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Sustainable Perceived Quality in Ovens Design

Expanding the perceived quality assessment parameters of Haier's oven control panel concepts to consider eco-design attributes and aligning them with Gen Z users' values

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List of Abbreviations

Abbreviation	Explanation
EU	European Union
EC	European Commission
Gen Z	Generation Z
SPQ	Sustainable Perceived Quality
PQ	Perceived Quality
PQAIR	Perceived Quality Attributes Importance Ranking
PQF	Perceived Quality Framework

Abstract

Drawing on the need to design appliances increasingly attentive to environmental sustainability and aligned with the interests of Generation Z, this study aims to provide a literature analysis of the concept of Perceived Quality (PQ) and how it is evaluated within the company. Sustainable Perceived Quality (SPQ) parameters will be provided to assess the product and its eco-design attributes. Given the attention provided by Haier Europe in evaluating PQ and the focus on a user-centric approach, this study investigates the parameters used to date to assess PQ and also highlights, in other studies on the subject, the lack of existing research on designing products with an eco-sustainable approach while maintaining a high PQ. The primary objective is to present a practical tool for designing and assessing SPQ, rooted in a thorough analysis of PQ and the requirements derived during field research to incorporate the eco-design concept into the product.

The is to introduce a pragmatic tool incorporating the eco-design concept into the product by designing and evaluating SPQ. This tool is based on an analysis of PQ and the requirements obtained through field research.

This research embraces Vezzoli's design for sustainability principles and Haier Europe's PQ parameters as a foundational framework for defining SPQ. Furthermore, using a research-through-design methodology, the study seeks to advance understanding by analysing case studies of Haier products to examine the concept of environmental sustainability as understood by the company. A subsequent study conducted on products from recent years, mentioned in major design awards, allowed for interviews with Gen Z users to derive insights that were then translated into design requirements for an oven control panel concept. This concept allowed testing the parameters that served as guidelines for the design in a focus group with Gen Z designers. The focus group validated the parameters, which were implemented based on the test results and encapsulated under a new PQ cluster, then subjected to a dual verification by the R&D team. In this final phase, a Concept Matrix was used to compare the new oven control panel concept with the current control panel and that of a competitor. The concept under analysis was evaluated according to SPQ parameters, and through the methodology of this matrix, it was possible to highlight the improvement in the concept in terms of SPQ.

The research enriches the understanding of the PQ concept and eco-design attributes, proposing a new approach to the product for Haier Europe, opening new scenarios for the design of control panels, and bringing products closer to the expectations of future consumers belonging to Gen Z.

Keywords: Perceived Quality; Sustainable Perceived Quality; Eco-design; Generation Z; House appliances; Oven.

1. Sustainability, its definition, and the related Generation Z needs

This chapter delves into the profound connection between sustainability and the evolving needs of Generation Z (hereinafter Gen Z), examining how this generation's values and preferences are driving transformative shifts in both institutional and corporate realms. One of the key mechanisms through which institutions worldwide are addressing these demands is the United Nations' Sustainable Development Goals (SDGs). These global goals serve as a framework to guide word-wide development toward a more sustainable future, emphasizing environmental protection, social equity, and economic progress.

In response to the clarion call of Gen Z and the global commitment embodied by the SDGs, companies are starting to embark on a journey to align their practices with sustainability imperatives. However, amid this noble endeavour, there exists a shadowy spectre known as "greenwashing." This deceptive practice involves the embellishment or misrepresentation of a company's environmental initiatives, blurring the lines between genuine sustainability efforts and superficial marketing tactics.

Throughout this chapter the multifaceted landscape of sustainability will be explored in the context of Gen Z's needs, the pivotal role of institutions through the SDGs, and the complex interplay between companies' responses and the persistence of greenwashing. Through a comprehensive analysis, the aim is to shed light on the profound impact of these dynamics on the contemporary business environment and the imperative for genuine commitment to sustainability in an age defined by the discerning gaze of Gen Z.

1.1 The importance of sustainability nowadays

In the past, the concept of environmental sustainability has not yet attained widespread awareness within the collective consciousness, and the magnitude of transformative measures necessary for such a developmental paradigm remains inadequately comprehended. Numerous studies suggest that humanity stands at the precipice of collapse, a state in which restoring the system to an equilibrium capable of supporting life for all Earth’s inhabitants will be unfeasible (Buchinger et al., 2000).

Nowadays, environmental sustainability has become a pressing concern due to the increasing recognition of the detrimental impacts of human activities on the

planet. Achieving environmental sustainability requires adopting sustainable practices in various sectors (World Wildlife Fund, 2023). It involves striking a balance between economic development and environmental protection, aiming to create a harmonious and regenerative relationship between human society and the natural world (United Nations, 2015)

A profound and immediate transformation is necessary, necessitating a systemic discontinuity. This change must commence without delay, as it is now a matter of years rather than decades (Hargreaves, 2015).

> In other words, it is required that we change how needs are fulfilled and develop consumption patterns and lifestyles based on the consumption of far fewer resources. It is increasingly acknowledged that we must urgently move towards socio-technical systems capable of operating within the planet's limits (Ceschin Fabrizio & Gaziulusoy Idil, 2020). As stated in the "Report of the World Commission on Environment and Development", where they defined this publication as "Our Common Future" the authors argue that: "[It] is not a prediction of ever-increasing environmental decay, poverty, and hardship in an ever more polluted world among ever-decreasing resources. We see instead the possibility for a new era of economic growth, one that must be based on policies that sustain and expand the environmental resource base" (United Nations, 1987, p. 11).

The topic of sustainability may appear to be a recent concern; however, as evidenced by this statement, it has been a matter of significant interest to the United Nations for more than three decades, with reaffirmation in 2015 with The Sustainable Development Goals (SDGs), later analysed later in the chapter. Recognizing the environmental predicament has instigated discussions and a reorientation of societal behaviour, particularly regarding the demand for sustainable products and services. This consumer-driven approach underscores the existence of such products and processes, constituting the theme of sustainable consumption. This trajectory highlights the significance of this progression and the necessity of making consciously designed products (Vezzoli, 2016). According to Bertoni (2017), linking sustainability to customer value is a fundamental strategy in supporting innovation activities and guiding design decision-making processes. This approach entails a meticulous examination of 'what' customers and stakeholders anticipate regarding sustainability attributes and 'how much' they value these capabilities relative to one another. Organizations can strategically align their innovation initiatives and design choices with the most impactful and valued sustainability features by discerning these preferences and priorities. This customer-centric approach bolsters a company's competitive advantage and fosters a more sustainable and resilient business model that meets the market's evolving needs.

Nevertheless, in the design field, a notable gap exists in the availability of design tools that are universally applicable and inclusive. The literature on this topic appears disjointed and, at times, fails to align with the practical requirements of designers (Arquilla & Paracolli, 2023).

For this reason, this research aims to validate a scheme of objectives features that can help designers have a specific tool while dealing with a product that needs to be sustainable.

One can employ green communication strategies to promote a novel product encompassing various approaches presented to consumers via label claims, advertising slogans, symbols, logos, trademarks, voluntary certifications, or even using colours or imagery that evoke natural environments (Riva, 2023). The most recent approach amalgamates the user's perceptions of an object and its derived satisfaction alongside a comprehensive analysis of the object' entire life cycle Product/Service System Design for Sustainability (Vezzoli, Delfino, et al., 2014). This approach adopts a holistic perspective by integrating social, environmental, and economic considerations in the design of products and systems. It regards products as integral components of larger systems and aims to create sustainable products and services that fulfil user needs, and exhibit reduced environmental impact.

Notably, existing evaluation tools in industrial design predominantly focus on strategic approach while offering limited support to designers during the development phase (Arquilla & Paracolli, 2023). Taking this claim what will be analysed will be an approach that can help designers delineate their project' requirements with strict needs through the development stage.

At the end of this chapter, is highlighted that there has been a sudden increase in the average threshold of attention given to the preservation of our living environment, prompting significant portions of the population to transition from mere interest to a genuine state of apprehension regarding the future and the welfare of forthcoming generations, as the environmental sustainability:

> "[It] refers to the practice of utilising and preserving natural resources in a manner that meets the present needs without compromising the ability of future generations to meet their own needs" (United Nations, 1987, p. 15).

Gibson et al. (2001) talking about the needs citated above said that addressing these needs is imperative, primarily due to the presence of contentious claims necessitating evaluation and the stark presence of destitution and oppression demanding intervention. Such endeavours must be approached with a keen understanding of diversity and active engagement with the beneficiaries. It is paramount to acknowledge that within distinct contexts, individuals invariably

require what can be deemed as the essentials for a dignified existence within that specific milieu. Furthermore, they seek, in a broad sense, opportunities for advancement, bearing in mind that the definition of improvement will fluctuate and hinge upon individual choices (ibid, 2001). According to Gibson et al. (2001) and stated by United Nations (1987) the focus on the consumption trends of Gen Z and the importance they give to sustainability, will be later presented by highlighting the aspects of sustainability that should be the key aspect to the product and design to meet the objectives of the European community and the needs of this future generation.

1.2 Gen Z: consumption needs, and the importance given to sustainability

Gen Z encompassing individuals born between 1995 and 2012, represents history's most diverse and digitally connected generation (European Employment Services, 2023). Growing up amidst a world grappling with climate change, pollution, and plastic waste, they possess a profound awareness of humanity's detrimental impact the environment (Treccani, 2020). Forbes designates Gen Z as "The Sustainable Generation" to underscore their consciousness of the matter and their greater propensity to alter their behaviours in response to these concerns (Petro, 2021).

Evidence of Gen Z's concern was studied by Yamane et al. (2021), who investigated the marginal generational differences of Gen Z in the Japanese context by conducting two separate studies. In the first they collected data through a survey to analyse the generational differences among the younger and older cohorts in sustainable lifestyles using a nationwide adult sample (n = 12098). The second study, arouse the job preferences of university students based on the SDG contributions of companies and expected income using conjoint survey experiment data (n = 668). The two studies revealed that younger people lean toward more sustainable lifestyles, with nearly half expressing a desire to live in a municipality focused on the SDGs. However, actual pro-sustainability behaviours, such as paying a premium for sustainable goods, were lower at 30.1%. Despite the discrepancies in pro-sustainability actions compared to older generations, the results suggest that young people contribute to a more sustainable society. In addition, awareness of the SDGs influenced the younger generation's preferences in choosing employers, indicating potential behaviour change despite the primary preference for good pay.

Figure 1. Climate Strike by Gen Z People
In this picture Gen Z activists floods the streets, brandishing vibrant signs and banners, united in a climate strike to demand urgent action for a sustainable future. Retrieved by (Bioneers, n.d.).

Kadence International, a worldwide market research agency, claims that a study conducted through a survey revealed that the 72% of Gen Z affirms that they have already changed their behaviour to reduce their impact on the environment and a 40% of Gen Z consumers in the UK prefer to buy from environmentally friendly brands (Shaw, 2023). Consequently, Gen Z exhibits a robust commitment to sustainability, with 82% expressing deep concern regarding the state of our planet. Those active people among Gen Z are engaged in efforts to mitigate their environmental footprint, as previously evidenced by modifying their behaviours to minimise their impact (Tyson et al., 2021).

Additionally, another noteworthy market study is the one conducted by Deloitte Global (2023) based on data collected from respondents (n = 14483) belonging to the Gen Z cohort across 44 countries encompassing North America, Latin America, Western Europe, Eastern Europe, the Middle East, Africa, and Asia-Pacific. The survey was conducted using an online, self-complete-style interview. Notably, the findings underscore the substantial influence of climate change concerns on Gen Z's decision-making processes, extending from matters such as family planning, home renovations, dietary choices, clothing preferences, career selection and workplace preferences.

The current studies of the sustainable behaviour of Gen Z are crucial, as they help determine the role this generation will naturally assume in terms of

environmental responsibility (Dragolea et al., 2023). Concerning their spending habits, Gen Z members exemplify their willingness to align their financial choices with their values (Shaw, 2023). Organisations are currently strongly emphasising green marketing strategies, which involve incorporating environmentally friendly practices throughout product design, production, promotion, and sale. As a result, consumers and producers have shifted their focus to environmentally friendly products, recognising the increasing significance of green marketing (Dragolea et al., 2023).

The realm of green marketing presents a significant susceptibility to the potential adoption of greenwashing practices, which will be examined in detail in the further subchapter "1.4 Greenwashing phenomenon: companies 'downside to market needs".

From an academic perspective, this entails investigating the factors that shape the demand for environmentally sustainable products among people belonging to Gen Z and assessing how these factors impact their willingness to pay more for more sustainable products (Gomes et al., 2023). The growing importance of this matter within Gen Z is evident, highlighting the adverse impact of sustainability concerns on their overall well-being and prospects (Dabija et al., 2019, 2020; Kadence International, 2022).

Therefore, it is crucial to establish a suitable methodology with specific characteristics that users are already familiar with and can employ when assessing a product's quality (Mitola, 2023). As a consequence of the research highlighted so far, the importance of future generations lending their attention to the topic of sustainability is being widely acknowledged (Kuhlman et al., 2010; Pucker, 2021), and it is already being discussed considerably over time by organisations such as the United Nations (2015). This will enable the development of an objective approach to designing new products (Arquilla et al., 2023; Dangelico et al., 2021), considering aspects that enhance the perceived quality (Walia et al., 2022) while accommodating individuals who value sustainability (Bellini, 2021). These are indications of the requirements arising from Gen Z, following what is highlighted by the United Nations (1987).

Hence, I argue that it is of significance to propose a novel approach to aligning product development with the requirements of stakeholders by developing an assessment framework that establishes parameters closely aligned with contemporary product expectations. Additionally, understanding assessment parameters for a design object will provide insights for designers to design products that can raise awareness about sustainability among those who are not yet engaged in the issue.

1.3 Global Pursuits of Sustainability: International objectives and strategies, the case of Sustainable Development Goals (SDGs)

In September 2015, the UN General Assembly, put forth a comprehensive framework for global Sustainable Development Goals (SDGs), encompassing a total of 17 goals and 169 individual targets. All the leaders from across the globe convened at the United Nations to collectively address pressing issues related to global development, human well-being, and environmental protection.

Figure 2. The 17 Sustainable Development Goals Iconography.

The image represents the 17 SDGs alongside their corresponding claims, each accompanied by its respective number. Retrieved by (United Nations, n.d.)

Also known as the Global Goals, were adopted by the United Nations as a universal call to action to end poverty, protect the planet, achieve social and economic development and ensure that by 2030 (United Nations Department of Economic and Social Affairs, 2015c).

The intent of the United Nations to underscore the imperative for change and the requisite response to the needs outlined earlier, particularly pertaining to future generations such as Gen Z, is evident. This assertion is further substantiated by Accenture (Lacy et al., 2022) report's emphasis on their dedication and adherence to the SDGs.

By taking into analysis sustainability, Gen Z, and how they are linked with house appliances, the SDGs involved the most are:

- The twelfth objective is "**responsible consumption and production**" with the aim of "ensuring sustainable consumption and production patterns" (United Nations Department of Economic and Social Affairs, 2015a); it is a call for a comprehensive set of actions from businesses, policymakers and consumers to adapt to sustainable practices. It envisions sustainable production and consumption based on advanced technological capacity, resource efficiency and reduced global waste (Eurostat, 2023b).

  At the European level, the composite index for Goal 12 exhibits a consistent positive trend, except for the year 2011. The most substantial improvements observed between 2010 and 2020, pertain to material circularity, which increased by two percentage points, and the urban waste recycling rate, which rose from 38% to 47.8% (Alleanza Italiana per lo Sviluppo Sostenibile, 2022).

- The thirteenth objective is specific to "**climate action**", and one of the goal targets is: "improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning" (United Nations Department of Economic and Social Affairs, 2015b).

For this, the United States declared that:

> "We also regret that the Political Declaration does not contain more ambitious language on tackling the climate crisis, especially given broad recognition of the negative impacts of climate change our ability to achieve the SDGs. The Political Declaration, for example, does not mention the imperative of limiting global temperature rise to 1.5 degree Celsius or the need for countries whose current targets are inconsistent with this goal to urgently step-up and align them with the level of effort necessary to achieve this goal. The best available science has told us that the 1.5-degree C goal is critical if we wish to avoid the most catastrophic impacts of climate change" (Carty, 2023, p. 2).

Through this declaration, the United States of America has adopted a critical stance by expressing its expectation for more specific guidelines about the SDG and a more substantial and stringent commitment to achieving the set objectives.

The result of the SDGs is revealed by statistics demonstrating that from 2006 to 2021, the European Union observed a notable rise in its Circular Material Use (CMU) rate. This rate, signifying the proportion of materials reused that

originate from gathered waste, ascended from 9.1% to 11.7%. However, it is noteworthy that since 2019, the CMU rate has experienced a marginal decrease of 0.3 percentage points. This decline implies that the European Union will need to exhibit more substantial advancements in the forthcoming years to fulfil its objective of sourcing 23.4% of the materials it consumes from collected waste by 2030 (Eurostat, 2023b; Haas et al., 2015).

Responding to the needs of Gen Z, the Sustainable Development Goals (SDGs) are currently shaping market dynamics, indicating that the value added by the environmental goods and services sector has outpaced overall economic growth (Eurostat, 2023b; Hamadeh, 2022).

In the upcoming subchapter, we will delve into an analysis of the response within the green market and examine how it may sometimes veer into the practice of greenwashing.

1.4 Greenwashing phenomenon: companies' downside to market needs

Previously, an analysis of the needs of Gen Z was conducted, highlighting the United Nations' recognition of the imperative to establish goals that guide the market towards sustainability while fostering new project opportunities. However, it is frequently observed that this trajectory, aimed at green marketing, often deviates into the realm of greenwashing.

Greenwash is defined as the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service (Parguel et al., 2011). It is a type of marketing and a way to make products more appealing to customers who care about the environment (BBC Newsround, 2021).

This phenomenon is also termed as "mere facade marketing," this constitutes an unethical corporate marketing practice wherein a company engages solely to enhance its green reputation and consequently capture the attention of a larger number of consumers, or rather, "consumActors." In today's context, consumers are individuals who make choices, seek information, communicate, evaluate, and assess the environmental impact of their purchases (Sgarbi, 2021).

On the other hand, the response to this "misuse" of the green market, the Italian Association for consumers endeavours to address the issue of deceptive marketing concerning the environmental impacts of products, commonly referred to as "greenwashing". This is being undertaken within the context of

the report on the implementation of the directive on unfair commercial practices, with an assessment of the potential necessity for specific measures in this regard (ADICONSUM, 2010). Companies engaging in green marketing may exaggerate or misrepresent their environmental initiatives, leading to deceptive perceptions among consumers (Pears et al., 2023).

What is frequently overlooked, however, is the impact this phenomenon can exert on the public: while there are instances where consumers may not realize they are being deceived, and others where they may discover it but remain disinterested in altering their behaviour accordingly, there are also occasions when consumers might opt to refrain from purchasing the product or, in extreme cases, exclude the entire brand from their purchasing choices (Meneghin, 2021). Nevertheless, it has been demonstrated that an entity affected by greenwashing is still perceived more favourably compared to the so-called "silent brown organizations", which refer to companies that do not engage in greenwashing but are entirely uninvolved in environmental aspects (De Jong et al., 2017).

Marquis et al. (2011) analysis demonstrates that institutional pressures exhibit significant effectiveness in reducing the practice of selective disclosure of environmental performance. Greenwashing engenders market saturation, potentially rendering environmentalism a vacuous attribute and undermining the efforts of genuinely committed companies striving for a greener future (Righetto et al., 2020).

This implies that greenwashing not only exerts a direct negative impact on green trust but also indirectly affects it through green consumer confusion and perceived green risk. Therefore, if companies aim to mitigate the adverse association between greenwashing and green trust, they must diminish the levels of green consumer confusion and perceived green risk among their consumers. By reducing the origins of green consumer confusion and perceived green risk, it is possible to mitigate the incidence of green consumer confusion and perceived green risk, thereby bolstering green trust (Chen et al., 2012).

What has emerged thus far serves as a clear indication that institutions, in this case, through the SDGs, can play a significant role in guiding the market. Simultaneously, companies, in their pursuit of securing loyal consumers, must steer clear of greenwashing practices. Instead, they should orient their production towards a sustainable design concept that is well-received by customers and environmentally beneficial.

1.5 Designing for environmental sustainability: exploring Vezzoli's approaches

In this chapter, the spotlight is directed towards design approaches for sustainability, as proposed by Vezzoli (2016). These approaches emphasize the paramount importance of considering environmental requirements right from the inception of the product development process. This consideration should occur in parallel with other critical factors such as cost, performance, cultural relevance, and aesthetic appeal. From a design standpoint, the approach underscores the notion that intervening directly in the product's design is a more eco-efficient strategy compared to the alternative of creating specialized products solely for the management of environmental impacts. This perspective is rooted in the concept of product life cycle management, a framework that seeks to holistically address sustainability across all phases of a product's existence.

1.5.1 Designing for Life Cycle Assessment (LCA)

The concept of a product's life cycle refers to the interactions between the environment and the multitude of processes that accompany a product from its inception, through its life, to its end-of-life stage. In essence, it interprets a product in relation to the flows of materials, energy, and emissions associated with the activities that accompany it throughout its entire existence. The product's life cycle, therefore, commences with the extraction of the resources required for the production of its constituent materials and extends to the final treatment of these materials after use.

Consequently, the entire life of a product can be perceived as a sequence of activities and processes, each of which involves a certain amount of material and energy, executes various transformations, and generates emissions of diverse nature. These processes are typically categorized into the following phases, serving as a framework to outline the product's life cycle:

i. pre-production;
ii. production;
iii. distribution;
iv. use;
v. disposal.

In this context, the approach involves adopting a systemic perspective to analyse all phases of a product's life cycle and assess their environmental, social, and economic implications. This approach, known as Life Cycle Design (LCD), offers the advantage of identifying the priorities specific to the product under

consideration. However, it comes with the drawback of being a more intricate design activity that necessitates access to a wealth of information available through databases and computational software tools. Moreover, the disposal phase entails an element of unpredictability due to techno-economic evolution.

1.5.2 Minimising material consumption

Minimizing material consumption entails the reduction of material usage for a given product, specifically across all phases of its life cycle and with regard to a specific service provided by that product, i.e., in relation to its functional unit. Employing fewer materials diminishes environmental impact, not solely by reducing the production of materials (pre-production), but also by avoiding their transformation (production), transportation (distribution), and disposal.

There are various approaches to achieve this goal:

i. Minimizing the material content of a product: this is achieved through dematerialization, miniaturization, digitalization, avoiding over-dimensioning, minimizing thickness values, stiffening structures with ribs, and omitting components or parts that do not serve essential functions;
ii. Minimizing waste and scraps: this involves selecting processes and employing simulation systems to optimize the parameters of transformation processes;
iii. Minimizing packaging: where unnecessary, packaging should be avoided, and when necessary, it should be integrated as a functional component of the product;
iv. Minimizing material consumption during use: this includes evaluating material efficiency for operation, passive material consumption, material recovery, and facilitating user actions that conserve materials;
v. Minimizing material consumption in product development: utilizing reconfigurable digital supports, employing variable consumption systems based on operational needs, and configuring the default state to minimize material usage are key strategies in this context.

1.5.3 Minimise energy

The reduction of energy consumption leads to a decreased environmental impact, as it reduces the need for energy generation, transportation, and storage. The goal is to minimize energy consumption across all phases of a product's life cycle, including pre-production, production, distribution, and design. Specifically, the following guidelines will be outlined:

i. Minimizing energy consumption in pre-production and production: this involves selecting materials with lower energy intensity, employing automatic equipment shutdown, and utilizing waste heat from processes for heating;
ii. Minimizing energy consumption in transportation and storage: strategies include reducing the weight of the product or packaging, using local materials and energy sources, and designing products that can be assembled at the point of use;
iii. Choosing the most efficient energy resource consumption systems during use: this entails designing products for collective use, facilitating user energy conservation, and implementing energy recovery systems;
iv. Adopting flexible energy resource consumption systems: setting default states with minimal energy consumption, employing reconfigurable digital supports, and implementing automatic power-off features;
v. Minimizing energy resource consumption in product development.

1.5.4 Minimise toxicity and harmfulness

Design choices should be oriented toward resources with minimal life cycle impact. Products should be designed using:

i. Non-toxic or low-toxicity resources: material and additive selection should prioritize minimising hazardous emissions, even during disposal treatments.
ii. Zero or minimal toxicity energy resources.

1.5.5 Optimise renewability and bio-compatibility

In the context of sustainable development aimed at safeguarding resources for future generations, resources' renewability, or exhaustibility, plays an important role. It is essential to clarify that resource renewability depends on both the specific rate of natural replenishment and the extraction frequency. In other words, a resource can be deemed renewable if, within a specific context, the human consumption rate is lower than the natural resource replenishment rate.

Achieving resource biocompatibility pertains not only to their extraction (renewability) but also to the emissions of the product system into the natural environment. Specifically, the outputs into the geosphere and biosphere should not disrupt ecosystem balance, mainly by not degrading the quality of natural capital (resources). In this regard, bio-degradable materials, for instance, are recommended. The guidelines encompass:

i. Select renewable and bio-compatible materials: utilize renewable materials, materials derived from production process waste, discarded materials, recycled materials, and biodegradable materials.

ii. Choose renewable and bio-compatible energy resources: opt for renewable energy sources.

These principles align with the overarching goal of sustainable development to ensure the responsible and harmonious use of resources, both in terms of renewability and environmental compatibility.

1.5.6 Optimise product life

In the context of environmentally optimizing the life of products, two viable strategies emerge:

1. Extension of Product Lifespan: this involves either prolonging the lifespan of products as a whole or extending the lifespan of specific components, essentially designing artifacts with longer utility;
2. Intensification of Product Utilization: this pertains to designing artifacts with high-frequency utilization, thereby minimizing non-usage. In other words, it focuses on maximizing product use.

Before delving deeper into these strategies, let's briefly revisit the concept (or rather, the concepts) of product lifespan.

Product lifespan measures the duration for which a product, along with its materials, can maintain its performance and behaviour at an accepted or predetermined standard level under normal usage conditions.

The measure of product lifespan can vary from product to product, contingent on specific functions; in some cases, it's synonymous with the expected product duration. The termination point of product lifespan is commonly referred to as disposal.

Several primary reasons contribute to this:

a. Performance degradation or structural wear and tear due to the repeated use of the product;
b. Degradation caused by environmental or chemical factors;
c. Damages resulting from accidents or improper use;
d. Technological obsolescence;
e. Cultural and aesthetic obsolescence.

A product that exhibits greater durability while serving the same function generally results in a reduced environmental impact. This is because a product

with a shorter lifespan not only generates waste prematurely but also indirectly contributes to environmental impact by necessitating early replacement. The pre-production, production, and distribution of a new product to fulfil the same function necessitate the consumption of additional resources and the generation of further emissions.

Regarding the usage phase, extending the life of a product does not inherently lead to reductions in environmental impact; in fact, it can even result in an increase, particularly when newer products exhibit greater environmental efficiency. In essence, for certain products for which the most significant environmental impact occurs during the usage phase, there may exist an optimal limit to their lifespan. In other words, if technological advancements offer new products with enhanced environmental efficiencies (such as reduced energy and material consumption or lower emissions) for the same service provided, there comes a point where the environmental impact of building, distributing, and disposing of a new product is offset by the improved performance during the usage phase. Consequently, there exists a potential threshold for product lifespan, a break-even point at which replacing it with a new one yields a lower overall environmental impact.

The guidelines are as follows: extending product lifespan and intensifying product use. To extend product lifespan, these can be further categorized into: designing appropriate lifespans;

i. enhancing reliability;
ii. facilitating upgradability and adaptability;
iii. promoting maintenance;
iv. supporting repairability;
v. enabling reuse.

Given this, products prone to quick technological advancements are typically less suitable for long-term durability.

1.5.7 Extend material life

Extending the life of materials means prolonging their existence beyond the lifespan of the products they are a part of. This kind of material reincarnation occurs through two fundamental processes. Materials can be reprocessed to obtain new secondary raw materials or incinerated to recover their energy content. In the former case, that is, secondary raw materials, it is called recycling when they are used to manufacture new industrial products. It is termed composting when the secondary raw material is compost, an organic and

mineral fertilizer used for soil enrichment. Firstly, it helps to avoid the environmental impact of material landfilling, and secondly, it makes non-virgin resources available for the production of materials or energy. The avoided impact of these processes can be considered as an indirect environmental benefit. It is a common belief that recycling is the best solution for a wide range of environmental issues. It is important to clarify that recycling processes also have their own environmental impact. Nevertheless, recycled materials still result in a net environmental gain.

Designing for the extension of material life can be articulated into the following guidelines. Concerning recycling, these essentially follow various phases of recycling:

i. Adopt a cascading approach;

ii. Select materials with efficient recycling technologies;

iii. Facilitate collection and transport after use;

iv. Identify materials;

v. Minimize the number of incompatible materials;

vi. Facilitate the separation of incompatible materials;

vii. Simplify cleaning;

viii. Enhance combustion;

ix. Promote composting.

1.5.8 Designing for disassembly

Conceiving and designing products that are easily disassembled means making the separation of parts or materials straightforward and cost-effective. This practice is commonly referred to as Design For Disassembly (DFD). The environmental reasons for adopting a DFD strategy include extending the life of products (maintenance, repair, upgradability, and refurbishment), extending the life of materials (recycling, composting, and incineration), and immobilizing toxic and harmful materials. DFD serves multiple strategies for reducing environmental impact.

Depending on the type of product, one of its components, or one of its materials, you can follow certain guidelines to facilitate disassembly:

i. Minimize and facilitate disassembly and separation operations;

ii. Use reversible joining systems;

iii. Employ easily openable permanent joining systems;

iv. Incorporate specific technologies and elements for destructive disassembly.

In the case of material separation that occurs partially or completely through fragmentation, it's essential to consider the following:

1. Use materials that can be easily separated once fragmented;
2. Employ inserts that can be easily separated once materials are fragmented.

1.6 Navigating Life Cycle Design constraints and uncovering new business opportunities for sustainable change

After the presentation of the Design for Sustainability approaches proposed by Vezzoli (2016). He explored the limitation of a Life Cycle Design (LCD) approach that often lies in its integration into a system with various actors having diverse interests, including economic interests that do not necessarily align with environmental impact reduction. Producers are frequently inclined to sell short-lived products, solely aiming to expedite their turnover. Resource savings, emissions minimization during the use phase, waste reduction, and more environmentally friendly disposal methods may not necessarily align with the objectives of a company selling the product. The cost associated with disposal is typically externalized and borne by the community (usually through taxes).

In particular, the issues do not typically arise during the transformations, which can be categorized as phase processes and fall within the scope of a specific economic actor (e.g., a producer of plastic materials for a washing machine manufacturer). Problems may surface during phase transitions, such as the sale of semi-finished products or goods from one actor to another, where there might be an economic interest in increasing resource consumption (material producers tend to sell as much as possible, as do product manufacturers). However, the characteristics of maximum potential efficiency during product use (resource and emission reduction) and the potential environmental valorisation of the discarded product are determined during the design phase, with the producer establishing the requirements.

Therefore, it can be argued that there is a direct interest in reducing consumption during phase transformations (managed by an economic actor). However, this generally does not occur during phase transitions (transfers from

one economic actor to another). Similar problems are encountered when examining the system of products and services that serve to satisfy specific demands. In traditional supply models, the various actors are not directly interested in reducing resource consumption.

In summary, the fragmentation of actors along the product's life cycle stages causes the eco-efficiency of the life cycle system not to align with the individual economic interests of its constituent actors. This misalignment may hinder the adoption of a product-centric LCD approach. Vezzoli, Kohtala, et al., (2014) subsequently raises the question of whether the urgency of sustainability-related changes prompts us to consider more radical opportunities linked to altering the very way we conceive offers, shifting alternative business models toward a production and consumption system that collectively reduces environmental impact. This leads to the proposition of eco-efficient Product-Service System (EE.PSS) business models:

> "Offer models that provide an integrated mix of products and services capable of meeting specific customer demands, […] where the economic and competitive interest of suppliers continually drives innovations with a lower environmental impact" (Vezzoli, Kohtala, et al., 2014, p. 31).

The proposition outlined above appears to be a valid strategy for Haier Europe. Integrating business models that offer a combination of products and services, with a strong emphasis on lower environmental impact, can attract new stakeholders who are acutely conscious of sustainability issues. This alignment with sustainability-oriented stakeholders could position Haier Europe as a forward-thinking and responsible player in the market, further enhancing its reputation and potentially expanding its customer base. Vezzoli (2016) further elucidates the possibilities of eco-efficient business models, proposing:

i. **Product-oriented Eco-efficient [1] Product-Service Systems: Services that provide additional value throughout the product's lifecycle.** This concept encompasses user assistance services such as maintenance, repair, or replacement. It underscores the importance of providing comprehensive support throughout the product's lifecycle, ensuring its optimal functionality and longevity. Such services benefit the user and align with sustainable practices by extending product life (as previously

[1] Eco-efficiency is achieved by the delivery of competitively priced goods and. services that satisfy human needs and bring quality of life, while progressively. reducing ecological impacts and resource intensity throughout the life-cycle (World Business Council for Sustainable Development, 2006).

evidenced by the LCD's approaches), minimizing waste, and reducing the overall environmental footprint of the product. Recognizing the significance of user support services can enhance customer satisfaction and contribute to their efforts to be environmentally responsible.

ii. **Result-oriented Eco-efficient Product-Service Systems: Services that deliver final outcomes to customers.** Here, the service regards the product as a package in which the company retains ownership to the user even after the sale. This ownership model incentivises companies to produce products with superior performance, which, in turn, translates into easier repairability and potential resale of refurbished products to another customer. By embracing this approach, companies can align their interests with extended product lifecycles, reduced environmental impact, and a commitment to sustainable, circular business practices. This innovative strategy promotes resource efficiency and fosters a more environmentally responsible product ecosystem.

iii. **Use-oriented Eco-efficient Product-Service Systems: Services that offer enabling platforms to customers.** In this latest model, the introduced service is well known as leasing[2]; the product might also feature higher technological sophistication, considering the reduced impact stemming from a smaller production scale. Nevertheless, adopting this model requires a shift in consumer behaviour and a change in users' perception of well-being. This transformative approach seeks to optimize resource use, promote sustainable consumption, and need a more eco-conscious mindset among consumers.

[2] A financial arrangement in which a person, company, etc. pays to use land, a vehicle, etc. for a particular period of time (Cambridge Dictionary, 2023b).

2. Haier Europe: history, brands, values and sustainability

In the following chapters, an introduction to Haier Europe is presented, encompassing its corporate identity, brands, core values, and sustainability initiatives. Haier Europe is a prominent player in the global home appliances market, recognized for its commitment to innovation and customer-centric solutions. The analysis begins with an overview of Haier Europe's history, its corporate structure and its diverse portfolio of brands. Subsequently, it delves into the organization's core values, which form the bedrock of its operations. Furthermore, it expounds on Haier Europe's approach to sustainability, elucidating the strategies and objectives that underscore its commitment to environmental responsibility and the creation of more energy-efficient products. This chapter provides an in-depth insight into Haier Europe's corporate identity and the guiding principles that steer its endeavours within the household appliances market.

2.1 Haier Group history

Haier Group, founded in 1984 by Zhang Ruimin, initially operated as a collectively owned small factory in Qingdao, China. The company began as a refrigerator manufacturer, but its commitment to quality and innovation quickly led to expansion and diversification into various household appliances (Haier Europe, 2023c). Haier's foray into the European market occurred in the early 2000s. The acquisition of European appliance manufacturers, such as Candy Group in Italy (Meneghello, 2018) and Fisher & Paykel in New Zealand (Gough, 2012), marked significant milestones in Haier Europe's journey. A strategic approach to market expansion has marked the company's growth. The company successfully navigated cultural and market differences by embracing localized strategies and tailoring products to meet European consumer needs. Its acquisition of the GE Appliances division in 2016 further bolstered its global presence and solidified its position in Europe (Riley, 2016). Haier Europe's commitment to innovation and quality aligns with its parent company's core values. The company has consistently introduced cutting-edge technologies and sustainable practices in its product offerings. Innovations like IoT-enabled appliances and smart home integration have helped Haier Europe maintain its competitive edge (Guo et al., 2020).

Haier Europe's market presence in the European region is substantial, with a strong presence in countries like Germany, Italy, France, and the United Kingdom. Its comprehensive product portfolio, including refrigerators, washing machines, air conditioners, and more, caters to diverse consumer demands (IFA Berlin, 2023b). While Haier Europe has achieved remarkable success, it has not been without challenges. Competition from established European appliance manufacturers, changing consumer preferences, and regulatory hurdles have posed obstacles. Owing to its three primary brands: Candy; Hoover and Haier, the company assumes a pivotal role in various European markets, diligently endeavouring to accommodate users' specific requirements across the diverse regions of Europe. However, the company's adaptability and willingness to invest in research and development have allowed it to overcome these challenges.

Haier Europe's journey from a small Chinese factory to a major player in the European home appliances market is a testament to its commitment to innovation, quality, and adaptability. The significance of Haier Europe within the European market becomes evident through a comprehensive analysis encompassing its historical trajectory, growth patterns, strategic endeavours, and market positioning. This examination underscores its substantial contributions to the global household appliance industry.

2.2 Haier Group: the company and its brands

This section is an informative introduction to the Haier Group and its associated brands. It offers a thorough overview of the diverse product portfolio these brands include and their specific target within the global market. By delving into this corporation and its diverse products, readers can comprehend the market presence and consumer-focused tactics utilized by the Haier Group.

2.2.1 Candy: history, strategy and products

Candy, an Italian household appliance brand, boasts a venerable history tracing its origins to 1945. Established by Eden Fumagalli in Brugherio, near Milan, Italy, the company initially specialized in producing washing machines. Its rapid prominence was predicated on pioneering design concepts and a commitment to impeccable craftsmanship Candy Hoover Group S.r.l., 2023a). Over the course of ensuing decades, Candy diversified its product portfolio to encompass a comprehensive range of household appliances, including refrigerators, dishwashers, ovens, and vacuum cleaners.

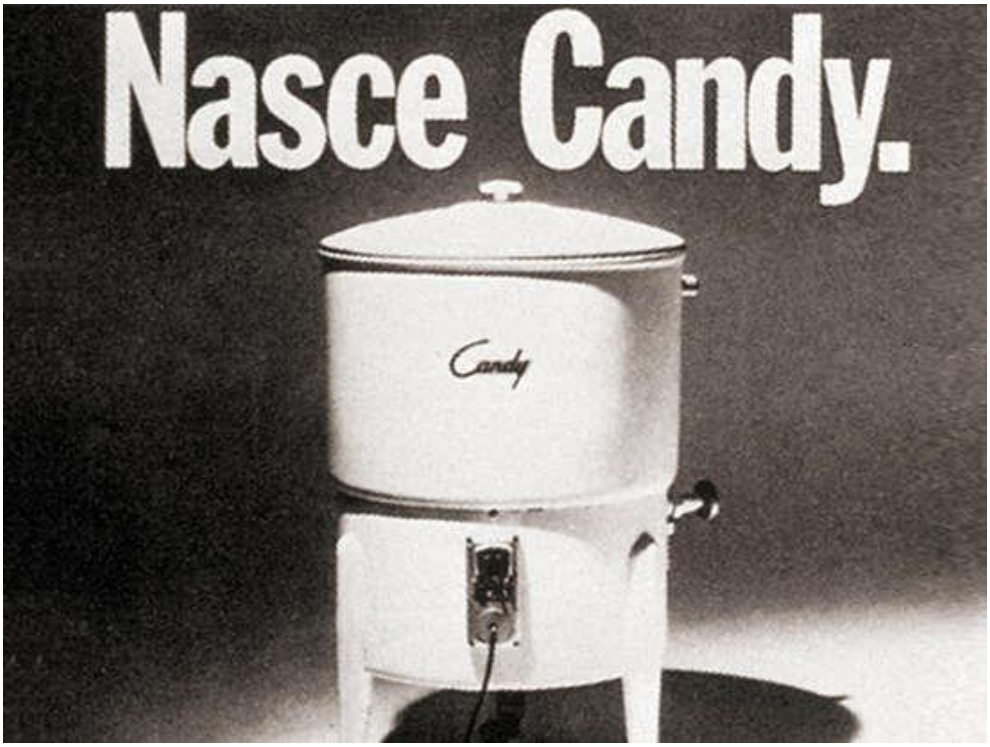


Figure 3. Candy advertisement for their first washing machine model 50.
Candy made the first model of an Italian washing machine. Retrieved by (Candy Hoover Group S.r.l., 2023a).

Candy has forged a formidable presence in both the European and global markets. Its pre-eminence is particularly pronounced in Europe, where it commands a substantial market share and enjoys widespread recognition (Dealer magazine, 2023). The brand's renown derives from its consistent delivery of dependable, efficient, and cost-effective appliances, rendering it a favoured choice among European consumers. Notably, Candy's strategic acquisition by Haier Europe in 2019 underscored its strategic significance in the Italian market (AD HOC Communication Advisors, 2019).

The brand's slogan, "Simplify your day", encapsulates its core message. It revolves around three keywords: "Smart," emphasizing intelligence and innovation; "Accessible," highlighting ease of use and availability; and "Italian," emphasizing the brand's Italian heritage and design influence (Candy Hoover Group Srl, 2023a). These elements collectively define the brand's ethos and product offerings, appealing to a wide audience seeking simplicity, sophistication, and quality in daily lives.

Figure 4: Candy Rapidò washing machine
Candy's latest washing machine model shows Italian heritage and design. Retrieved by (Candy Hoover Group S.r.l., 2023g)

Candy's product offerings encompass a diverse spectrum of household appliances designed to cater to the multifaceted needs of consumers. Key product categories include the following.

- **Washing machines:** innovative in designs, offering a variety of models with different capacities and features, including energy-efficient options
- **Refrigerators and freezers:** a wide range including single-door, double-door, and built-in models, designed to meet different storage and energy-efficiency requirements;
- **Dishwashers**: come in assorted sizes and configurations, from compact countertop models to full-sized built-in units, providing efficient and effective dishwashing solutions;
- **Ovens and cooking appliances**: different models of ovens, cooktops, and kitchen ranges designed to make cooking more convenient and enjoyable. These appliances incorporate advanced cooking technologies and innovative features;
- **Vacuum cleaners:** for home and commercial use, including upright and canister models with various attachments to facilitate versatile cleaning applications (Candy Hoover Group S.r.l., 2023b).

In conclusion, Candy's illustrious trajectory is characterized by its enduring commitment to innovation and quality, exemplified through a diverse array of household appliances tailored to meet the discerning demands of consumers. The brand's reputation for excellence continues to resonate in Europe and beyond, underscoring its indelible mark in household appliances.

2.2.2 Hoover: history, strategy and products

Hoover is a renowned and historically significant brand within the vacuum cleaner and household appliance industry. Its inception traces back to 1908, when W.H. Hoover founded the company in North Canton, Ohio, USA (Candy Hoover Group S.r.l., 2023f). Notably, Hoover pioneered the introduction of the first upright vacuum cleaner, ultimately becoming synonymous with the very concept of vacuuming, as evidenced using the term "hoovering" in certain regions (Wikipedia, 2006). Throughout its history, Hoover has consistently led the field in vacuum cleaner innovation, introducing noteworthy advancements such as the beater bar and disposable dust bag (Franchini, 2019).

Figure 5. Hoover upright vacuum cleaner model 543
Here one of the earliest model of 1936 with beater bars that alternated with the sweeping brushes helps to vibrate the carpet while sucking (Islington Education Library, n.d.).

Hoover's influence extends globally, earning recognition in numerous countries across the world. While it initially established its prominence in the United States, the brand has successfully expanded its presence into diverse international markets. Hoover's reputation for manufacturing top-tier and dependable vacuum cleaners has significantly bolstered its standing in the household appliance sector, with the brand being frequently associated with innovation and efficiency within the cleaning industry (E-duesse.it, 2022).

Figure 6. Hoover vacuum cleaner HF9
Compared to the Figure 5, is clear the evolution tha brand made mantaining the upright position of their products. Thanks to the dust container now the bag is not nedeed, that helps in obtaining a light and modern product (Candy Hoover Group S.r.l, 2023a).

The brand's guiding principle, encapsulated in its motto, "Quality for life," underscores its unwavering commitment to delivering enduring excellence. Hoover offers an array of meticulously crafted high-quality products designed to enhance consumers' daily living experiences within their homes. The significant keywords of "performance" emphasise the brand's dedication to providing exceptional functionality, "wellbeing" underscores its commitment to improving the overall quality of life for consumers, and "trust" signifies the brand's reputation for reliability and dependability.

These core elements collectively define Hoover's mission to enrich the lives of its customers through the provision of performance-oriented, wellbeing-focused, and trustworthy products (Haier Europe, 2023d). Among the products

offered by the company are a comprehensive range of household cleaning devices, including:

- **Vacuum cleaners:** Hoover manufactures a variety of vacuum cleaner types, including upright, canister, stick and handheld models. These vacuum cleaners come equipped with various features such as powerful suction, advanced filtration systems, and versatile attachments for different cleaning tasks;
- **Carpet cleaners:** are machines designed to deep clean carpets and upholstery and used for both residential and commercial applications;
- **Steam cleaners:** for cleaning and sanitizing surfaces without the use of chemicals. These devices are effective for cleaning floors, tiles, grout, and more;
- **Washers and dryers:** with innovative features for laundry care;
- **Cordless vacuums:** provide convenience and flexibility for quick cleaning tasks;
- **Air purifiers:** with HEPA filtration to improve indoor air quality by removing allergens and pollutants;
- **Ovens:** the harmony of linear forms and meticulous attention to detail make Hoover ovens suitable for complementing the design of various kitchen styles. Additionally, thanks to their innovative cleaning programs, they offer convenience in maintenance (Candy Hoover Group S.r.l., 2023e).

This analysis shows how Hoover's rich heritage and steadfast dedication to excellence have firmly established it as a renowned and dependable household appliance brand. By spearheading advancements like the upright vacuum cleaner and consistently innovating, Hoover has proven its unwavering commitment to improving consumers' daily experiences. Its worldwide presence and reputation for reliability and efficiency have reinforced its industry prominence. Through a diverse range of cleaning solutions, Hoover remains true to its mission of providing products driven by performance, focused on enhancing wellbeing, and characterized by trustworthiness, ultimately streamlining, and enhancing the lives of its customers.

2.2.3 Haier: brand and products

The catchword "Connect to Extraordinary" embodies Haier's commitment to delivering high-quality products that enhance consumers' home lives. Haier's core objective is to seamlessly integrate technology into consumers' daily

routines, empowering them. Through its premium and stylish offerings, Haier leverages unique advanced technologies to address the ever-evolving demands of modern households (Haier Europe, 2023b). The brand's focus on superior design ensures not only functionality but also aesthetics. Ultimately, Haier provides a tailor-made experience, aligning its products with individual preferences and fostering an extraordinary connection between technology and consumers in their home environments (Haier Europe, 2023a).

Figure 7. Haier washing machine and dryer in a setting.
The series I-Pro 7 is one of the premium model that wants to be the perfect ally for users with the most advanced technologies (Candy Hoover Group S.r.l, 2023c).

The company's product portfolio encompasses various categories, catering to various aspects of modern living. Here are some key categories of Haier products:

- **Refrigerators:** a comprehensive range of refrigerators, including top-mount, bottom-mount, side-by-side, and French door models. They are known for their innovative features, energy efficiency, and stylish designs;
- **Washing machines:** they exist in various capacities and styles, from traditional top-loaders to high-efficiency front-loaders. They are equipped with advanced technologies such as smart sensors and self-cleaning features;
- **Air conditioners:** are designed to provide efficient cooling and heating solutions for homes and businesses. They often incorporate smart

features like remote control and Wi-Fi connectivity for convenient operation;

- **Freezers and chest freezers:** exist in varied sizes to accommodate various storage needs;
- **Dishwashers:** are available in both built-in and portable models and are known for their quiet operation and efficient cleaning performance;
- **Ovens and cooking appliances:** various cooking appliances, including ovens, cooktops, and microwave ovens, exist. These products often feature sleek designs and advanced cooking technologies such as AI.
- **TVs and home entertainment:** a line of LED and smart TVs that deliver high-quality visuals and sound. Many models have smart features, including streaming capabilities (Candy Hoover Group S.r.l., 2023c).

In the realm of smart home solutions, what has transpired is that Haier occupies a prominent position with this wide range of appliances, providing amenability to remote control and monitoring via smartphones and other compatible devices. These technologically advanced appliances frequently integrate seamlessly with Internet of Things (IoT) ecosystems, augmenting their experience.

2.3 The meaning of sustainability for Haier Europe and its commitment to the environment

The relationship between Haier, Candy, and Hoover is characterized by a multinational ownership structure that fosters collaboration and innovation in the household appliance industry. The key driver of their synergy is the emphasis on connectivity and advanced technologies, enabling remote control and monitoring of appliances. This connectivity enhances the user experience and aligns with eco-friendly initiatives (IFA Berlin, 2022). It was clear how these brands expanded their global reach together, offered complementary product lines, and conducted collaborative research and development. Their customer-centric approach caters to modern consumer preferences, strengthening brand reputation and maintaining a competitive advantage in a dynamic market. This relationship positions them as leaders in delivering cutting-edge, tech-driven household solutions (Candy Hoover Group Srl, 2023b). The integration of technology, connectivity, design, and sustainability are core principles at Haier, emerging particularly from its multi-brand strategy. In 2020, the Milan Experience Design Centre was established to shift from a product-centric

approach to a customer-centric design, focusing on enhancing user experiences and fostering ecosystems for Candy, Hoover, and Haier brands (Candy Hoover Group Srl, 2023c). Technology is a powerful tool to achieve the brand's goals, emphasizing leadership in IoT and connectivity. By reducing the distance to consumers and promptly responding to their needs, Haier strives to create innovative solutions tailored to people's lives, enhancing connected user experiences across product lines and families (Candy Hoover Group Srl, 2023b).

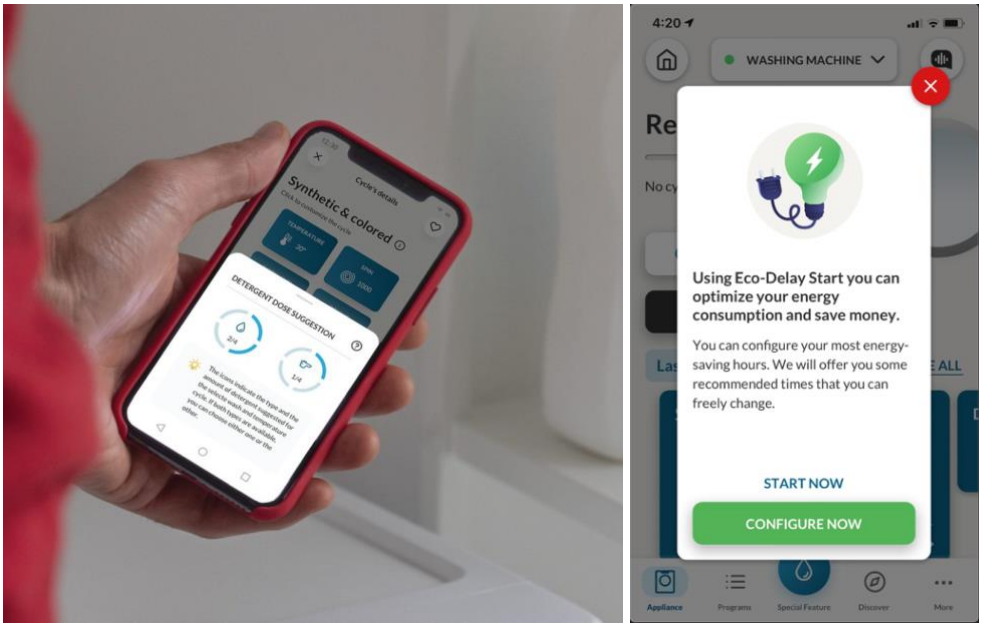


Figure 8. App Hon by Haier Europe.
Screenshots of the UI through the navigation on the App giving tips on the energy consumption (on the right) or the best cloths' wash mode to reduce the detergent dose (on the left) (Candy Hoover Group S.r.l, 2023b).

Furthermore, sustainability is a central pillar in Haier's strategic plan, capitalizing on artificial intelligence and connectivity to reduce social and environmental impacts. This signifies a holistic approach that combines innovation, design, and sustainability to create rich and relevant user experiences while aligning with global sustainability goals (Candy Hoover Group Srl, 2023d). Haier's dedication to innovation, design excellence, and product quality has rendered it a highly regarded selection among global consumers. The products associated with the brand are frequently acknowledged for their robustness, energy efficiency, and user-centric attributes, rendering them a favoured option for contemporary households in pursuit of dependable and innovative home appliances.

Haier's commitment to environmental sustainability emerges particularly from its participation in energy libelling initiatives, underscoring the company's

dedication to producing appliances with less environmental impact and compliance with current regulations. Haier's adherence to rigorous energy labelling standards empowers consumers to make informed choices that align with global efforts to reduce energy consumption and promote sustainability, further reinforcing the company's role in fostering environmental responsibility within the industry.

In this section, two case studies are presented, drawing from the preceding discussion. These cases exemplify Haier's commitment to environmental sustainability, particularly its active participation in energy libelling initiatives, translating into real-world actions and outcomes. Through these case studies, a deeper understanding of how Haier's practices are presented and aligned with global efforts to reduce the energy consumption of produced appliances.

2.3.1 Bionicook: Ovens with AI for best cooking performance

The latest ID series, presented at IFA 2023, the world's largest consumer electronics and home appliances trade show (IFA Berlin, 2023a), embeds this technology called “Bionicook”, and the new series presented at the fair was also presented for its A++ energy efficiency rating, which aims at showing Haier's commitment to environmental consciousness (Garbellini, 2023; Piva, 2023). While the ID series boasts a remarkable array of features centred on cooking performance, premium aesthetics, energy efficiency, and enhanced user experience, it is necessary to critically examine whether these elements align with the evolving market trends and Gen Z's heightened sustainability expectations. One noticeable aspect is the advanced technology integrated into these appliances, particularly the Bionicook system with its Bionic Vision camera and intelligent cooking parameters. While these features enhance the cooking experience, the green market and Gen Z emphasize sustainability and environmental responsibility. This emphasis may encourage a deeper exploration of how these advanced technologies can reduce food waste, minimise energy consumption, and promote eco-friendly cooking practices.

Figure 9. Haier Bionicook ID Series Oven
The new oven with an in-oven camera for assisted cooking will help the user through the cooking phases of the process. This function enable users to see inside the oven, thanks to its door screen, without opening the door (Garbellini, 2023).

Furthermore, the smart connectivity and remote-control features offer incredible convenience. However, to better resonate with eco-conscious consumers, the focus could shift toward leveraging these capabilities to optimize energy usage, improve cooking efficiency, and provide users with real-time data on the environmental impact of their culinary choices. For instance, providing insights into the carbon footprint of different cooking methods or suggesting more advantages that could make the ID series even more appealing to sustainability-minded individuals.

In terms of aesthetics, the premium design is undeniably attractive and can cater to the preferences of discerning consumers. Exploring sustainable and eco-friendly materials for construction could be considered to further align with green market trends, but this approach is analysed before in Optimise renewability and bio-compatibility. Additionally, incorporating design elements highlighting the product's energy-efficient attributes or eco-friendliness can enhance its appeal to a sustainability-focused audience, previously analysed in Minimise energy. Even the option to share one's own recipes directly on social media aligns with Gen Z's preferences. However, it

needs to be clarified how a conscientious user can perceive this product and its closely related functions, such as the possibility of having recipes with an updated database that perfectly aligns with the sustainability approach already examined in Optimise product life.

In summary, the ID series excels in many areas relevant to contemporary consumers, but to fully capture the attention of the green market and Gen Z, it could benefit from a more pronounced emphasis on sustainability. Integrating innovative technology, smart features, and aesthetics could be leveraged to offer users a comprehensive eco-friendly attitude, in line with the increasing demands for more sustainable products.

2.3.2 Washpass: the first subscription-based professional washing ecosystem at home

Washpass represents a smart washing machine that autonomously configures washing cycles utilizing the advantages of artificial intelligence. It operates through an all-inclusive monthly subscription service, encompassing the costs associated with the machine's usage, detergents, installation, maintenance, and support. This innovative solution promises to enhance performance by a substantial 70%, significantly reducing the user's effort (Barbera, 2023; Candy Hoover Group S.r.l., 2023d). One distinct feature of this offering is the presence of four custom-designed detergents within the washing machine, utilizing a concept called "Chemical Disaggregation." This system optimizes each wash cycle, reducing waste, promoting savings, and minimizing environmental pollution. Furthermore, the washing machine can identify when a detergent cartridge is running low, subsequently arranging to deliver replacement cartridges (Altroconsumo, 2022; Candy Hoover Group S.r.l., 2023d).

Users who have tested this service find it convenient due to its user-friendly and hands-off approach, alleviating the need for routine or extraordinary maintenance. Additionally, they appreciate the system's ability to provide guidance on reducing economic and energy consumption based on specific time intervals. It also offers recommendations for adjusting wash temperatures and frequency, which can be influenced by photographing the clothing items to be laundered (Capone, 2023).

Figure 10. Haier Washpass Washing Machine
The new washing machine service with its detergents' bottle by Nuncas. The quantity of detergent will automatically decided by the clothes' kilos and the wash mode selected (Candy Hoover Group S.r.l., 2023d).

As observed previously with the Bionicook (Figure 9), incorporating smart connectivity and remote-control functionalities within this product provides users with insights into their energy consumption (Altroconsumo, 2022; Candy Hoover Group S.r.l., 2023d; Capone, 2023). Moreover, it assists in optimizing energy utilization and offers valuable recommendations for enhancing the environmental sustainability of their laundry practices. These considerations align with the principles proposed by Vezzoli (2016), as discussed in subsequent analyses Designing for environmental sustainability, even though they are not prominently highlighted as significant product features. Examples of such alignment encompass the potential reduction in detergent usage, inclusive product maintenance, and the subscription model that encourages shared product utilization instead of individual ownership. These aspects collectively encompass a diverse range of eco-design[3] strategies that extend beyond mere claims of energy efficiency. Furthermore, in terms of aesthetics, these features, akin to the Bionicook, empower conscientious users with immediate insights into the eco-designed nature of this household appliance.

[3] The integration of environmental aspects into the product development process, by balancing ecological and economic requirements. Eco-design considers environmental aspects at all stages of the product development process, striving for products which make the lowest possible environmental impact throughout the product life cycle (European Environment Agency, 2001).

In conclusion, the Washpass boasts numerous attributes that cater to the requirements of modern consumers; nevertheless, to captivate the eco-conscious Gen Z, a more conspicuous emphasis on sustainability would be advantageous and more appealing.

2.4 Ovens: a cross-product in Haier Group brands

As evident from the diverse product portfolios previously illustrated in Haier Group: the company and its brands, it can be observed that, particularly, the materials, including ferrous and non-ferrous metals, plastics and several types of electronics (Rodriguez Quintero et al., 2022, p. 121), main oven's components will be later presented in Oven components. This abundance of materials makes their proper management at the end of life a relevant aspect of their life cycle (Vezzoli, 2016). It is necessary to know whether consumer behaviour is aligned with the objectives promoted by policies such as the WEEE[4] Directive and the principles of the Circular Economy. This is fundamental to determine whether more awareness-raising actions are required to guide consumers towards priority strategies in the waste hierarchy, such as reuse and repair (European Commission, 2012). Focusing on ovens, as it is a cross product in group's brand, its sales of electric ovens are slightly increasing from 11.6 million in 2020 to 11.9 million in 2030 (+2.5%), with an increase in the electric share that is estimated to be around 87% of installed ovens in 2030 (Rodriguez Quintero et al., 2022)(Rodriguez Quintero et al., 2022). Some 11.5 million electric ovens are sold annually in the EU (European Commission et al., 2015). Eurostat's [5] investigation into 28 countries of the European Union (EU28) production statistics for 2018 unveils a notable shift in product composition. Specifically, it shows that over 40% of the units produced were cooking fume extractors, whereas electric ovens accounted for 29%, as depicted in Figure 11. This distribution contrasts with the initial phase of the study, where ovens represented just 13% of the total units produced, indicating a transformation in

[4] Waste from Electrical and Electronic Equipment (WEEE), EU rules on treating waste electrical and electronic equipment, to contribute to sustainable production and consumption (European Commission, 2012).

[5] Eurostat, namely the Statistical Office of the European Union, is tasked with publishing statistics and quality indicators at the European level, enabling cross-country and cross-regional comparisons (European Commission, 2023b).

market demand over the period under scrutiny (Rodriguez Quintero et al., 2022, p. 75)

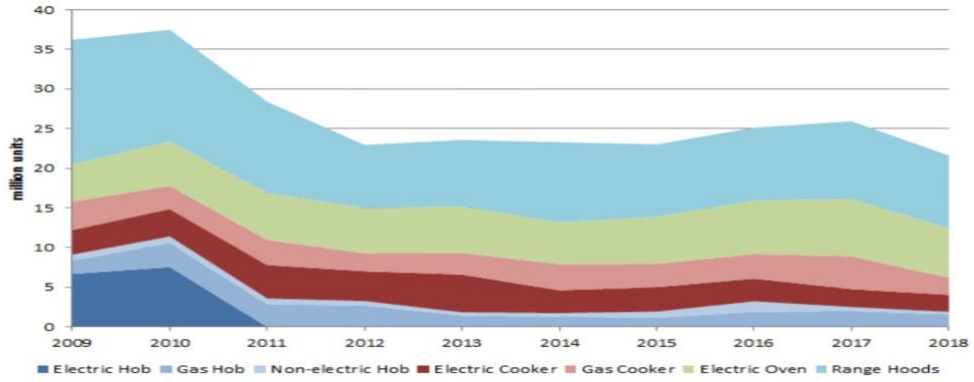


Figure 11. Eurostat analysis on oven's production units
Significant numbers of units produced are visible when comparing the units of Electrical Oven to other household appliances, earning second place in terms of number of units (Rodriguez Quintero et al., 2022).

Further supporting evidence arises from the ongoing examination of oven sales conducted by Eurostat, Figure 12. In 2018, a substantial volume of approximately 6 million units was sold, a significant figure. Notably, the sales of gas ovens were meagre, so they do not register as a visible component in the graphical representation, underscoring the overwhelming dominance of electric ovens in the market (Rodriguez Quintero et al., 2022).

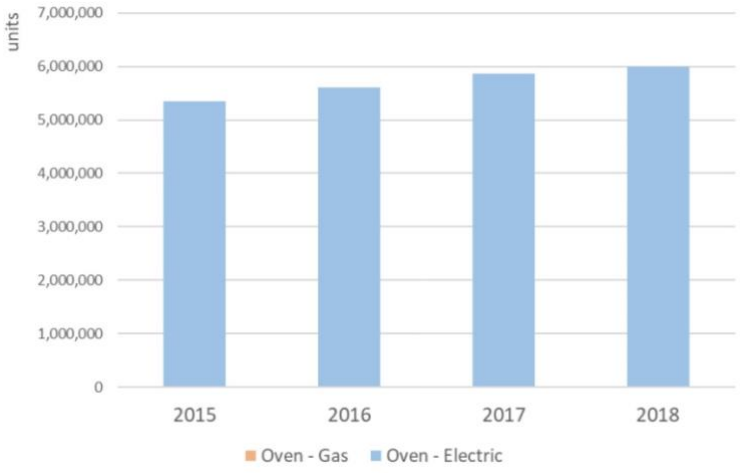


Figure 12. EU sells of electric ovens vs gas ovens units in 2015-2018
The graph shows the relevant number of Electric Oven units sold, where Gas Oven are so few that are no visible (Rodriguez Quintero et al., 2022).

Based on the same trend, Haier's internal marketing data shows that the Italian market comprises over a million units sold in 2022, of which Haier Europe

accounts for 19.50 %. Given these data and trends, the research exclusively focuses on the built-in electric oven, representing the most impactful oven category today and in the future regarding units sold and diffusion. Moreover, Haier does not produce an electric free-standing oven (Haier Europe, 2022). and this provides a further rationale for focusing the present research on the analysis of electric built-in ovens.

Figure 13. Haier ovens category product
From left to right: Candy Timeless oven, Hoover H-oven, Haier S2 (Candy Hoover Group S.r.l., 2022a, 2022b).

The same importance given by the company to this household category is shown by the Milan Experience Design Centre of Haier Europe, which conducted a design research study in 2020, focusing on oven usability and prospective design requisites for ovens to be developed by 2023; this study will be further examined in-depth later on in Haier Europe and its PQ parameters.

3. Product perceived quality: meaning, importance and approaches

3.1 Perceived Quality definition: Exploring Aaker and Gavin's approach

Aaker et al. (2000) describe perceived quality (hereinafter PQ) as a unique form of connection, partly due to its influence on brand associations in diverse contexts and partly because its impact on profitability has been empirically validated. PQ pertains to an individual's judgment regarding the superiority or excellence of a given product. It differs from objective quality, which relates to the verifiable superiority of a product according to predetermined ideal standards (Zeithaml, 1988). Inevitably, a disparity between perception and reality exists. Aaker provides an alternative definition of perceived quality as "the customer's perception of the overall quality or superiority of the product or service concerning its intended purpose, relative to alternatives" (Aaker, 2009, p. 135). Perceived quality is distinct from actual or objective quality, product-based quality, and manufacturing quality (Aaker, 2009). It can be seen as the distinction between overall quality and undetected quality. Despite the numerous definitions put forth by scholars, they share a collective understanding that perceived product quality refers to the consumer's perception of the overall components of a product, encompassing both tangible and intangible characteristics (Vantamay,2007).

A classification proposed by Garvin (1984) consolidated the different viewpoints on PQ into five general approaches to defining quality: (i) transcendent approach, (ii) product-based approach, (iii) user-based approach, (iv.) manufacturing-based approach, (v) value-based approach. The transcendent approach (i) regards quality as an inherent excellence that can only be comprehended after encountering a series of objects that exhibit its characteristics. The product-based approach (ii) perceives quality as a precise and measurable variable. The user-based approach (iii) considers quality as a subjective measure dependent on the customer's or end-user's desires and needs. The manufacturing-based (iv) approach views quality as adherence to standards or requirements. Lastly, the value-based approach (v) regards quality as a trade-off between desirable quality attributes and costs, resulting in a delicate and subjective price-equity relationship (Garvin, 1984).

Garvin (1984) further delves into PQ, suggesting that leveraging perceived quality facilitates brand extensions into new product categories, particularly for

robust brands, thereby increasing the likelihood of success. Research encompassing 18 proposed extensions across six brand names revealed that perceived quality significantly influenced the evaluation of these extensions. The brand value enhances the customer base, loyalty, and effectiveness of marketing programs, rendering all elements, including advertising and promotion, more efficient. High perceived quality directly impacts purchase decisions, reinforcing the overall effectiveness of the marketing strategy.

While the literature identifies various approaches to defining quality (Espinosa et al., 2019; Oude Ophuis et al., 1995; Solin et al., 2023; Stylidis et al., 2019), Garvin (1987) proposed eight fundamental dimensions to achieve quality gains, by underlying these characteristics: (i) performance; (ii) features; (iii) reliability; (iv) conformance; (v) durability; (vi) serviceability; (vii) aesthetics; (viii) perceived quality (Garvin, 1987).

This perspective aligns with marketing and branding strategies, reminiscent of certain principles from Vezzoli, previously illustrated Designing for environmental sustainability, and European Commission approaches that emphasize an eco-driven design, later in EU regulations for ovens: a new energy labelling. Leveraging perceived quality for brand extensions reflects a strategic approach to product development and consumer perception. The acknowledgement of perceived quality's impact on brand loyalty and marketing effectiveness resonates with the ethos of designing products not only for functionality but also for their broader impact on user experience and brand reputation, echoing themes previously presented in Vezzoli's sustainability-centric design methodology and the European Commission's eco-design directives.

These dimensions have remained unchanged since Garvin's original publication and have been widely employed in contemporary literature as a basis for measuring product quality or constructing quality constructs specific to an industry or artefact of interest (Stylidis et al., 2019). Applying PQ to an eco-design approach highlights the necessity, as emphasized by Alli et al. (2019), for product designers to have specific guidelines applicable in the early stages of the design process or product assessment studies. However, no distinct methodology currently combines users' emotional responses and perceived quality characteristics for sustainable products, aiming to enhance the likelihood of success in the market. As also stated by O'Brien (2018), the quest for sustainable products necessitates changes in the physical aspects of systems and structures and a fundamental transformation in individuals' beliefs, values, worldviews, paradigms, behaviours and practices. This personal sphere of transformation is crucial in shaping how people perceive, define, and construct sustainable systems and products. The shift towards sustainability

demands a holistic approach encompassing external changes in products and systems and internal changes within individuals, influencing their decision-making processes and consumption patterns.

The research centres on the significance of perceived quality in a product, elucidating how it imparts a sense of durability to customers, fosters brand loyalty, and enables users to establish an emotional connection with a product that aligns closely with their needs. The following chapter illustrates how PQ is integrated into a product. Subsequently, an analysis of the PQ parameters specific to Haier will be presented, serving as an initial reference for the research findings.

3.2 How PQ links to a design and how it can differ

By applying the concept of PQ to a product, Solin et al. (2023) explore the idea that similar to the subjective nature of beauty, quality relies on the consumer's perception; this has led to the emergence of a user-based approach in defining quality. Various scholars in quality management argue that, from the user-based standpoint, quality is akin to "fitness for use" or "fitness for purpose." This approach is considered more customer-centric and linked to customer satisfaction compared to the internal perspective of "manufacturing quality". The PQ concept encompasses the subjective aspect of quality and integrates external factors or cues that influence quality, such as brand name, image, and reputation. According to what was presented in the previous section, this approach is considered more customer-oriented and more intricately linked to customer satisfaction than the more internal approach to manufacturing quality. The concept of PQ not only captures this subjective side of quality but goes on to embrace the external determinants or cues of quality, such as brand name, image and reputation (Solin et al., 2023), which according to Garvin is “the primary stuff of perceived quality” (1987, p. 107).

3.2.1 Stylidis’s Perceived Quality Framework and Attributes Importance Ranking

Stylidis et al. (2019) presented the Perceived Quality Framework (PQF), Figure 14, utilizing human perceptual processing; this framework systematically outlines, tests, and explores product designs.

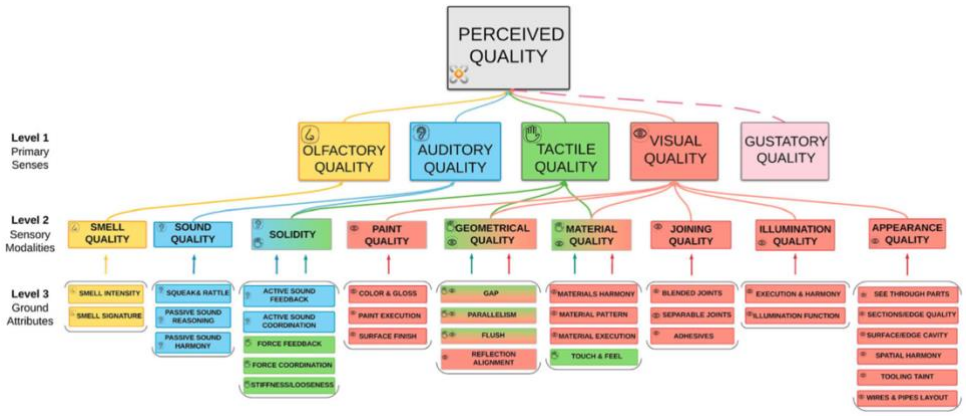


Figure 14. Attributes levels of the Stylidis's PQF
The 3 levels of PQ evaluation and their macro topics are shown which are divided into sub-categories starting from the primary senses, and then going deeper with more specific characteristics of the product (Stylidis et al., 2019).

The perceived quality attributes in this structure are categorized based on the primary human senses involved in their evaluation, including (i) visual, (ii) tactile, (iii) auditory, (iv) olfactory and (v) gustatory aspects. The second level of attributes in the PQF, informed by industry knowledge input, is structured as Sensory Modalities. In the research context, sensory modularities refer to the nine distinct sets of product attributes designed for presentation to humans. A customer should comprehend the significance of each ground attribute and be capable of ranking and prioritizing its importance among other ground attributes. Such customer feedback is crucial in the optimal perceived quality equation-balancing activity. The framework can be used widely to explore and test product designs regarding perceived quality. The Perceived Quality Attributes Importance Ranking (PQAIR) method, in Figure 15, was developed by Stylidis et al. (2019). to aid engineers or designers in assessing the relative importance of perceived quality attributes for the final product. This method deliberately integrates objective, measurable information about perceived quality with customers' subjective product quality evaluations.

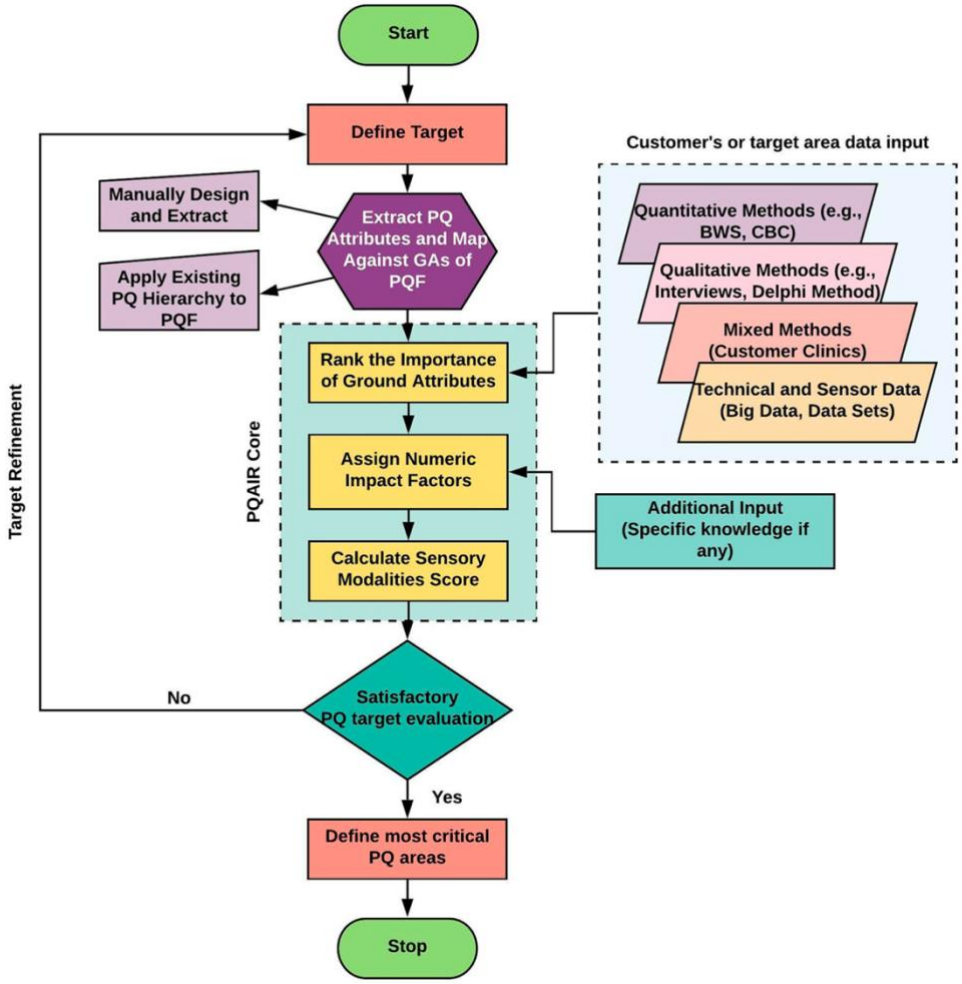


Figure 15. Stylidis's PQAIR method analysis procedure
This method provides guidelines for evaluating the PQ and field research project phases to obtain inputs to also outline the critical aspects (Stylidis et al., 2019).

The central aspect of this new method involves ranking all identified Ground Attributes based on their importance. This ranking can be achieved through internal company knowledge or customer data analysis, contributing to importance scores for each branch of the structure within the PQF. The current challenge for companies is transitioning from achieving the expected quality level of a product to assessing its perceived quality. Evaluating perceived quality is more complex as it involves customer sensory assessments (Maire et al., 2013).

In the upcoming chapter, the company matrix will be examined to establish and quantify various parameters defining the perceived quality of products. Given the emphasis on ovens, the main aspects and technicalities associated with them will be analysed. The objective is to initiate the development of new measurable

values, contributing to enhancing a novel matrix that incorporates sustainable criteria for products in our imminent future.

3.3 Haier Europe and its PQ parameters

The perceived quality is examined from the company's perspective throughout the process, as illustrated in Figure 16. This analysis involves two key actors: the customer and the product. The company identifies these actors as "Quality pillars" within the total quality process. The customer is positioned between expected and perceived quality, representing customer satisfaction. Expected quality refers to what consumers anticipate from a product, while perceived quality is shaped by consumer perceptions based on sensory and cognitive knowledge, culture, habits, product competency, and usage.

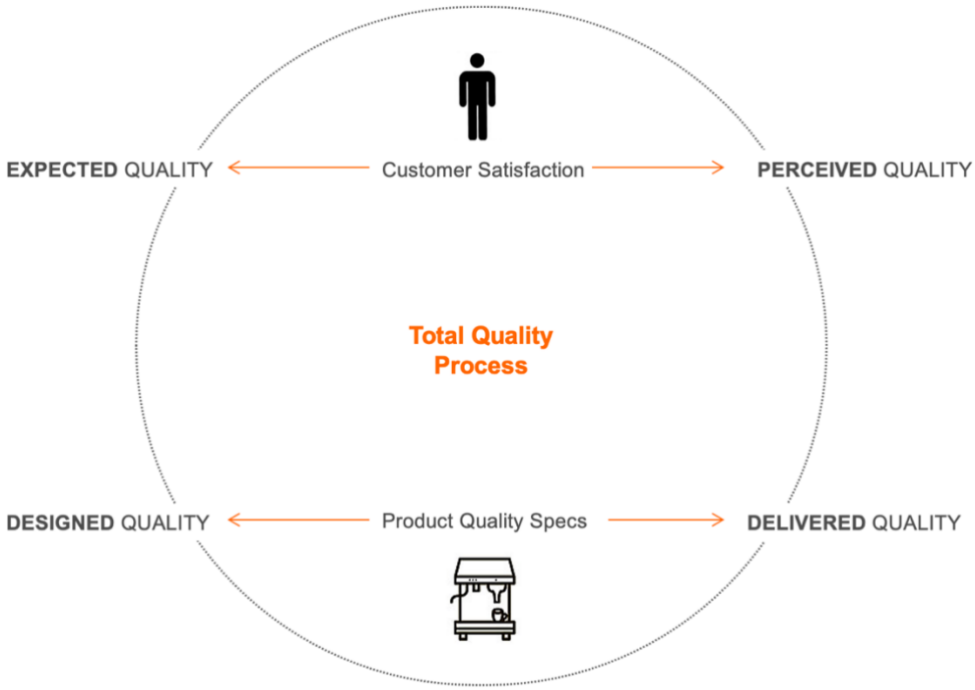


Figure 16. Haier Europe Total Quality Process Scheme
Indicates the process and the protagonists, consumer and product, involved in the quality of the delivered product.

On the other hand, the product embodies all the quality specifications, with two parameters: Designed quality (the dimensions/data for designing a product) and Delivered quality (the level of quality with which a product is made). This circular approach influences perceived quality by users and increases the company's know-how, sensitivity to product quality, and knowledge of competitors' products. It also aids in preventing and resolving quality issues at

earlier stages, reducing cost impacts, and ensuring high customer satisfaction. In the Table 1 all the PQ parameters utilized by the company are showcased, with each belonging to distinct categories organized under a cluster structure.

Cluster	*Categories*	*PQ parameters*
i. Product design	Design harmony, component alignment, holes/see-through, fasteners, visible components, and sharp edges.	• Do you notice any unpleasant design consistency among different elements? • How do you evaluate the components' alignment? • How do you evaluate any visible holes? • How do you evaluate technical visible components (e.g., screws, gaskets, etc.)?
ii. CMF	Colour grains gross, material authenticity, innovative material, moulding quality, coating quality, forming quality	• Do you notice continuity and harmony in the colour match? • Do you perceive the material's look, feel and sound authentic according to their scope? • Do you notice any new material? • Do you notice any visible design or manufacturing moulding surface? • Do you notice any visible irregularity or deformation on the coated surface? • Do you notice any visible irregularity or deformation on the forming surface?
iii. Human Factors	Product logic, perceived cleanability and maintainability, capacity and reach, robustness, lighting quality, audio quality	• Could the configuration, layout, and organization be considered intuitive for usage scope and not require instruction to be used? • Do you consider any part of the product easy to clean? • Do you think the product has been designed with appropriate capacity and reachability based on daily use? • Do you think that the product is perceived as durable? • Could light position affect visibility in daily use? Which intentional sound makes the product according to the function?
iv. User Interface	UI ease of use, engaging user experience, UI innovation, UI readability, control feedback, connectivity	• Do you need to learn the UI before using it? • Is the user engaged in exploring all the functions? • Are there any sensors to facilitate the UI usage? • Do you think that the controls are visible and easy to read? • Is there consistent feedback on user controls? • Is it easy to be identified and connected?

Table 1. Haier Europe PQ Clusters and Parameters
Internal paarmeters used nowadays to evaluate the product's PQ, divided by their clusters.

These parameters (Table 1) span various company areas such as engineering, marketing, design, quality, and manufacturing and are used by Haier Europe as a tool to evaluate products. The analysis involves evaluating the product through four clusters: (i) product design, (ii) colour, material, and finish (CMF), (iii) human factors and (iv) user interface. The tool can be applied in all phases of the product development process, but it is recommended at the project's outset to define product specifications. After technical or industrial pre-series, it can also be used to verify results against the initial design. The evaluation employs a scoring system from -3 to +3, where -3 indicates "unacceptable" (associated with red colour, see Figure 17) and +3 indicates a "competitive advantage" (associated with green).

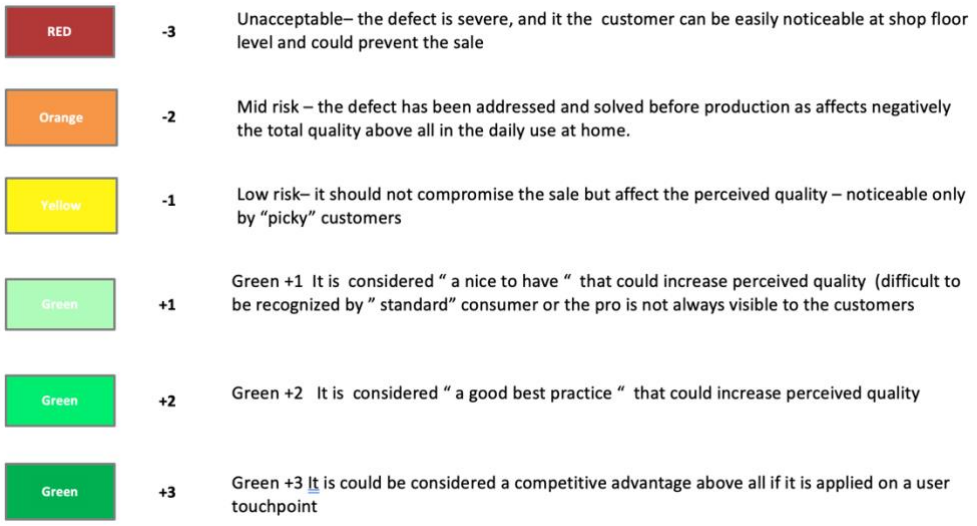


Figure 17. Score System to Evaluate the Parameters
The scale -3 to +3 used by Haier to rate each parameter while invastigating the product's PQ.

The parameters are evaluated in an Excel file (Figure 18) using vertical columns for the four clusters, scores, comments, and any relevant pictures.

CFM	WHI		
QUESTIONS	score	comments	foto
color grain gross			
door deflector and glasses		frame cover glass	
frame and handles	-1	handle in contrast with frame	
panel aesthetich and knobs	-1	for matt knobs in contrast with ring and glass	
material autenticity	2		
innovative material			
moulding quality	1		
coating quality	1		
forming quality	-1		
cavity and accessories	-1		
door parts	1		
panel parts	-1		

Figure 18. Haier Europe Evaluating PQ Parameters Tool
An example of analysis by the PQ parameters.

When comparing products, the same scheme is adopted. The outcome is a table with a gap analysis, highlighting weak points for each cluster and suggesting effective changes. The tool includes a column for "available solutions" to mark whether existing solutions can be adopted or if there are budget/time constraints. The last column notes considerations for implementing weak points to achieve the highest delivered quality and its corresponding perceived quality. An example from the current Haier oven production is shown in Figure 19, illustrating how this tool facilitates benchmarking among internal and competitor products. By assigning grades to parameters, the company can prioritize specific aspects, opening new avenues for product improvement and gaining experience to enhance delivered quality over successive projects.

CLUSTERS	GAP	STEP1	STEP2	SOLUTION AVAILABLE	NOTES
PRODUCT DESIGN	Alignments all 5 defined parameters(see next slide)	X on current halino	X- will be extended also on radial Halino		
	See trough: gap door panel and door structure too visible		X		Necessary ventilation revision
	Sharp edges and design harmony			X	All new aesthetic will keep this outcome from beginning
CFM	Coating quality	X			
	Moulding quality and Forming quality	X front frame and enameled tray	X new cavity top		
	All aesthetic observations			X	All new aesthetic will keep this outcome from beginning
HUMAN FACTOR	Pruduct logic: consider more poka yoke accessories as AEG	X			
	Cleanability: accessories springs and click and clean	X: only accessories	X: click and clean moved		
	Travel and swings: noises on accessories	X			
	Capacity and reachability: handle too close to glass			X	All new aesthetic will keep this outcome from beginning
UI	Display lens quality and touch sensitivity	X-to evaluate light grey glass	X		Current FT bitron is very poor vs competitors

Figure 19. Haier Europe PQ Parameters Tool on Oven's Analysis
Here the weak points are displayed with any possible next step to enhance the PQ

In the upcoming section, "6.3 Testing the concepts by using SPQ parameters", we will delve into the examination and potential refinement of specific parameters introduced here. This process aims to enhance alignment with Sustainable PQ and the user requirements identified in "5.2 Field research on case studies: interviews on Gen Z users".

3.3.1 Global Trends and Technological Benchmarking: Crafting a Roadmap for Haier's Future Oven Offerings from an internal design research

The investigation was carried out by Haier's design team in 2021 in preparation for the product release scheduled for 2023. Their research encompassed a survey of 177 respondents in Italy, 49 in the United Kingdom, and 63 in various other countries. The comprehensive research was structured into two primary segments: the first involved primary research aimed at gaining an in-depth understanding of how individuals interact with ovens, their requirements, and the factors influencing changes in their oven usage experiences. The second segment, secondary research, sought to elucidate users' initial encounters with ovens, the elements that initially captivate users, and the mechanisms through which individuals are introduced to ovens.

Based on the survey findings, a series of cards were generated, presenting novel scenarios derived from the quantitative research insights. Subsequently, a more profound qualitative analysis was conducted, guided by the "So What" question, delving into product, service, and brand aspects. This endeavour aimed to provide innovative design solutions that address user needs and emerging trends. Noteworthy insights and trends that emerged from the research include the prevalence of disconnected cooking through smartphone applications, with 64% of respondents reporting seldom or never using the Wi-Fi function for this purpose. Additionally, the prominence of displays was emphasized, as 46% of participants reported using ovens equipped with display user interfaces. Interestingly, convention and fan were favoured by 70% of users, with most eschewing specialized functions in favour of conventional or fan modes. The study underscored the significance of aligning the user experience with the brand's values and keywords, emphasizing the importance of a brand-driven user experience. Therefore, four over five senses were used to choose and examine the trends. As illustrated in the diagram below, gesture represents the dynamic element and tensions that are easily identifiable; proportion denotes the ratio governing the primary body geometry and the distinctive features of overall surfaces; composition and layout indicate the arrangement, relationship, and division treatment between different volumes or elements; details highlight the interaction with the decorative and technical elements relating with the distance of interaction from 5 meters to 5 centimetres, as schematize in Figure 20.

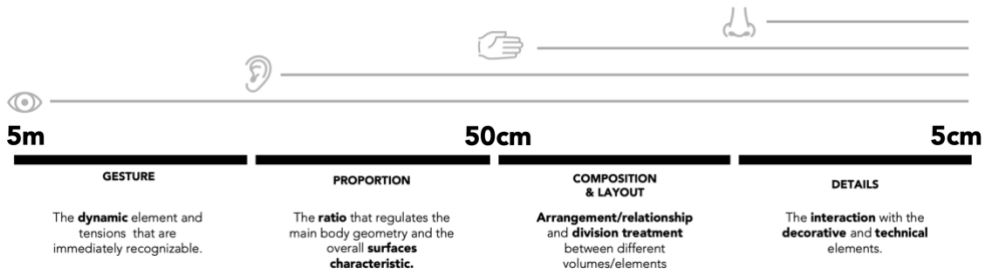


Figure 20. Haier Europe Design Research of Experience Design Language
A visual description of the different levels of user's interaction by the senses.

This research proved instrumental in discerning elements that align with Haier's values, drawing inspiration from trends, and emphasizing the significance attributed to user experience, particularly concerning the human five senses. In this context, using the five senses is a user-experience lens for analysing trends. This approach aligns with what was previously outlined in "3.2.1 Stylidis's Perceived Quality Framework and Attributes Importance Ranking", where these attributes are instrumental in evaluating the perception of quality.

3.3.2 Five stars: internal marketing analysis to define Haier's product positioning

The 5-stars method, employed by Haier's internal marketing department, involves a competitor assessment grounded in consumer satisfaction, as indicated by the analysis of 5-star ratings. This evaluation encompasses six main categories of product properties, including (i) design, (ii) structure, (iii) cooking performance, (iv) features, (v) cleaning system and (vi) ease of use. Brands are selected based on price bands, and the top-rated models are chosen from each brand's most recent 50 reviews.

In a study on ovens, the Countries considered were Italy, France, United Kingdom, Germany, Spain and Poland. The brands selected were: Electrolux; AEG; Bosch; Siemens; Miele; Whirlpool; Hotpoint; Samsung; Neff; Beko; Teka; Balay; Amica. What emerged from this internal research, shown in Table 3, is that the first three categories are cooking performance, features and ease of use- The percentage is based on the total comments (n = 3616); one review can count more than one comment, for all the brands in all the selected countries.

	Product categories	**%**
i.	Design	15
ii.	Structure	15
iii.	Cooking performance	22
iv.	Features	18
v.	Cleaning system	7
vii.	Ease of use	18

Table 2. Most Rated Product Categories with 5 Stars Analysis
Here are shown the results of the analysis conducted by the marketing team to understand the users' needs in ovens features and characteristics by making the analysis on competitors.

Analysing the design category, the only adjectives used were stylish, elegant and wide (the latter refers to the glass). The analysis reveals that, within the design category, eco-design is also not considered in this marketing tool, as per the PQ parameters used by the company. However, the properties associated with the user-friendliness category, in particular intuitive UI and user-friendly, emerged as relevant for the user experience and are hence considered significant for PQ, as the user has different levels of interaction based on the Primary Senses.

3.4 How can the Perceived Quality of ovens be effectively enhanced through a sustainable design approach targeted at Gen Z?

At this stage, the research will investigate how the perceived quality of ovens can be effectively enhanced through a sustainable design approach targeted at Gen Z. The research proposes the integration of a new cluster in Haier's PQ parameters related explicitly to eco-sustainability to more accurately assess the ovens' PQ through an eco-design approach targeted at Gen Z; This initiative aligns with the green consumer perspective of Gen Z and, following Garvin's suggestion, involves brand extensions into new product categories. The goal is to elevate the company's know-how and establish an emotional connection with users who prioritise eco-conscious products. This integration aims to align more effectively with stakeholder needs and cultivate a green perceived quality that augments brand expertise. The analysis seeks to better understand PQ by merging these perspectives, in other words, by blending Stylidis's theoretical framework, Haier's practical evaluation methodology, and Vezzoli's eco-design strategies. The designed approach aims to enhance the evaluation process, presenting a more holistic perspective on PQ, specifically focusing on environmentally conscious Gen Z users.

With the present research, various actions were developed, adopting a multi-method approach. First, ovens, EU regulations, and relevant case studies were analysed. Then, specific interviews with Gen Z users have been conducted to understand emerging needs and preferences to inform the development of a concept proposal. This proposal has been tested and validated using the newly defined PQ parameters, allowing Haier to benchmark its products and compare them to competitors and its oven offerings in an eco-sustainable approach.

4. Ovens: contemporary policies and product typologies and specifications

The primary aim of this chapter is to provide an in-depth examination of the various policies governing household ovens. It will do so by analysing the specific regulations established by the European Union related to ovens and the recently updated energy labelling standards. Furthermore, this chapter will delve into the product specifications, exploring the components of these appliances and elucidating the distinctions in their principal characteristics. The focus of the section is to present these policies and argue and emphasize their significance in shaping the oven market and ensuring more energy-efficient and environmentally friendly household appliances.

4.1 EU regulations for ovens: a new energy labelling

The energy labels were initially introduced for various domestic appliances in 1994 and further expanded in 2004. Employing a comparative scale ranging from A (representing the highest efficiency) to G (indicating the lowest efficiency), the EU energy label has been pivotal in guiding consumers toward selecting more energy-efficient products. Simultaneously, it incentivises manufacturers to foster innovation by adopting energy-efficient technologies (European Parliament, 2018).

In 2014, the Commission adopted implementing measures under the Eco-design Directive and the Energy Labelling Directive (European Commission, 2014a) applicable to domestic ovens, hobs, and range hoods. The measures currently in force contain review clauses, and the regulation setting a framework for energy labelling also requires rescaling existing energy labels (European Commission, 2017). In 2019, 93% of consumers recognised the energy label, and 79% actively factored it into their purchasing decisions when seeking energy-efficient products. This data underscores the notable impact and effectiveness of the energy label in influencing consumer choices and fostering the adoption of energy-efficient products (European Commission, 2023).

Labels will enable consumers to distinguish more clearly between the most energy-efficient products. At the same time, it is meant to encourage manufacturers to continue research and innovation into more energy-efficient technologies.

In the same year, the European Commission (2014) implemented directive 2009/125/, which was created to provide a framework for setting co-design requirements for energy-related products (European Parliament et al., 2009). The new regulation 66/2014 clarified further the previous directive: *"with regard to eco-design requirements for domestic ovens, hobs and range hoods"* (European Commission, 2014b, p. 1). What crystallizes from this regulation is the primary environmental focus concerning the products covered, a focal point that this regulation deems paramount, which is energy consumption during the usage phase. It is discerned that standby and off-mode functions may account for a considerable portion of the overall power consumption associated with domestic cooking appliances. However, these functions are not deemed essential, given that domestic cooking appliances' electricity and gas usage such as ovens, hobs, and range hoods during the usage phase, holds the utmost significance regarding environmental impact (European Commission, 2014b).

As illustrated in the previous chapter, the research emphasises residential energy consumption, focusing on the kitchen. Related to this topic, the European Commission has therefore launched the revision of the current eco-design and energy labelling implementing measures for the product group "domestic ovens, hobs and range hoods". The Commission's Directorate-General (DG) for Energy coordinated the review study undertaken by the Commission's Joint Research Centre[6] (JRC). The revision methodology follows the Commission's Methodology for the Evaluation of Energy-related Products (MEErP)[7], consisting of the following steps: (i) scope definition, standard methods and legislation; (ii) market analysis; (iii) analysis of user behaviour and system aspects; (iv) analysis of technologies; (v) environmental and economic assessment of base cases; (vi) assessment of design options; (vii) assessment of policy scenarios.

The thorough examination of the product category through the steps will provide valuable research findings for the potential revision of current regulations. This research process relies on existing scientific data, adopts a life-cycle perspective, and involves input from expert stakeholders (European Commission, 2011). The analysis conducted by Rodriguez Quintero et al. (2022),

[6] The JRC provides independent, evidence-based knowledge and science, supporting EU policies to positively impact society (European Commission, 2020).

[7] The Methodology for the Eco-design of Energy-related Products (MEErP) was developed to provide operational guidance to the European Commission and contractors providing it with technical assistance in performing the preparatory study for the Eco-design of a product (European Commission, 2022b).

some data seen previously in Ovens: a cross product in Haier Group brands, encompassing market dynamics and consumer behaviours, has underscored the influence of price and operating costs on cooking appliance purchasing decisions. These factors have a significant impact on consumers' choices. Durability also emerges as a key determinant, with consumers exhibiting a preference for appliances that assure extended service intervals without the need for frequent maintenance or facing critical malfunctions. Notably, 79% of consumers attach great importance to integrating durability criteria into the product design.

Furthermore, the level of energy literacy among consumers is another pivotal factor. Households with low energy literacy often underestimate the advantages of investing in energy-efficient appliances. Educational campaigns can be crucial in elevating energy literacy levels to address this challenge, consequently fostering the adoption of energy-efficient appliances. It is advisable not only to provide the metrics presented on labels but also to clarify the practical implications of these metrics for consumers at the point of purchase. In this context, translating energy savings into tangible benefits that resonate with consumers, such as the amount of light required to illuminate a room for a specified duration, is recommended.

From this juncture, it becomes apparent that a research-through-design approach can be instrumental in further exploring how product properties can be embedded to communicate essential aspects to users effectively. The product can embed key attributes like durability, reparability, energy efficiency, and eco-sustainability. By doing so, products fulfil their intended functions and act as educational tools, enlightening users on the importance of these eco-conscious features. This user-centric approach can transform consumer behaviour, making sustainability considerations an integral part of the decision-making process and contributing to the broader adoption of eco-designed and energy-efficient appliances.

The study continues giving some product’s tips like transitioning to intelligent or more energy-efficient appliances that presents an opportunity for substantial energy consumption reduction during cooking. Additionally, it's imperative to acknowledge that consumer behaviours can significantly influence the durability of products. because the way in which individuals utilize and maintain appliances can impact their lifespan. As for the repairability of domestic cooking appliances, from a consumer perspective, obstacles to repairing used appliances are closely linked to the perception that such repairs are often not cost-effective, given the competitive prices of new equipment. Moreover, limited awareness regarding where to seek appliance repair services

further contributes to this prevailing consumer attitude (Rodriguez Quintero et al., 2022).

Drawing upon statistics provided by Eurostat, which collects and categorizes data regarding household energy consumption by distinct end-uses since 2017, unequivocally demonstrates the multifaceted nature of energy utilization within households. The new energy labelling system (European Commission, 2017) from Eu is a valuable tool for identifying appliances with low energy consumption, thus enabling consumers to make environmentally responsible choices. Household energy usage encompasses a spectrum of activities, including heating spaces and water, cooling living areas, cooking, illumination, powering electrical appliances, and additional auxiliary end-uses extending to energy consumption beyond the primary residential structure. Notably, in 2021, the residential sector, representative of households, constituted 27% of the total final energy consumption, underscoring its substantial role in the overall energy landscape (Eurostat, 2023a). Figure 21 illustrates the clear demarcation between energy consumption attributed to electrical household activities and the energy specifically allocated for cooking.

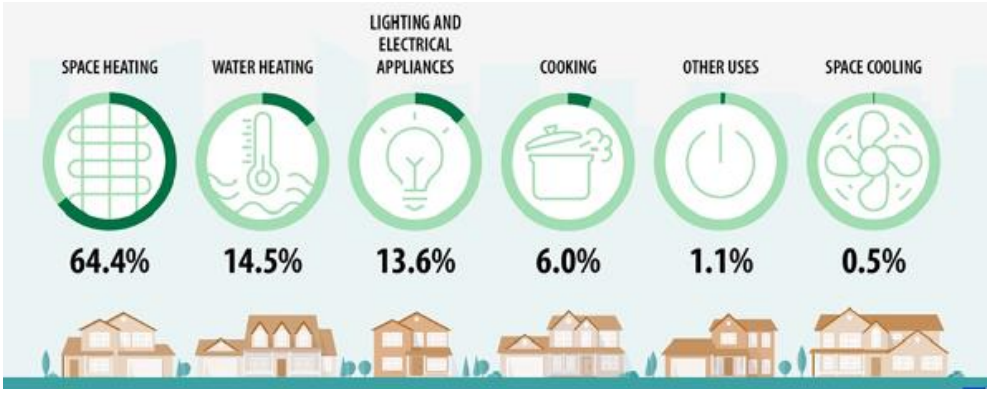


Figure 21. Eurostat Analysis on Household Appliances Energy Consumption
The data are giving evidences on the energy consumption caused by each of the products' categories in the house context (Eurostat, 2023a).

The European Commission (European Commission, 2022a) by the Directorate-General for Environment, declared that around 80% of a product's environmental impacts are determined at the design phase. After that, the commission wrote a proposal for eco-design for sustainable products regulations, where are explained some requirements essential for eco-design:

> "It does so by providing for the adoption of delegated acts containing requirements related to product durability, reusability, upgradability and reparability, the presence of substances of concern in products, product energy and resource efficiency, recycled content in products, product remanufacturing and high-quality recycling, and for

> reducing products' carbon and environmental footprints. It also provides for the creation of a digital product passport ('product passport'), for the setting of mandatory green public procurement criteria and creates a framework to prevent unsold consumer products from being destroyed" (European Commission, 2022a, p. 97).

The points expounded on the objective proposed by the European Commission (EC) previously explored in Designing for environmental sustainability: exploring Vezzoli's approaches, using Vezzoli's holistic methodologies, which comprehensively cover all the multifaceted elements that the EC emphasizes. The EC has recognized the necessity for a systematic tracking and reporting mechanism concerning the consequences of eco-design, energy label, and tire labelling measures. This includes an anticipation of potential forthcoming initiatives. The goal is to enhance the Commission's understanding of the evolving impacts over time and improve its forecasting and reporting capabilities. As part of this vision, the European Commission anticipates a notable surge in the electric oven market share, increasing to 87% of installed ovens by 2030, reflecting a substantial rise of +2.5% compared to 2020. Concurrently, a corresponding decline is foreseen in gas ovens, amounting to -3%. These changes are instrumental in achieving an expected reduction in energy consumption of -12% by 2030 compared to 2020 levels (Rodriguez Quintero et al., 2022).

This action undertaken by the European Union demonstrates the urgent need for informed public consciousness to mitigate the environmental consequences of these appliances. By adopting new regulations, such as the new energy labels, and cultivating a sustainability-oriented culture, the European Union can lead in driving society toward a more environmentally conscious future. This proactive approach of the new energy labels not only equips consumers with the information required to make environmentally responsible choices, as observed in the increasing interest in energy-efficient households, but also compels manufacturers to adopt a more eco-design perspective through many different initiatives. In doing so, the EU plays a significant role in the design and research phase, aiming to reduce the product's impact from the moment of its initial design.

4.2 Oven typologies and architecture

The European Commission (2014b, p. 2) defines an oven as "an appliance or part of an appliance which incorporates one or more cavities using electricity and/or gas in which food is prepared by use of a conventional or fan-forced mode". Rodriguez Quintero et al. (2022) in the "Preparatory study of eco-design and energy labelling measures for domestic cooking appliances", give a complete technical product description, saying that domestic ovens can be classified in multiple ways depending on the characteristics of the main components. As far as the mounting configuration is concerned, ovens can be classified as built-in or free-standing. Household ovens can be fuelled by either electricity or gas. The primary components of both types of ovens are similar or identical, with the primary distinction lying in the heating method. The designs of cooking appliances have undergone rapid evolution in recent years. In the beginning, were with traditional and purely functional designs and sizes; there is now a prevailing trend to provide ovens, hobs, and cooking fume extractors that blend the characteristics of cooking appliances with those of furniture pieces (HomeAdvisor, 2021; Rodriguez Quintero et al., 2022).

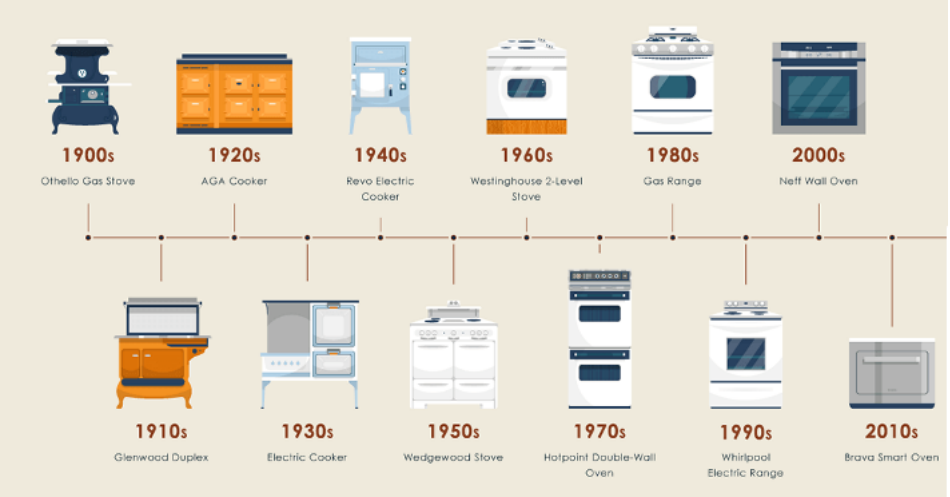


Figure 22. Visual Stove's Evolution from 1900s to 2010s
The evolution of the stove shows the change in needs and habits throughout history. It should be noted that the product has shrunk in size (HomeAdvisor, 2021).

4.2.1 Bult-in oven

Built-in ovens are installed comfortably in the wall, embedded between other kitchen cabinets or appliances (Figure 23). Ovens usually offer a wide variety of heating modes or settings; the names of these settings are usually marketing-driven (Rodriguez Quintero et al., 2022).

Figure 23. Haier Built-in Oven Inside the Cabinet
Haier S2 I-Turn oven in a setting (Candy Hoover Group S.r.l., 2022).

As discussed by Berg et al. (2021) built-in ovens, unlike traditional stoves, offer greater flexibility regarding their placement within the kitchen. An emerging widespread trend is positioning the oven at eye level, elevating it to a natural focal point in the kitchen's layout. Manufacturers primarily adopt an approach that emphasizes integration and contemporary styling. Consequently, the overall design expression strikes a delicate balance between remaining unobtrusive and possessing distinctive elements that set them apart. Consequently, the finer details often distinguish the aesthetic expressions of the ovens available in the market. Particularly noteworthy aspects include the layout of the user interface, the choice of knobs and buttons, and the design of door handles. Additionally, it is common for several brands to be under the ownership of the same parent company, such as Haier, Hoover, and Candy, or Electrolux and AEG. As a result, some parts and components are shared across these brands, contributing to the similarity in their aesthetic appearances.

4.2.2 Free standing oven

Freestanding ovens, often referred to as cookers, offer a high degree of flexibility in terms of installation. They can be set up independently from kitchen cabinets or smoothly slotted into available spaces within the kitchen cabinetry. These versatile appliances are rightly known as cookers since they incorporate both an oven and a hob in a single unit. A freestanding range

represents an incredibly adaptable kitchen appliance model, ideal for integration into diverse kitchen layouts. These ranges are self-contained units featuring a cooktop surface and one or two ovens below. They are available in various versions, such as gas, electric, or dual fuel, each with a control panel that manages the cooktop and oven functions.

Furthermore, freestanding ranges are designed with finished sides to be installed within kitchen cabinetry or as stand-alone units. This versatility makes them a top choice for various kitchen setups. Notably, the protruding back guard on these ranges serves a dual purpose, housing the controls and safeguarding the wall behind the range from any spills or splatters (Electrolux, 2023; Rodriguez Quintero et al., 2022; Whirlpool, 2023).

Figure 24. Electrolux Free Standing Cooker with Gas Oven
The picture rappresent the product with the cooker and the oven integrated in one product (Electrolux, 2023).

4.2.3 Oven's components

Generally, the main components of domestic ovens are listed below and depicted in Figure 25.

- **Cavity**, where the food is located for cooking;
- **Chassis**, the structure that supports the cavity and the rest of the oven assemblies;
- **Door**, which enables access to the cavity;
- **Control panel,** which contains the UI and gives access to the oven's cooking functions and settings;

- **Heating elements**, which will differ depending on the heat source, might be on the bottom, on the top or in the back part around the fan;
- **Thermostat**, which is used to control the temperature inside the cavity;
- **Fan,** which is used to distribute heat evenly in convection ovens/mode, in the back part inside the cavity;
- **Insulation,** which restricts the heat loss between the chassis and the cavity;
- **Cables or pipes** transfer energy from the heat source to the electrical resistance or heating element.

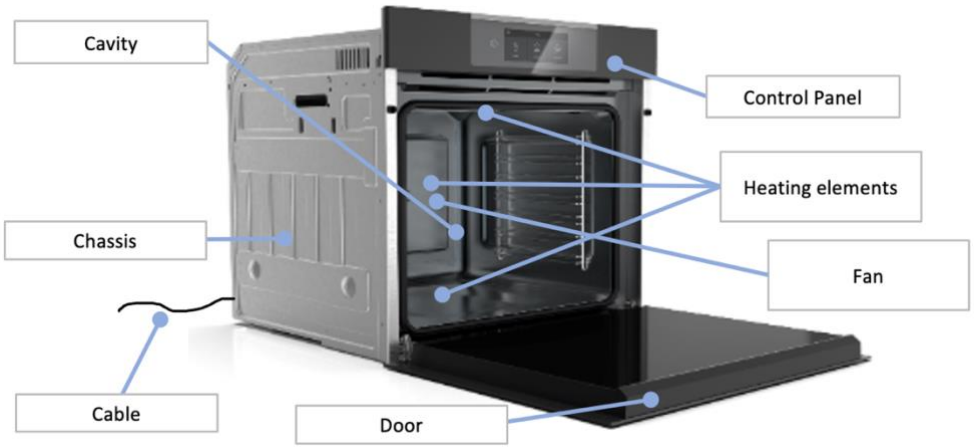


Figure 25. Oven's Main Components
All the main parts of the oven are described.

In an electric oven, an electric current is directed through a wire located within the heating element. This current encounters electrical resistance, causing the wire to heat up and, in turn, warm the surrounding area of the element. Typically, the wire is coiled and enveloped by compacted magnesium oxide powder before being enclosed in a protective casing.

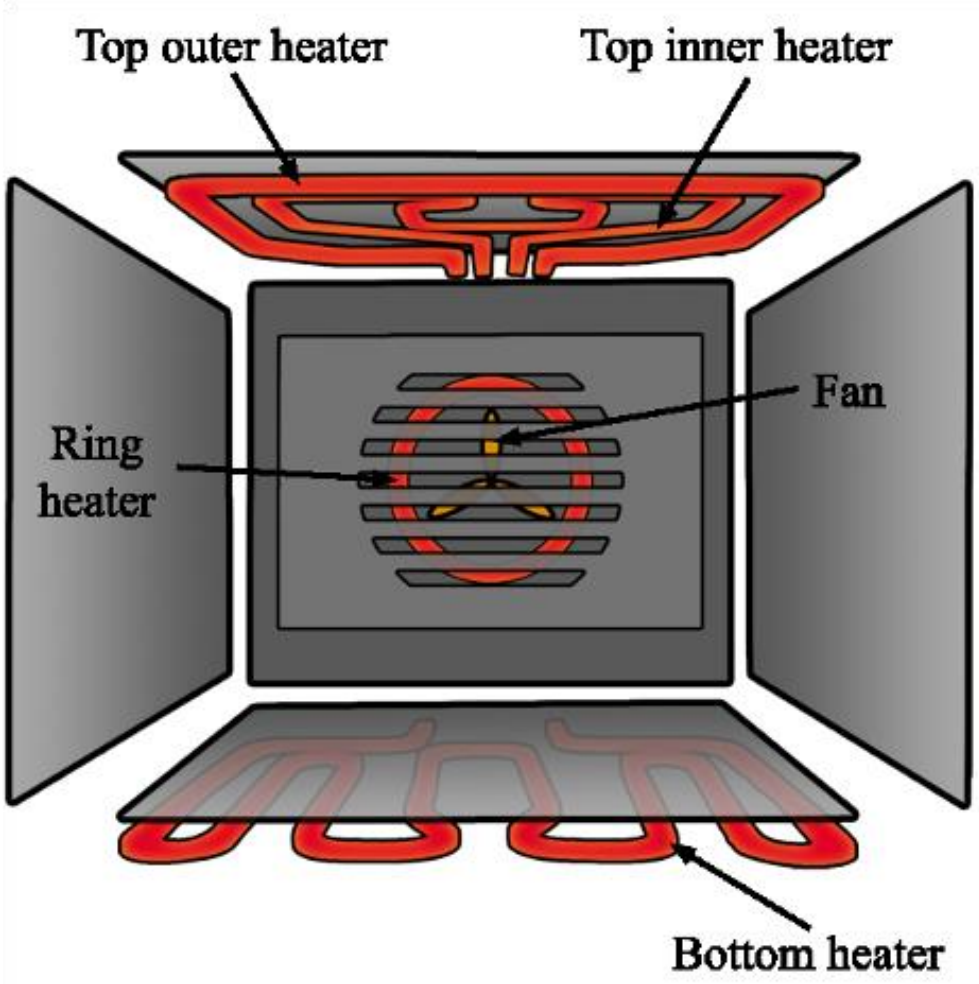


Figure 26. Oven's Heating Elements and Inner Cavity
The structure of the different heating elements and their positioning inisde the cavity (Laboreo et al., 2016).

This material offers exceptional thermal conductivity and dielectric resistance. Electric ovens typically offer a broad range of heating modes thanks to the nature of the energy source and its potential for temperature modulation.

4.2.4 Oven's control panel

In this analysis, an exclusive focus on the oven's control panel[8] is undertaken to examine this component (Figure 27). The control panel plays a significant role in user interaction and defines the usability of the entire appliance. Given the user-based approach advocated by Garvin (1984), the framework scrutinized

[8] the part of a machine or system that contains its controls Fare clic o toccare qui per immettere il testo.

by Sylidis, and the insights derived from Haier's design team research, it becomes evident that perceived quality, from the user's standpoint, is intricately linked with their initial interaction with the product. This is particularly crucial when users, such as those in retail settings, cannot physically test the product.

The research focuses on this specific phase of the oven's control panel, aiming to unravel the dynamics of user-product interaction and perceived quality by building on the insights gathered thus far. By narrowing the scope to this specific element, the goal is to delve deep into its design, functionality, and user interface. This approach enables a targeted response to the research question, fostering a comprehensive understanding of how the control panel aligns with user expectations and eco-design perceptions. As a critical interface between the user and the appliance, the control panel significantly influences the overall user experience, starting from the first approach the consumer has when seeing it for the first time or more when buying it in a reseller shop. This focused analysis aims to uncover insights into user perception, ease of use, and potential areas for improvement, ultimately contributing to the enhancement of the eco-design perceived quality of the oven, starting from an external and easy-to-see component that can open future scenarios for a whole approach to the product.

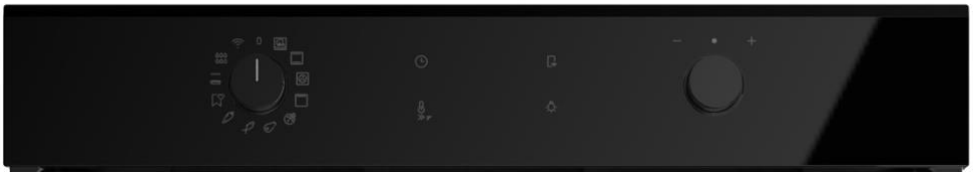


Figure 27. Haier Oven's Control Panel
A focus on the Control Panel with the knobs and icons for each functions.

5. Case studies analysis

In the chapter, an examination of recent product trends is presented. The selected products or concepts are subjected to scrutiny, with a focus on PQ and eco-design aspects. Following this analysis, detailed presentations of each chosen case study are provided. Subsequently, these products are incorporated into interviews with people of Gen Z to obtain valuable insights into their perspectives and preferences. This field research aims to offer a nuanced understanding of how these products align with PQ parameters and eco-design principles while also considering the preferences and expectations of the target audience, Gen Z.

5.1 Case studies selection

The case studies selection includes 20 case studies comprising products and concepts. This selection criteria were based on their presence at major events such as IFA Berlin Fair 2023 and Milan Design Week[9] 2023, or recognition through esteemed awards like IF Design Award[10], Green Product Award[11], and Red Dot Design Award[12]. The chosen products span the years from 2019 to 2023. Some products were identified using the keyword "Sustainability," while others were selected based on at least one of the sustainability-focused approaches highlighted in the design to ensure a more comprehensive exploration. Although the primary focus of this research is ovens, the analysis of these case

[9] An event in balance between the presence of the fair Salone del Mobile and that of the events spread throughout the urban area. An offer that connects quality to technology, the result of the best design companies' creativity, able to develop every year its own activity to innovation of products and living solutions (Studiolabo S.r.l., 2023).

[10] The iF DESIGN AWARD, with nearly 11,000 entries from 56 countries last year, stands as one the most prestigious design awards in the world. Owned by the non-profit iF Design Foundation, the award emphasizes design's global impact and ensures impartiality with our professional jury upholding strict screening criteria (iF Design, 2023).

[11] The international Green Product Award distinguishes products and services since 2013. It is aimed at projects on the market from start-ups and established companies. The Green Concept Award celebrates visionary concepts not on the market yet (Green Product Award, 2023).

[12] Red Dot Design Award is one of the world's largest design competitions. The Red Dot Label has become established internationally as one of the most sought-after marks of quality for good design (Red Dot, 2023).

studies seeks to unveil emerging market trends with substantiation from the design landscape and the prestigious design associations mentioned earlier.

From the first approach, the analysis of products in the contemporary market reveals, aligned with what has been seen so far, a growing convergence of technological innovation and environmental consciousness in the concepts and products. New products integrating IoT and AI, are designed with energy efficiency and resource conservation in mind to contribute to reduced environmental footprints or embed a new way of designing. Furthermore, consumer demand for such products is rising, indicating a shifting paradigm towards eco-conscious consumption. The research of case studies started from an analysis of possible products derived from already-mentioned trends: sustainability, smartness, and eco-friendliness.

This analysis selected the most recent product or the one with a specific focus on eco-design. After that, a cross-graph methodology was employed to evaluate and categorize products systematically based on four key parameters. The selection of these parameters aligns seamlessly with the research objective of analysing eco-designed products, highlighting the trend by other brands in the market and understanding their quality perceived impact. Therefore, the chosen parameters encompass the eco-design approach, perceived quality, and their respective opposites. This deliberate selection forms the basis of a quadrant framework designed for classification, facilitating a nuanced evaluation of products based on their eco-design strategies and perceived quality. These parameters include the eco-design approach, perceived quality, and their respective opposites, creating a quadrant framework for classification.

i. Eco-designed: Products falling within this category demonstrate a coherent eco-design approach, utilizing new recycled materials, innovative aspects in terms of user experience, efficient manufacturing processes, reduced number of components, or energy efficiency.

ii. Not eco-designed: Conversely, products in this category exhibit limited or no emphasis on an eco-design approach, often characterized by non-renewable resources, do not add a new user experience of the product, energy-intensive production, or a complex architecture in terms of components.

iii. High Perceived Quality: Products positioned here can be perceived as superior in quality by consumers. They may boast exceptional durability, advanced features, a good perception of the touch and feel, interesting and innovative technologies or materials, or a strong brand reputation.

iv. Low Perceived Quality: On the other hand, products categorized as having low perceived quality may lack durability, have basic features, old technologies, already seen materials or suffer from poor consumer reputation.

The cross-graph approach allows for a comprehensive assessment of products, classifying eco-design-driven and perceived quality-driven products as essential factors in their evaluations.

Following the initial product classification using the quadrant framework, the primary objective was to gain deeper insights into the products in the quadrant that best align with the study's goals, where eco-designed and perceived quality intersect. The three chosen case studies emerged as highly relevant to this research due to their incorporation of innovative aspects. These products are well-aligned to instigate new habits and enhance customer experiences with high perceived quality in eco-sustainability. They adopt diverse eco-design approaches, showcasing innovation in areas such as design for disassembly, providing real-time energy consumption information to users, and introducing inventive ways to communicate the use of recycled materials in household appliances.

The following sub-chapters will present these features for the chosen case studies. The product's company claim is introduced and subsequently examined. A dedicated analysis will also be presented, given the research focus on the control panel as a crucial product component. The chosen case studies include:

1. QuickSelect features a dishwasher interface function that incorporates an eco-sustainability parameter;
2. BESPOKE represents a product family with a specific focus on the washing machine due to its intricate control panel and robust Life Cycle Assessment (LCA) approach;
3. OLI is an unconventional concept car offering a novel user experience and various design approaches for sustainability, contributing to a notably high perceived quality.

Subsequently, the research will explore conducting interviews with Gen Z users to evaluate the case studies and extract new insights. This aims to validate the features and expectations associated with these products, offering a comprehensive framework that encompasses all the essential parameters for assessing Sustainable PQ.

5.1.1 Electrolux: examples of a new sustainable product function: QuickSelect

The company website presents the function: "Get into the groove – Electrolux QuickSelect nudges dishwashers towards sustainability" (Electrolux Group, 2020). In pursuing sustainability, using a dishwasher is more eco-friendly than hand washing due to reduced energy and water consumption. However, consumer behaviour research by Electrolux revealed a lack of understanding regarding conventional dishwasher cycle programs. The most energy-efficient option is often the most extended program, causing potential confusion. In response, Electrolux employed lean testing in the preliminary stages of product development, involving consumers in rigorous prototype testing. The outcome is an intuitive interface, allowing users to easily choose cycle length and additional options while the "Ecometer" provides audio-visual cues indicating the eco-performance of the selected setting. The company declared that QuickSelect has been highly appreciated by consumers, achieving a star rating of 4,7 to 5.

Figure 28. QuickSelect function by Electrolux
The Ecometer is visible in the left side of the dishwasher control panel (Electrolux Group, 2020).

By focusing on the control panel, the familiar functions are replaced by a slider integrated into the UI, featuring two parameters: Quick and ECO. The slider's design implies a scrolling action, with a bar indicating increased time as it

approaches the ECO function. Adjacent to this is an 'Ecometer' status bar on the left, progressing as time increases. Users do not have control over this display, but it visually represents the transition to the eco function, displaying a full green bar indicating responsible user behaviour. The control panel is straightforward, featuring a few buttons that enhance the clarity of interaction levels. The decision to use hollow geometry for the slider aids in perceiving the affordance of the product. A small screen displays the wash duration and the Ecometer bar. The panel's black colour aligns with other products in the same category, and the green of the Ecometer bar stands out. This approach signifies a shift in function selection, emphasizing eco-sustainability over traditional criteria like the type of dishes. It also reflects an educational approach, aligning with the recommendations of the European community.

The design approach to the product and the priority given to the eco-design approach effectively align with the EU regulations and the market's needs; at the same time, the product is designed to let the users know their impact on the environment, eventually leading to a behavioural change through this awareness. Electrolux decided to embed this eco-design approach in a function that clearly exemplifies the approaches proposed both by Vezzoli and European Commission, but is not perceivable its eco-design approach if the kitchen counter hides the UI.

5.1.2 Citroën: OLI

The initial observation pertains to the product's slogan: "Citroën OLI [all-ë], our radical, responsible and optimistic approach" (Citroën, 2023), and they continue saying that

> "Designing electric cars is good. But for us that's not enough. Our Citroën Oli [all-ë] concept car has been made as light as possible to consume as little electricity as possible while guaranteeing a range of 400km. It has been designed with recycled and recyclable parts to extend its life" (Citroën, 2023).

Figure 29. Citroen OLI concept car
The first image shows the external design of the car, the second present its layout inside (Citroën, 2022).

The homepage features a video presentation of the car, starting from discussing waste and pollution linked to plastic. The narrative revolves around the superfluous elements of cars, which Oli tries to contrast through its design, simplifying complex ideas into a minimalistic form. This challenges conventional notions of car design and suggests novel, unconventional uses, introducing intriguing possibilities for applying new materials and sustainability-focused design approaches (Citroën, 2022).

Citroën also emphasised the electric essence of this conceptual vehicle through its name, where OLI is pronounced [all-ë], aligning with the company's logo. While sustainability is not explicitly mentioned on the website, certain key principles of design for sustainability, discussed earlier, are evident. Concepts like lightness, involving the reduction of components and designing for disassembly, are highlighted to minimize energy consumption. Components like the on-board computer are notably streamlined, allowing connection through a smartphone instead of a dedicated screen. Additionally, detachable speakers reduce technological components, emphasizing longevity and facilitating easy replacement or interchangeability for repairs.

By focusing on the control panel: As previously highlighted, the control panel establishes direct communication with the smartphone, reflecting a design approach aimed at minimizing components and technology. Given that it is a conceptual design, limited information is provided, but the video vividly illustrates the emphasis on a novel user experience in interaction. A designated space is allocated for the smartphone to facilitate connectivity, discouraging its use while driving. Furthermore, the integrated display combines the odometer and dashboard with music and light information. The casing also serves as an integral part of the system, offering the potential to reduce components and optimize their function beyond the car. While the overall finishes align with current market products, the design's eco-friendly intent may not be visually apparent unless considering the entire product.

While being a conceptual vehicle, this car embodies numerous eco-design aspects. Its unconventional design sets it apart from the cars we are familiar with, aligning not only with an eco-sustainable approach but also with a perceptible representation of it.

5.1.3 Samsung BESPOKE: FuoriSalone 2023 exhibition

The Samsung BESPOKE appliance collection is introduced with a vision and commitment to sustainability, encompassing both environmental and social aspects. This commitment is visually represented through icons categorizing sustainability into "planet" and "people." The website emphasizes three primary product categories: washing machines, refrigerators, and air conditioners. However, this analysis focuses exclusively on the washing machine category, presented on the company website as: “The BESPOKE Grande AI Washer Journey: Before, During and After Your Use” (Samsung Electronics,2023); in the different section of the product’s life cycle they specify that most of the material comes from post-costumer recycled plastic used or minerals mined with respect for human rights and the environment, they had a transition to 100% of renewable energy, they use recycled packaging, the introduction of new technologies that

help reducing microfiber and e-waste programs for recycling. Furthermore, they continue declaring:

> "The ultimate aim of our sustainability efforts, seeks to help our customers join in our journey to contribute to more sustainable future of our planet through everyday activities" (Samsung Electronics, 2023).

During the Milan Design Week exhibition, these facets were showcased within a space that epitomized the various approaches adopted by the company, demonstrating its dedication to minimizing environmental impacts. The context was characterized by using raw materials and a colour palette leaning towards light blue, beige, and green.

Figure 30. BESPOKE washing machine by Samsung
On the left the whole washing machine, on the right the focus on the control panel (Samsung Electronics, 2023).

By focusing on the control panel, immediately noticeable is the colour, a serene grey-blue shade, a departure from the typical white or, at most, grey hues of most washing machines. However, no information regarding sustainability is discernible on the control panel, which is different from what is presented on the website or during the exhibition. The inscriptions related to technology suggest remote connectivity through an app and the incorporation of AI, yet no indications point toward eco-sustainability. Positioned at the centre is a satin-finished steel knob and the display alludes to the potential for control selection once the product is activated.

Examining this product family is intriguing due to the company's commitment to a sustainable footprint, its environmental concerns, and its focus on social aspects. The comprehensive Life Cycle Assessment (LCA) approach is implemented to provide users with detailed information, enabling a deeper understanding of the product and its alignment with eco-design principles. While the design for sustainability is notable, its clarity in terms of an eco-design approach may not be immediately perceived by users upon initial inspection; the interviews conducted and reported in the next section provide some insights into the perception of the sustainability of this product.

5.2 Field research on case studies: interviews with Gen Z users

The case studies outlined earlier underwent an interview process to assess the clarity of their intent and approach concerning eco-sustainability. The interview served the dual purpose of gauging the product's perceived quality by employing cluster-specific questions already embedded in Haier's PQ evaluation tool. Furthermore, potential project insights derived from the interviews will be considered to evaluate a novel approach and requirements for the proposed control panel concept to be presented subsequently.

5.2.1 Interview target and case studies presentation

The interview was exclusively conducted with individuals from Gen Z, aged between 23 and 25, irrespective of gender. It involved individual interviews with a sample size of 6 participants. No prior information or hints about the research topic were provided to ensure unbiased data collection.

The presentation of case studies followed the same sequence as before. For the QuickSelect case study, participants were shown a product interaction video, followed by questions aimed at gauging the clarity of the interface and the user's perception of the product's emphasis on environmental and energy efficiency aspects. Subsequently, the OLI case study was presented, accompanied by a video, and participants were asked specific questions to identify any perceived strengths in the product that highlighted its commitment to eco-design approaches and the introduction of a new user experience. For the final case study, as previously mentioned, the specific instance of the washing machine was showcased, attempting to display the Milan Design Week setup photos and assess whether users perceived the same sustainability theme in the product as created in the exhibition space. Annex 1 includes all the photos related to the BESPOKE case study.

The objective of this subsequent interview was to delve into the needs of Gen Z users and their perceptions of eco-sustainability drawn from the presented case studies. The aim was to formulate guidelines serving as tools for analysis and design through an eco-design approach. The data was collected, after the approval of the users, thanks to the recording of the voice and a consequent reanalysis thanks to the transcription of the collected material. The subsequent section outlines the insights from the project and how they were translated into parameters.

5.2.2 Interviews insights: understanding the perspectives of Gen Z users

Insights derived from interviews with the Gen Z sample are summarized below and categorized by case study. The most appealing aspect of the QuickSelect case study is the feasibility of having a function explicitly centred on energy consumption, which operates very clearly and smoothly. Initially, some users did not notice the Ecometer, but upon presenting specific pictures and asking more direct questions, users grasped the function of this parameter without requiring an explanation. This enhanced the clarity of the product's focus on eco-sustainability, with users describing it as a product that instils a sense of responsibility and awareness about dishwashing practices. No comments were made regarding incorrect use of colour or unexpected functions for the user.

Concerning the OLI machine, users expressed appreciation for the shift in habits and the novel way of interacting with the machine. They liked the connection between the reduction of components and the utilization of recycled materials with a minimalist approach, translating into a sense of modernity for the users. Some users raised safety concerns, possibly influenced by the inability to examine or test drive the car physically. However, the designated place for the phone that alters the car's infotainment[13] concept was well-received.

Samsung's BESPOKE case study evoked mixed reactions. While some users perceived the product as minimalist and modern, others likened it to regular washing machines. A notable concern was the discordance in colours, which some found disturbing when combined. The product was seen as technological and, therefore, energy-efficient, indicated by the lettering on the control panel,

[13] is used to refer to radio or television programmes that are intended both to entertain people and to give information. The word is formed from 'information' and 'entertainment' (Collins Dictionary, 2023).

although users could not explain its specific meaning or function. The knob received appreciation, but the absence of visible functions or other buttons led to confusion regarding how to interact with the control panel. Furthermore, while the design was acknowledged, users felt it did not adequately reflect the expected elements like raw, porous materials in light sand, green, light blue, or clearly recycled materials.

The insights from the interview were:

- Having a simplistic UI;
- Use of colours that clearly communicate their eco-sustainability;
- Use of raw materials that give a sense of roughness;
- Reduce the function and components at minimum;
- Reduce the technology, using other products that the users already have.

These insights underscore the target group's needs and contribute to the analysis of PQ concerning the eco-sustainability theme explored so far. They will also inform the development of the concept and parameters to be proposed later to answer the research question about how a sustainable design approach can effectively enhance the PQ.

5.3 Linking the interviews' insights on perceived quality to a sustainable approach

This last section of the chapter aims to establish connections with PQ and distil insights garnered from the interviews. The objective is to incorporate user needs emerging during the interviews and align seamlessly with the eco-design. This integrative approach serves as a foundation for conceptualizing a product that resonates with user expectations, harmonizes with PQ principles, and embodies sustainable design principles advocated by Vezzoli.

Ceschin et al. (2020) said that adopting eco-design practices necessitates a strategic approach to design decisions at the organizational level and a more comprehensive understanding of the systemic impact of these decisions. The proposed statement underscores the critical importance of integrating eco-sustainability considerations into the product development process. It implies that for effective eco-design, environmental considerations should be incorporated right from the initial stages of conceptualization and continue to influence every project phase.

Vezzoli (2016) talking about eco-designed products and their perception emphasizes that for an innovation to be truly environmentally sustainable, it's not enough; it must also be perceived as an improvement over unsustainable alternatives, necessitating aesthetic appeal. The term "aesthetics" here encompasses the intricate combination of features that make an object visually pleasing and ultimately satisfying. When discussing the aesthetics of sustainability, it involves envisioning a diverse array of aesthetics derived from sustainability values and manifested in various forms. In essence, it's not about a singular form but a plurality of forms, colours, and qualities that come together in interactions.

The statement indeed aligns with the essence of this research, which seeks to provide a comprehensive framework for the design phase, emphasizing an eco-design approach from the outset, but also a tool to evaluate a product even at the end of its design process. The goal is not just to create environmentally sustainable products but to ensure that they are perceived as improvements over non-sustainable alternatives. This involves considering aesthetics in a broader sense, encompassing a variety of forms, colours, and qualities, and integrating these aspects seamlessly into the design process. The research aims to contribute to a holistic understanding of eco-sustainable design, taking into account both the environmental impact and the perceptual aspects that make a product aesthetically compelling.

In the upcoming chapter, we will unveil a redesigned control panel, crafted through a process that commences with a thorough analysis of prevailing trends. Drawing inspiration from design for sustainability approaches carefully selected during the research journey, this redesign considers the parameters derived from user insights. The pre-existing PQ parameters, which will be subsequently outlined, serve as a foundation.

To ensure the robustness and effectiveness of the proposed control panel concept, a focus group will be convened. This gathered group will participate in validating the design by providing ratings and insights. Through this comprehensive approach, we aim to not only align with contemporary design trends and sustainability principles but also to integrate user perspectives and validate the Sustainable PQ parameters in a collective evaluation.

5.4 Sustainable Perceived Quality (SPQ) Parameters

Based on the clusters presented in "3.3 Haier Europe and its PQ Parameters" and informed by the findings in "5.2 Field Research on Case Studies: Interviews on Gen Z users," some parameters have been reworked and introduced to evaluate the SPQ of the product or guide its design, as done in this study in "6 The Concepts of an Eco-designed Oven's Control Panel." The purpose of these parameters is to create a new cluster dedicated to environmental sustainability that can be integrated with the existing clusters currently used by the company.

The parameters for the new SPQ cluster are presented in Table 9, maintaining the same structure as the current parameters. They are presented in the form of questions within a macro-category. As highlighted earlier, the SPQ parameters encompass some that were already existing or modified to align more closely with user needs, deriving from all the clusters previously addressed in "3.3 Haier Europe and its PQ Parameters" of: i. product design, ii. colour, material, finishing (CMF), iii. human factors, iv. user interface. This approach emphasizes that the concept of eco-sustainability should involve every aspect of the product to ensure high-quality delivery that reflects the user's expected quality.

Cluster	*PQ parameters*
Sustainability	i. Do you notice continuity and harmony in colour matching? ii. Do you notice any new material? iii. Do you perceive it's a sustainable material in terms of touch and feel? iv. Do you think its configuration (layout) is essential for its function? v. Do you understand why it is minimal? vi. Do you perceive it durable? vii. Do you think the technology is enough? viii. Do you think the UI is clear and essential for its functions? ix. Do you perceive it's a product designed with and eco-design approach? x. Do you think is coherent with eco-sustainability? (Reducing components, easy to disassemble, reducing waste, etc.)

Table 2. SPQ parameters.
In the table are presented the parameters by the analysis of the current PQ parameters, the novel ones are schematize under the new 'Sustainability' cluster.

The parameters thus analyse the CMF of the product, which is most closely tied to the sensory realm of touch and visible aesthetics for both appealing design and material durability. It then moves to the product's User Interface (UI), enabling an approach that reduces components and functions so that users can still benefit from the product while minimizing unnecessary or strictly utilitarian technology. Finally, aspects are closely related to approaches for environmentally sustainable design. This new cluster of 'Sustainability' introduced into the PQ parameters used nowadays by the company, needed to be validated. The next chapter presents how the validation was performed by developing some rough concepts and assess their SPQ through a focus group and by using the SPQ parameters. These research instances were fundamental to understand the SPQ parameters potentials and identify any weaknesses that can be addressed to provide a more accurate and consistent tool with the target the proposed theme.

6. Research through designing concepts of ovens' control panels: validation of SPQ parameters

This chapter focuses on introducing and deliberating upon a novel control panel designed for ovens. The primary objective is to elevate the PQ of the ovens through a sustainable product design approach. The intention is to test the crafted SPQ parameters. The subsequent sections elaborate on these parameters and present them for scrutiny in a focus group setting. The aim is to validate the efficacy and relevance of these parameters through constructive feedback and evaluation within the focus group.

6.1 Sustainable design approach chosen for guiding the concept design

Based on the conducted research, the analysis of Vezzoli's approaches and European community guidelines for eco-design and energy labelling, it can be inferred that adopting their introduced methods can lead to design constraints that will define the product in a more eco-sustainable manner. The relevant approaches identified based on the above are:

- minimizing material consumption,
- minimizing toxicity and harmfulness,
- optimizing renewability and biocompatibility.

The selected approaches are those found to be most consistent with the users' needs, as emerged during the interviews conducted for this research. They aim to achieve the set objective of enhancing the PQ of the product not only at an aesthetic perception level but with a more structured approach that allows for the adequate attribution of eco-design. Furthermore, the parameters derived from the PQ will be followed to clearly communicate to the user why their "distinct" appearance is compared to other ovens on the market. Therefore, straightforward user interfaces with few navigation levels are proposed, introducing a minimal number of functions to ensure a clear and visually clean layout.

6.2 The Concepts of an Eco-designed Oven's Control Panel

As described in the preceding chapter, this section aims to outline the process of idea generation in alignment with the constraints set by case studies, field user research, Vezzoli's guidelines, and CMF trends derived in the context of environmental sustainability. Regarding materials, the research has identified a sample of 5 materials, analysed in "6.1.1 Materials selection: study of sustainable materials", that will be used in the proposed concepts to enhance the PQ and align the product with Gen Z's values consistently with the chosen eco-design approach. A research-through-design approach was employed to answer the research question: how can the Perceived Quality of ovens be effectively enhanced through a sustainable design approach targeted at Gen Z? The aim of this design was to develop few rough design ideas of control panels based on the insights collected during the interviews in order to test the process of brainstorming, aimed at addressing the research question through the application of the chosen design process, considered the eco-design approach by incorporating Vezzoli's sustainable design principles and the pre-analysed materials. This process resulted in the development of five ideas characterized by the attributes mentioned above, as detailed in Table 8.

	Ideas	*Characteristics*	*Inspirations*
Interface design	Simplified UI	Few buttons, smaller display, e-ink display, heron	Logitech keyboard, e-reader
	Smart knob	Magnetic knob, connected smart knob, visible components	Midea SmartTap UX, NEFF TwistPad, Fairphone case, Nothing
	No UI	Lattice mesh structure, UI via app	Bicycle saddle, shoe sole
CMF design	Clear plastic	Making inner components visible	Fairphone case, Nothing
	Recycled & bio-composite material	Let the material showing its sustainable properties	Many products with recycled materials

Table 3. Ideas for concept development.
The tab contains the main idea that drove the construction of three distinct concepts, while the characteristics offers a more detailed aspects to provide information about each idea and its inspiration.

As described in Table 8, the five concepts each have a different focus and exemplify the needs derived from user interviews.

6.2.1 Inspirations for the concepts design

6.2.1.1 UI inspirations

For the UI part of the Control panel, some products were analysed that reflect the insights obtained from interviews with users, therefore interfaces that are essential but can guarantee the correct functioning of the product and a pleasant user experience of browsing the product. Subsequently, the individual inspirations for each concept will be explained and will characterize the control panel of each concept. Three products were chosen: the Logitech keyboard, the Midea smart knob and the use of the smartphone with magnetic charging to have a control panel without a physical UI. But also in terms of materials were used the inspiration of clear plastics like Nothing or Fairphone are doing in their product (Figure 35). More details are provided later in the section of each concept.

6.2.1.2 Colour, material and finishing inspirations

Reviewing the insights derived from interviews with Gen Z users, it becomes apparent that primary attention was directed towards the product's Colour, Material, and Finish (CMF), the User Interface (UI) and the overall user experience. However, these aspects were not immediately evident upon the initial interaction with the product but were grasped as users became more familiar with the function or the product as a whole. Sustainability concerns mainly surfaced concerning energy consumption but were not prominently emphasized during the initial encounter with the product. Consequently, the focus will be on selecting the most suitable combination of colours, materials, and finishes to provide a streamlined user experience. This approach will be based solely on essential control panel features and aims to convey an eco-sustainability ethos in the visual perception, irrespective of the viewer's proximity to the product.

Selecting the appropriate material is imperative not only for crafting a well-designed product but also for catering to the revitalized sensibilities of the public. A growing fascination with the expressive and sensory attributes of objects drives this. Consumers are increasingly inclined to engage with products tactilely, desiring to manipulate, touch, and experience them first-hand. Consequently, a quest is to enrich products with enhanced sensory qualities (Lerma et al., 2013). DeLong et al. (2012) explain how colour is a potent tool for conveying intricate information by eliciting emotional responses. Shape and colours are recognised before contents, following the sequence shape,

colour, and, only after, content. Green hues are often linked with numerous products and services, conveying sustainability messages. Despite its promotion as the colour of sustainability, green's primary association remains with the environment. Other relevant colours and their reasons for association are presented in Table 4 below.

Colour	*Association*
Green	Natural, environmental, colour of recycling symbol, media influence and advertisement, going green campaigns and slogans
Brown	Natural, environmental, earthy, recycled
Tan and beige	Natural, environmental, earthy, no dye, organic
Blue	Water, natural, environmental, earthy, recycled
White	Pure and clean, no dye, organic

Table 4. DeLong's colours association
Data on colours provided by DeLong et al. (2012).

Based on the information provided in this table, an in-depth exploration of CMF was undertaken at the Hida lab (2023), an online CMF Design library. Various mood boards have been found, incorporating the previously emphasized aspects of natural, earthy, or recycled colours and materials, displayed underneath in Table 5.

Trend name	*Description*
i. Modern Organic	Introducing the ethical and sustainable Vegan CMF Mood Board. The vegan leather, made from natural materials such as Korean paper, cactus, and mushrooms, has a classic look and a texture similar to real leather. Complete a natural and organic mood using composite materials from recycled seashells that produce a unique terrazzo effect and real stone sheets with natural textures.
ii. Green Vibes	A mood board composed of environmentally friendly CMF for an eco-friendly movement for the earth. Use it for an artless, simple, and eco-friendly mood made with various environmentally friendly CMF, including PCR-PET, a composite material made by recycling oyster shells and vegan leather.
iii. New Naturalism	A feast of colours and textures close to nature. Natural design that clearly and concisely shows the element of nature is gaining attention. Open-pored wood with natural wood grain texture and thin wood film are used as partial decoration elements of the product. The soft, shining stone is used as a design element in a larger area.

Table 5. Hida lab mood boards based on eco-sustainability.

Figure 31. Hida lab's mood boards based on eco-sustainability.
The mood boards are here visually presented in order as described in Table 5. exemplifying their CMF trends (Hida lab, 2023).

In a study, Sossini et al. (2022) analysed the perception of the aesthetics of various products and materials by asking 135 respondents to choose the most sustainable based on visual perception. The products recognized as sustainable were those with natural colours, imperfections, and visible inclusions. Another set of images presented material samples, including bioplastics, bio-based resins with fibres, and one recycled fossil-based plastic. Earthy colours, rough and irregular surfaces, and natural colouring characterized sustainable materials. Additionally, composites with natural-coloured fibres and recycled materials with coloured inclusions resembling fossil-origin were identified. This suggests two ways sustainable materials can be presented: by showcasing their 'imperfect' and irregular nature or by mimicking traditional natural materials while concealing their source. However, both approaches may not effectively communicate with consumers. Materials emphasizing their

naturalness often focus on green aesthetics, which may not always be appreciated due to associations with low-quality but high-cost concepts. This study, supported by Hida lab mood boards (Figure 31) visually illustrate and confirm how the sustainability trend is complemented by colours and materials reminiscent of nature, serving as a starting point for a brief and focused investigation into eco-sustainable materials.

The research has identified five materials selected for the characteristics, as detailed in Table 6, more technical data are present in Annex 2. The selected materials were found on MaterialDistrict (2023) (for materials i, ii, iii, iv) and on the European Circular Economy Stakeholder Platform (2019) (for material v) by using the filters renewable and natural materials. The choice of materials was guided by Vezzoli's approach of increasing the use of recyclable, recycled or biocompatible materials. Furthermore, from the insights of the interviews with users, the need to have material that could be perceived as such as much as possible emerged. So the search used the filter of: sustainable, renewable, recycled. Subsequent development will have to evaluate not only the technical feasibility of using these materials and any production limitations, but also a tactile user test of the material to ensure a good touch and feel of the selected material. The materials samples are presented in Figure 32 to convey the conferred alignment and perception of eco-sustainable materials visually.

Material name	*Producer*	*Description*
i. Heron	Smile Plastics	A small-run production, innovative techniques, and hand-prepared approach form a unique assortment of unusual and distinctive sustainable textures. Eco friendly materials are full of creativity and individuality, perfectly suited to a multitude of applications.
ii. Tefor	ABET	Obtained from recycled manufacturing wastes. The recycled laminate is made of thermoplastic polymers and cellulose fibres, impregnated with thermosetting resins at different degrees of polycondensation
iii. Solanyl	Rodenburg Biopolymers	Solanyl is a smart series of biobased and biodegradable end compounds mainly based on reclaimed side stream starch from potato processing, industry grain, root, seed and/or flour based resources. A renewable and biodegradable substitute for plastic.
iv. Arboskin	Tecnaro	This bio-plastic consists of over 90% bio-polymers, and a little under 10% is a mix of inorganic mineral compounds.
v. Cofeefrom bio, eco or strong	Coffeefrom	A thermoplastic materials in which the recycled coffee grounds constitute a new input. Mainly suitable for injection molding, our pellets adapt to several application contexts. Divided in bio, eco and strong for different percentage of PLA or polyethylene in the compound.

Table 6. Relevant recycled or bio-compatible materials selected.
The description provides details for each material, offering a comprehension of its type and key characteristics.

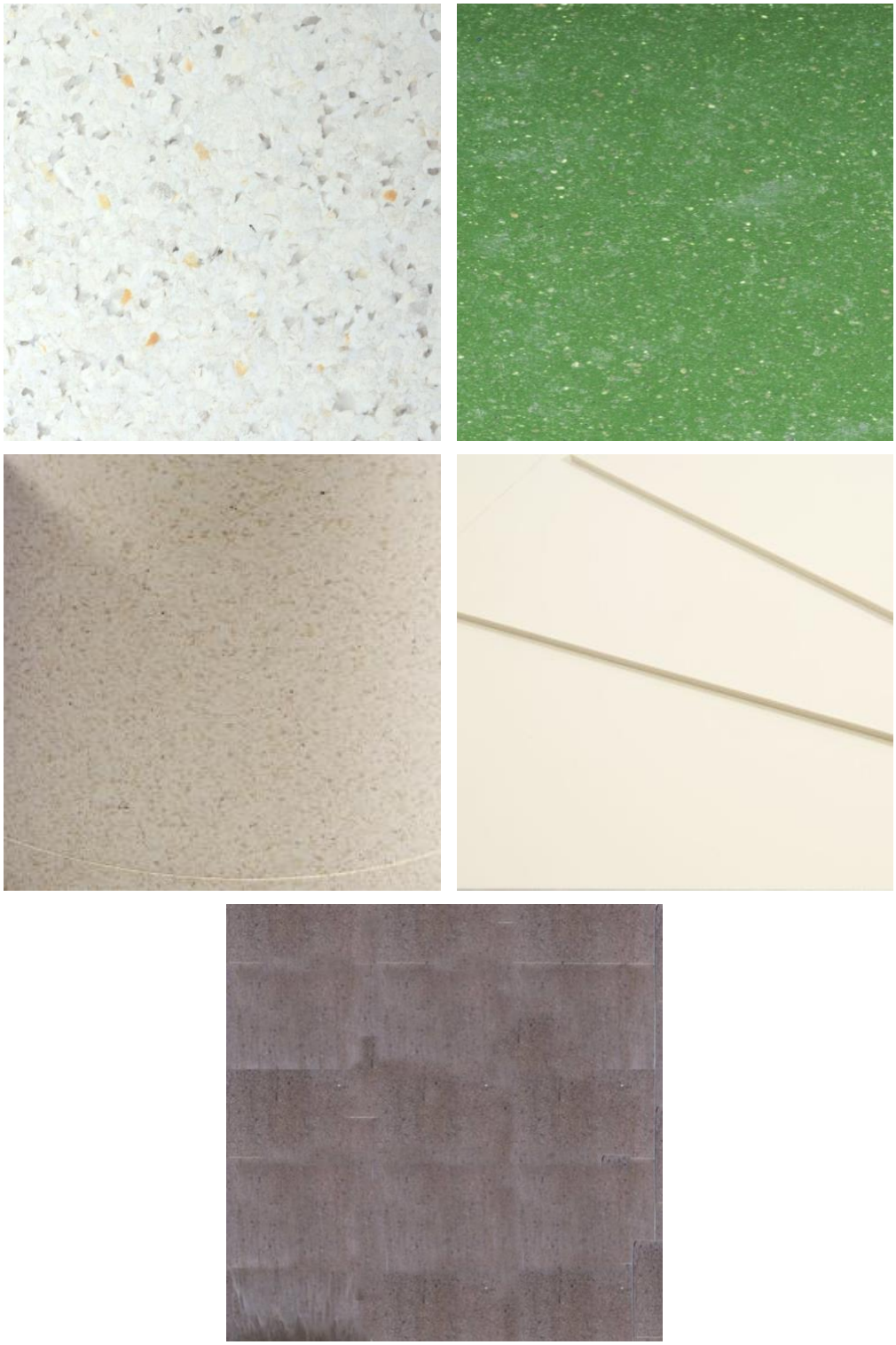


Figure 32. Five sustainable materials selected.
The materials presented in Table 6 are shown in the figure in the same order, starting from the first on the left. i. Heron, on the right ii. Tefor, on the second row iii. Solanyl and iv. Arboskin to the last v. Coffeefrom. Retrieved by (Coffeefrom, 2023; MaterialDistrict, 2012, 2014a, 2014b; Smile Plastic, 2023)

As previously highlighted, these materials, owing to their characteristics aligned with eco-sustainable approaches, can enhance the PQ of the product and, more prominently, convey the eco-sustainability of the product, introducing a shift in people's habits and mindset. Additionally, this aligns with the research's target audience as previously investigated in the CMF trends, aligning with the insights from the interviews described in "5.2.2 Interviews insights: understanding the perspectives of Gen Z". Subsequent phases of the research will centre on the chosen material, evaluating it regarding engineering aspects such as manufacturing, food contact, or temperature. Nonetheless, at this juncture, these considerations are not deemed imperative for the specific objectives of the current study.

6.2.2 Concept A: Simplified UI and recycled plastic control panel

The concept is centred around simplifying interaction by reducing buttons, creating an interface with a straightforward and analogic layout inspired by the Logitech keyboard in Figure 33. It utilizes an e-ink display to decrease energy consumption and let the display last longer (Saghar et al., 2023), applying Vezzoli's approaches as the material is bio-compatible with a CMF corresponding with the analysed trends, but also reduction in interaction with the product makes it easier, leading to a decrease in technical components and achieving a miniaturization of the display, see Figure 34.

Figure 33. Logitech Keyboard K780
The keyboard presents a simplistic layout with rounded shapes. The material suggests the usage of a recycled one giving the perception of sustainability (Logitech, 2023).

Figure 34. Concept A: Simplified UI and recycled plastic control panel.
The picture represents the novel control panel on a current cavity's oven.

6.2.3 Concept B: Smart Knob and Transparent control panel

The concept is based on a smart knob, proposed by Midea (iF Design, 2020) which can be easily connected to regular household appliances to enable artificial intelligence functions and engaging voice interactions. The interaction is inspired by those used by competitor companies such as NEFF or Samsung (Figure 33). This allows for an enhanced user experience not only through integration with multiple kitchen appliances but also by reducing the number of knob components. It aims to consolidate to a single connected device with a display, thereby minimizing the number of product displays. Drawing inspiration from brands like Fairphone or Nothing (Figure 35), recycled and transparent plastic is employed to increase visibility of internal components. This design choice aims to involve the user in understanding what lies behind

the control panel, potentially facilitating disassembly for repair or product disposal, in line with the design principles advocated by Vezzoli, see Figure 36.

Figure 35. Inspirations for Concept B
Starting from the right is shown the NEFF TwistPad, the clear cover of Fairphone that shows the inner components, The SmartTap Ux by Midea and the Nothing earphone with visible components (Fairphone, 2018; iF Design, 2020; NEFF, 2014; Nothing, 2023).

Figure 36. Concept B: Smart Knob and Transparent control panel.
The Midea's knob is applied on the control panel as it substitute the physical UI.

6.2.4 Concept C: Zero UI and Meshed control panel.

The concept C is based on the applied concept found in various products such as shoes or bicycle saddles (Figure 37), where a lattice structure is utilized to decrease the material percentage in the product, thanks also to the new manufacturing processes such as additive manufacturing (Eplus 3D, 2023), allowing for distinctive shapes (Figure 38). Furthermore, considering users' expressed interest in a product incorporating technology from other products they already possess, this concept incorporates the phone into the control panel using magnetic connection, integrating the mobile device into the product, and assigning it a specific position during cooking. Therefore, the strengths of the concept lie in reducing the material percentage used, minimizing technology by utilizing functions through an app and delegating them to another device that integrates seamlessly.

Figure 37. Lattice structure applications.
On the left the 3D structure is applied to a bicycle saddle, on the right an Adidas shoe's sole with the same concept (Howarth, 2015; Yanko Design, 2022).

Figure 38. Concept C - Zero UI and Meshed control panel.
The concept uses the magnectic attachment to give an addressed position to the smartphone that can be connected via bluetooth to the Haier hOn app for remote contorol of the oven.

6.2.5 Variations

Other variations were created based on the concepts A, B and C, presented in Figure 39, 40 and 41. with a different proposal of material CMF of the already presented versions. The choice to create variants of the concepts already presented arose from the possibility of evaluating new avenues for possible future development, furthermore were investigated in the focus group, after having presented each concept in its details of usability, choice of materials and eco-design approach could be perceived differently and some interesting ideas could arise to confirm or deny what was previously investigated. The variations take up some of the concepts already investigated such as the use of transparent plastic (for the variation of concept A) which allows the visualization of the components inside and can facilitate the design for disassembly in a product disposal or repair phase, to extend its life cycle. The variation of proposal B varies the material which is not transparent but a plastic such as Tefor. The latest proposal uses Coffefrom and aimed to investigate whether the effect of the material could coherently communicate its eco-sustainable approach without ineffectively maintaining a high perception of quality for the application context.

Figure 39. Concept A variation with clear plastic.
Here is shown the concept A as a second possible variation with another colour for the selected material.

Figure 40. Concept B variation with green rough recycled plastic
Here is shown the concept B as a second possible variation with another colour for the selected material.

Figure 41. Concept C recycled & bio-composite material.
Here is presented the concept (iii) with a variation using the Coffeefrom material

All these concepts have been subsequently tested in a focus group, aiming to validate the parameters created to assess the SPQ by presenting these concepts, which are already designed with project requirements based on an eco-design approach, and with the goal of assisting in conducting the user test. Particular enthusiasm was aroused by the variation C, one of the designer through the test said:

> "I like the material made from coffee, I imagine it rough, I find it interesting, I would remove the black part and do everything with that material".

As has been said, this analysis could open up future considerations for the implementation of variations and further validations

6.3 Testing the concepts by using SPQ parameters

6.3.1 Focus Group with Gen Z Designers

As previously indicated, the concepts presented in "6.2 The Concept of an Eco-designed Oven's Control Panel" were conceived to test the SPQ parameters outlined in "6.3 Testing the concepts by using SPQ parameters". The decision to conduct the focus group exclusively with individuals from Gen Z was made to ensure a grasp of the needs derived from the prior research and a comprehensive understanding of the project theme. Moreover, the choice was made to select only a group of designers to facilitate a more creative discussion on the topic and engage in direct comparisons regarding user expectations related to the theme. The focus group involved six designers (n=6) with diverse backgrounds in Industrial Design, User Interaction and User Experience Design, or Design and Engineering.

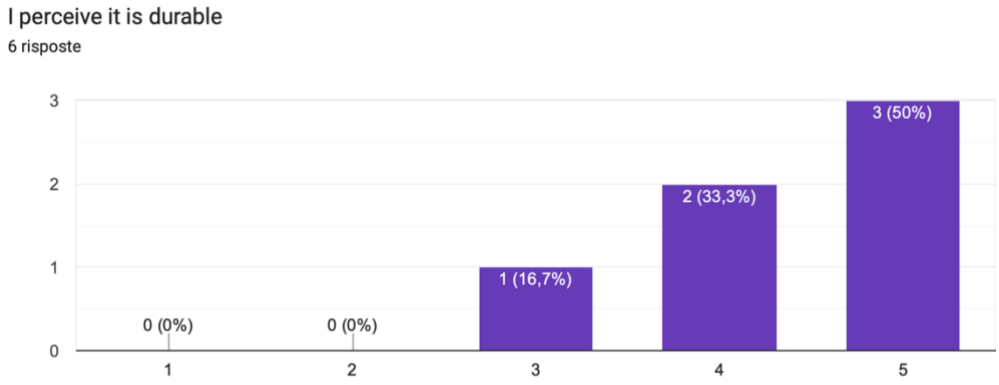
Initially, the theme was introduced, aiming to minimize bias by providing only general information without delving into the research topic. Subsequently, the current production product was presented, emphasizing that the research would focus on redesigning the control panel as the primary distinguishing element of the product with which users interact the most. Then, a questionnaire was administered where, instead of presenting parameters as questions, they were formulated as statements. Participants were required to evaluate each concept on a scale from 1 to 5 for each parameter, where 1 indicated complete disagreement and 5 signified total agreement. This approach was repeated for all three concepts to obtain validation on which users perceive as superior in terms of SPQ. After the questionnaire, each concept was presented in detail, and participants were asked for positive and negative feedback for each, viewed as potential enhancements to the concept. This prompted further discussion to thoroughly explore the perceived aspects of each concept.

Finally, certain concepts that were initially rejected were revisited, and potential aesthetic and CMF variations were introduced to gather additional feedback for

potential improvements to the concept. The next section delves into the analysis of the focus group results.

6.3.2 Findings on concepts and SPQ parameters

For a detailed analysis of the questionnaire results during the focus group and the specific outcomes for each concept and its parameters, refer to Annex 3 for more details on the test results; here only the main findings are reported. The focus group highlighted that a comprehensive redesign approach to the product can better emphasize the intent related to SPQ. However, it was observed that the first presented concept, depicted in Figure 34, was perceived as the strongest. It was deemed the most durable with superior colour matching (Figure 43), where the material itself exhibited greater clarity in presenting as innovative, specifically applicable to eco-design. The e-ink display was highly appreciated for energy efficiency, and the overall more analogue interface aligned with a more eco-sustainable concept. Negative feedback pertained to the UI, which was deemed lacking due to the absence of a confirmation button. It was suggested to swap the 'selection' and 'on/off' buttons for a simplified layout.



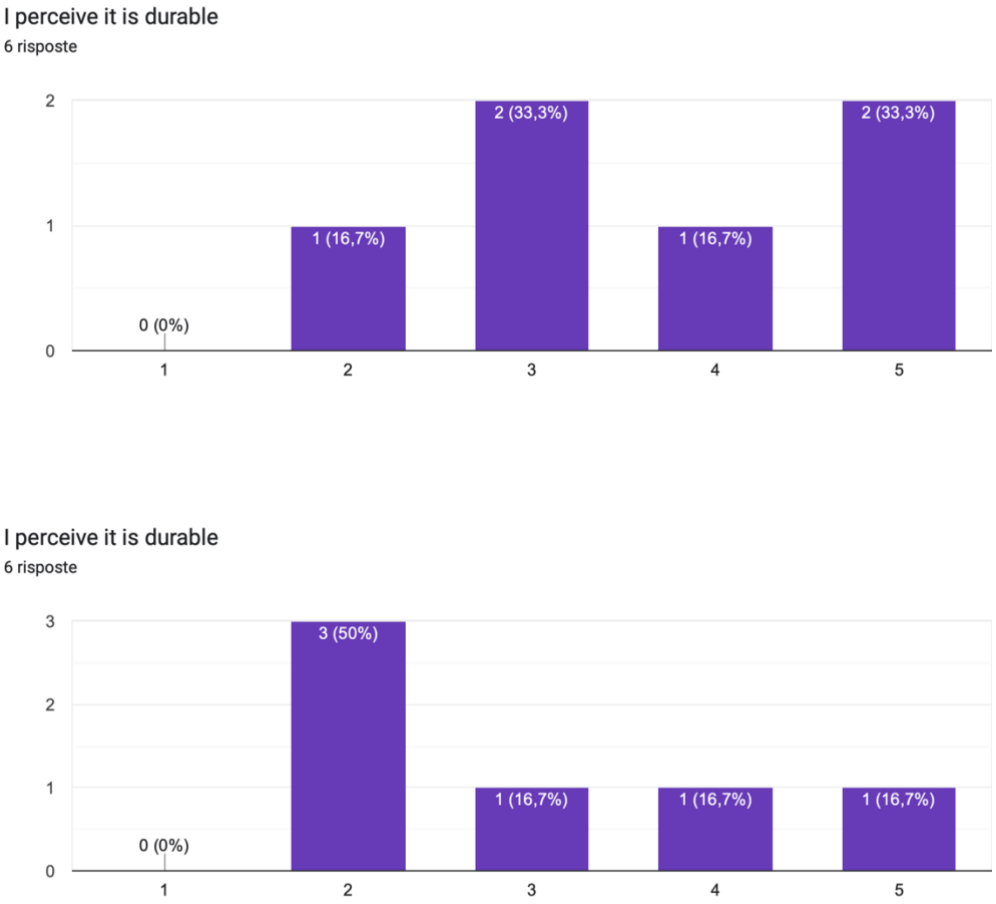
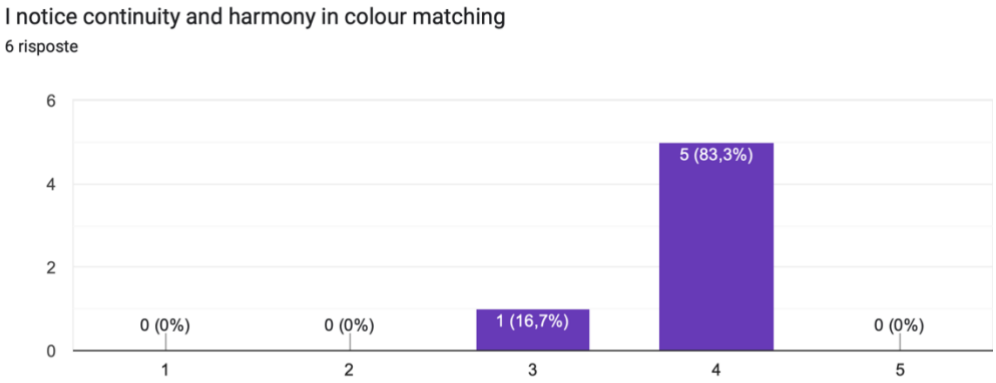
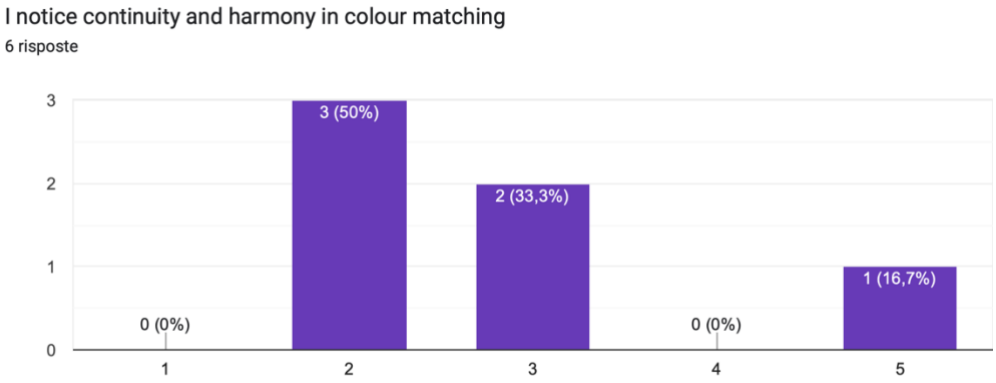


Figure 42. Data from the evaluation on concepts of the durability by SPQ parameter. In order from the Concept A, B, C are presented the results from the focus group with designer given evidence of the durability given by the concept A.





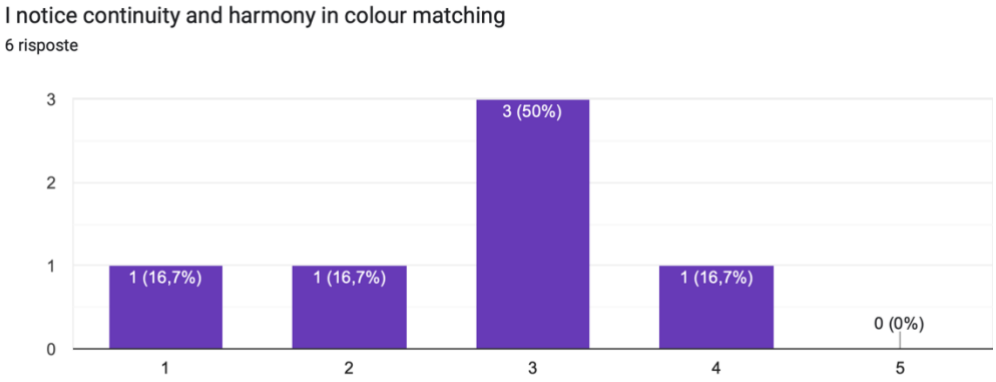


Figure 43. Data from the evaluation on concepts of the colour matching by SPQ parameter.

In order from the Concept A, B, C are presented the results from the focus group with designer given evidence of the higher match in terms of CMF.

As for the concept B (Figure 36) it was perceived as lacking dimensionality, and the transparency of the material created a sense of mismatching for the overall product. The material was perceived as less eco-friendly than the previous one. While it was seen as minimalist, it was deemed too essential, compromising the product's usability, especially due to the magnetic and smart knob, which was viewed as tedious in use for multiple kitchen preparations and less aligned with a concept of durability.

The concept C (Figure 38) received the least appreciation; the lattice was seen as unfriendly for product cleaning, rendering it unsuitable for kitchen use. Mismatching was sensed due to the voids generated by the structure. The layout was inconsistent with the product, causing interaction challenges. It was perceived as maximalist rather than minimalist due to the redundancy of hole geometry. Additionally, it was seen as less durable and more of an aesthetic rather than functional or eco-design-oriented solution.

Regarding the last variations evaluated, the concept utilizing plastic derived from coffee production waste (Figure 37) was found intriguing in terms of touch and feel, besides being appreciated for its eco-design-oriented approach. It was suggested to have the entire control panel made of that material for increased overall harmony. The second (Figure 38) was considered conceptually aligned with Gen Z but lacked justification for the choice of material transparency. The third (Figure 39) was liked for its almost irreverent pop concept, even in usage, leading to considerations about potentially removing the control panel to entirely change the product's user experience by just using the smart knob.

From this focus group experience, it can be inferred that the parameters allowed a proper product analysis, revealing the first proposal as stronger than the others. The concepts, generated from user insights and research, proved effective in creating a concept coherent with user expectations. The next section highlights potential improvements for smoother and more detailed product analysis or design based on these findings.

6.4 SPQ parameters improvements based on findings

Following a subsequent analysis of the data collected at the end of the focus group, it was revealed that, from the discussion that ensued after evaluating the concepts through the questionnaire, the parameter (iv) “Do you think its configuration (layout) is essential for its function?”, was insufficiently illustrative and caused confusion with the distinction from parameter (viii) “Do you think the UI is clear and essential for its functions?”, as it is also related to

the UI. Consequently, it was decided to divide parameter (iv) based on the user's interaction levels with the UI. Thus, the new parameters, presented in Table 10, will investigate these aspects, starting from the powering on and off the product, confirming the selected cooking function, selecting the temperature, and finally, confirming the set parameters. Furthermore, parameter (viii) in the Table 9 was removed, as it proved to be indistinct from the preceding (iv) and did not generate different investigative insights.

Cluster	*PQ parameters*
Sustainability	i. Do you notice continuity and harmony in colour matching? ii. Do you notice any new material? iii. Do you perceive it's a sustainable material in terms of touch and feel? iv. Do you think its configuration (layout) is essential for turning it On/Off? v. Do you think its configuration (layout) is essential for selecting a function? vi. Do you think its configuration (layout) is essential for selecting a temperature? vii. Do you think its configuration (layout) is essential for confirming? viii. (If it is) Do you understand why it is minimal? ix. Do you perceive it durable? x. Do you think the technology is enough? xi. Do you think the UI is clear and essential for its functions? xii. Do you perceive it's a product designed with and eco-design approach? xiii. Do you think is coherent with eco-sustainability? (Reducing components, easy to disassemble, reducing waste, etc.)

Table 7. Updated SPQ parameters.
After the focus group the parameters presented here have been updated according to what emerged throught this user's validation.

These new parameters clarify certain aspects that were ambiguous during the evaluation process, as revealed by the outcome of the focus group. Thus, with the addition of the new parameters (iv, v, vi, vii) in Table 10, the old one (iv in Table 9) is further specified, mitigating the confusion it previously caused. Further validation of these parameters will occur through the expertise validation in the subsequent chapter.

6.5 Expert Validation: Concept Matrix using SPQ parameters

To obtain validation from Haier Europe, the inquiry arose regarding the feasibility of validating parameters in the absence of a tangible product for assessment. The recommendation by the expert involved in the research, that is the co-supervisor of the thesis, was to employ the Concept Matrix model, a tool routinely utilized in the design phase by the R&D department before initiating supplier exploration. This tool facilitates a comparative visualization of the existing scenario and the envisaged project, substantiating the inquiry through evidence based on the specified parameters. This chapter elucidates the Concept Matrix and subsequently employs it in appraising the proposed new control panel concept to ascertain its comparative advantage over the baseline case.

6.5.1 Concept Matrix: What Is It and How It Works

The Concept Matrix is employed by the R&D team within the company to assess a comparative status of its own products or design solutions, which may be based on competitor products or internal company products. This analysis also involves prioritizing certain evaluation parameters that carry different weights depending on the necessity of that function. This prioritization is done by assigning a numerical value to each parameter, the sum of which must equal 1. Since the analysis is comparative, a baseline product is chosen, to which a score of 0 is assigned for each parameter. The product or function associated with the baseline becomes the product for comparison as an improvement or detriment by assigning a score for each parameter. Once the value is assigned to the parameters, they are multiplied by the weight assigned during the comparison phase. The outcome of the conducted analysis result in a score for each analysed product or function that can be greater or less than 1. From this value, it will be easy to determine how much the compared solution is an improvement or detriment compared to the 'baseline'. This validation tool suggested by the R&D team will be applied to the concept designed in this research to compare and validate the parameters identified in Table 10, to evaluate the SPQ.

6.5.2 Evaluating the Concept of The New Control Panel with a Concept Matrix by The Sustainable Perceived Quality Parameters

As mentioned earlier in this section, the aim is to analyse the redesigned control panel concept using the Concept Matrix proposed by the company to conduct a comparative analysis of the new eco-designed control panel compared to that of the new Haier S2 (Figure 40) oven platform and a competitor. Thus, the

control panel will be evaluated as a single component and the subject of analysis for the three oven models. The chosen competitor is the Anträtta (Figure 41) model resold by IKEA, as it has been identified by the company as a potential client for the proposed redesign in this study, aligning with the demands and user base of this Swedish multinational. Additionally, it stands out among the options for an A+ energy class and a medium-high price range, allowing for a meaningful comparison.

Figure 44. Haier S2 Oven.
The new Oven platform considered as baseline for this Concept Matrix evaluation

The Haier S2 model has been chosen as the 'baseline,' being the starting point for the redesign in this research. Various weights have been assigned to each evaluation parameter, giving a higher score to those parameters considered more critical for the investigation.

Figure 45. IKEA Anträtta Oven.
The model of oven selected by the expeter for the validation of the parameters by the comparison between the baseline and the redesign (IKEA, 2023).

The parameters have been assigned an 'importance score' of 0.15, 0.1, 0.075, and 0.005, and they are distinguished by three different colours based on their importance: high, medium, and low (Table 11).

Low importance	0,0075
Midium importance	0,05
High importance	0,1 / 0,15

Table 8. Colours legend for parameters' importance
The associated colours are presented in correspondance to the level of importance

In Table 12, the assigned scores of importance and the respective colour legend are visible, while Annex 4 contains the entire Concept Matrix. To link the Concept Matrix to the PQ evaluation tool used by the company, it was decided to add a column to provide a score from -3 to +3, as in the PQ tool presented in "3.3 Haier Europe and its PQ parameters" in Figure 17. This score will be evaluated in comparison to the 'baseline' and multiplied by the assigned weight to obtain the 'grade'. So, each parameter will have a 'score of importance' based on Table 11 and this value will be multiplied by the 'score' from -3 to +3 given for each product under analysis and then 'grade' will be the result of the weight for each parameter. The total of the 'grades' will be the result of the analysis for each product by a value positive or negative respect to the baseline.

SPQ parameter		Score of importance
i.	"Do you notice continuity and harmony in colour matching? "	0,075
ii.	I notice a new material	0,1
iii.	In terms of touch and feel do you perceive it's a sustainable material?	0,1
iv.	Do you think its configuration (layout) is essential for turning it On/Off?	0,05
v.	Do you think its configuration (layout) is essential for selecting a function?	0,05
vi.	Do you think its configuration (layout) is essential for selecting a temperature?	0,05
vii.	Do you think its configuration (layout) is essential for confirming?	0,05
viii.	(If it is) Do you understand why it is minimal?	0,05
ix.	Do you perceive it is durable?	0,1
x.	Do you think the technology is enough?	0,075
xi.	Do you perceive it's a product designed with and eco-design approach?	0,15
xii.	Do you think is coherent with eco-sustainability? (Reducing components, easy to disassemble, reducing waste, etc.)	0,15

Table 9. SPQ parameters with the assigned score of importance
The colours are associated with the importance giveng to the parameter and its consequent score on the right column.

For a more impartial judgment in evaluating the proposed Haier ECOven concept, it was decided to start with the scores obtained from the questionnaire during the focus group (Annex 2), calculate the average results for each value, and bring it to a scale from 1 to 7 to align with the -3 to +3 evaluation method used by the company. For the Anträtta oven, the parameter evaluation was conducted based on the baseline.

SPQ parameter		Score of importance	Score	Grade
i.	Do you notice continuity and harmony in colour matching?	0,075	1	0,0750
ii.	I notice a new material	0,1	3	0,3000
iii.	In terms of touch and feel do you perceive it's a sustainable material?	0,1	2	0,2000
iv.	Do you think its configuration (layout) is essential for turning it On/Off?	0,05	2	0,1000
v.	Do you think its configuration (layout) is essential for selecting a function?	0,05	2	0,1000
vi.	Do you think its configuration (layout) is essential for selecting a temperature?	0,05	1	0,0500
vii.	Do you think its configuration (layout) is essential for confirming?	0,05	-1	-0,0500
viii.	(If it is) Do you understand why it is minimal?	0,05	2	0,1000
ix.	Do you perceive it is durable?	0,1	2	0,2000
x.	Do you think the technology is enough?	0,075	2	0,1500
xi.	Do you perceive it's a product designed with and eco-design approach?	0,15	2	0,3000
xii.	Do you think is coherent with eco-sustainability? (Reducing components, easy to disassemble, reducing waste, etc.)	0,15	2	0,3000
			Total grade	**1,825**

Table 10. The Redesign proposal evaluation by SPQ parameters and their scores of importance
The SPQ parameters received a score based on the value from -3 to +3 (Figure 17) and the 'grade' is the result by the weight of each parameter and the 'score'.

The analysis outcome reveals that the control panel proposed in this research has an improved score of +0.825, while Anträtta (Table 14) has a deteriorating score with a final 'grade' of -0.575 compared to the 'baseline'.

SPQ parameter		Score of importance	Score	Grade
i.	"Do you notice continuity and harmony in colour matching? "	0,075	-1	-0,0750
ii.	I notice a new material	0,1	0	0,0000
iii.	In terms of touch and feel do you perceive it's a sustainable material?	0,1	-2	-0,2000
iv.	Do you think its configuration (layout) is essential for turning it On/Off?	0,05	-1	-0,0500
v.	Do you think its configuration (layout) is essential for selecting a function?	0,05	-1	-0,0500
vi.	Do you think its configuration (layout) is essential for selecting a temperature?	0,05	-1	-0,0500
vii.	Do you think its configuration (layout) is essential for confirming?	0,05	0	0,0000
viii.	(If it is) Do you understand why it is minimal?	0,05	0	0,0000
ix.	Do you perceive it is durable?	0,1	-1	-0,1000
x.	Do you think the technology is enough?	0,075	-2	-0,1500
xi.	Do you perceive it's a product designed with and eco-design approach?	0,15	-3	-0,4500
xii.	Do you think is coherent with eco-sustainability? (Reducing components, easy to disassemble, reducing waste, etc.)	0,15	-3	-0,4500
			Total grade	**-1,575**

Table 11. Anträtta evaluation by SPQ parameters and their scores of importance.
The SPQ parameters received a score based on the value from -3 to +3 (Figure 17) and the 'grade' is the result by the weight of each parameter and the 'score'.

This Concept Matrix analysis confirms that the control panel reflects an eco-design approach consistent with the needs of Gen Z, as previously indicated by the focus group conducted to validate the parameters and the concept. Furthermore, it emerges that the SPQ parameters, through this analysis tool, enable both detailed design and analysis to measure the level of SPQ, providing

detailed values for each parameter, allowing for a comparative evaluation of the product.

7. Conclusion, limits and future implementation

In the corporate context, this analysis initiates supplier research to validate various product components and the product's technical feasibility in parallel with the team of technicians and mechanical designers. However, this research concludes at this stage, verifying the improvement compared to the initial state and applying an eco-design approach to provide a SPQ evaluation tool to enhance the product's value in line with Gen Z preferences. Additionally, the conducted research has offered another perspective within the company on sustainability, illustrating its alignment with the needs of tomorrow's consumers. The investigated tool aspires to serve as a design and analysis instrument during the product development phase, aiming to consider the necessary requirements for delivering a product that reflects market expectations. Thus, this tool amalgamates expertise from various company sectors such as marketing, design, and R&D, fostering collaboration to generate a product that fully embodies all PQ parameters and remains innovative in the market.

The importance of designing environmentally friendly appliances has been emphasized multiple times, driven not only by trends but by a need related to pollution arising from production and its environmental consequences. Consequently, it is crucial to focus not only on one aspect of sustainability design, but products designed for the coming years should incorporate a comprehensive Life Cycle Assessment (LCA) approach. This is essential for achieving the 2030 European goals, perhaps even ahead of schedule, to cultivate corporate expertise that can attract the Gen Z target audience to purchase these appliances. Given that Haier Europe already has 2025 goals for the circular and sustainable economy, this new tool aligns with and opens new project scenarios to contribute to achieving this milestone.

Nevertheless, the limitations of this tool may be identified in the method of conducting field research. The small sample size of interviewees may limit the accuracy of collected data, which could be addressed in a subsequent research development. The testing methodology could also be modified and enhanced, for instance, by explaining the concepts before presenting the questionnaire to interviewees to gauge if product interaction becomes clearer. Alternatively, validating the concept using a 1:1 scale prototype might have provided insightful design inputs, particularly concerning user experience and CMF. Furthermore, the Concept Matrix employed at the end of the process to compare products lacked final validation; thus, for further testing of SPQ parameters, a new questionnaire with updated parameters and a comparison of the three oven models could be presented to a larger sample.

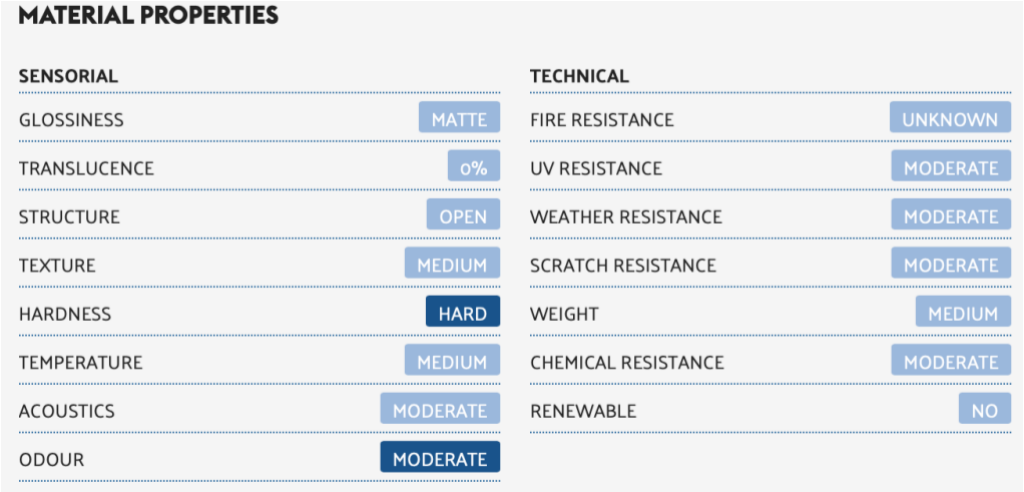
As mentioned earlier, after this phase, the product moves into the engineering stage. In this phase, the selected materials from the research need validation for their actual compatibility with regulations related to temperature, possible food contact, etc. Alternative materials reflecting the research findings could be identified without compromising the study, and these materials could be subjected to another evaluation using the provided tool. Additionally, all suggestions arising from the focus group to enhance user experience or refine CMF details, which were not implemented due to time constraints, could be incorporated. In the context of a design for disassembly approach or product lifespan extension, Haier Europe could consider offering a service for the disposal and recovery of materials or the replacement of individual control panels or components in case of malfunction, rather than replacing the entire oven. An interesting suggestion from the focus group was to apply the same approach to the entire oven to make the product's eco-design approach even more perceptible. However, to provide a more innovative user experience, clearly demonstrating a departure from conventional ovens, the removal of the control panel could be considered, and a new level of interaction through a smart knob, as presented in the research concept, could be explored. Furthermore, the R&D team has proposed extending the approach to another product category, namely microwaves and compact ovens, to establish a new product family extension all tied together by the same eco-design approach.

Annexes

Annex 1

Annex 2

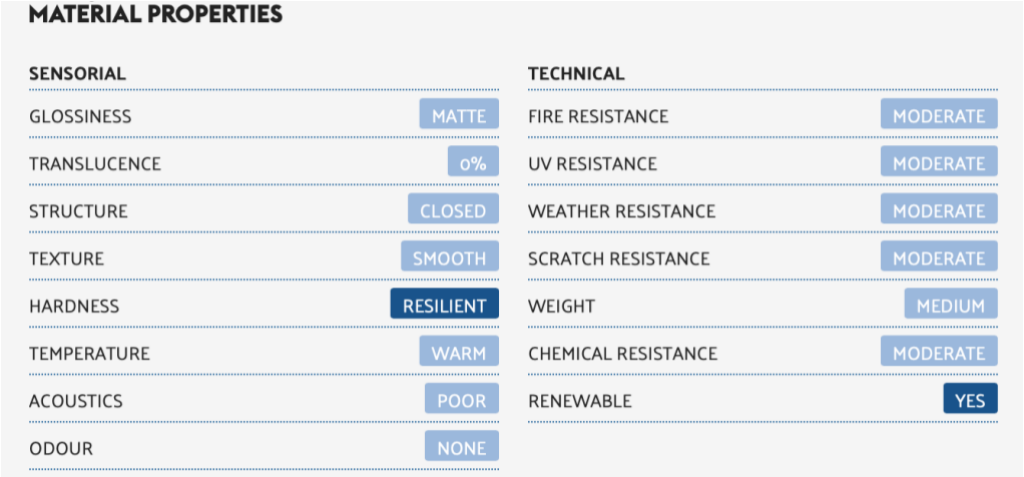
Tefor



MATERIAL PROPERTIES

SENSORIAL		TECHNICAL	
GLOSSINESS	MATTE	FIRE RESISTANCE	UNKNOWN
TRANSLUCENCE	0%	UV RESISTANCE	MODERATE
STRUCTURE	OPEN	WEATHER RESISTANCE	MODERATE
TEXTURE	MEDIUM	SCRATCH RESISTANCE	MODERATE
HARDNESS	HARD	WEIGHT	MEDIUM
TEMPERATURE	MEDIUM	CHEMICAL RESISTANCE	MODERATE
ACOUSTICS	MODERATE	RENEWABLE	NO
ODOUR	MODERATE		

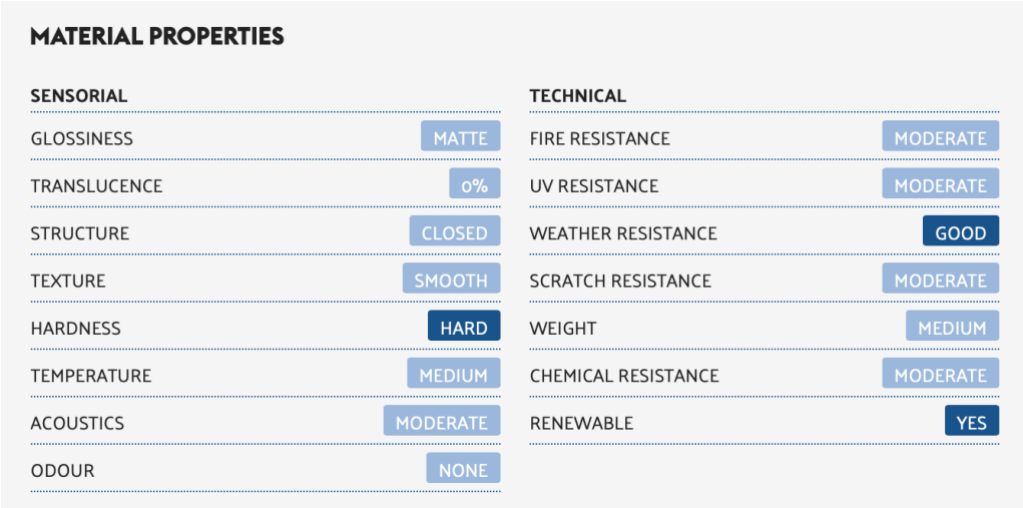
Solanyl



MATERIAL PROPERTIES

SENSORIAL		TECHNICAL	
GLOSSINESS	MATTE	FIRE RESISTANCE	MODERATE
TRANSLUCENCE	0%	UV RESISTANCE	MODERATE
STRUCTURE	CLOSED	WEATHER RESISTANCE	MODERATE
TEXTURE	SMOOTH	SCRATCH RESISTANCE	MODERATE
HARDNESS	RESILIENT	WEIGHT	MEDIUM
TEMPERATURE	WARM	CHEMICAL RESISTANCE	MODERATE
ACOUSTICS	POOR	RENEWABLE	YES
ODOUR	NONE		

Arboskin



Coffeefrom® Bio is our first material, consisting of coffee grounds of industrial origin (10-20% in variable composition) mixed with a biopolymer, PLA. Thanks to its renewable and organic nature, Coffeefrom® Bio is 100% biodegradable, suitable for injection molding and 3D printing in multiple application fields. These include packaging, automotive, tableware and service products. On the final injection molded products, Coffeefrom® Bio shows the natural imperfections of coffee. The material, born with its own history, already has a "tanned" color and a grit always slightly different. The softening temperature (VICAT) is 59° degrees.

Coffeefrom® Eco is composed of coffee grounds of industrial origin (10%) mixed with a low-density polyethylene (LDPE) obtained from a post-industrial recycling process. A 100% recycled material, flexible and lightweight, suitable for injection molding.

On the final products, Coffeefrom® Eco enhances the natural imperfections of coffee and gives a translucent effect, ideal for playing with transparencies. The softening temperature (VICAT) is 85.3 C

Coffeefrom® Strong is composed of coffee grounds of industrial origin (10%) mixed with a high density polyethylene (HDPE). Ideal for applications that require higher mechanical properties, Coffeefrom® Strong is a rigid material, suitable for injection molding. On the final products, Coffeefrom® Strong enhances the dark color of the coffee wastes, with a grainy and compact effect. The softening temperature (VICAT) is 123° degrees.

Heron

All the Classics and Heron Wash materials are made from chemically inert recycled plastics. There may be trace levels of VOC, as well as aromas from the

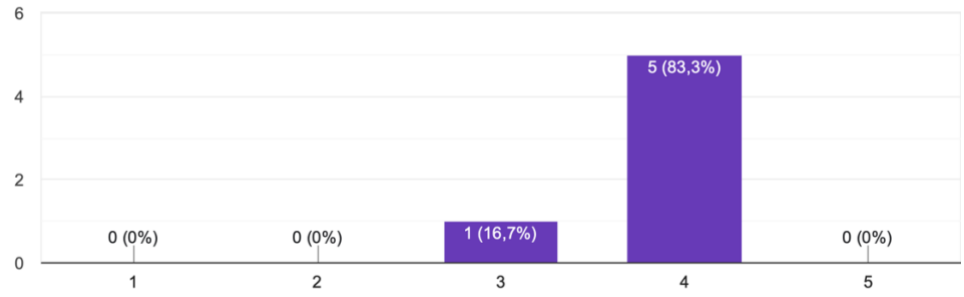
products' previous life. It can be produced softer, rubber-like, or custom-made. Allowing you to have a solid and consistent decorative edge. In terms of finishing can be matt / planed finish and can be polished. All the materials can be machined, drilled, cut (router, CNC), water cut and fixed using adhesives and screws. The Smile Plastics company can provide a moderate UV resistance for their materials, except for some which are only for internal applications.

Annex 3

Concept A

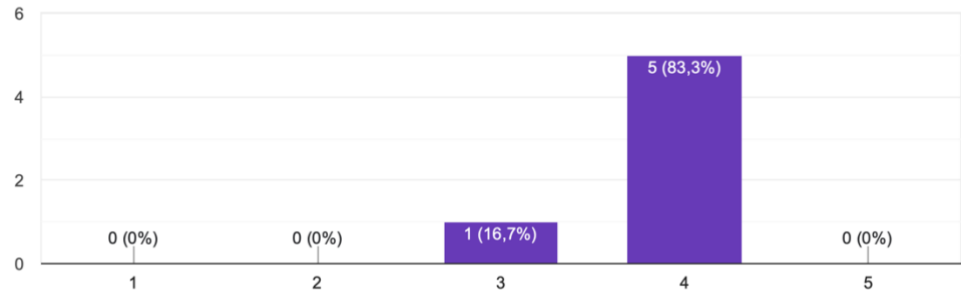
I notice continuity and harmony in colour matching

6 risposte



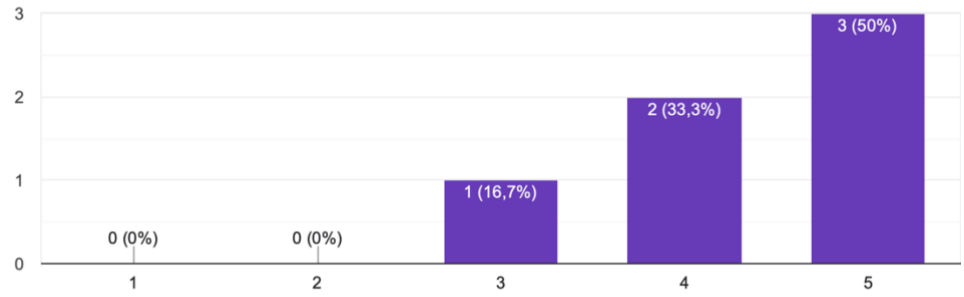
I notice continuity and harmony in colour matching

6 risposte



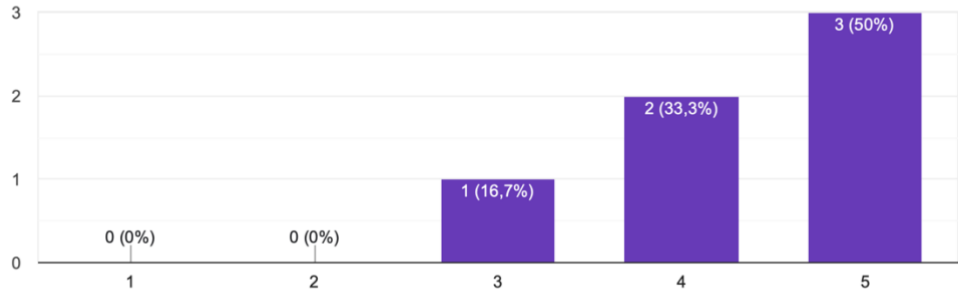
In terms of touch and feel I perceive it's a sustainable material

6 risposte



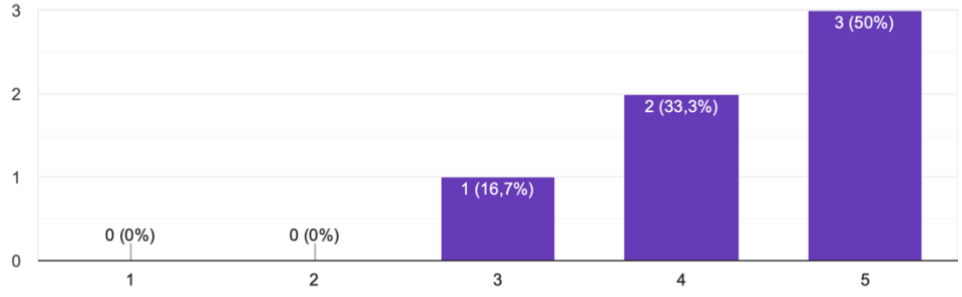
In terms of touch and feel I perceive it's a sustainable material

6 risposte



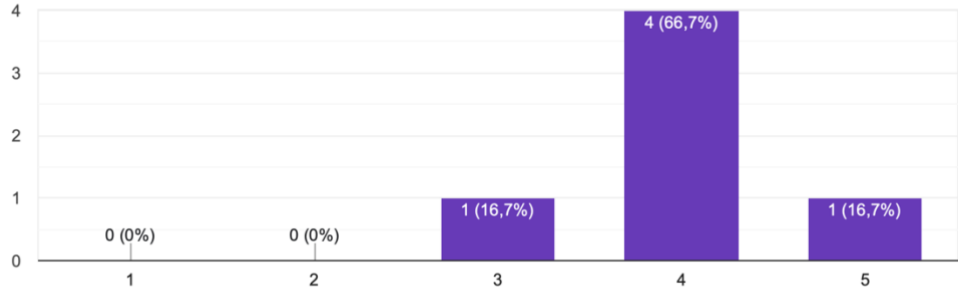
In terms of touch and feel I perceive it's a sustainable material

6 risposte



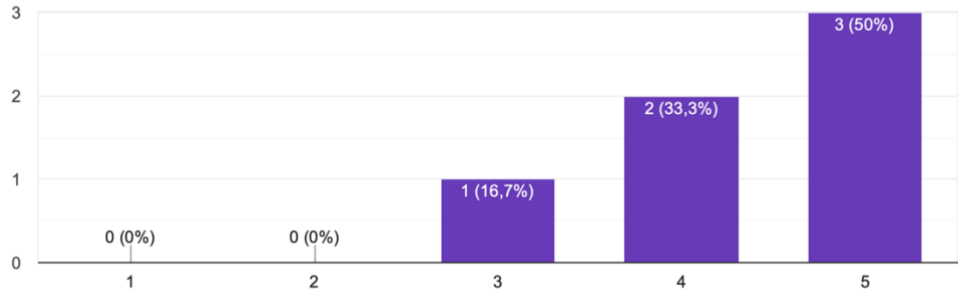
I understand why it is minimal

6 risposte



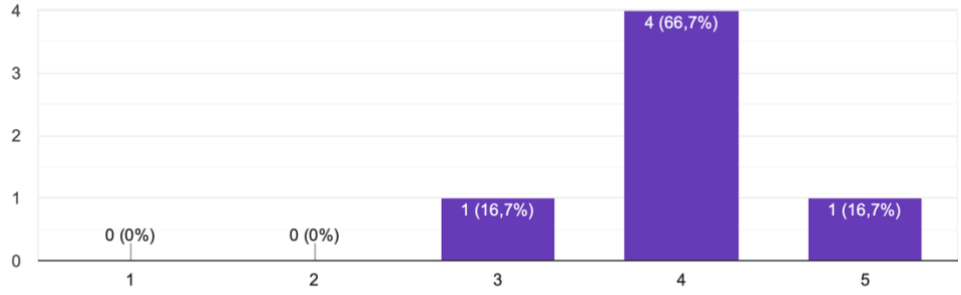
I perceive it is durable

6 risposte



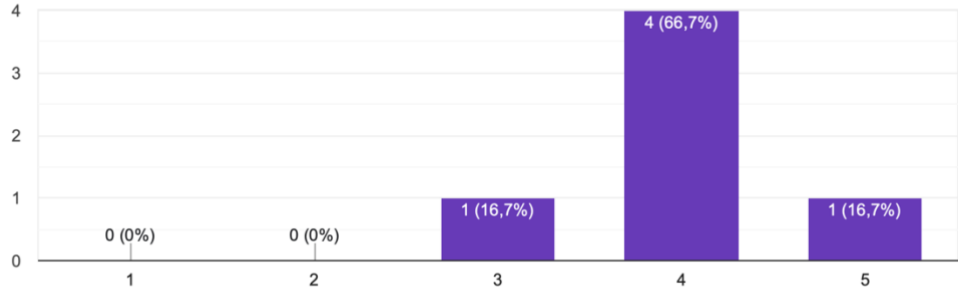
I think the technology is enough

6 risposte



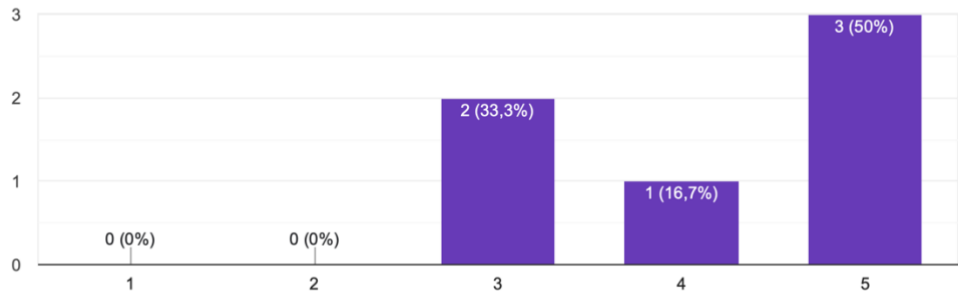
I think the technology is enough

6 risposte



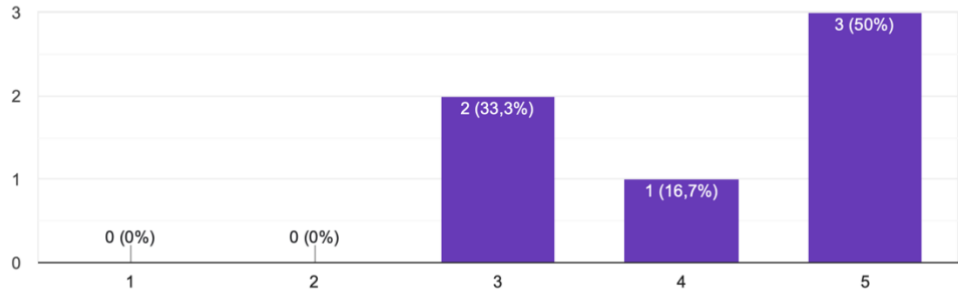
I perceive it's a product designed with and eco-design approach

6 risposte



I perceive it's a product designed with and eco-design approach

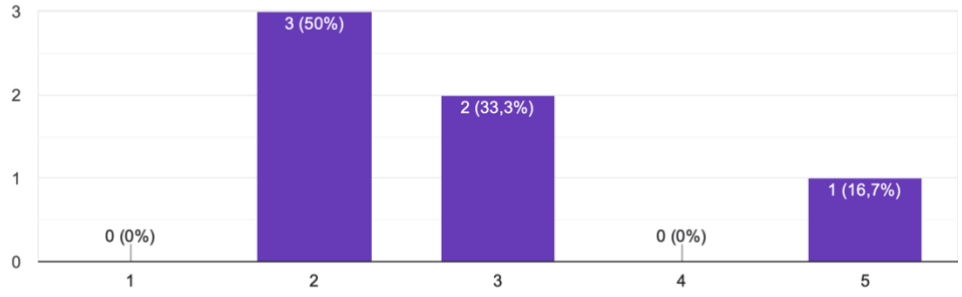
6 risposte



Concept B

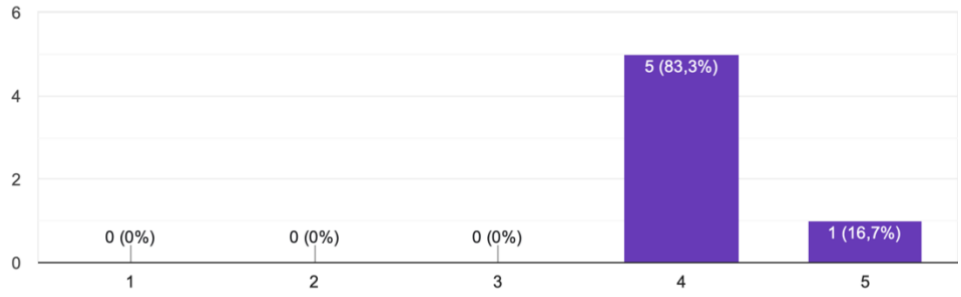
I notice continuity and harmony in colour matching

6 risposte



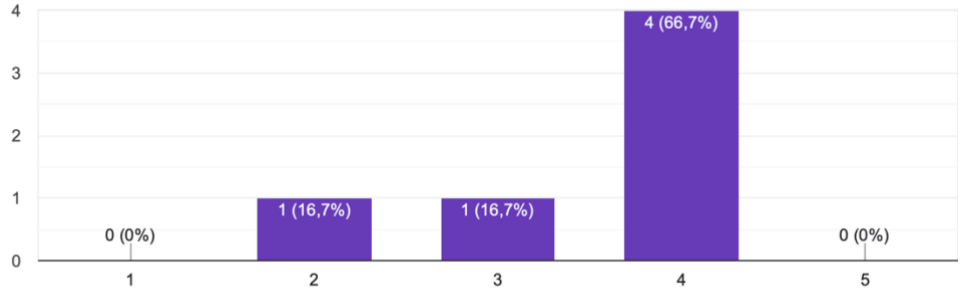
I notice a new material

6 risposte



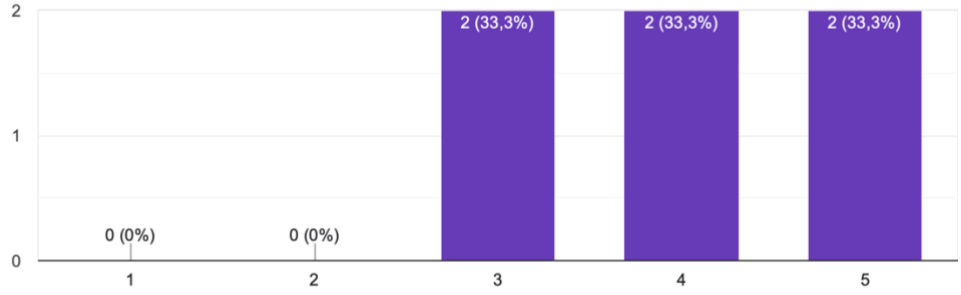
In terms of touch and feel I perceive it's a sustainable material

6 risposte



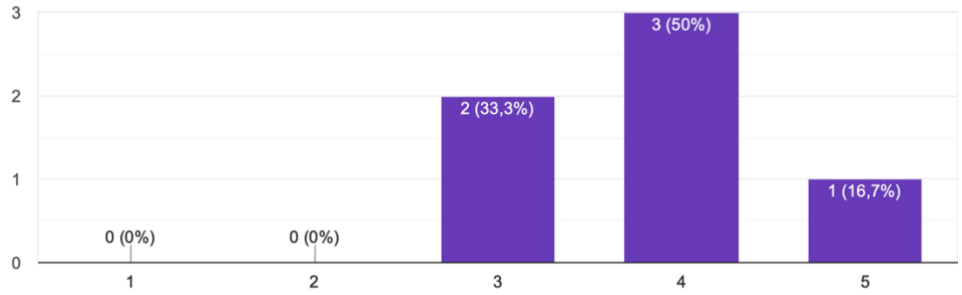
I think its configuration (layout) is essential for its function

6 risposte



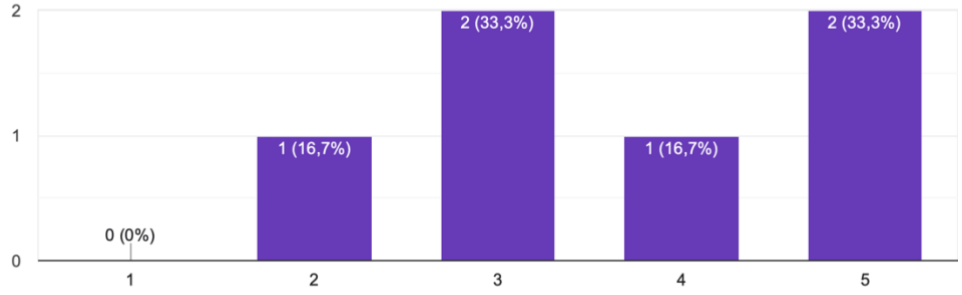
I understand why it is minimal

6 risposte



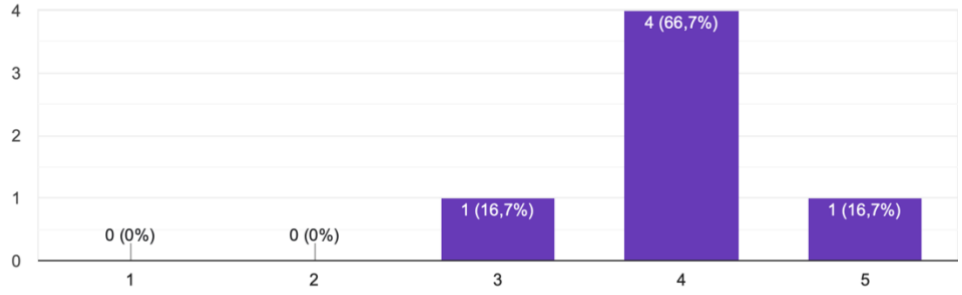
I perceive it is durable

6 risposte



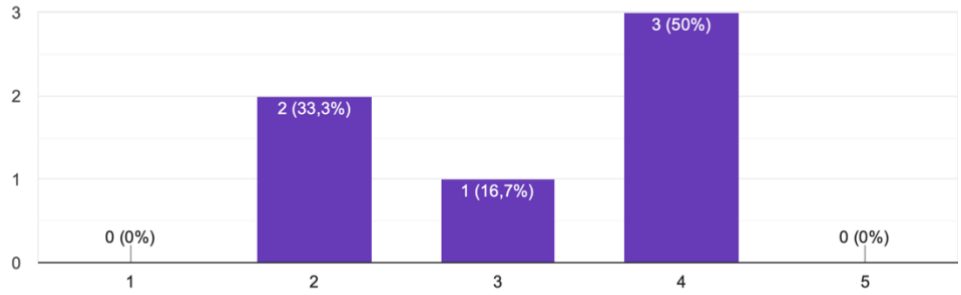
I think the technology is enough

6 risposte



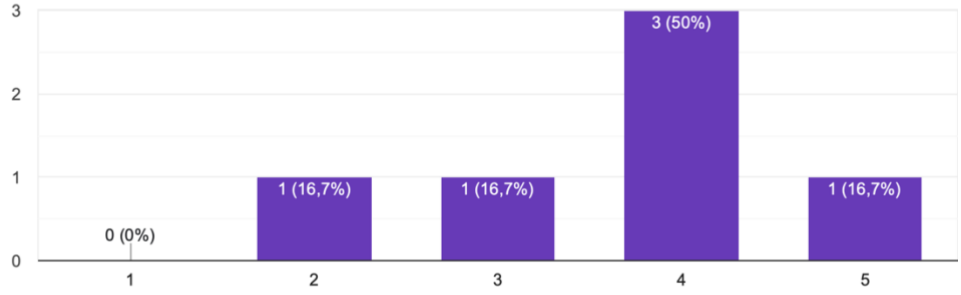
The UI is clear and essential for its functions

6 risposte



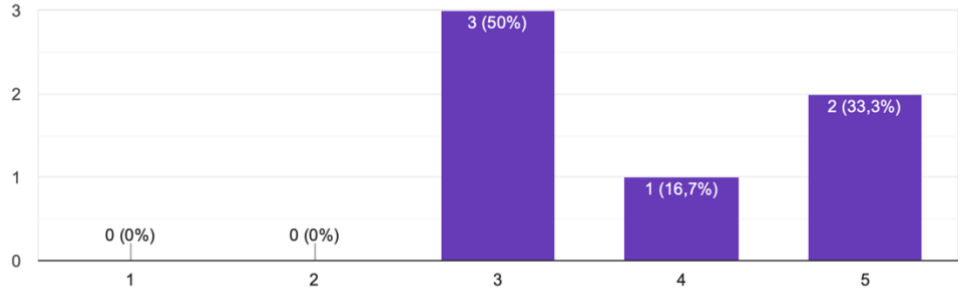
I perceive it's a product designed with and eco-design approach

6 risposte



I think is coherent with eco-sustainability

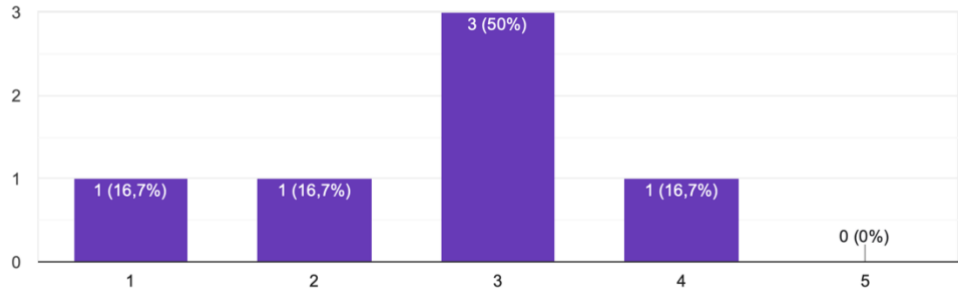
6 risposte



Concept C

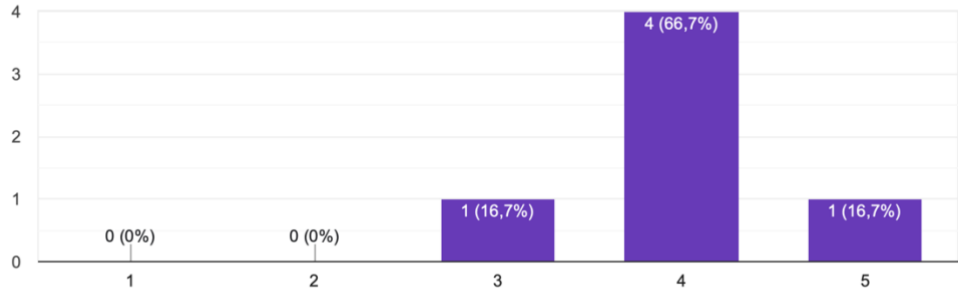
I notice continuity and harmony in colour matching

6 risposte



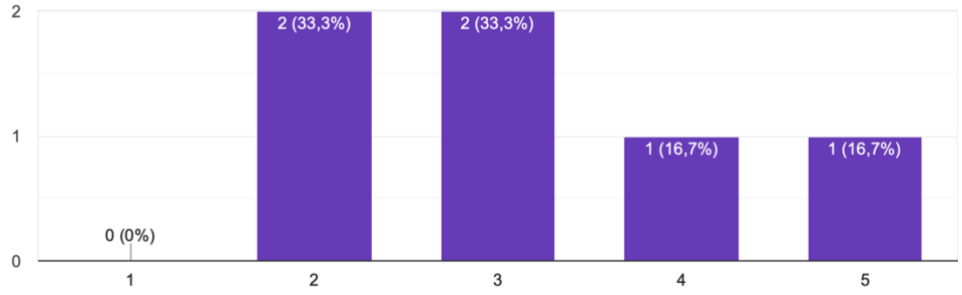
I notice a new material

6 risposte



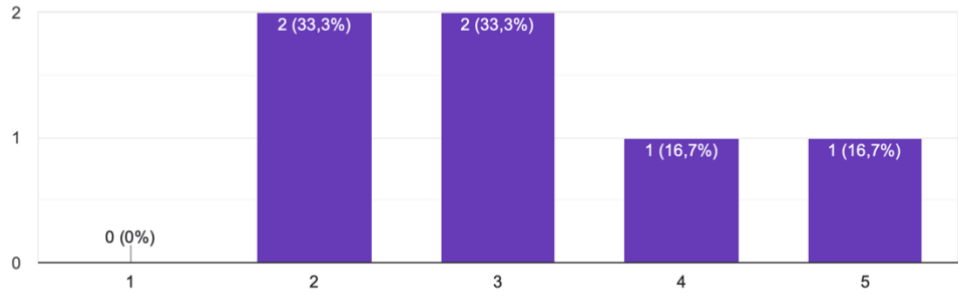
In terms of touch and feel I perceive it's a sustainable material

6 risposte



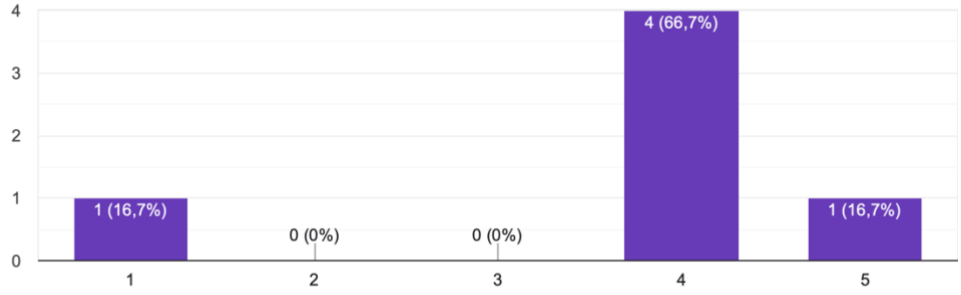
In terms of touch and feel I perceive it's a sustainable material

6 risposte



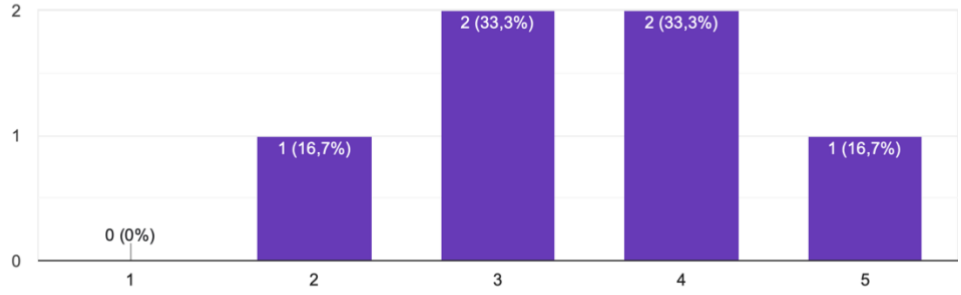
I think its configuration (layout) is essential for its function

6 risposte



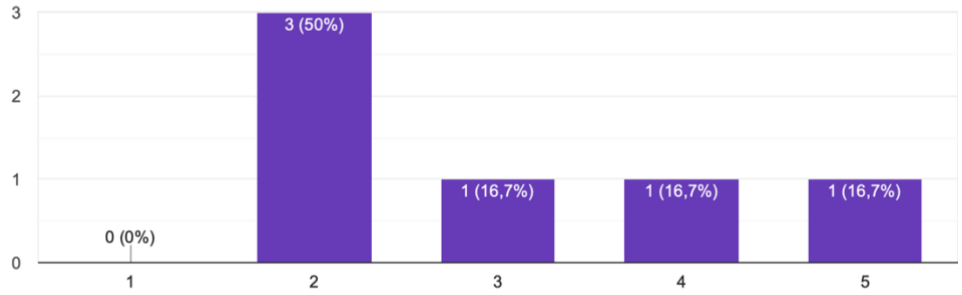
I understand why it is minimal

6 risposte



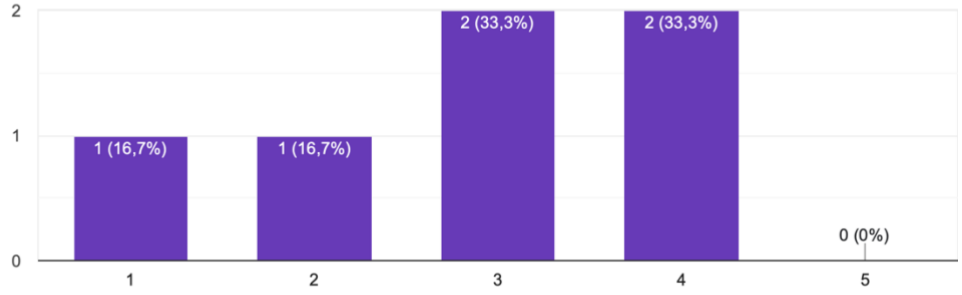
I perceive it is durable

6 risposte



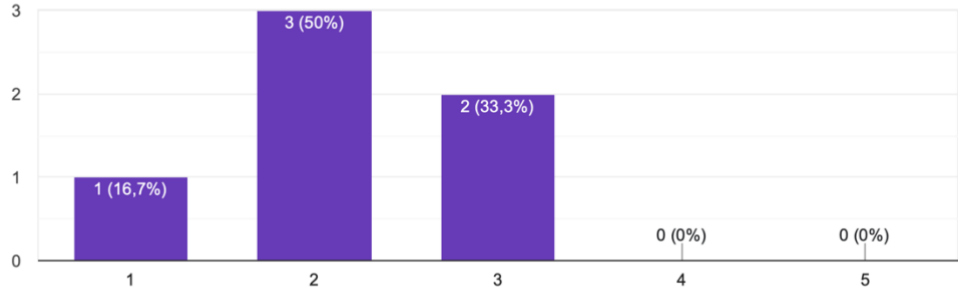
I think the technology is enough

6 risposte



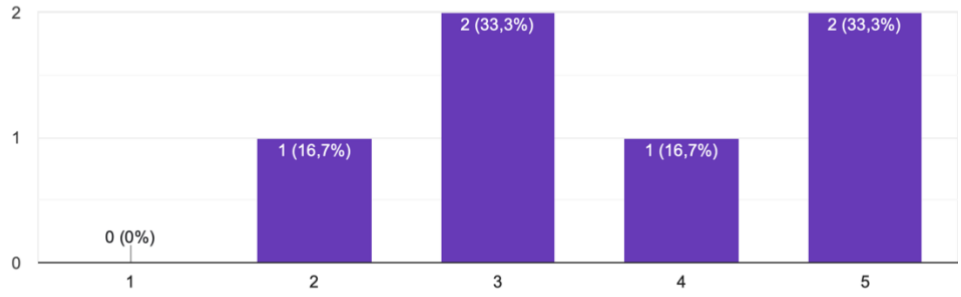
The UI is clear and essential for its functions

6 risposte



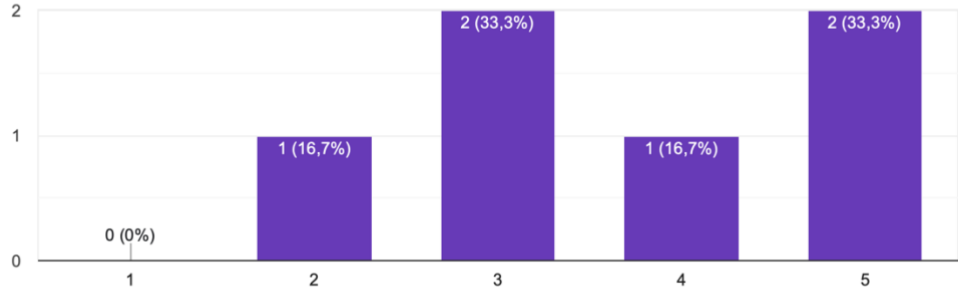
I perceive it's a product designed with and eco-design approach

6 risposte



I think is coherent with eco-sustainability

6 risposte



Annex 4

Oven								
Control panel								
Sustainability	Score of importance	BASELINE	Haier ECOven			IKEA Anträtta		
Questions			Score	GRADE	Comments	Score	GRADE	Comments
Do you notice continuity and harmony in colour matching?	0,075	0	1	0,0750	low cause a whole approact	-1	-0,0750	
I notice a new material	0,1	0	3	0,3000		0	0,0000	
In terms of touch and feel do you perceive it's a sustainable material?	0,1	0	2	0,2000		-2	-0,2000	
Do you think its configuration (layout) is essential for turning it ON/OFF?	0,05	0	2	0,1000		-1	-0,0500	push-push mechanism is additional and superfluous
Do you think its configuration (layout) is essential for selecting a FUNCTION?	0,05	0	2	0,1000		-1	-0,0500	push-push mechanism is additional and superfluous
Do you think its configuration (layout) is essential for selecting a TEMPERATURE?	0,05	0	1	0,0500		-1	-0,0500	push-push mechanism is additional and superfluous
Do you think its configuration (layout) is essential for CONFIRMING?	0,05	0	-1	-0,0500		0	0,0000	
(if it is) Do you understand why it is minimal?	0,05	0	2	0,1000		0	0,0000	
Do you perceive it is durable?	0,1	0	2	0,2000		-1	-0,1000	pushpush mechanism
Do you think the technology is enough?	0,075	0	2	0,1500		-2	-0,1500	too many levels
Do you perceive it's a product designed with and eco-design approach?	0,15	0	2	0,3000		-3	-0,4500	
Do you think is coherent with eco-sustainability? *(Reducing components, easy to disassemble, reducing waste, etc.)*	0,15	0	2	0,3000		-3	-0,4500	
	1			1,825			-1,575	

-3 unacceptable, could prevent the sale noticeable at the shop
-2 mid risk, defects solved before production, as effect negatively the overall quality
-1 low risk, noticeable only by "picky" customers
0 neutral, not evaluable
1 nice to have, could increase PQ, difficult to understand by "standard user"
2 a good best practise
3 competitive advantage if applied on a user touch-point

LOW IMPORTANCE
MID IMPORTANCE
HIGH IMPORTANCE

References

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