ResearchLEAP

Journal of International Business Research and Marketing
Volume 3, Issue 5, 2018
journal homepage: www.researchleap.com

Consumer Product Design: Patterns of Innovation, Market Success and Sustainability

Robin Roy
Emeritus Professor of Design & Environment, School of Engineering and Innovation, Faculty of Science, Technology, Engineering and Mathematics, The Open University, Milton Keynes, UK

DOI: *10.18775/jibrm.1849-8558.2015.35.3004*
URL: *http://dx.doi.org/10.18775/jibrm.1849-8558.2015.35.3004*

Keywords:
Consumer, Products, Innovation, Sustainability

ABSTRACT

This article summarizes some of the content and conclusions of the author's recent book, Consumer Product Innovation and Sustainable Design, which discusses the innovation, design and evolution of six consumer products –bicycles, washing machines, vacuum cleaners, electric lamps, television and mobile (cell) phones – from their original inventions to the present. It discusses common patterns of innovation, how environmental concerns and legislation have influenced the design, and some of the effects these products have had on the environment and society. The article also uses lessons from the successes and failures of examples of these products to draw out guidelines for designers, engineers, marketers, managers and educators on how to design successful new products and to design for the environment. It concludes with trends and sustainability challenges for future consumer product design and innovation.

1. Introduction

This article summarizes some of the content and conclusions of the author's recent book, Consumer Product Innovation and Sustainable Design. The evolution and impacts of successful products (Roy, 2016). The book was inspired by the author's archive collection of the magazine. This (UK) Consumers' Association publication and the more recent website provide a unique written and visual record of the evolution of consumer products marketed in Britain from 1957 to the present.

The core of the book comprises case studies of six classes of consumer product – bicycles, washing machines, vacuum cleaners, electric lamps, television equipment and mobile (cell) phones. The case studies draw upon the author's previous research (e.g. Roy, 1994; Roy, 1999; Roy and Tovey, 2012); relevant reports plus numerous other sources, to track the technological innovation and design evolution of these products from their original inventions to the present day. The case studies also examine when, why and how environmental criteria, such as improved energy and materials efficiency, became part of the specification of these product classes; the influence of socio-economic and cultural factors on their innovation and design; and some impacts of these products on society and the environment.

The article draws on empirical evidence from the product case studies to provide general conclusions about patterns of technological innovation and design evolution. The article also makes use of the evidence of the case studies to provide practical lessons for product designers, engineers, managers and marketers, and for educators of these professions. The lessons cover, for example, what makes some consumer products successful and others market failures; how to design for reduced environmental impacts; and general trends to help plan future products.

Before developing the product case studies, it was important to understand how the reports published in which are produced. The Consumers' Association buys the products to be tested from ordinary retailers and then employs a variety of methods to evaluate them (Which Ltd., 2014). The methods have evolved over the years, but from the early days they have included laboratory tests to provide objective measures of performance; for example, how well a washing machine cleans samples of stained fabric. Another long-established method is obtaining the views of panels of experts on products in use in the laboratory; for example, opinions on the picture and sound quality of a TV set. Other evaluation methods include trials of products by consumers chosen from Consumers' Association members. Such trials might involve, for example, users with children steering different pushchairs around an obstacle course in the test lab, and using the products at home, and then completing a feedback questionnaire. The results of these evaluation methods, plus information on prices, product specifications and features, are then analyzed. Conclusions on which products consumers are recommended to buy (or avoid) based on their price, specifications and performance are provided in which magazine and now also online.

Given the range of consumer products that tests, it was necessary to choose which ones to focus on. The choice of the six product classes listed above was based on selecting for examples of mechanical, electro-mechanical, electrical and electronic products; different levels of complexity and rates of technological and design change; and the relative importance of engineering, aesthetics, ergonomics and environmental factors in their design.

A case study of the invention, design, innovation and evolution of the bicycle provided a framework for researching the other product classes. The framework involved investigating each product class's technological and design history; the effects of environmental regulation and socio-economic forces on design; the product's impacts on the environment and society; and likely future developments. A variety of methods were employed to conduct the research, including reviewing reports on the products from the early 1960s to the present; internet and literature searches; visits to museums and shops; and interviews with users and retailers.

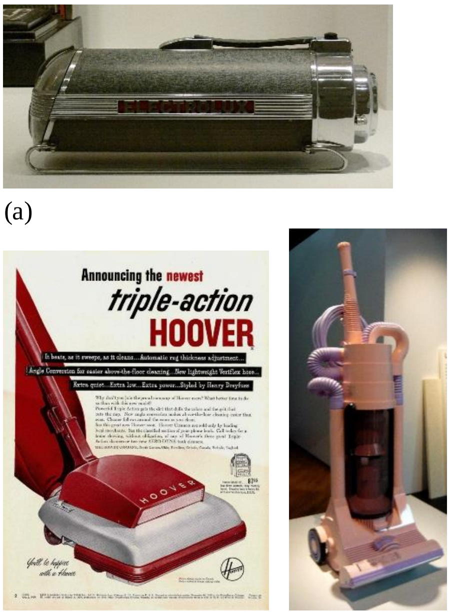
There is not space in this article to give full details of the case studies – these are provided in the book. Instead, it will provide conclusions from the case studies and extract some practical lessons for those involved in the planning, design and introduction of new products and innovations.

2. Patterns of Innovation

The first conclusion is that the different product classes follow similar patterns of technological innovation and design evolution; going through one or more divergent, convergent and divergent phases – a pattern first identified by the author for the case of bicycles (see Roy and Tovey, 2012, p. 176).

For all the products, one or more key inventions, such as the 1861 Velocipede pedal cycle or Edison's 1879 carbon filament electric lamp, were created that started a divergent phase of design experimentation and technical development. Early designs often look like an assembly of functional components, but which become increasingly integrated as the parts are enclosed and the product is designed as a whole. This phase of evolution is typically driven by the attempts by inventors, designers, engineers and manufacturers to eliminate the deficiencies of existing designs and produce better performing, more usable and desirable products. Utterback and Abernathy (1975) described this as the 'Fluid Phase' of innovation.

Following this early divergent, experimental phase, one or more 'dominant designs' typically emerge – as originally proposed by Abernathy (1978). The dominant products' designs converge on one or more technologies and configurations, for example, the classic diamond frame bicycle or conventional upright and cylinder vacuum cleaners (Figures 1a, 1b). Instead of the divergent experimentation of the fluid phase, the efforts of designers, engineers and manufacturers focus on making incremental product improvements and stylistic changes and on introducing new or improved components, materials and production processes. The changes in this phase are driven by continued attempts to improve, and eliminate the shortcomings of, existing designs, to reduce production costs and respond to customer feedback and changing fashions. Manufacturers typically create product variants for different market segments and may start designing to reduce environmental impacts.



(a) (b) (c)

Figure 1: Dominant designs: cylinder and upright suction vacuum cleaners. (a) 1937 Electrolux Model XXX cylinder cleaner styled by industrial designer, Lurelle Guild, with streamlines to suggest speed, which remained in production until 1954. (b) 1950 Hoover Model 29 upright vacuum cleaner designed by Hoover's consultant industrial designer, Henry Dreyfuss. (c) Disruptive innovation: Dyson's first dual cyclone vacuum cleaner, the 1986 'G-Force', made and sold in Japan.

Sources: Figure 1a http://commons.wikimedia.org/wiki/File:Electrolux_vacuum_cleaner_Model_30_DMA.jpg This work has been released into the public domain by its author User FA2010. Figure 1b INTV1980 / http://en.wikipedia.org/wiki/File:Hoover_model_29_ad.jpg Figure 1c Robin Roy

The case studies show that this dominant design phase is typically followed by another period of technological divergence and design variety. This phase arises because designers, engineers, manufacturers, and new entrants to the market, start to apply new product or process inventions, technologies, materials and components to create radically new products and so-called ‘disruptive' innovations (Utterback, 1994; Christensen, 2000), such as Dyson's first cyclonic vacuum cleaner (Figure 1c). The new technologies, materials and components may also be applied to reduce the costs of and improve existing products. An important driver for the development of these innovative and improved products is to cope with stagnating or saturated consumer demand. Innovation is also required to fend off competition from low-cost manufacturers, to generate new consumer wants, and to meet environmental and safety legislation or standards. The technological competition seen in the early divergent phase of product innovation reappears in this second divergent phase. In this phase, dominant designs may endure alongside the innovative products – as conventional bicycles have since the successful introduction of many recumbent, folding, electrically-assisted, and other new cycle designs, and incandescent light bulbs did for a time in competition with compact fluorescent lamps. Or they may disappear, as analogue mobile phones and TV sets did when digital phones and television systems were introduced or as LED lamps began to displace incandescent light bulbs.

Although there are patterns of divergence, convergence and divergence for all the case study products, there are differences in the rates and extent of change depending on their technologies. Washing machines, an electro-mechanical product, are still in an early second divergent phase with front- and top-loading automatics still dominant, but with new technologies appearing, such as washers that clean with the aid of air bubbles (Figure 5c), electrolyzed water or reusable plastic beads. Electric lighting, after converging on the dominant tungsten filament incandescent lamp in the early 20th C, has since been in a divergent phase with fluorescent and halogen lamps challenging but is about to converge again towards solid-state LED designs. The electronic products, television and mobile phones, have already passed through two divergent and convergent phases and are entering another divergent phase, for example with designs with bendable, organic light emitting diode (OLED) screens.

For business strategists, product planners and marketers understanding such patterns of innovation is important. This is because if they know where their business and products are located in the evolution of their industry, they should be better able to anticipate change, exploit opportunities and avoid being overtaken by new competitors or technologies.

3. Designing for Product Success

While many innovations and new products fail to diffuse into widespread use, others have become highly successful in terms of adoption and commercial profitability. What do the case studies suggest distinguishes these successful products from the less successful ones?

3.1 Genuine Innovation

For a genuine innovation, or ‘first to the world’ product, to succeed it must offer a function or other benefit that previously did not exist and that consumers need or want, at an acceptable price. Here are some examples:

Solid state, light emitting diode (LED) lamps offer greater energy efficiency and compactness, cooler operation and lower running costs than halogen incandescent and compact fluorescent lamps and so, as their price falls, LEDS are displacing these older technologies (Figure 2).

Figure 2: Electric lamps and their relative energy efficiency ratings on the EU Energy label. Left: tungsten halogen electric lamp (rated C); centre: compact fluorescent lamp (rated A); right: LED lamp (rated A+).

Source: Robin Roy

Digital television offered the advantages of multiple channels, higher definition and better sound than analogue TV; and then flat panel LCD, LED and OLED screens have provided advantages of much slimmer TV sets with larger screens providing even higher picture quality and using less energy than previous CRT designs.

The iPhone when first introduced in 2007 offered many advantages over other smartphones, including greater ease of use, touchscreen keyboard and icons, and desirable design. Its successor, the iPhone 3G (Figure 3 left), then also offered an increasing number of ‘apps' via the App Store. Other manufacturers were forced to develop their own touchscreen smartphones based on the concepts pioneered by the iconic iPhone.

Figure 3: The 2008 iPhone 3G (left), which succeeded the original 2007 2G iPhone, was a genuine innovation with its touchscreen, icons, screen-dominated design and access to the App Store. These smartphones have been developed through many models to the 2014 iPhone 6 Plus (right) and later iPhone 6, 7, 8 and iPhone X designs with larger, sharper screens, improved cameras and new operating systems.

Source: Robin Roy

Dyson's first UK-made cyclonic cleaner, the 1993 DC-O1, offered several benefits over conventional vacuums: no loss of suction, no replacement dust bags and innovative-looking, user-centered designs. Despite selling at twice the price it quickly captured 20% market and forced other manufacturers to produce bag-less and cyclonic cleaners.

3.2 Relative Advantage

Very few new products are 'first to the world' innovations, but are based instead on established technologies and so must compete with products from rival suppliers. To succeed such new products must offer what consumers consider to be genuine advantages over rival products, services or systems; what Rogers (1995) calls 'relative advantage'. For example, Sony's Trinitron color TV tube offered better picture quality than conventional color CRTs, something highly valued by consumers, and so made Sony TVs very successful in the 1970s (Figure 4a). Conversely, the LaserDisc (Figure 4b), a high definition rival to video-recorders launched in the 1980s failed the test of relative advantage. The player and discs were more expensive than VCRs and video cassettes, could not be recorded on, and could only store a shorter recording. For consumers, all these disadvantages outweighed the LaserDisc's higher definition pictures.

Thus, to be chosen in preference to competing products, manufacturers must develop products that offer a set of advantages; especially an equal or higher specification and a better functional performance than rival products at a competitive price. They should, of course, address other factors influencing consumer choice, including the brand image; emotional appeal; and practical issues such as fitting space in the home.

(a) (b)

Figure 4: (a) Significant relative advantage: 1970s Sony TVs with an innovative color Trinitron cathode ray tube, which provided a superior picture formed from lines rather than dots. This was valued by consumers and so made Sony TVs highly successful. (b) Inadequate relative advantage: the Philips LaserDisc player provided superior picture quality to rival video-cassette recorders, but this advantage was out-weighed by the LaserDisc's higher price, shorter playback time and inability to record. It failed to catch on.

Sources: Figure 4a RobSkitmore/http://objectwiki.sciencemuseum.org.uk/wiki/Image_E2005.343.2_Sony_Trinitron_TV.html Creative Commons Attribution Licence http://creativecommons.org/licenses/by/2.0/4b Robin Roy

3.3 Good Design

In the early experimental phase of innovation, products are often conceived as assemblies of functional or engineering components with relatively little attention paid to their ease of use, form, color, finish and user interfaces. As the products evolve, increasing effort is typically devoted to their industrial design to make the products more usable, visually and tactilely appealing, contemporary or fashionable. This involves an increasing role for industrial and product designers and ergonomists in the development process. For example, Gantz (2012, p.107) writes about the use of industrial designers by vacuum cleaner manufacturers to boost sales from the 1930s onwards (see Figures 1a and 1b above):

"For these early industrial designers, getting into the business was like shooting sitting ducks. Every product was ugly, ungainly and obsolete in style having been designed by engineers who were totally focused on functional performance, but oblivious to the new modern design trends and unaware of the public desire for more attractive appearance."

Electric washing machines are another example of a consumer product that started as an assembly of functional parts – a wooden tub, external motor, drive belts, wringer, etc. (Figure 5a). As they evolved the parts became more integrated; first with the mechanical parts enclosed, then with the cabinet design changing from round tubs on legs reminiscent of earlier machines to box shapes (Figure 5b). With the introduction of automatic washing machines, the drying mechanism was integrated into the cabinet instead of being provided by a separate spin drier. With further evolution washing machine controls became more sophisticated and so more attention was paid to user interface design and informative displays (Figure 5c). The latest machines are increasingly sleek in form with large flush glass portholes and electronic displays echoing contemporary product and kitchen aesthetics.

(a) (b) (c)

Figure 5: (a) Electric washing machine with powered wringer, made in Canada c.1920. The wooden tub with a rotating wooden 'dolly' inside is like those of earlier manual machines. The exposed motor could be hazardous; (b) Modern Indian top loading twin-tub washing machine; (c) Samsung Ecobubble™ washing machine, with electronic controls, 2013.

Sources: Figure 5a www.oldewash.com Courtesy of Lee Maxwell. Figures 5b and 5c Robin Roy

3.4 Affordable Price

When first introduced innovative products command premium prices and so are mainly adopted by wealthy consumers or enthusiasts. For example, before World War 2 vacuum cleaners were luxury goods only afforded by the upper middle classes, who bought them partly to address the 'servant problem'. Then with improved scale and efficiency of production, and to expand the market, manufacturers normally reduce prices. If the unique functions or advantages relative to the competition are considered by consumers to represent 'value for money', many more then begin to adopt or purchase the product.

For example, small-screen color TV sets, when first introduced in the USA in 1954, cost the equivalent of about $13,000 (approximately 11,000 Euros) so, until the launch of much lower priced, larger screen models, had a very limited market. In 1967 Britain a color TV cost about £300 (about £4750, or 5370 Euros, today) so most people rented. Six years later the price had almost halved, and sets had become more reliable, so it became more worthwhile to buy (Consumers' Association 1972). Today you can pay from £150 (170 Euros) to nearly £3000 (3400 Euros) for a high definition TV, depending on screen size and resolution (Which? Ltd., 2015). However, the technology, product platforms and many components are common to different models across the price ranges. Thus, good quality TV sets have become affordable for almost everyone in industrialized countries, with upmarket models available at premium prices for those who can afford or want them.

3.5 System Compatibility

Consumer products often must interface with other products and systems, so compatibility with these other technologies is essential. To diffuse widely the products also have to be compatible with consumer preferences and meet any prevailing national or international standards and legislation. Thus, the success of the first digital mobile phones was facilitated by the EU's agreement to adopt GSM digital technology, which became the standard most widely adopted outside the USA.

The importance of system interdependency and compatibility has been highlighted by Shove (2003). She argues that clothes laundering should be viewed as a 'system of systems' in which washing machine designers have to take into account the actions of detergent manufacturers, textile and fabric producers and users. Thus, washing machines designed for different markets need to provide wash temperatures and programmes that suit the existing – and likely changes – in detergent formulations, fabrics, clothes and laundry habits of consumers in different countries and climates.

4. Designing for the Environment

Making, transporting, using, maintaining and disposing of products all have impacts on the environment, which may include ecological damage (e.g. climate change, loss of landscapes and wildlife), resource depletion, and risks to human health.

Designing products to reduce impacts on the environment (DfE) may be undertaken to different levels. Brezet (1997) proposed four levels of DfE; subsequently termed green design; ecodesign; sustainable design; and sustainable innovation (Figure 6).

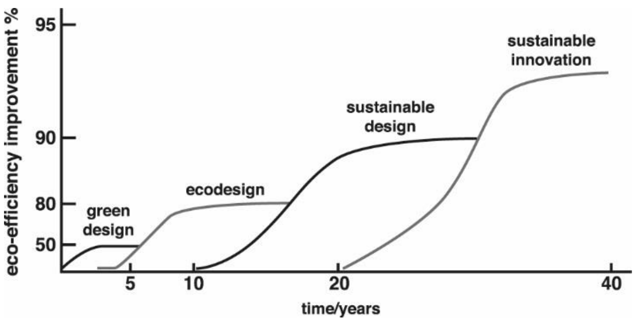


Figure 6: Different approaches to, or levels of, designing for the environment.

Source: (Roy (2006) adapted from Brezet (1997) p. 22)

4.1 Green Design

Green design is the approach most manufacturers use when they begin to address product environmental impacts; typically focusing on tackling one or more impacts necessary to satisfy environmental regulations, even if these impacts are not the most significant.

For example, concern about the environmental impacts of television did not become a significant factor in equipment design until the early 21st Century. However, there was growing concern about the electricity used when TV equipment was left on standby, although this was a relatively minor problem in the context of total energy use. This stimulated the 1999 International Energy Agency's '1 Watt Initiative', which led to 'green' TV designs whose standby energy use fell from about 5 watts to 1 watt or less. Similarly, concern about the large amount of TV and other electronic waste led to the 2003 EU Waste Electrical and Electronic Equipment (WEEE) legislation aimed at promoting recycling of equipment such as discarded TV sets, while the Restriction of Hazardous Substances (RoHS), introduced at the same time, forced manufacturers to reduce or eliminate hazardous materials (e.g. mercury and lead) in TV equipment.

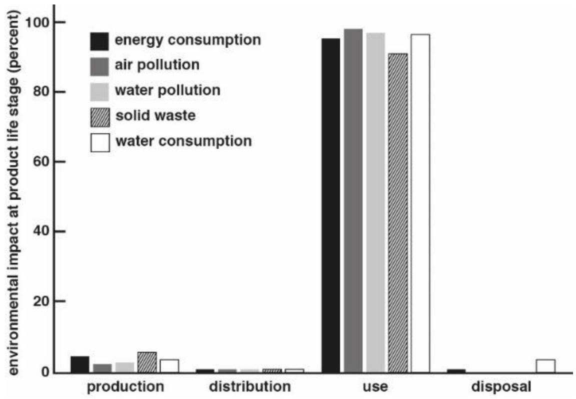
4.2 Ecodesign

Ecodesign, the next level of DfE, attempts to assess environmental impacts throughout a product's life cycle in order to focus on the most important impacts.

The primary driver for manufacturers to shift from green design to ecodesign has been environmental regulation and legislation. These include the US 1992 voluntary Energy Star program, the EU's 2009 Ecodesign for Energy-related Products Directive and Directives on Eco- and Energy Labelling of products. 'Environmental champions' within companies may hasten the adoption of ecodesign approaches in advance of legislation.

The EU Ecolabel for washing machines, for example, rested on a 1991 life cycle analysis (LCA) study that demonstrated that over 90% of the machines' environmental impacts occurred at the use phase (Figure 7a). This determined that the main Ecolabel criteria for washing machines were low energy, water and detergent consumption. This stimulated Hoover (UK), under the leadership of its Engineering Director at the time, to ecodesign its 'New Wave' range of washing machines (Figure 7b), which were awarded the first Ecolabel in 1993, replaced in 1996 by an EU Energy label (Roy, 1999).

LCA studies of mobile phones carried out by different manufacturers indicated that the impacts of their products varied widely, but were concentrated on the materials extraction, component manufacture and use life cycle phases. In response different manufacturers focused their efforts on different measures; from Apple auditing its Far Eastern factories to ensure pollution compliance to Nokia (before it was taken over by Microsoft) designing energy efficient phone chargers.



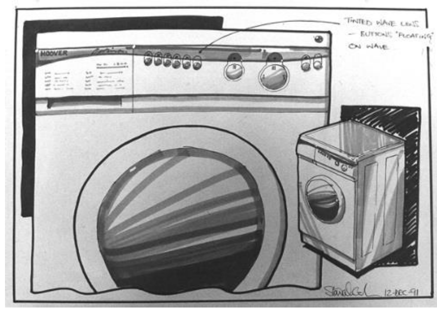


Figure 7: (a) Washing machine life cycle impacts (b) Design of the electronic control panel for the 1993 Hoover New Wave washing machine range, awarded the first EU Ecolabel for its low energy, water and detergent use achieved by scooping up water with perforated 'spray paddles' and showering it over the wash in the tub.

Source: (a) (Adapted from Durrant et al. 1991) (b) Robin Roy courtesy of Hoover Ltd., UK.

A drawback of LCA-based ecodesign is that it is complex and often difficult to translate into designs. Most companies, therefore, employ methods based on 'life cycle thinking', rather than LCA studies. At Philips, for example, product development teams are expected to focus on one or more Green Focal Areas – energy efficiency; packaging; substances; weight; recycling and disposal, and lifetime reliability (Philips 2014). Philips found that using its Green Focal Areas checklist helps to identify the most important environmental impacts of products. For example, Philips Lighting found that as well as energy efficiency, product life is important for reducing the impacts of lamps because a long life saves materials.

4.3 Sustainable Design

Sustainable design aims to provide a product's essential function using the least environmentally harmful technical solution; for example, powering it with solar energy instead of grid electricity or batteries. Sustainable design also includes socio-economic considerations, such as a product's fair trade implications and workplace health and safety. The main drivers for attempts at sustainable design tend to be NGO and media pressure acting with internal corporate sustainability policies or environmental champions.

An example of sustainable design concerns smartphones. In moving from ecodesign to sustainable design, Microsoft and Apple now attempt to reduce smartphone energy and resource use by incorporating power-saving software, minimizing materials use, and eliminating more harmful substances than is required by legislation. They have also been persuaded (by pressure groups such as the Gaia Foundation) to consider factory conditions and raw materials sources; for example to avoid child labor and 'conflict minerals' such as tantalum and gold, which may be mined by African slave labor and traded under the control of violent armed groups.

A more radical approach to sustainable smartphone design is the 'Fairphone', which was conceived by a Dutch social enterprise to avoid using conflict minerals. The new Fairphone 2 has a modular design for ease of repair and its Chinese manufacturers are chosen to provide fair pay and healthful working conditions. The Fairphone was funded via pre-orders from the public with about 100,000 phones sold by May 2016 (Fairphone, 2016).

4.4 Sustainable Innovation

Sustainable innovation is even broader in scope than sustainable design and goes beyond products to systems. Sustainable innovation involves providing a particular function using environmentally optimal product-service systems, taking into account the socio-economic sustainability of any proposed new product-service system. The main drivers for attempts at sustainable innovation are ideas from research, niche market trials, or future-oriented government policies such as the Dutch National Programme for Sustainable Technology Development (Weaver et al. 2000).

For example, a more sustainable system for providing clean clothes might include:

- innovative washing machines (e.g. plastic bead washers for domestic use that use minimal water and detergent);
- commercial or communal laundries equipped with additional environmentally efficient technologies (e.g. water recycling);
- a clothes loan or rental service (e.g. the UK retailer, M&S, proposed a clothes rental, repair and cleaning service – the 'infinite wardrobe' – as part of its environmental 'Plan A' (Barry 2015)).

5. Social Influences and Impacts

Inventors, engineers, designers and manufacturers need to understand that new products and innovations are not the inevitable results of technological progress or human creativity. Socio-economic, political, commercial and cultural forces influence which new products and innovations are created, introduced and adopted. For example, Burns (1998) describes how the historical development of television was not merely the result of scientific and technological innovations. Its evolution was shaped by government controls on broadcasting frequencies, international alliances on broadcast standards, patent disputes, and dedicated engineering teams in companies like RCA in America and EMI in Britain.

Shove (2003) furthermore argues that people's behavior in the use of products is strongly influenced by conceptions of what is 'normal', itself shaped by cultural and economic forces. For example, with post-War cultural shifts in Western society towards higher standards of cleanliness and hygiene – and as more textiles became machine-washable – clothes and linen began to be washed more frequently. The spread of automatic washing machines then increased the weekly wash to an almost daily wash in many industrialized countries. Likewise, the design and marketing of vacuum cleaners have, since their invention, been shaped by socio-cultural concerns about home cleanliness, health and hygiene (Gantz, 2012).

Hence, although designers, engineers and manufacturers cannot control socio-economic, cultural and political forces, it is important that they appreciate that such forces affect innovation and so should consider the broader context in which they are attempting to innovate.

6. Designing for the Future

Anticipating future technologies or classes of consumer product is difficult, but it is possible to discern some general trends.

6.1 Computers in Product Development and Manufacture

Computers have become essential tools for design and manufacture, as well as for remote collaboration between research engineers, product development teams and companies around the world. Computer communications have enabled the globalization of production and computer-aided design, while rapid prototyping and 3D printing have allowed designers and manufacturers to produce a much greater variety of products and variants than was previously possible. This has provided consumers with a considerable increase in product choices. However, it has also encouraged companies to launch new models more frequently, leading consumers to discard and replace products more often (Pereti, 2014). The shorter product development and replacement cycles are resulting in higher resource consumption and waste, lessening the benefits of attempts at the same time to design for reduced environmental impacts.

6.2 Smart Consumer Products

Information and communications technology (ICT) is being applied in many more consumer products. This goes beyond the information processing capabilities of products such as ultra-high definition TVs and robotic vacuum cleaners. For example, internet-connected washing machines will enable the machine to be turned on remotely by an energy supplier when the grid is lightly loaded or when a domestic solar energy system is generating electricity (Bourgeois et al. 2014).

This is part of a general trend towards the interconnection of different products and systems; the so-called ‘internet of things’, in which everyday objects have network connectivity allowing them to send and receive data. Examples include mobile phones becoming the remote control for lights, washing machines and televisions, and TVs sharing content wirelessly with other devices such as tablet computers and mobile phones.

As part of this process, companies such as Apple, Microsoft and Amazon try to get consumers to buy into their whole ‘eco-systems' of related products and services with smartphones as the integrating component. Google's ecosystem, for example, attempts to encourage consumers not only to use its internet browser and search engine, but also buy its Android tablet computers and smartphones, use its email and online software services, and buy its apps (Which? Ltd., 2015). Apple's great commercial success, Riedel (2014) argues, is due to its product-service innovation of bundling products such as its iPhones with services such as iTunes and the App Store. This has not only enabled Apple to offer chargeable content to consumers but also to take a percentage of the revenue. Apple also opened up the App Store to third-party developers to allow them to offer software and services to users and charge for these, from which Apple also takes a cut.

6.3 User-Centred and Inclusive Design

Designers and manufacturers are beginning to understand the importance of developing products to meet the needs, wants and demands of users that go beyond what can be discovered by conventional market research. User-centered design involves, for example, making detailed observations of user behavior; product developers co-designing with consumers in creative workshops; and designers becoming users in order to understand how to improve the consumer experience.

Inclusive design extends the user-centered approach by trying to design for the needs and abilities of all potential users, including the young, the old and people with disabilities. The idea is that if a product is designed for those who may have difficulties, it should be easy to use by all – for example, by ensuring that the controls of a washing machine can be understood and operated by anyone.

Donald Norman (2007) has pointed out, however, that the simultaneous trends towards making products more user-centred and automating them can conflict. He gives the examples of the built-in programmes on products such as washing machines, microwave ovens and heating controls that unnecessarily restrict what the user is able to do. Norman, therefore, advocates designing products that provide for appropriate inputs of human and machine intelligence in their operation and maintenance. Smart products such as internet-connected lighting and refrigerators have also been criticized for being over complex for most consumers. For example, a refrigerator that warns when the food inside is out of date or you are running out of an item requires users to scan barcodes and log their shopping into the appliance's computer. The ‘fridge will also suggest healthy recipes on its door screen if the user has entered their age, weight and Body Mass Index. Reviews have questioned whether consumers can be bothered to use such innovations (O'Leary, 2012).

7. Conclusion: The Need for Sustainable Design and Innovation

As noted earlier, designing for the environment is evolving from green design approaches to sustainable product-service systems innovation. Examples of the latter approaches are now emerging, such the M&S infinite wardrobe. It is now possible, for example, to lease LED lighting as a service package, thus overcoming the initial cost of buying an efficient lighting system.

The shift to sustainable design and innovation is of growing urgency as ownership of consumer products spreads from industrialized countries, first to newly industrialized countries such as China and then to low-income countries. For example, over two billion people already own a washing machine and an estimated further three billion in developing countries will want machine laundering by 2050 (Rosling 2010). The level of smartphone ownership in China already exceeds that in Britain. Electric lighting and TV will spread to the over one billion people in India and Africa currently without electricity. At the same time consumers in industrialized, and the middle classes in newly industrialized, countries, are likely to continue buying higher specification, ‘smarter' products, such as robot vacuum cleaners and larger screen TVs. They are also able to choose from an increasing variety of new products emerging in the divergent phases of innovation that was discussed in Section 2.

In the future global ownership of consumer products seems likely to approach saturation, which combined with an expected increase in population to 9.6 billion by 2050, will contribute towards unsustainable emissions and pollution levels and pressure on natural resources unless future products, services and systems are designed for sustainability.

References:

- Abernathy, W. J. (1978) The Productivity Dilemma, Johns Hopkins University Press, Baltimore USA.
- Barry, M. (2015) Plan A, Presentation at the Sustainable Innovation 2015 international conference, University of the Creative Arts, 9-10 November, Epsom, Surrey, UK. http://tinyurl.com/gwck93h (Accessed February 2016).
- Bourgeois, J., van der Linden, J., Kortuem, G., Price, B. A. and Rimmer, C. (2014). Conversations with my washing machine: an in-the-wild study of demand-shifting with self-

generated energy, in 2014 ACM International Joint Conference on Pervasive and Ubiquitous Computing (UbiComp 2014), 13-17 September, Seattle, Washington, US, ACM, pp. 459–470, http://oro.open.ac.uk/40465/ (Accessed October 2015).

- Brezet, H. (1997) Dynamics in ecodesign practice, UNEP Industry and Environment, 20(1–2), pp. 21–24.
- Burns R.W. (1998) Television: an International History of the Formative Years, Institution of Electrical Engineers, London.
- Christensen, C. M. (2000) The Innovator's Dilemma, First Harper Business, New York.
- Consumers' Association (1972) Colour TV rentals, reliability and servicing, Which? September, pp. 279-286.
- Fairphone (2016) Fairphone story, May
- https://www.fairphone.com/en/2016/05/26/100000-fairphone-owners/ (Accessed October 2018).
- Gantz, C. (2012) The Vacuum Cleaner. A history, Macfarland and Co, Jefferson NC, USA.
- Norman, D. A. (2007) The Design of Future Things, Basic Books, New York.
- O'Leary, J. (2012) I'm not hungry for a smart fridge, Which? Conversation, 19 January http://tinyurl.com/pwctbgc (Accessed October 2015).
- Peretti, J. (2014) The men who made us spend. Episode 1, BBC2 TV, 28 June.
- Philips (2014) Our Green Products, http://tinyurl.com/ou34hgb (Accessed February 2015).
- Riedel, J.C.K.H. (2014) Towards an understanding of Apple's success — Conceptualising product-service-business bundles, in Proceedings International Conference on Engineering, Technology and Innovation (ICE), Bergamo, June 23-25, IEEE, pp. 1-6 http://tinyurl.com/pak4mk4 (Accessed October 2015).
- Rogers, E.M. (1995) Diffusion of Innovations, (4th edition), The Free Press, New York.
- Rosling, H. 2010, The magic washing machine, [YouTube video of TED Talk], December, http://tinyurl.com/4gsx2wq (Accessed November 2014).
- Roy, R. (1994) The evolution of ecodesign, Technovation, 14(6), pp. 363-380. Crossref
- Roy, R. (1999) Design and Marketing Greener Products: the Hoover Case, in Charter, M. and Polonsky, M.J. (eds.) Greener Marketing (2nd Edition), Greenleaf, London and New York, pp. 126-144.
- Roy, R. (2006) Products: new product development and sustainable design, T307 Innovation: designing for a sustainable future, Block 3, The Open University, Milton Keynes, UK.
- Roy, R. and Tovey, M. (2012) Bicycle design: creativity and innovation, in Tovey, M. (ed.) Design for Transport. A User-Centred Approach to Vehicle Design and Travel, Gower, Aldershot, UK. pp. 167-200.
- Roy, R. (2016) Consumer Product Innovation and Sustainable Design. The evolution and impacts of successful products, Routledge, Abingdon, UK. (ISBN Hb: 978-0-415-86997-3; Pb:978-0-415-86998-0) https://www.routledge.com/posts/12172
- Shove, E. (2003) Comfort, Cleanliness and Convenience: The Social Organization of Normality, Berg, Oxford, UK.
- Utterback, J. M. and Abernathy, W. J. (1975) A dynamic model of product and process innovation, Omega 3(6), pp. 639-656. Crossref
- Utterback, J.M. (1994) Mastering the Dynamics of Innovation, Harvard Business School Press, Boston, Mass., USA.
- Weaver, P., Jansen, L., van Grootveld, G., van Spiegel, E. and Vergracht, P. (2000) Sustainable Technology Development, Greenleaf, London and New York.
- Which? Ltd. (2014) About Which? Which? research, http://tinyurl.com/ole645v (Accessed August 2014).
- Which? Ltd. (2015) Test lab buyers guide. TVs, audio and home entertainment, Which? August, pp. 68-73.