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Ecofitting Circular Economy: An alternative approach to market, consumption, and design towards zero emissions

Dr Artur Grisanti Mausbach
Senior Research Fellow at the Royal College of Art
Intelligent Mobility Design Centre
PhD Vehicle Design (RCA), Master of Environmental Urban Structures (USP), Architect and City Planner (USP).
Contact: artur.mausbach@rca.ac.uk .
Royal College of Art. 4 Hester Road SW11 4AX London. UK

Dr Farhana Safa
Research Associate at the Royal College of Art
Intelligent Mobility Design Centre
Master of Arts Vehicle Design (RCA)
Contact: farhana.safa@rca.ac.uk
Royal College of Art. 4 Hester Road SW11 4AX. London. UK

Professor Dale Harrow
Director and Chair at the Royal College of Art
Intelligent Mobility Design Centre
Contact: dale.harrow@rca.ac.uk .
Royal College of Art. 4 Hester Road SW11 4AX London UK.

Dr Cyriel Diels
Deputy Director at Royal College of Art Intelligent Mobility Design Centre
Contact: cyriel.diels@rca.ac.uk .
Royal College of Art 4 Hester Road SW11 4AX. London UK.

Abstract

This paper reports the initial findings of the Ecofitting. The project proposes a new circular economy strategy to contribute towards zero-emissions in a sustainable manner by retrofitting the existing fleet of ICE cars. Requirements for Ultra Low Emission vehicles will create a fleet of 15 million non-compliant ICE cars in the UK alone which is currently expected to be exported, recycled, or disposed of. Ecofitting may not only benefit the individual OEM, but the wider supply chain and ultimately the wider economy by developing an entire ecosystem around remanufacturing, redistribution, repair, reuse, refurbishment, and design.

Ecofitting proposes an alternative strategy that not only involves the electrification of this fleet but, importantly, the customisation and personalisation of these vehicles to create desirability, promote behavioural change, and long-term ownership. As such, design is at the heart of this new strategy. The research identified trends in automotive design, lifestyle, and behaviour of the next generation of consumers that can support an alternative approach to automotive design. It concludes by proposing that Ecofitting design shall reflect values of sustainability in aesthetics.

Keywords — circular economy; retrofitting, automotive design; sustainability, aesthetics.

Introduction

This paper reports the initial findings of Ecofitting at the Intelligent Mobility Design Centre (IMDC) of the Royal College of Art (RCA). The research project initiated looking at the potential of the conversion of ICE cars into electric as a strategy to collaborate on shifting to a more sustainable mobility. In addition, related to the context where it is developed, the research investigates a sustainable and responsible solution for private cars that are soon to be non-compliant with clean air zone regulations predominantly in the UK.

The objective of Ecofitting is to develop a new strategy to contribute towards zero-emissions by reusing and retrofitting existing car fleets to electric drivetrains, as opposed to current industry strategies based on the creation of new products. This avoids the massive impact of end of life and disposal. At the same time, re-using vehicles will require updating in usability, safety, and aesthetic to make them attractive to costumes. Ecofitting will then, create opportunities to new customising options, enhancing long-term ownership of vehicles.

While there are also challenges on the development of business and engineering, the focus of IMDC research is on sustainable automotive design. The project will apply design research methodologies to investigate the implications of Ecofitting and its wider impacts. In doing so, the Ecofitting project aims to collaborate in the

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development of new design paradigms, business models, and manufacturing approaches as part of a circular economy.

A scoping stage defined the objectives and focus of the research, through the study of current market trends, aesthetic trends, development of legislation and regulations. Initial research referred to the current context around car industry and impacts of the new emissions standards. The project identified a market segment for Ecofitting - the relevant sections of the existing fleet to be prioritised for electric conversion. Furthermore, it discusses an alternative approach to automotive design, market and consumption: defines the Ecofitting Landscape, presenting initial thoughts about how stakeholders could participate on this circular economy; and investigates how current cultural trends can support the development of a new automotive design aesthetics.

The last section of this paper summarizes the key findings and describes the next steps of the research, including the Feasibility Study funded by UKRI CENTS (United Kingdom Research and Innovation - Circular Economy Networks in Transport Systems).

Note: Ecofitting is the name of the research project and it is a term created by IMDC to refer to the activity and to differentiate it from retrofitting.

I. CONTEXT

Currently, there is no sustainable solution for the large existing fleet of internal combustion engine cars. While these vehicles are being progressively banned from use in places with more strict regulations, that does not guarantee a reduction in global emissions if the destiny of the fleet is not managed properly.

Under new EU rules, the average CO^2 emissions of all cars sold in the UK from 2021 must fall below an average of 95g/km for car makers or else face heavy fines [1], and the UK ban of petrol and diesel vehicles has been brought forward to 2035, when every new car sold will be zero emission [2]. The introduction of Clean Air Zones in the UK, ULEZ (Ultra Low Emission Zone) in London from 2019, and to be extended in 2021 [3], determines that non-compliant vehicles will be charged a fine to circulate. The measures object improvements on air quality, health and reducing emission of greenhouse gasses, and consequently, climate change.

As positive as this is for our future, a question remains as to the fate of the millions of non-emission compliant vehicles that will be rendered redundant overnight. The restrictions to petrol and diesel vehicles from EU, UK or city levels, will create a context where there is no security for the people who are likely to see their own vehicles, losing their value and ultimately, their function. It may also accelerate the replacement of industry products and increase the rate of ecological impacts of production, especially considering the higher ecological footprint for production of EVs. While this might create a demand for new electric cars, it does not consider if people are prepared to replace their vehicles, financially or emotionally.

Considering this, Ecofitting questions:
Which viable options do private car owners have to transition to electric mobility?
What is the most responsible way of dealing with these non-compliant vehicles?
How to develop alternatives that will make people embrace the transition to EVs?

As observed by Manzini and Vezzoli [4], the process of change to a sustainable society needs to be undertaken carefully to achieve its objectives in an inclusive way. It is necessary to be cautious on the impacts of the transition to sustainable mobility, understanding the implications of the processes and its externalities. Stuart Walker [5], Quadruple Bottom Line for Sustainability added that we need to inform our creative design endeavors with their Practical Meaning, Social Meaning, Personal Meaning and Economic Means.

The way that cars are produced and consumed can be considered a part of a linear economy. The introduction of new cars in the market is supported by the hypothesis that their production creates jobs and economic growth, and the product provides a mobility solution. Nevertheless, all new cars require an abundance of energy and raw materials to be produced.

The lifecycle of a private car includes passing from hand to hand on processes which are difficult to control, and so it is its end of life. One prospect for the current ICE fleet is the scrapheap, which adds to wastage, and another is to sell these vehicles en masse to countries that are yet to enforce stringent emissions legislations, continuing to add to environmental pollution. However, both actions do not provide a responsible solution. The ecological approach to this problem would be ‘Recycling, Reusing, and Reducing’, and the industry is currently working on the first ‘R’. Although cars can be recycled to a great extent, having private cars recycled is not a straightforward process in the current model. It is necessary that strategies are put in place to reduce the amount of energy and raw materials used to deliver mobility solutions, and to reuse

and extend the life of existing vehicles in a more sustainable way. The remanufacturing process, updating and re-adapting for its original use, or to a different use, is a possibility to extend the lifecycle of the vehicles. At the same time, strategies should consider the possibility of creating ways and providing information for car owners to decide about the destiny of their cars, considering the economic, personal, practical, and social consequences.

II. IDENTIFYING THE FLEET

Converting classic cars to electric, making them cleaner, more reliable, and easier to maintain is already a growing trend in small businesses and OEMs [6,7,8]. It can be considered a niche activity that explores the emotional connection between people and classic cars, to create an opportunity to develop business and products. To develop the industry sustainably, Ecofitting aims to expand this trend beyond just classic cars via the conversion of millions of non-compliant vehicles by garages, small/medium businesses and OEMs, and repurposing them into a circular economy.

IMDC's initial research looked at UK government targets for clean-air zones and zero-emission vehicle phasing to identify a timeline and scope within which the context of Ecofitting would be most relevant. The cars made before 1980 will be protected under the Classic Car exemption [9]. Therefore, although classic cars are attractive to owners to convert, they are not legally limited to circulate on UK´s Ultra Low Emission Zones. Additionally, especially when looking at cars before the 1980´s it is more complex to retrofit them in a way they would provide a level of safety which could be accepted today.

All cars made from 1980 until the implementation of the current emission standards are worthy candidates for Ecofitting. By looking at data from the Department for Transport (see figure 1)[10,11], it has been identified that as of 2019, there is a fleet of 15.1 million diesel and petrol cars currently on the road in the UK that are non-compliant with clean air zones. These cars are the main focus of the Ecofitting proposal. Other 53.5% of the fleet, which are compliant to the ULEZ, can be a part of a second Ecofitting wave, also converting them to zero-emissions. Currently, only 0.2% of the UK fleet is zero emission.

Ecofitting can help significantly to meet UK´s zero emission targets faster. This not only extends the life cycle of cars, saves production energy and raw materials, but may also open up new possibilities for business and design to change current consumption patterns and how we understand and produce cars in the future.

III. AN ALTERNATIVE APPROACH TO MARKET, CONSUMPTION, AND DESIGN

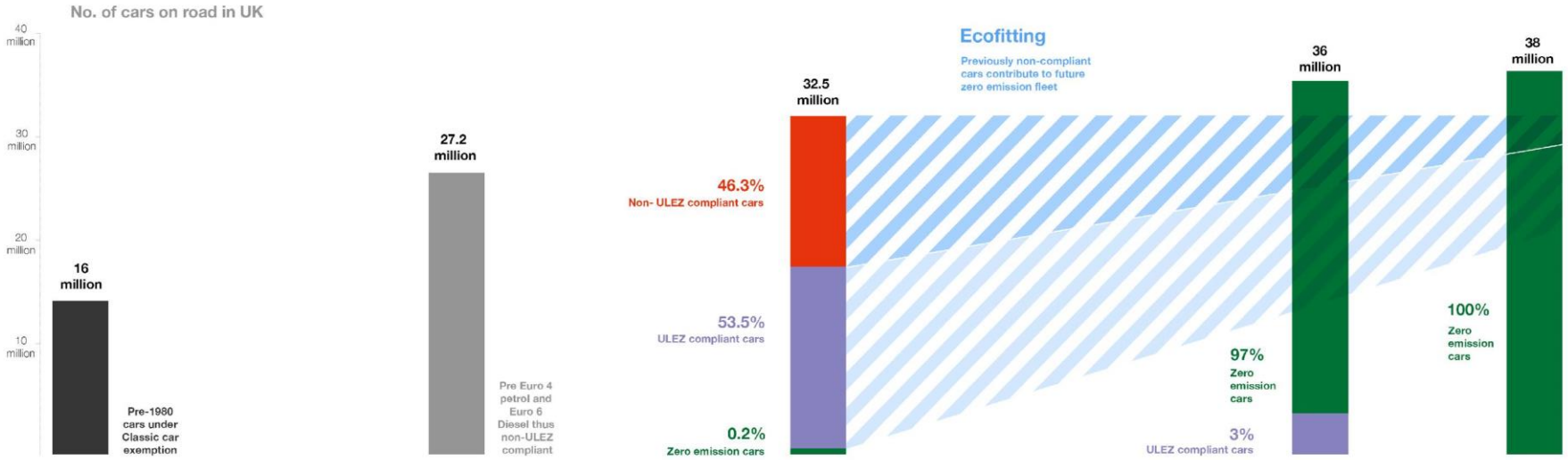
Stuart Walker [12] points out that our consumer society encourages "social ills through the constant supply of novelty and status-oriented goods with invidious marketing techniques that incite socio-positional competitiveness". The automobile, as a product, is central to this problem, from the development of the model-year concept by General Motor´s Alfred Sloan to the current struggles of the industry and its negotiations with governments and society as whole.

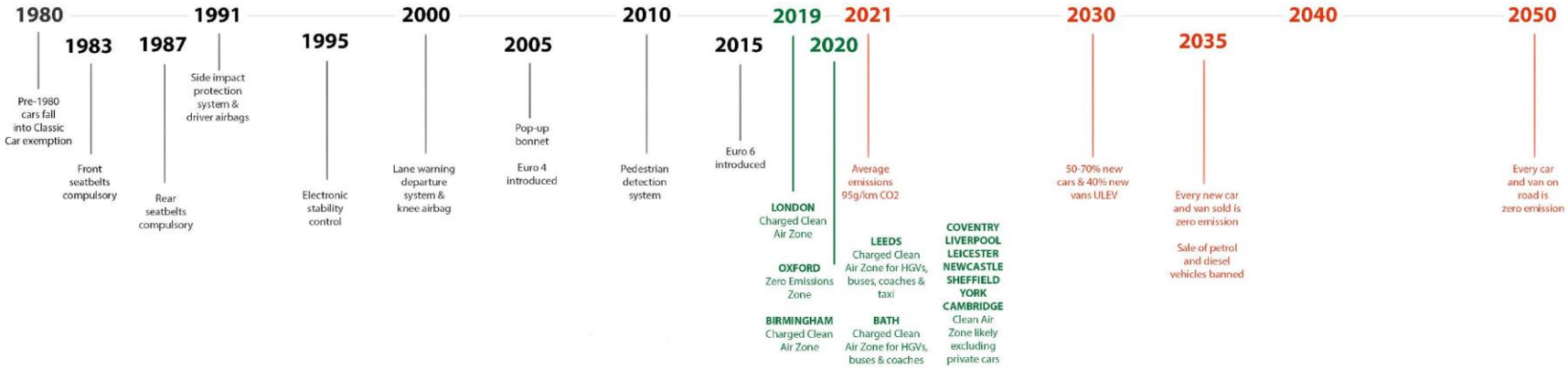
Recently, the development of a new plant in Wales for the car company Ineos was suspended [13]. The plant would employ only 200 people, initially, and it demanded a large commitment from the local government. This follows other cases abandoned plans for the expansion of the industry, according to an article on the Guardian [14], Nissan Sunderland costed 741 future jobs, Jaguar Land Rover announced the cut 4,500 jobs in January 2019 - also early consequences of the Brexit process. And it adds to the job's losses due to closure of plants: 1,700 jobs at Ford Bridgend and 3,500 at Honda Swindon. Although, according to the Society of Motor Manufactures and Traders [14], 186,000 people are employed directly in the industry in the UK, this shows that at the least there is a uncertain level of security for the workers and a high risk on the commitments made by governments to support the industry as it presents itself nowadays. It is also important to consider the impact of the manufacturing structures in the environment. People in Grünheide, 38km south-east of Berlin, recently protested against Tesla plans to build a "gigafactory" in the place, questioning the impacts in the natural environment, water supply and on their personal life [15].

In the other hand, a circular economy approach can be based on smaller scale of infrastructure, involving local garages and small business. Remanufacturing creates and opportunity to involve different stakeholders contributing for the development of a green economy, which would have a different concept of efficiency. Ecofitting would be less focused on speeding-up and lowering cost of manufacture, and more on creating jobs and involving people in a meaningful contribution to sustainability and to creating a culture of design and craft. It aims for greater independence for the local motor industry and helps stimulate the economy by guiding the development of new businesses and further products by sustainable principles.

ECOFITTING TIMELINE

CONTRIBUTION TO ZERO EMISSION STRATEGIES





Data on all licensed and registered cars from Department for Transport

Currently, OMEs contribute to the transition to zero emission through the production of electric vehicles and, significantly, parts of electric vehicles. The production of parts and also kits to conversion to electric can be a significant contribution of the OEMs to remanufacturing. VW has started to provide kits to convert original Beetles and Campervans [8] (figure 2). Other OEMs, like Jaguar and Aston Martin [6,7], have produced demonstrators, usually based on classic models, but apparently without the intention to create a new business model around them. OEMs would also be capable to market the products, as fully remanufactured models or parts and kits to EV conversion, using its dealer network and financing models.

Figure 2. Beetle converted to electric.

The circular economy approach, nevertheless, should favor the integration of OEMs with SMEs. The latter might be more adaptable to the constrains and requirements of the activity of converting car to electric, which require specialized craft and labor. There are many businesses developing conversion to electric. Companies like Transition-One [25], in France, focus on developing the solution from specific models, and having the possibility to expand the portfolio progressively. In the UK, Electric Classic Cars has worked with bespoke project and its activities are portrait on the Vintage Voltage TV reality show. Smaller local garages could also perform the conversion to electric, helping Ecofitting to reach to different communities. For the local garages, it is strategic to find ways to adapt to a non-ICE based activity. The same challenge applies to tuning companies. Moreover, DIY process, would naturally be part of it.

The activity of restoration is directly linked with Ecofitting since it is also based on existing cars. The proposed approach, however, is not solely based on preserving the aesthetics of the past, but, more importantly it proposes that interventions on the aesthetic are welcome to adapt to new uses, to communicate a new mindset, and a different approach to consumption.

Private cars would be upgraded as private houses, customized and adapted to new uses through time, becoming an object of long-term ownership. And as it happens within architecture, small design practices can act directly with private owners to provide services of personalization and customization. Closer to cars, the activities of customizing, bespoke design and personalization have similar process and stake holders in the café-racer culture, which expands owning a motorcycle to a lifestyle. A good example of the Ecofitting approach is the ZeroLAB Bronco (figure 3), which incorporates upgrades on interior and exterior in addition to the conversion to electric.

Figure 3. ZeroLAB Bronco interior.

Ecofitting studies the development of a new industry and product, allowing the development of a more meaningful, longer-lasting connection between people and products. Walker [16] indicates that to a great extent, the aesthetic qualities of a product are a function of the system that produces it. ‘It follows that the aesthetics of most consumer products are, in fact, the aesthetics of immoderate waste and environmentally and socially damaging practices’. Also, according to Walker, [12], the focus on sustainability will change this perception, 'product aesthetics would start to embody and reflect a system of production which is sensitive to the environment, respectful of human dignity and social equity, and indicative of an approach which values diversity, harmony and equilibrium”.

Deciding about the destiny of the current ICE fleet has environmental, social, and economic implications. In addition, concerning automotive design, there are cultural and emotional implications related to the historic and symbolic values of cars. While creating routes to sustainable mobility it is important to consider people´s needs and aspirations, to deliver different solutions and alternatives that we will embrace.

The automobile was set as both a utilitarian and a symbolic object from its inception. Whilst becoming the materialization of modern man's desires and aspirations [17], the car has changed cities, reshaped culture and developed its own mythical context [18]. The car evolved from practical tool to fashionable object. "To Alfred Sloan, from General Motors, the same car represented an opportunity to seduce the consumer with ideas of social competition and cultural modelling" [19]. Cars had to attract the consumer, to communicate different qualities, and to express personality, value, and innovation. Automotive design psychology became complex, desirability becoming a consequence of both the physical configuration of an object, its meaning, and later, the values it represents.

Consumers are regularly enticed and encouraged to buy new vehicles or facelifted models featuring the latest technology and following popular design trends. However, there is also evidence of a counter to this narrative as exemplified by behavior car design trends studies at the IMDC [20], that gives credit to the feasibility of Ecofitting. New-Classics and Retro design cars have been successful for more than thirty years, and this continues with the latest arrival of a steady stream of Retro-Electric cars. The new addition of Retro-electric cars such as the Mercedes Benz Vision EQ Silver Arrow, Vision Mercedes-Maybach 6 cabriolet, the Honda EV concept and the Peugeot E-legend concept are at the same time an effort of traditional car companies to keep the status quo, and a response to a nostalgic taste of the general public, which also indicates a misconnection to the latest car design aesthetics.

Figure 4 Honda EV concept.

IMDC research on European Gen-Z consumers [20] indicates a tendency on more disruptive consumer behavior trends, which does not fit to the mainstream automotive design standards. Partly as consequence of this, the new generations are not attracted to cars as in the past. The research also indicate that the next generation is likely to look beyond the physical beauty and practical aspects of products, and to search for their meaning and ethical value.

The disruptive attitude of the next generation can be explained by the success of the Burning Man Festival [21]. Based on the Californian desert, the music and art festival includes the temporary building of a city (figure 5), following its own rules of sustainable practices. As much as the portrait of an aesthetic and a lifestyle, it proposes a mobility model where only bicycles and walking is allowed, and specially-build "monster" cars are treated as art expressions (figure 6). How different the vehicles produced at the Burning Man Festival are, reflects the changes in context, tastes and habits which are challenging the aesthetic paradigms of the industry, and the need to find an alternative automotive design aesthetic.

Figure 5. Temporary city built for the Burning Man Festival in California.

Figure 6. Car built for the Burning Man Festival.

Having in common with the Burning Man the building of a lifestyle as the most significant issue, the cultural movements of car restoration, owning and driving classic cars, custom motorbikes, and vintage car clubs are becoming increasingly popular [22]. In the cases of vintage cars and motorbikes, it defines a long-term commitment and longevity of products. To an extent, a café-racer bike does not age, but it is open to unlimited adaptations and personalization.

Furthermore, events like the annual Goodwood Festival of Speed are attended by over 200,000 visitors over a long weekend [23], and TV shows about restoring and marketing vintage cars have a regular and popular presence. These are all indicators of the complex and intimate emotional relationship between people and cars, as an image or consumer product, contributing to the development of long-lasting ownership with social, cultural, and environmental benefits.

Ecofitting proposes an alternative approach to automotive design, with opportunities for vehicle customizability and upgradability, concurrently questioning the status-oriented renovation of products and the dependence on the model-year concept, and investigating car desirability based on values, providing the industry with a new holistic intellectual approach.

It brings together the retrofitting experiences in architecture, approaches of interior design and fashion, cultural movements of car restoration, café-racer and customizing, to the possibilities of local design, production and prototyping, and configuring a new landscape for the development of car design. To Mausbach [18] in the context of sustainability, "the aesthetics will be manifested with more diversity, with respect to local culture and individuality." Also according to Mausbach [18], a "new language will only change the image of the automobile if it can be understood as a representation of new values that are not associated with socially and environmentally damaging practices". Therefore, Ecofitting must have a particular aesthetic, recognizable as distinct from previous ones.

The expected aesthetic will reflect the process of adaptation and conversion to electric and would not look to perform unnecessary repairs aimed to create a polished finished product. While it bridges traditional craftmanship and traditional philosophies - like Kinsukuroi [24], which shows the scars of the repaired ceramic; it can also incorporate local production and rapid prototyping latest technology. As stated by Walker [12] "the aesthetics of sustainability are not so much an objective, but more a result of systems of design and manufacturing which are consistent with sustainable principles. (…) If the system of manufacturing itself adheres to sustainable precepts, then product aesthetics will embody and reflect the sustainable values inherent to that system.'

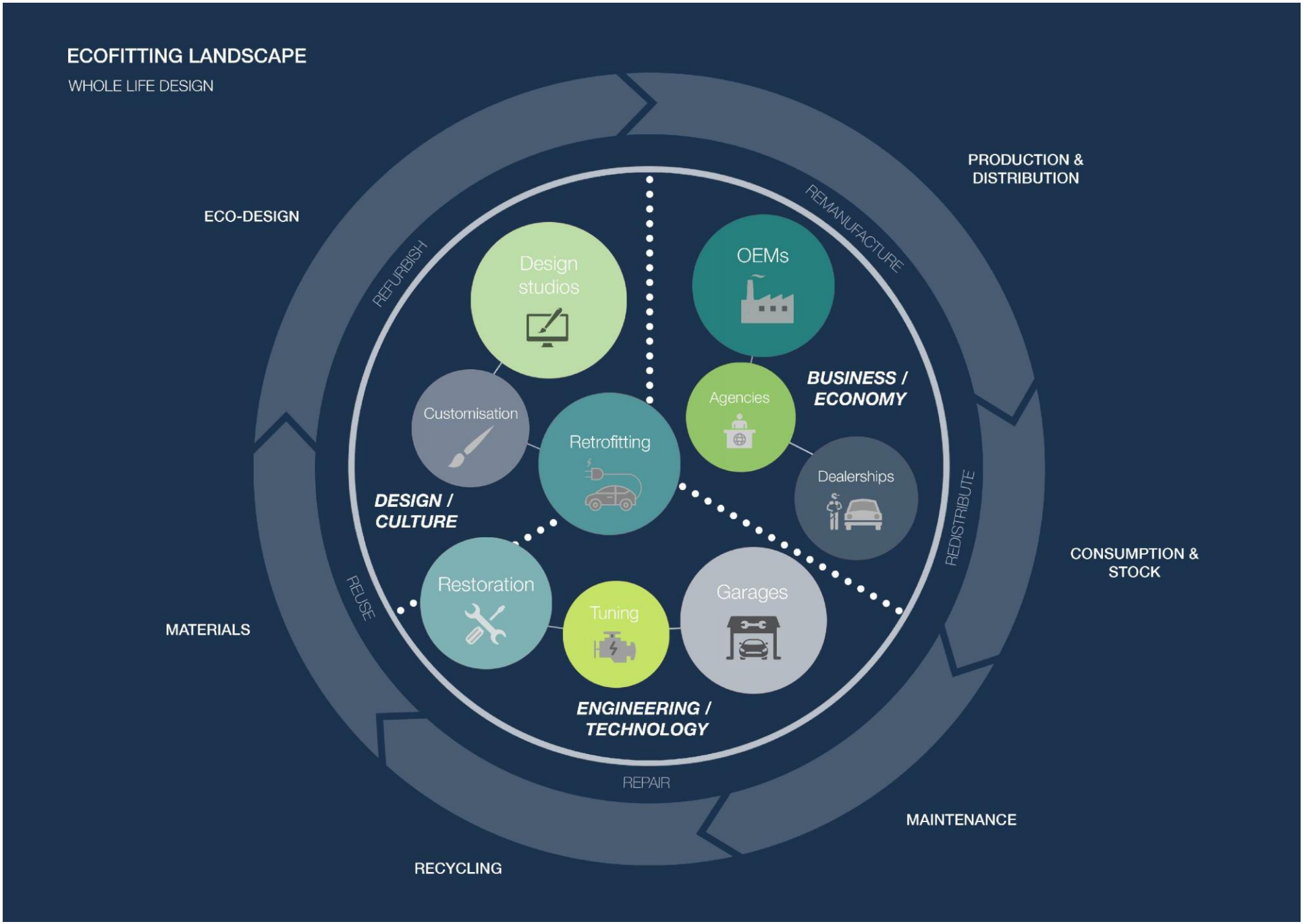
IV. INITIAL FINDINGS AND FUTURE RESEARCH

This paper reports the Ecofitting scoping studies at the Royal College of Art and introduces the concept of Ecofitting as a sustainable and responsible solution for private cars, enhancing long-term ownership, customizing, and upgrading them to electric drivetrain. Ecofitting proposes an alternative approach to market consumption and design which is based on the activities of a circular economy, explained in figure 7.

This scoping research has identified the target market of vehicles that are appropriate for Ecofitting and outlined the contribution to achieving zero-emissions through electric drivetrain conversion. By encouraging the act of reusing, recycling, and updating products in usability, technology and aesthetics, the project promotes whole-life design and provides opportunities to engage a wide network of stakeholders as part of a future industry. However Ecofitting is not intended purely as an engineering upgrade, but a proposal to develop new design aesthetics to prompt long lasting ownership that improves the product experience, changes consumption patterns, appeals to the customers, and protecting consumers' financial investment by guaranteeing an extension of their vehicle´s life.

Moreover, the initial studies point out that the importance of understanding the cultural barriers to implementation of Ecofitting, which makes the project a challenge for automotive design. It also indicates that future consumer behavior might favor disruptive design trends, and the association with an alternative and more meaningful lifestyle. This process will produce a new car design aesthetic which will reflect the values and process within Ecofitting. It also highlights the cultural trends of customizing, tuning, and interest in retro-design vehicles as a connection point to consumers, and opens routes to new innovation in vehicle design contributing to the creation of a circular economy and a more socially responsible society.

To better answer the questions about what viable options do private car owners have to transition to electric mobility, and the viability of the Ecofitting Circular Economy, the project next steps will be developing a feasibility study, with the support of EPRSC CENTS, followed by case studies with industry partners. The activities will be developed applying IMDC design research methodology to focus on how to develop alternatives that will make people embrace the transition to zero emission mobility.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PRODUCTION & DISTRIBUTION
ECO-DESIGN
REMANUFACTURE
REFURBISH
Design studios
OEMs
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Agencies
Customisation
Retrofitting
Dealerships
DESIGN / CULTURE
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