

Design for Next Connected Appliances

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Design for Next Connected Appliances

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Abstract: After a deep recession in 2009, home appliance manufacturing has evolved quickly, increasing sales and forecasting of a huge spread of Internet of Things connected products. Despite the potential of the IoT as a future scenario for the development of major home appliances, data collected on actual purchases seem to contradict the trend. Manufacturers justify this gap with the consumers' resistance to adopt new technologies and to change their habits. Nevertheless the consumer claims a lack of perceived benefits in connected appliances, showing strong concern about data transfer to third parties. Investigate user needs and focus on the environmental sustainability of products could solve this techno-stress, allowing the user to perceive the benefits. This paper aims to guide companies and designers, through the application of the Systemic Design approach, to change their goals, allowing them to achieve product innovation together with an environmentally conscious product design.

Keywords: Systemic Design, environmental sustainability, Internet of Things, connected appliances, product innovation.

1. Introduction

Over the decades following the post-World War II up to recent times, household appliance manufacturers have evolved different mechanisms and framed different strategies to make their business successful. Back to the '80s most of the companies realized that their markets in Europe and the USA were saturated. They began to focus on emerging markets and hence, it came the need for globalization. The strategy developed led to economies of scale, product synergies and a strong brand presence (Shyam, 2008). However from the beginning of the new century, this industry has faced several challenges, including the incursion of low-cost-country competitors, which pushed the manufacturers to lowering prices and replacing the production at the expense of quality (Bernard, 2007). Later on, they found at his own expense that relying exclusively on cost reduction strategies in response to foreign competition could not be considered an effective strategy, since it leads to losing market share, undermining their competitive position (Spanos et al., 2004). From 2009 to 2013 a deep crisis affected the industry (Mintel, 2016), highlighting a general lack of new strategies. However some producers began to focus on the design process, with the aim to innovate the industry. Technological improvement has occurred and the vigorous progress in the Internet of Things (IoT) solutions is promoting the development of connected appliances.

1.1 Strategies

Before the crisis the entrance of a low-cost competitor was generally followed by companies' differentiation of products, cutting of prices or both (Bernard, 2007). Nevertheless strategic success could be identified on how a manufacturer adapts to changes in a turbulent market (Shyam, 2008). Although the competition from low-cost countries is a relevant issue, some big players tackle the problem by increasing investment in R&D, segmenting their products to reach the needs of different regions and developing connected appliances (Electrolux, 2015). Among the strategies developed, in addition to those concerning mergers and acquisitions (i.e. Haier and General Electrics, 2016; Whirlpool and Indesit, 2014), we can include the Open Innovation and the cooperation with big players in other industries. Electrolux is currently working with Google to implement connected appliances integrated with Google's smart home platform, while both Electrolux and Whirlpool are working with Ikea to develop built-in solutions with smart features. This trend suggests many other partnerships.

1.2 Market

Nowadays the market of household appliances is still remarkable. In 2014, the total turnover of the major appliances weighted USD 44 billions, representing 350 millions of units (Volpe, 2015). This analysis relied on 50 manufacturers and included refrigerators and freezers, washers and dryers, dishwashers, hoods and cooking appliances. For this reason, the attempt to develop innovative strategies in this area seems to be significant (Fiore et al., 2016). Indeed from 2013 the appliance sector experiences an average growth rate of around 12 per cent per annum (Intel, 2016). The reason of these increases, along with the renewed purchasing power, could be identified in the entrance of new young and omni-channel consumer asking for new features (37 per cent), while the replacement of a worn-out appliances remains the most common purchase motivation (3/5 of new purchases, around 58 per cent). Energy conservation seems to grow in importance. 30 per cent of consumer chooses to upgrade their appliance for energy saving options. Nearly 1/4 (22 per cent) of Americans replaced their last appliance to get a bigger model. Finally, 1/5 (19 per cent) consumer replaced appliances as part of remodelling or renovation (Intel, 2016). Currently we are not able to draw a parallel with the European market since there is a lack of similar studies able to confirm or contradict these trends.

1.3 Problem definition

While market studies indicate the development of connected appliances as a future scenario for the evolution of the sector (Acquiti Group, 2014; 2016) and appliance manufacturers continue to innovate with new smart features and technologies, Intel research reveals that smart appliances so far have failed to spark significant interest in American households (Figure 1), which is confirmed their low purchase rate (Gfk, 2016b).

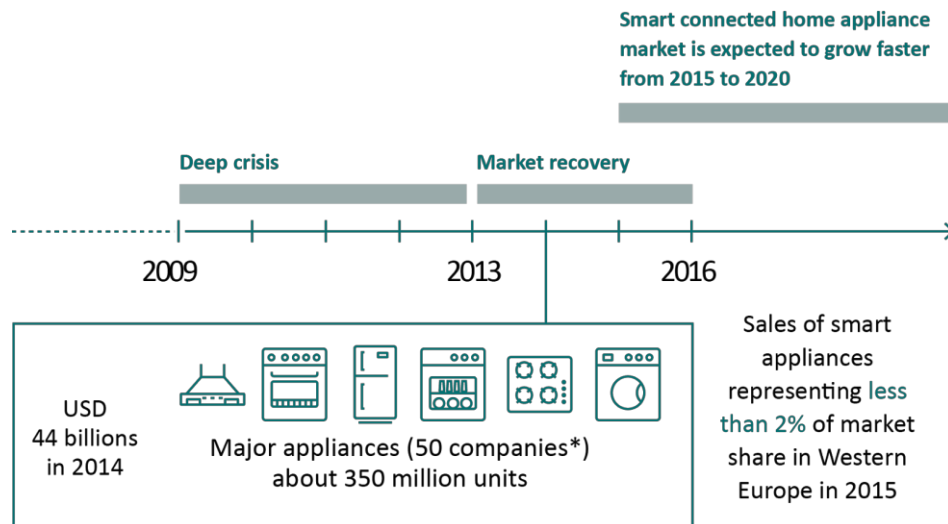


Figure 1. Problem definition.

1.4 Identification of causes

Gann, Barlow and Venables (Gann et al., 1999) made a comparison between the development of smart home systems and the early market of electric appliances. We resized the first term of comparison by considering smart appliances instead of smart home systems in general, in order to compare two groups of defined objects: the early developed appliances and the smart-connected ones.

“Before demand for electrical appliances took off, a number of preconditions had to be met, including a cheap supply of electricity, cheap and reliable appliances and the installation of a distribution and wiring system” (Aldrich, 2003 p.23).

Nowadays the scenario is not so far from that. As mentioned by the social scientist Frances K. Aldrich the high initial investment is still an obstacle to the consumer take-up, as well as the dependence on old housing stock, which push to equipping houses retrospectively. We can identify some barriers to market development in a poor usability in addition to a strong technology push by suppliers (Aldrich, 2003).

From recent market studies (Accenture Interactive, 2015) (Gfk, 2016a) we can draw some conclusion about what currently hinders the development of connected appliances, highlighting some common causes:

1. General lack of perceived benefits in connected appliances, able to motivate the purchase;
2. Quick evolution of technology and privacy concerns;
3. High price compared to benefits.

2. Solution strategies

2.1 Lack of perceived benefits

The lack of perceived benefits gives us the opportunity to shift the focus from “technology push” solutions, to “need pull” ones. Furthermore there is a lack of data and experiments to understand the actual use of appliances, which leads to a gap in the literature about current actions and household tasks. Moreover it leads to lost sight of the original aim of appliances, i.e. help the user

and simplify daily user operations (Berg, 1994). Recently Bonino and Corno (2011) noticed a failure in meeting user expectations, although we prefer considering needs instead of expectations. The anthropocentric vision of design (Ma, 2015) can be replaced by a holistic one, in which multiple aspects are taken into account simultaneously. By the end of the last century Aldrich considered “meeting the real user needs” and “improving functionality, ease of use, affordability, reliability, maintainability, flexibility, adaptability upgradability, replicability and ease of installation” (Aldrich, 2003 p.23) as possible solutions for the development of smart home. In this paper these considerations are combined with a design methodology based on needs, requirements and performances, a methodology that identifies the early design stages, by structuring the decision-making process in the scenario analysis (Germak and De Giorgi, 2008) (Ciribini, 1984). Almost twenty years after Aldrich, we decided to include a wider network of stakeholders able to define three levels of requirements¹ that come from the user, the product and the environment.

The explicit decision-making made in the design process should involve a wide network of stakeholders and it requires an inclusive approach (Devon and Van de Poel, 2004), to make sure the right people are included in the decision-making (Devon, 2004). This network is project-specific and it refers to the product or service to develop.

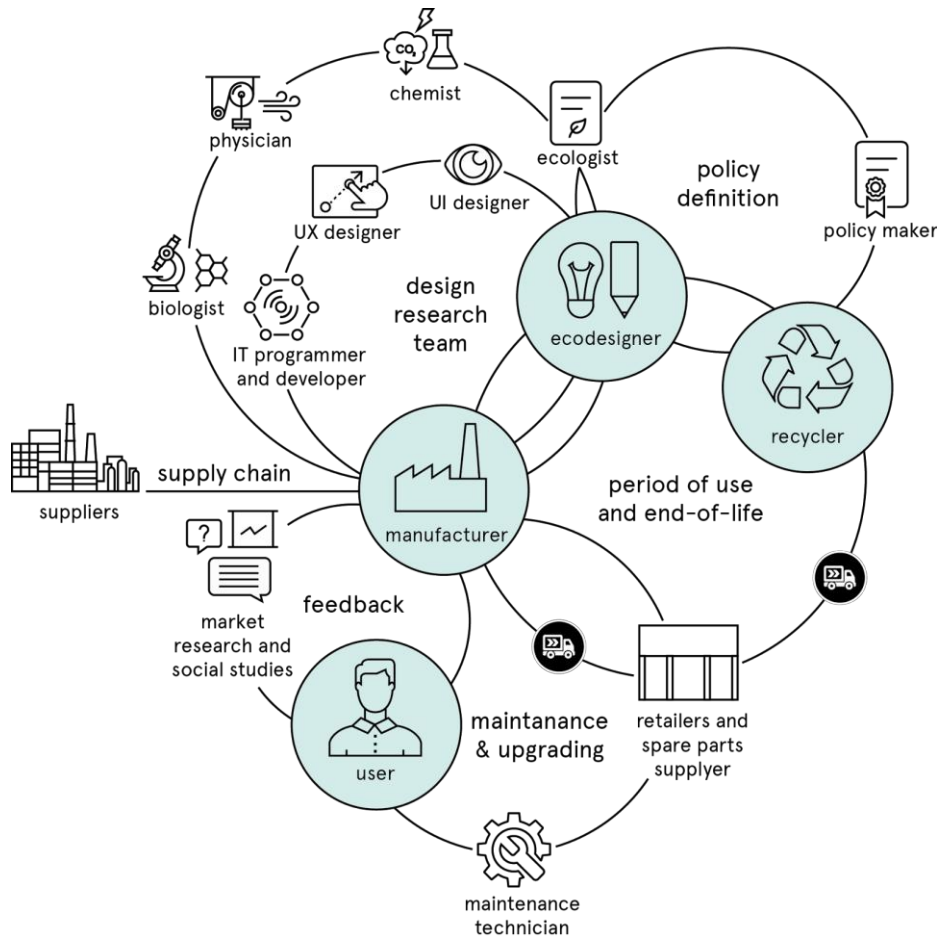


Figure 2. Network of stakeholder needed to develop connected appliances.

¹ A requirement is the transposition of a need in technical terms. It aims to achieve a purpose adding some features and specifications

For the development of connected appliances we provide a specific network of stakeholders (Figure 2) which includes:

- the design team (eco/UI/UX designers, IT programmers and developers, biologists, physicians, chemists, ecologists) able to indicate user, product and environmental requirements;
- companies with their supply chain and retailers define product requirements;
- anthropologists and social scientists investigate consumer needs;
- consumers provide his needs;
- recyclers define product and environmental requirements.

According to UNI 8289 standard, which defines seven basic classes of needs (Table 1), we translated, adapted and divided them as follows.

Table 1. Requirements

User requirements	1. Safety	Health
		Information
	2. Comfort and wellbeing	
	3. Aesthetics	
Product requirements	4. Usability	
	5. Management and maintenance	
	6. Upgradability	
Environmental requirements	7. Environment protection	Safety
		End-of-life
		System

2.2 User requirements

Focusing on the user, we take into account some objective needs, without pushing new ones on him (Bonino and Corno, 2011). We seek to address the existing and forecast some future issues (Figure 3 and 4).

1 User safety

Health

- / avoid poisonous, irritating or corrosive emissions
- / avoid formaldehyde emission
- / avoid sick building syndrome
- / allow air circulation and ventilation

Information

- / use normed and conformed materials
- / consult a material experts for their choice
- / prevent accidental injury
- / protect children from danger
- / avoid hot accessible parts
- / provide thermal insulation
- / hot and fire resistance
- / limitation of the fire propagation

Information

- / manage sensitive information
- / collect only the data needed to improve the product
- / delete every piece of information that is not (or no longer) needed
- / ensure privacy even towards other family members
- / avoid user profiling, tracking and stalking
- / prevent misuse by third parties
- / ensure that the user is never exposed to risks
- / inform the user and share information
- / provide elaborated contents like feedbacks, visualizations, advices, tips

Figure 3. User safety

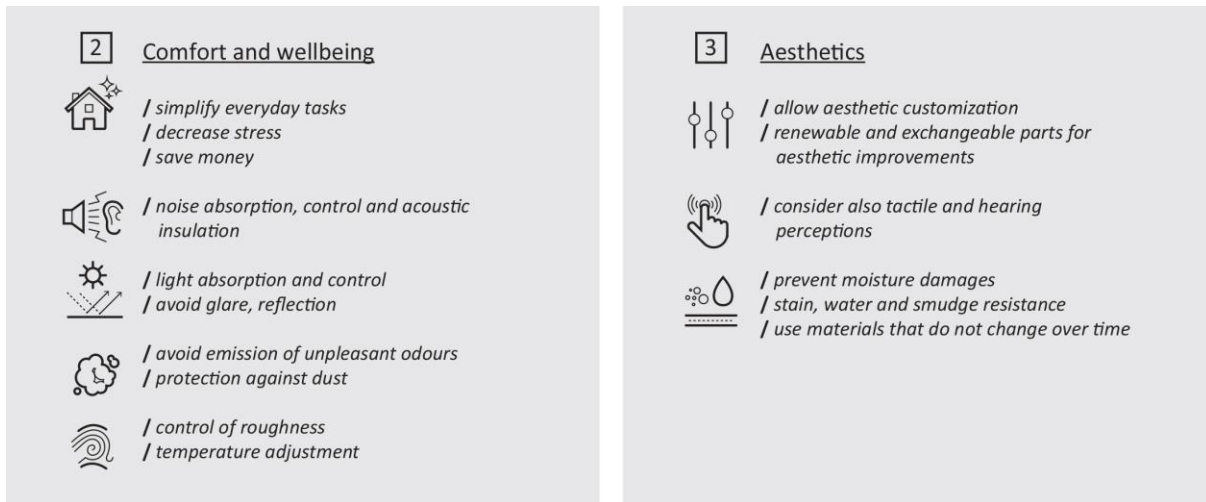


Figure 4. Comfort and wellbeing; Aesthetics

This quick overview refers to user, its safety, comfort and satisfaction.

Far from being exhaustive, this list of requirements can be considered as a tool to structure the decision-making process. According to a specific project, the next step should be prioritizing these needs and set the target values of that project. Moreover, they can be integrated and, once specifically analysed, they should be investigated directly with the user through surveys and focus groups.

The importance of involving the user in this kind of studies begins to urge. It emerges as lack of user-validation and real-world trials (Bonino e Corno, 2011) intelligent solutions and functionality validated with the user (Aldrich, 2003). There is the need for research experiment in the real world because:

“Much of the complexity emerges in the interplay of activities and relationships between household residents.” (Aldrich, 2003, p.26)



Figure 5. Usability

2.3 Product innovation

Focusing on the product, here requirements are borrowed from Good Design (Munari, 1997) such as reduction, functionality modularity and usability, but also accessibility, maintenance and upgradability (Figure 5 and 6). There is a tight boundary between product and service design.

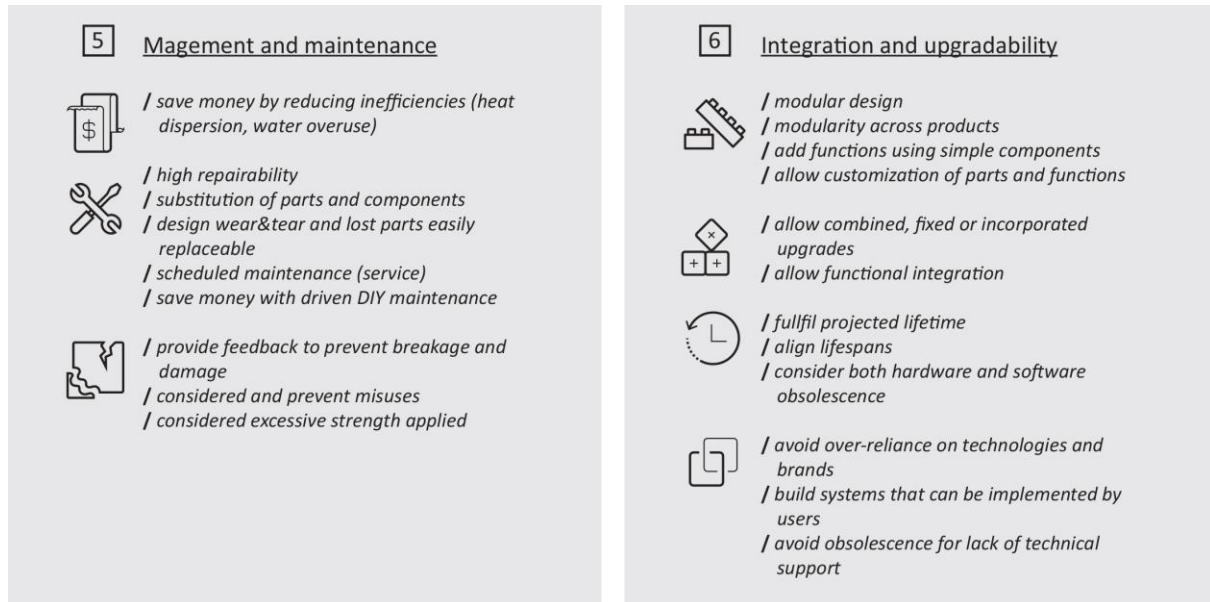


Figure 6. Management and maintenance; Integration and upgradability

The first step towards product innovation is seeks to understand current products and current uses of them. This is also the step with the greatest lack of information. In particular we should investigate:

- How a current electric appliances work, through their disassembly and the study of their components;
- The context in which the appliance works;
- The current user behaviour related to the appliance.

We address the lack of information below (p.9 Collecting missing information).

2.3 Environmental-conscious product design

What is often missing in “technology push solutions” and “consumer pull” ones is a focus on environmental sustainability. Environmental requirements do not refer exclusively to regulatory aspects, energy consumption and the energy class. We are quite used to it. What is missing is an overview about streams of energy, water, air, heat and all the output involved, an holistic and systemic view of it (Bistagnino, 2011). In this way the product design might take a new path towards sustainability.

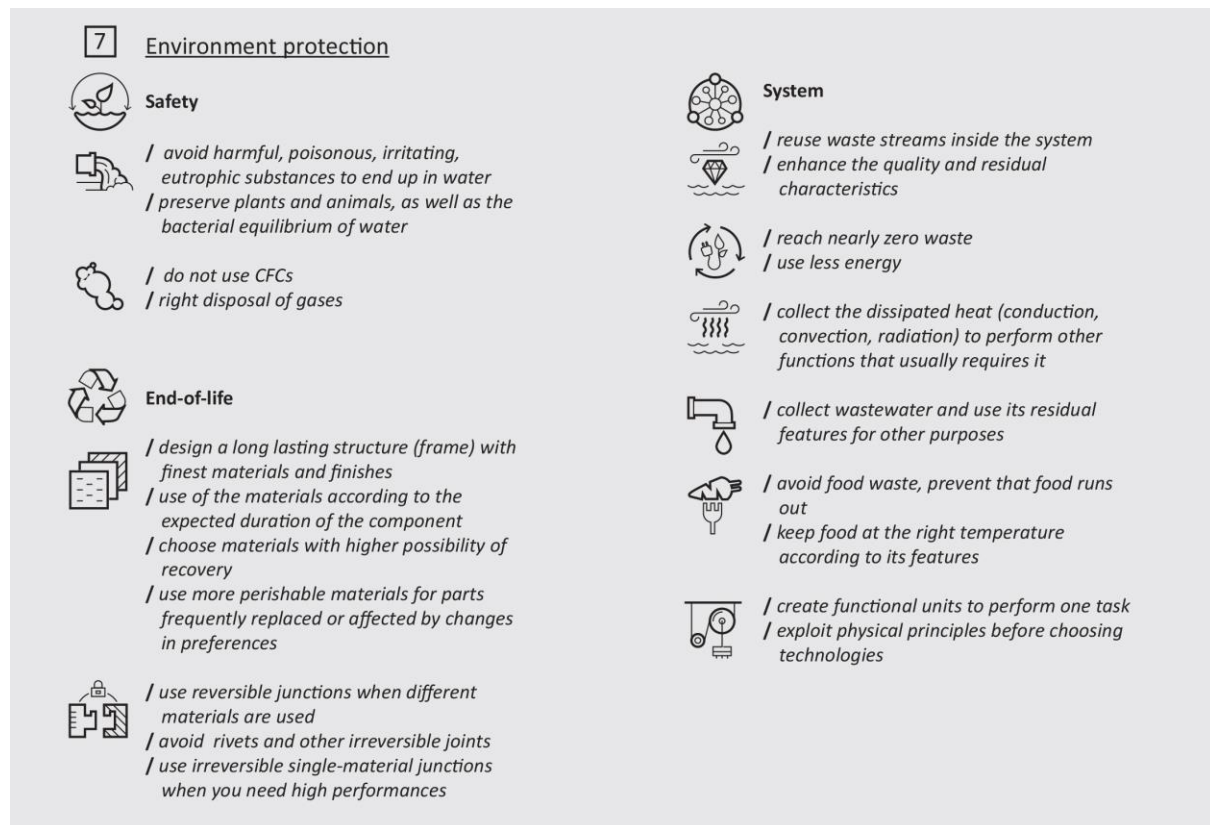


Figure 7. Environmental protection

“Sustainable design, which by one formulation is at least to reduce the impact of design on the environment, is nullified when the scale of its realization in material and energy consumption exceeds its aggregate impact reductions” (Chan, 2016 p.6)

The second step towards sustainability involves a change of perspective, focusing on resources and processes.

- What resources are actually involved;
- Which resources can be changed, reduced or saved;
- Which resources deserve to be enhanced and exploited after their primary use, becoming part of another system (open systems)
- Which connections can be activated (exchange, transfer, share and so forth)

2.5 Quick evolution of technology and privacy concerns

We can glimpse different causes (mainly fears and concerns) that hinder the technological development of connected devices, such as:

- **Control.** Loose the control over automated system activities (Bonino and Corno, 2011). This perception is exacerbated by the fictional idea provided by literature and cinema of the technology as an entity that takes control over its occupants (Aldrich, 2003)
- **Complexity.** Feel inadequate in facing innovative and disruptive technologies (complexity) (Bonino and Corno, 2011)
- **Obsolescence.** “Disconnection between the long life expectancy of most major appliances and the far faster life cycle of most technology. Smart features on an appliance sold today

may feel dated long before the appliance itself is worn out” John Owen, Senior Household Analyst, Intel Group Ltd.

- **Security and privacy.** Provide to strangers an access breach to the household through technology and give data to third parties.

Far from dealing with ethical issues, which are widely discussed in a previous paper (Fiore, 2016), this paper looks at technology as a means to collect the information needed to ensure a proper design.

Collecting missing information

In the design phase some pieces of information are available, others are difficult to obtain. Some of them can be acquired through a thorough research. However every design task is characterized by a huge amount of missing information about actual use, both unavailable and undeterminable (Negroponte, 1970). In particular the design stage needs timely data related to household habits and behaviour.

Far from the current gadget-oriented vision of the smart appliances, we argue that Internet of Things (IoT) technologies can drive the design of connected appliances to play a major role in environmental sustainability. A more accurate understanding of how householders use their appliances could provide key information for designing more sustainable devices with the ability to detect, prevent and anticipate some issues. Investigating the use of water, electricity and the production of waste could lead the household to avoid unnecessary use of resources and design new products based on user needs. However the designer needs to figure out what to measure, which parameters relate, what is the result to achieve and to what end.

2.6 High price compared to benefits

“Although the youngest, and presumably most tech-savvy, consumers are considerably more likely than their older counterparts to say they would pay more for smart features, the reality is that most don’t have the financial means to afford the super-premium price tags that most smart appliances carry” (Intel, 2016)

This point seems to be of little significance, since the development of connected devices does not imply an increase in prices. However, the costs can be evaluated with cost-benefit analysis (CBA) and should include other evaluations such as LCA and LCC analysis during the design stage. LCA analysis depends on the choices made by the designer and the manufacturing company (e.g. materials, volumes, technology integration) while LCC should consider real costs (Fiore et al., 2016a). Both of them cannot be performed or forecasted at this stage.

One of the solutions suggested by Aldrich dealing with smart home in general, was to provide modular system of smart home technology, which people can acquire in stages. Translated into actual terms we may assume to provide the domestic platform on which the pieces (i.e. connected appliances) can be added, as the user buys them. In this way the user does not need to live in a newly built house to experience innovative service. Google Nest, for example, addresses this ease of installation, but it is far from this scenario since it does not deal directly with stream of resources. However, its ability to learn from user behaviour (learning system) is still noteworthy.

3. Conclusions

Although few papers on smart or connected appliances are available in the academic literature, there are many efforts in other areas (Smart Home, Ambient Intelligence and Pervasive Computing) that

can provide the scientific background. “A number of people have pointed to multidisciplinary as the way forward for the design of information technology in general” (Aldrich, 2003 p.30). In addition to the “smart/connected” topic, part of the scientific background belongs to the product design (appliance), and then Ciribini, Munari, methodologies such as design for disassembly and systemic design have been addressed in order to understand the mismatching of needs and solutions perceived by the user. Data-driven design should be used to promote “consumer pull” solutions, avoiding “technology push” ones. However a larger number of stakeholders in both decision-making and product development should be taken into account, together with a marked consideration of environmental sustainability aspects. We do not push for the over-use of technology on new products, although we found that data about current products and their timely use are missing and are likely to hinder an overview about the user, slowing the matching between needs and solutions.

In this way the technology can be used on transition products, i.e. actual products refurbished with sensors to collect information about the user’s habits, the qualities of water and air, the actual energy consumption and heat dissipation, the noise and so forth. These tools can be used in the research activity to get timely data and aims to design with a clear overview.

Shifting the focus from technology to the requirements listed in the three sections above, the decision-making tool aims to create a specific set of values for each project, whose fulfilment may be perceived as innovative.

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