Consuming the million-mile electric car

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Abstract: Unlike for many consumer products, there has been no strong environmental case for extending the life of internal combustion engine cars as the majority of their environmental impact is fuel consumed in use and not the energy and materials involved in manufacturing. Indeed, with improving fuel efficiency, product life extension is environmentally undesirable; older, less fuel-efficient cars need to be replaced by newer more fuel-efficient models.

Electric vehicles (EVs) are predominantly considered environmentally beneficial by using an increasingly decarbonised fuel – electricity. However, LCA analyses show that EVs have substantial environmental impacts in their materials, manufacturing and disposal. The high 'embedded' environmental impacts of EVs fundamentally change the case for product life extension. Thus, product life extension is desirable for EVs and they are suited to it. While petrol and diesel cars have an average lifetime mileage of 124,000 miles (200,000 Kilometres), the case for the million-mile (1.6 million Kilometre) electric car appears strong.

Although it may be technically possible to produce a million-mile EV, how will such vehicles be consumed given that the car consumption is complex, involving, for example, extracting use and symbolic value? In this contribution we explore the nature of the relationship between cars and the consumer that moves beyond technical and functional value to understand what form of access consumers require to an EV across its entire 50-year life. If such consumption aspects are overlooked then, even if the million-mile car is technically viable, it is unlikely to be adopted and the environmental benefits they may yield will be lost.

Introduction

Popular literature about the Million-Mile Car (Car and Driver 2018, Popular Mechanics 2012, Wired 2010) has generally framed vehicular longevity as a feat of personal responsibility achievable only by careful and dedicated drivers, assuming that the million-mile car is to be designed and consumed using existing practices only supported by the fanatical devotion of their owners. This article explores the notion of a Million Mile Car, more specifically the Million Mile Electric Vehicle (EV), not as a rare feat achievable by the dedicated but as an attractive choice not just environmentally but also in terms of user convenience and business proposition. Additionally, we argue that the Million-Mile EV is a logical conclusion of developing industry trends, although significant changes in the ways cars are designed, consumed and supported will be required. In this contribution, we explore the nature of the relationship between cars and consumers that moves beyond technical and functional value to understand what form of access consumers require to such an EV across its entire 50-year life. Here, consumers are likely to desire not just functional value from EVs but also symbolic value to project a social image. Cars become soon aesthetically and technically obsolete and lose symbolic value for consumers, leading to frequent replacements, so the million-mile car needs to be designed for both technical and stylistic/social upgrading over its 50-year life. New business models and utilisation patterns will be needed to absorb the high initial costs of electric vehicles, to facilitate such a customised refurbishment process and to enable consumers to exchange vehicles frequently.

The Case for the Million Mile EV

Unlike for many consumer products, there has been no strong environmental case for extending the life of internal combustion engine (ICE) cars as the majority of their environmental impact is fuel consumed in use and not energy and materials involved in manufacturing and end-of-life disposal (Patterson et al 2011). Indeed, with improving fuel efficiency, product life extension is environmentally undesirable. Older, less fuel-efficient cars need replacing by newer more fuel-efficient models.

EVs are predominantly considered environmentally beneficial by using an increasingly decarbonised fuel – electricity. However, life-cycle analyses show that EVs have substantial environmental impacts in their materials, manufacturing and disposal (*ibid).* The high 'embedded' environmental impacts of EVs fundamentally change the case for product life extension. Further, electric motors have fewer moving parts, requiring less maintenance and have the technical potential for a much longer life compared to ICE cars. Thus, product life extension is desirable for EVs and they are suited to it. While petrol and diesel cars have an average lifetime mileage of 124,000 miles (200,000 Kilometres) (Ricardo-AEA 2015), the case for the million-mile (1.6 million Kilometre) electric car appears strong.

The Challenges of the Million Mile EV

Although it may be technically possible to produce a million-mile EV, how will such vehicles be consumed given that car consumption is complex, involving, for example, extracting use and symbolic value? Here the EV already faces difficulties in the consumer market. Electric vehicles have higher acquisition costs than ICE cars, making it difficult for them to compete with traditional vehicles (Cherubini et al. 2015). The high purchase cost of EVs, coupled with steep depreciation and the cost of battery pack replacements do not map well onto existing models of car purchase and use patterns. Establishing EVs within ICE car consumption institutions and culture is a fundamental challenge. However, while the technical aspects of the million-mile electric car have attracted considerable attention, there is scant research on their consumption and on strategies to stimulate and manage it. With a car designed for ultra-long product life, consumer issues are likely to be even greater than those faced now by EVs. The million-mile EV would have a life of at least 50 years and needs to be designed for refurbishment, modernisation and restyling. Such a vehicle would probably be best provided under a lease or service package and not outright purchase. Although there may be some market segments for new high priced EVs and then post-refurbished/modernised cars, such a vehicle lends itself to a lease/service package model (Cherubini et al. 2015). To some extent the car market, with the use of personal leases for new cars, has such a model but rolling this out across the 50-year life of the million-mile car is something novel for consumers.

Research indicates that whether a product is suitable for recycling, refurbishment or remanufacture or not greatly depends upon decisions made during the design process. There are specific product properties that may have a positive or negative effect upon particular life extension measures, such as disassembly or cleaning (Hatcher et al 2011). Until recently, product life extension (through longer product life, refurbishment and remanufacturing) was not routinely dealt with in most design practices (Bakker et al 2013; Hatcher et al., 2011). In the case of cars, particularly, the general assumption was that the vehicles would largely be recycled as scrap metal after reaching their end of life. However, owing to current trends in material substitution for fuel efficiency and safety in vehicular design, the percentage of electronics, plastics, composites and other non-metallic parts that cannot be recycled through traditional processes is increasing (Despeisse et al., 2015). With the growth in the complexity and embedded value of vehicles, designers increasingly take into account the disassembly, remanufacture and recycling processes and there is a growing case for radical lifecycle extensions. Consequently, there is growing interest in the development of a variety of strategies for resisting or postponing obsolescence (making a product easy to maintain) or reverse it (making products easy to upgrade and refurbish). There are several socio-technical design challenges for designing long-life products. Design considerations for product-life extension include reuse of the product itself, maintenance, repair, technical upgrading and a combination of these. Emotional and cultural dimensions must also be taken into account. For example, designing for attachment and trust can support product life extension by creating products that will be loved, liked or trusted longer (Bocken et al., 2016, den Hollander et al 2017). In addition to product innovation, companies must develop innovative circular business models to capture financial benefits from increased product longevity, which they would not be able to achieve in a linear model (Bocken et al., 2016).

With a diverse consumer market for vehicles, business models could take a number of forms depending on nature of the consumers themselves. *Product Service Systems* (PSS) could be particularly valuable (Cherubini et al. 2015) to explore the types of consumer access appropriate for the technical and financial characteristics of the million-mile car. A PSS is a system of products and services supported by networks and infrastructure designed to be resource efficient (Mont 2002). For example, the Million Mile EV could be made available through a rented or leased vehicle package or could also form part of a more comprehensive Mobility as a Service (MaaS) offering.

The manufacturer (OEM) would then be responsible for maintenance and disposal of the vehicle. In the case of EVs, a manufacturer acting also as PSS provider would have incentives to enhance remanufacturability through design, as a means of extending a physical product's life cycle (Hatcher et al 2011). PSS offer the advantage of making service providers (rather than users) responsible for monitoring resource use, controlling parts and materials for EVs on the road and organizing end-of-life treatment and resource reclamation (Saidani et al 2018). A number of PSS-style models are possible (Cherubini et al. 2015) and probably a range of such options could be developed to suit the variegated and changing needs of different consumers (Cook 2014; Catulli, 2019). Indeed, there may be various opportunities to develop new leasing models, for example extending the present personal lease package for new cars to older cars throughout their lifetime, for flexible city car lease. In some instances, such offers could be integrated within transport systems using smart city technologies (cf. Valdez et al, 2017; Cook, 2018).

A review of trade literature suggests that the industry is already developing the required capabilities. Accenture (2018) claims that by 2030, revenues from manufacturing and selling vehicles (around €2 trillion) will be only marginally higher than they are. By contrast, revenues from mobility services are projected to soar to almost €1.2 trillion. Consequently, automakers are expected to evolve their value propositions from "hardware provider" to "integrated mobility service provider" (McKinsey 2016). The transition is not necessarily inspired by ecological concerns but rather by awareness of the rapid pace of technology: "*The increasing speed of innovation, especially in software-based systems, will require cars to be upgradable. As shared mobility solutions … with shorter lifecycles will become more common, consumers will be constantly aware of technological advances, which will further increase demand for upgradability in privately used cars as well*" (McKinsey 2016).

The Modular EV – A potential Million-Mile Solution

One approach to make it easier for 50-year old vehicles to remain technically and stylistically functional is modular design. The concept of upgradeable cars was explored by EV makers such as Tesla as a way to address the rapid obsolescence that can be caused by rapid developments in battery capacity (Forbes 2014). On a whole-vehicle-level, some players in the automotive market have already presented scalable and modular vehicle concepts (Figure 1). These vehicle concepts are generally associated with MaaS to address urban traffic issues (Ulrich et al 2018). Several major automakers have delivered prototypes exploring variations of that concept. The Urbanetic concept by Mercedes Benz, for instance, is based on a self-driving, electrically powered chassis that can take different switchable bodies depending on the intended use (Fig 2). The modules are designed so they can be switched automatically or manually in a matter of minutes and the autonomous chassis can make its way to its next location without any body attached. While the company explains that the rationale for the modular design is flexibility, a modular design would also support longevity. One major problem that could be expected from a million-mire car with a 50-year lifespan is that it would be easy for it to become aesthetically obsolete, losing symbolic value for consumers and requiring replacement even if the mechanical components remain sound. A modular design, combined with PSS, would make it easy for manufacturers to refurbish and update the passenger module in response to the latest stylistic trends, without compromising the longevity of the "platform" with motor, batteries and other components with high embedded environmental costs. If the social and even emotional dimensions of consumption are not taken into account, however, such offering might face implementation challenges (Li and Voege 2017) because consumers might see such PSS as less able to enable their everyday activities and project their identities (Catulli 2019).

Conclusions

We have discussed a number of issues associated with consuming the million-mile electric car and suggested one approach in which a PSS would be combined with flexible, modular vehicle design to provide such offering. Several major manufacturers (Fig. 1) are already exploring modular designs largely under the assumption that they will be used to provide MaaS. While this is only one of the many potential approaches that would make the million-mile car work, it illustrates the importance of a design where technical and social aspects support each other. The long-life car is more than a technical challenge and technical design needs to allow for unforeseeable changes in behavioural, symbolic, stylistic and lifestyle factors. An exploration of industry trends suggests that many elements of the million-mile EV are emerging – but a key set of consumer factors have received limited attention. Unless they become the focus of the million-mile car design, then it may fail to become the central business model of the automotive industry. If business models and socio-technical consumption aspects are overlooked when designing both vehicles and systems in which they are embedded, then even if the million-mile car is technically viable it is unlikely to be adopted and the environmental benefits they may yield will be lost.

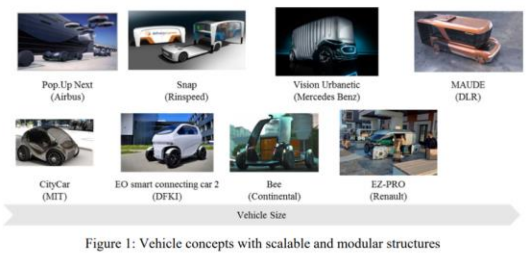

Figure 1. Concept vehicles by major manufacturers exploring modular approaches (Ulrich et al. 2018)

Figure 2. Vision Urbanetic concept © Daimler.

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