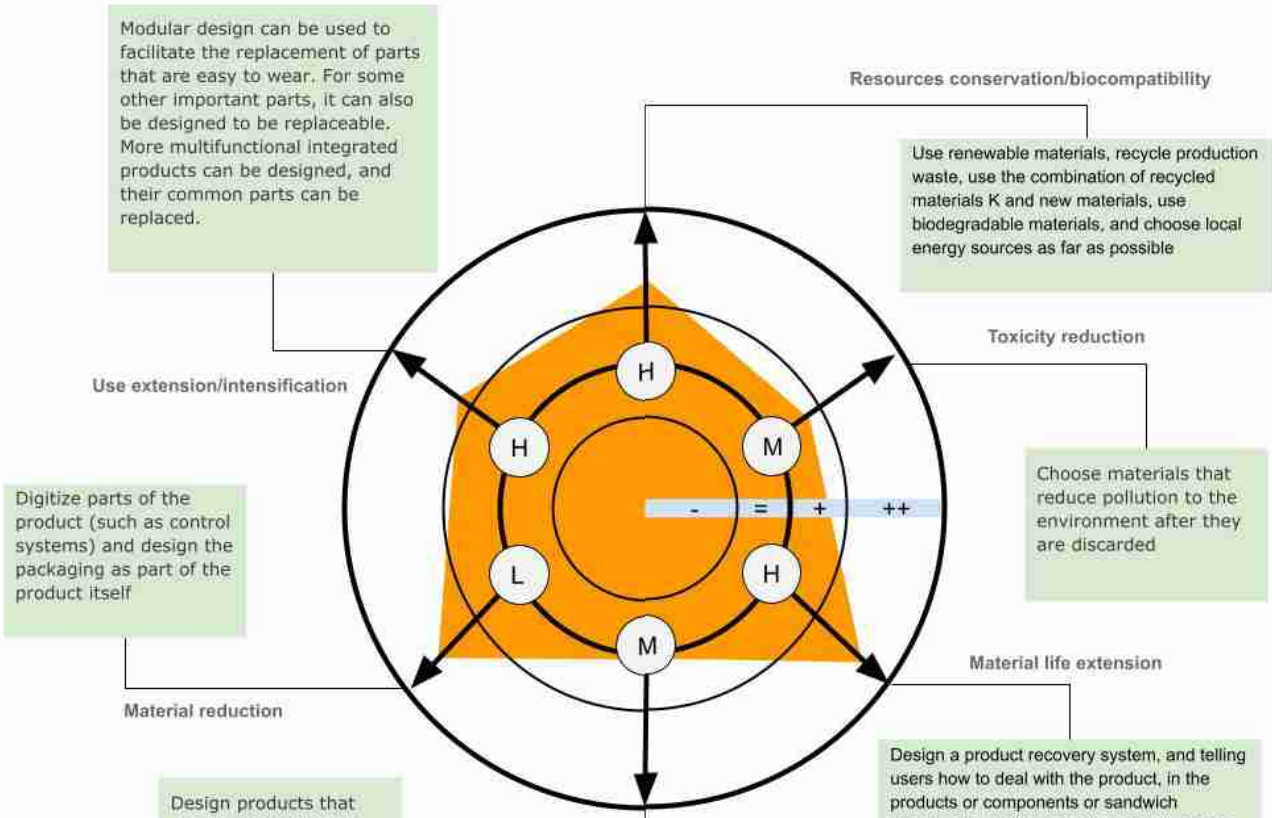
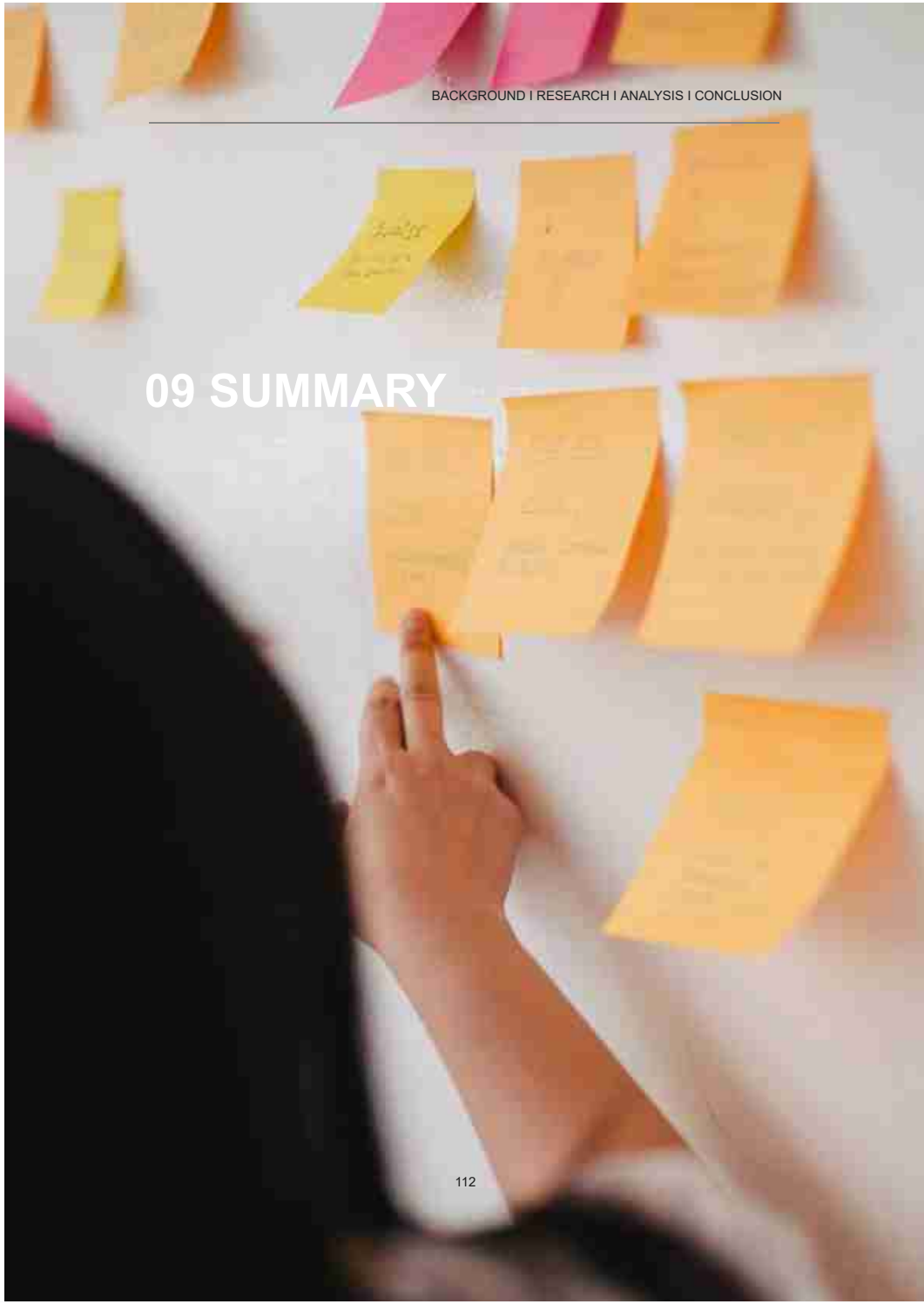


IMPROVEMENT	PRIORITIES
WORSE:-	HIGH:H
NO:=	MEDIUM:M
INCREMENTAL:+	LOW:L
RADICAL:++	NONE:N

Overall. After system redesign. Effectively improve the sustainability of the original product. Not only realizes the recycling and reuse of materials. At the same time, the design of the product has become more modular. Easier to repair. Furthermore, the company helped improve users' environmental awareness. Of course. If we change the design strategy, all the steps after that will change and will also affect the final change, so this is just a possibility I mentioned. In the future, there may be more and better design strategies to improve the entire system. And product design.



09 SUMMARY

SUMMARIZE

The purpose of this study is to identify effective sustainability strategies for consumer electronics companies (with JBL Pro as the analysis target). Through quantitative and qualitative analysis of consumers' intentions, designers' and companies' opinions, it can be concluded that, for consumers, using social media to improve users' environmental awareness and product publicity is a significant factor. For product designers, material innovation and design strategy are essential factors in sustainable design. The results show that improving consumers' awareness of environmental protection makes it easier for them to purchase sustainable design products. The selection of recyclable materials and the design of the circulation system can improve the recovery rate of products. Meanwhile, designers need more design guides to guide the design. To sum up, We believe that for companies, these sustainable strategies can be concluded into three parts:

SOCIAL DESIGN

In social design, We will strengthen communication with users. For example, inform users of product recycling methods and publicize the importance of sustainability and protecting the environment. Through these measures, users can increase their environmental awareness and participate more actively in purchasing sustainable designs.Compared with the traditional user experience, users are not just using products. They will also pay more attention to the product and our environment. So we will deliver a more positive social impact in this way.Because in our current product system, we pay too much attention to product sales. Little attention is paid to the product and what it means to users. So in this way. We will completely subvert the previous strategy and strengthen communication with users through social platforms.

ECO-DESIGN

In eco-design, we consider reducing the impact of products on the environment, improving the efficiency of product use, and reducing product materials and packaging. In this way, it is ensured that the least energy is used in the production process. At the same time, in the distribution process, reduce the emission of harmful pollution to the environment. As a company and marketing our products, we also have the responsibility to protect our environment. It can not only improve the environment but also increase users' trust in us. So this is a win-win result.

CIRCULAR DESIGN

In circular design, We focus on sustainable systems through a sustainable system. Improve product life cycle. There is also the ability to repair, as well as the reuse rate. Furthermore, when the end of life is reinvested in recycling. We put quality first in the current product considerations, so we have not considered enough other factors. So this is why we want to consider the product in the current production system. Add in maintenance and recyclability of the product and the repeated use of the product to improve these aspects. Furthermore, these improvements will not conflict with the previous strategy.

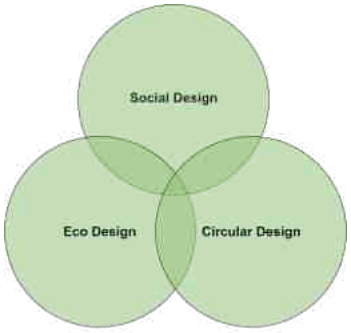


Fig. 39 Sustainable Design Strategies

REFLECTION

This study developed sustainable systems and sustainable design guidelines through sustainability tools. Although insufficient commercial data limited the generality of the results, the development of strategy and evaluation through scientific tools provided new insights.

Based on these conclusions, consumer electronics business companies should consider using scientific sustainability tools to design sustainability strategies. Further research is needed to determine the relationship between the actual growth of the business (product sales) and sustainability, as profitability is critical for business companies.

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