

ECOFITTING

circular economy design upgrading cars to zero emissions



Royal College of Art

INTELLIGENT MOBILITY DESIGN CENTRE

ECOFITTING

**circular economy design
upgrading cars to zero emissions**



Research funded by CENTS (Circular Economy Network+ in Transportation Systems; EP/S036237/1), funded by UKRI (UK Research and Innovation).

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2020-2021

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Executive Summary

Ecofitting is a sustainable solution for the large UK fleet of internal combustion engine cars that is rendered non-compliant with initiatives like the **Ultra-Low Emission Zones**. Focused on sustainability and conceived as **circular economy** strategy, Ecofitting goes beyond just electrification, opening an opportunity for new approaches to automotive design, and to cater for generational shifts in desirability.

The Ecofitting feasibility was developed at the Royal College of Art Intelligent Mobility Design Centre with the support of **CENTS (Circular Economy Network + In Transportation Systems)** from February 2020 to January 2021. Parts of this report were previously published in separate papers and magazines, and presented in conferences.

The project explored the development of novel design directions to expand the trends of converting ICE cars into electric vehicles (EV) as an additional strategy **towards zero-emission** mobility.

The research identified the **cars made from 1980** until the implementation of the current emission standards are worthy candidates for Ecofitting. The project identified a stakeholder's landscape and their potential roles and activities, configuring a **circular economy**, and potentially **disruptive industry**.

The State-of-the-Art research looked at related material culture, studying trends in alternative approaches to automotive design which are **more aligned to the expectations of next generation** consumers. The research mapped the current trends in conversion of ICE into electric, identifying opportunities to expand.

Ecofitting, ICE and EV strategies were compared through a sustainable design perspective. The need to understand subjective aspects related to aesthetic experience, aesthetic properties, values, worldviews, and tastes, initiated the development of an extended view on sustainability include these issues. A **Quadruple Bottom Line Analysis of Sustainability** tool was developed and pointed out that Ecofitting can have a significant impact in the automotive industry, society, environment, and people.

The project findings indicate that there are promising opportunities for developing automotive design differently, with **designers connecting to users** to update their cars, and users reconnecting emotionally to their cars; there are opportunities for alternative suppliers and SME to become part of a **new automotive ecosystem** providing more sustainable solutions; there are opportunities to develop new products to be incorporated as usability and technology updates; there is a need to develop an **online platform** to facilitate Ecofitting and inform responsible consumer choices on upgrades; there is need to establish policies to certificate and incentivise Ecofitting. Finally, the study points out that Ecofitting is an effective sustainable solution which respects emotional and cultural values of cars, promotes long-term ownership and can **change how cars will be designed in the future**.

Project Team



Dr Artur Grisanti Mausbach | Senior Research Fellow

Artur is a Senior Research Fellow, research supervisor and studio leader at IMDC. He is an architect and urban planner, designer, educator and researcher committed to sustainability. Artur has an MPhil in Environmental Urban Structures and BA and MA in Architecture and Urbanism (University of São Paulo Brazil), and a PhD in Vehicle Design (Royal College of Art, UK). Artur has worked globally as a consultant for car industry and has designs built in the UK, Austria, Germany and Brazil. He worked as consultant for Hyundai and Mahindra, especially on

the development of new car aesthetics for emerging markets; and worked on the design of a Fiat racing car. Artur also delivered presentations in conferences, universities, and to Porsche Consulting. He is a regular contributor to Car Design News, TV shows, and jury of design prizes. At IMDC he leads the Automotive Transitions Studio exploring the paradigm shifts of the car industry, its transition to a focus on sustainability, its connection with aesthetics, car design heritage, material culture and people. He led Ecofitting, Choreography of Mobility and Joyful Journey projects, and research for SAIC and Ford.



Dr Farhana Safa | Research Associate

Farhana is a former eye surgeon who left an established career in medicine to pursue her passion for car design. Upon completing a masters at the Royal College of Art in Vehicle Design, she joined the creative exterior design team at Land Rover, contributing to both automotive design and strategy. She has a wide creative scope also working in fashion, film and as an automotive photographer, and is keen to use her unusual background and skills to make a valuable contribution to the future of automotive design.



Dan Quinlan | Research Associate

Dan Quinlan work as a vehicle designer extends from developing future facing production models to creating abstract concepts. He has worked on the Innovate UK-funded GATEway project, the Future London Taxi and Future Luxury at the Hyundai-KIA lab. Dan is a graduate of the Royal College of Art's Vehicle Design course specialised in ideation, illustrating designs in a digital and physical medium and translating conceptual designs into tangible outputs. Dan also worked as exterior designer at Nissan (2012) on various productions vehicles.

Acknowledgment

This work is dedicated to Artur Henrique Mausbach Filho.

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2. The Concept of Ecofitting

2.1. Introduction

Ecofitting 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 consumers. This involves not just electrification but, importantly, the customisation and personalisation of these vehicles to create desirability, promote behavioural change, and long-term ownership.

Ecofitting may not only benefit the individual OEM, but the wider supply chain and ultimately UK plc by developing an entire ecosystem around remanufacturing, redistribution, repair, reuse, and refurbishment. Ecofitting will then, create opportunities to the development of new design paradigms, business models, and manufacturing approaches as part of a circular economy.

While there are many challenges on the development of business and engineering, the focus of IMDC research is on sustainable automotive design. The project applies design research methodologies to investigate the feasibility of Ecofitting and its wider impacts. The research objective is to envision and demonstrate how non-compliant vehicles could be redefined promoting an environmentally and socially responsible material culture that is also aesthetically expressive of its values. It also investigates how alternative cultural trends can support the development of a new automotive design aesthetics.

The feasibility project includes the following activities:

- A study of the context.
- State-of-the-art of the material culture related to Ecofitting.
- A cross-disciplinary analysis of the sustainability of the design concept exploring the environmental, economic, socio-ethical and subjective dimensions, and providing a comparative measure of the expected impact of Ecofitting compared to current trends for EVs and the industry ICE status quo.
- A design experimentation investigating future design directions for Ecofitting and exploring new circular design solutions extending the life cycle through the conversion of cars to electric.

Furthermore, the impact of design outputs will indicate the feasibility of Ecofitting as a design strategy.

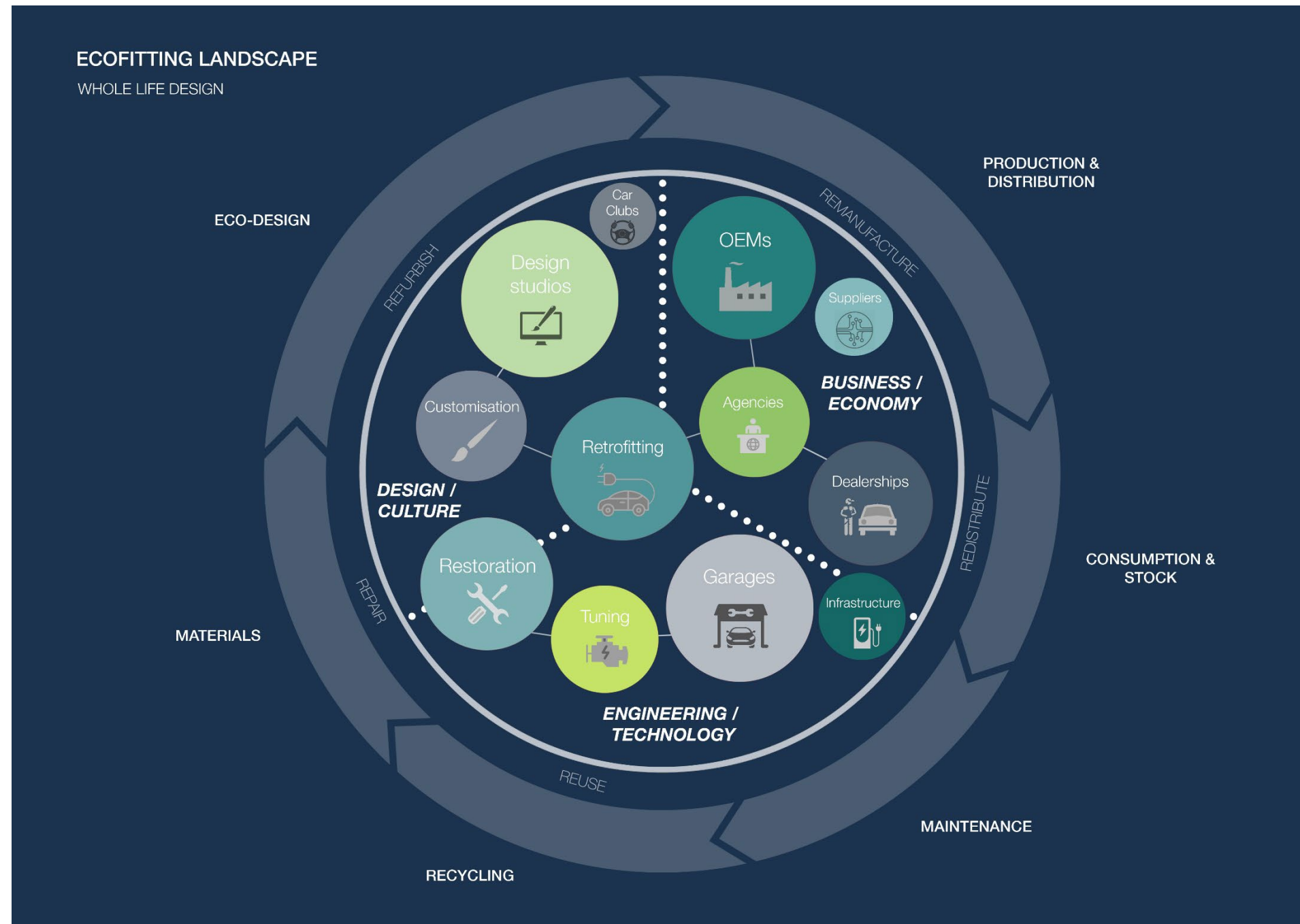


Figure 1. Ecofitting Circular Economy Landscape

2.2. The problem

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 CO₂ 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 (European Commission, 2020), and the UK ban of petrol and diesel vehicles has been brought forward to 2030, when every new car sold will be zero emission (BBC News, 2020). The introduction of Clean Air Zones in the UK, ULEZ (Ultra Low Emission Zone) in London from 2019, and to be extended in 2021 (Transport for London, 2021), 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 gases, 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 on petrol and diesel vehicles from the 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 matter 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 (1998), the process of changing 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 impact of the transition to sustainable mobility, understanding the implications of the processes and its externalities. Stuart Walker (2017) added that we need to inform our creative design endeavors with their Practical Meaning, Social Meaning, Personal Meaning and Economic Means, pointing out the need to consider a Quadruple Bottom Line for Sustainability.

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 solution to mobility. Nevertheless, all new cars require an abundance of energy and raw materials to be produced. During its lifecycle, a private car passes 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 personal, environmental, economic, and social-ethical consequences.

2.3. 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 (Aston Martin Lagonda, 2018; O' Kane, 2019; Jaguar, 2020). 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 and 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 (Buy a Car Team, 2020). 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 and comfort 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 (2018) and gov.uk (2020) (figure 2), 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 Ecofitting. Another 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 energy production 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.

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 research will then, investigate trends in material culture that defines a space for Ecofitting, in parallel to the identified fleet. Moreover, to evaluate which vehicles are likely to be candidates for Ecofitting we must consider the complex and intimate emotional relationship between people and cars, and how in a context of sustainability, social, cultural and environmental values can contribute to the development of long-term ownership.

ECOFITTING TIMELINE

CONTRIBUTION TO ZERO EMISSION STRATEGIES

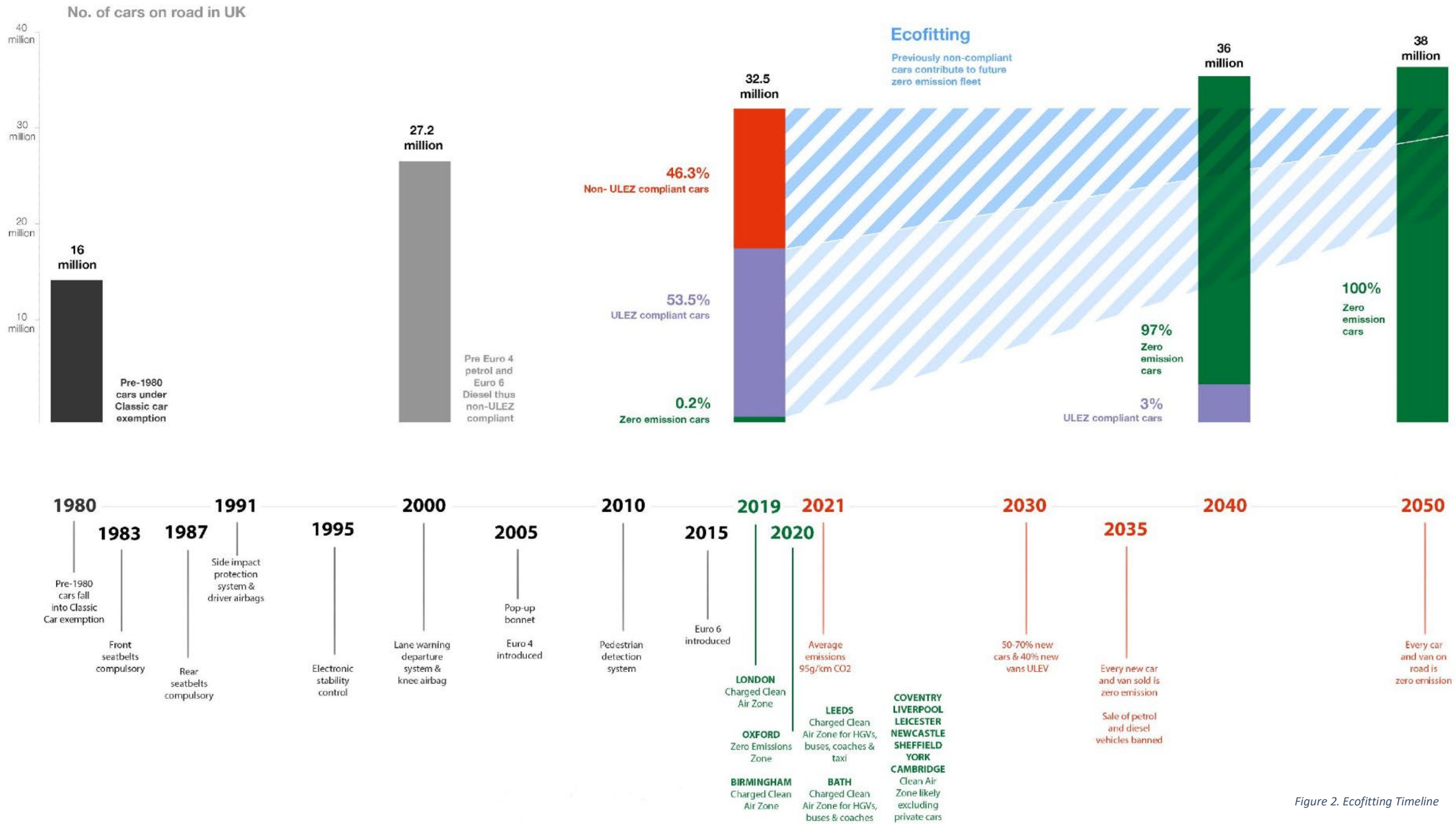


Figure 2. Ecofitting Timeline

2.4. Evaluating a design and production system through a sustainable perspective.

The analysis of a design and production system is grounded on specific criteria, which were defined according to the viewpoint of a specific context and ideology. According to Yuval Noah Harari (2018), the twentieth century presented a battle between fascism, communism, and liberalism, ultimately won by the latter, but as “history took an unexpected turn”, a crisis also hit the liberalism. While the economic crises of 2008, is cited as one of the reasons for the degeneration of liberalism, the climate crises and the sanitary crises highlighted that the aims and achievements of society were vain, and the criteria needs to be reviewed. According to Umberto Eco (2016) a crisis has extended to the concept of community, giving rise to “unbridled individualism”, and “led to the collapse of ideologies”; then, without sharing values or being part of something, individuals are pushed to follow consumerism. One which Stuart Walker (2017) signals as the kind of consumerism that turns everything obsolete, creating more frustration than satisfaction, and cultivating a society of selfishness, envy, and greed. Walker (2017) adds that the “consumer society encourages all these social ills through the constant supply of novelty and status-oriented goods combined with marketing techniques that incite socio-positional competitiveness”.

The design developed as part of the twentieth century economic systems is a reflection of their values and production systems. In the automotive industry, the pursuit for higher qualities of the products and efficiency of the systems has been aligned to the mindset of societies which were less attentive to the consequences of their actions to others and the environment, according to Jackson (2009), a “age of irresponsibility”. As Stuart Walker (2014) describes, “an almost pathological quest for the next technological advancement is driven by a desire for competitive advantage to ensure increase of sales of mass-produced products which, in turn, create financial growth”, which is almost understood as an end on itself. Even the undeniable evolution of safety standards in automotive design did not come easily. It costed many lives and the effort of notable figures like Ralph Nader. Nevertheless, at some point the industry learned how to use safety as a new selling point, and the same is happening to electric cars. Then, frequently the new electric cars are designed to fit to business as usual, society, ethics, and aesthetics as they used to be. Albeit deeper transformations are needed to deal with the crisis humanity is facing now. To be able to transform we need also to evolve our viewpoints and be open to change our assumptions in many areas, observing how the change in one area needs to be synchronized with the changes in others to be effective. Particularly, to get to a better model of interaction between industry and natural environment, social, ethical, aesthetic, and economic paradigms need to shift, and both subjective and objective points of view need to be addressed.

The automotive industry recent crisis is also consequence of its incapacity to understand the necessity to evolve or change its philosophy. From the development of the model-year concept by General Motor’s Alfred Sloan to current marketing disputes, to merges, acquisitions and emission scandals, the objectives, and the consequences of the industry’s acts are questionable. While its product aesthetics are representative of these processes, its paradigms, set from the 1950s, also deny the changes in society in the last decades.

The past century also presented alternatives to the discourses of liberalism, communism, and fascism, which envisioned a different society. Alastair Fuad-Luke (2004) remembers the steps from the founders of British Arts and Crafts which noticed the environmental degradation associated with the development of the industrial production; to the economy of materials with functionalism and modernism; the early works on environmental design by Buckminster Fuller and writings of Victor Papanek; the hippie movement in the 1960s; to the definition of Sustainable Development in 1987. Subsequently, the “Earth Summit” which gathered 172 governments in Rio de Janeiro, Brazil, in 1992 for the United Nations Conference on Environment and Development set the Agenda 21 for society to follow. But mostly, sustainability was understood as a bolt-on to the system and not a change on the system itself.

A significant aspect of the systemic change aiming sustainability is the adoption of a circular economy model, instead of a linear model. Although it is closely related to a simpler development of product lifecycle, it aims wider benefits to society, business and environment which require changes on attitudes of consumers, improving communication and sharing information on supply-chains, doing business on unusual ways, understanding the new position of stakeholders, and others which without the very change in products and design would be ineffective. This kind of change would impact the economic model and might not produce the same amount of profit - if that was to be considered an objective - but can produce other matters of economic gain, such as inclusion and sharing. Moreover, there is a possibility to explore other forms of social benefit, institutional success and personal fulfilment which are not favoured on the linear economy model.

An important aspect of the circular economy model is the integration of the consumer, or user, in the system, expanding the activity as an integral part of community and creating cultural change. As stated by Walker (2017), “the discipline of design - as an applied art that draws upon the human imagination and valorises creativity – has the opportunity to play an important part in manifesting alternatives and tangibly demonstrating different priorities”. To evaluate a design and production system through a sustainable perspective, we consider that design is informed by social, ethical, economic, environmental, and also subjective and personal considerations. A holistic approach, should consider both tangible and intangible aspects of design, focusing on the deeper meaning and wider shared benefits, instead of financial gain translated in money or carbon offset credits.

This research investigates the state-of-the art of Ecofitting, looking at cultural and behaviour changes, trends in automotive design and material culture that are related, or supportive to the practice of Ecofitting. In addition, the current context of the automotive industry is studied comparing to scenarios of introduction of EVs, and Ecofitting, in the perspective of Environmental Sustainability, Economic Sustainability, Socio-Ethical Sustainability, and Subjective Sustainability. The tools and methods used on this study are mainly design research methods - some developed at the Royal College of Art, and they are referenced in the following respective chapters. The methods aim to project the analysis criteria into an evolved context of relation between people, industry, and environment, considering that to achieve a positive and wider change is necessary to think from the viewpoint of the sustainability paradigm.

3. The Automotive Design Context

3.1. Transitions of the Automobile

In the beginning of the twentieth first century the car faces a moment of radical change. Electrification of powertrains, shared use, and autonomy challenge the paradigms of the automotive industry, but more widely it also interferes on the way people use, consume and experience cars.

Cars have never been merely a tool. From its inception, it was both a utilitarian and a symbolic object, which quickly evolved into its own imaginary context, represented by the myths of Speed, Freedom and Comfort (Mausbach, 2010). In the process, the car also developed from practical tools to fashionable objects, and while progressively the technology became widespread, the symbolic aspects gained more importance in design and marketing. Cars had to attract the consumer, to communicate different qualities, and to express personality, value, and innovation. Stephen Bayley (2008) points out that “To Alfred Sloan, from General Motors, the same car represented an opportunity to seduce the consumer with ideas of social competition and cultural modelling”. Moreover, Bayley suggests that the expected functional character of the object would become secondary, saying that “these powerful cars are not transport, they are aphrodisiacs” (Bayley 1986). The opening dialogue of his 1986 book defined priorities in life as “sex, drink and fast cars”, indicating that generating joy was the main function of the car. As much as this could be representative of that moment in time, it has little connection to the development of mobility and environmental issues in real life.

According to Stuart Walker (2001), our aesthetic experience of an object is a consequence of our contextual experiences, which are divided into natural, spiritual, and ethical. The natural context accounts for the interaction with the physical world – observing color, shapes, and textures. The spiritual context represents the search for meaning or the psychological association that values the object beyond its material issues. Finally, the ethical context deals with the social dimension and the consequences of habits and culture. As automotive design evolved, its psychology became complex, and the aesthetic experience is a consequence of both the physical configuration of an object, its meaning, and later, the values it represents. Through the last century, the car presents an interesting case, evolving from being the symbol of humans’ aspirations for *speed*, *freedom*, and *comfort* to being questioned about the core values that justify its production and use.

While the process of judging and admiring design is driven by the aesthetic experience and this is bound to change according to context, understanding the changes in behaviours and attitudes becomes a significant part of the examining the feasibility of a design and production system. Stuart Walker (2017) proposes extending the foundation of sustainability to a Quadruple Bottom Line, pointing out that creative design endeavors should be informed by their Practical Meaning, Social Meaning, Personal Meaning and Economic Means. When looking at the transition of the automobile, we should also investigate the subjective aspects of design, addressing spiritual and personal issues, aesthetic proprieties, and aesthetic experiences.

It is necessary to be cautious on the impact of the transition to sustainable mobility, understanding the implications of the processes and its externalities. The transition to electric is essential to meet the urgent emission standards, independently if the cars will be shared or private, autonomous or driven. While new regulations create a pressure to the industry, it may also accelerate the replacement of vehicles and increase the rate of ecological impacts of production and disposal. This process may create a demand for new electric cars, but it also needs to consider – beyond the infrastructure challenges - if people are financially and emotionally prepared to replace their vehicles. The London Ultra Low Emission Zone puts more pressure on those who can afford to replace their vehicles by a new electric car (Figure 3).

In the one side, it is necessary to offer alternatives to people to change to more sustainable mobility. In the other side, it is necessary to understand the values which will define the aesthetic experience in the context of sustainability. Only then, it will be possible to develop designs that will make people embrace the transition to electric cars.

In the following sections, we will discuss the current context of car aesthetics and the changes in behaviour and attitudes which shape the state of the industry when Ecofitting is being proposed as an alternative route to the transition of the automobile.



Figure 3. Car showing protest against the ULEZ in London (2021).

3.2. Automotive Design Taxonomy

3.2.1. Mapping trends in Automotive Design

The word taxonomy comes from the Greek word taxis, meaning arrangement and division, and nomos, meaning law. It also refers to the science of classification according to a predetermined system. Applying design research, we use taxonomy is used to identify and classify car design trends. In previous research at the Royal College of Art (Mausbach, 2010), we developed a taxonomic study of looking at exterior and later, interior design of cars, from its invention to selected production and concept cars of today. The initial reference for this study was the work of Professor Paolo Tumminelli, published on the book *Car Design* in 2004. But while the initial approach of Tumminelli was mainly the analysis of shape and form, the research at the RCA expanded to typologies and metaphors, which sometimes are the most significant aspect of the design, or the focus issue to be observed. This taxonomy study is mainly focus on cars market in the Europe, USA, and Japan. In this section we look at a 40-year period, to understand how Ecofitting relate to the current trends in Automotive design.

3.2.2. The endurance of the designs referencing the past

Through taxonomic research we observe which trends influence the current development of new designs. It is also possible to identify which trends have an enduring significance, being constantly renovated, or making the aesthetic of the product last longer in the public taste. An interesting case is the *Retro* trend, which started in the late 1980s with cars like the Mazda Miata and Chrysler PT Cruiser, and has remained successful for decades, with the VW New Beetle, Mini, Fiat 500, and others. The *Retro* was soon accompanied by a *New Classic* trend, which presented extensive use of design elements of past classic and has become a favorite language for traditional European brands like Bugatti, Aston Martin and Bentley. *New Classic* also remained popular after 20 years, and it has an influence on the language of the *Conservative* trend of electric cars, as *Retro* has on the *Retro-Revival*. The latter proposes, through cars like Honda e and Peugeot e-Legend, that the future EVs will be based on designs of the past. In those cases, the reference past is not anymore, only the 1950s or 1960s, like it was for most of Retro and New Classic, or the Retro-Revival VW E-Bully, but it is also the 1970s or 1980s. All these trends indicate that part of the public have difficulty accepting new aesthetics, or they still have some of affection for the cars of the past, or both.

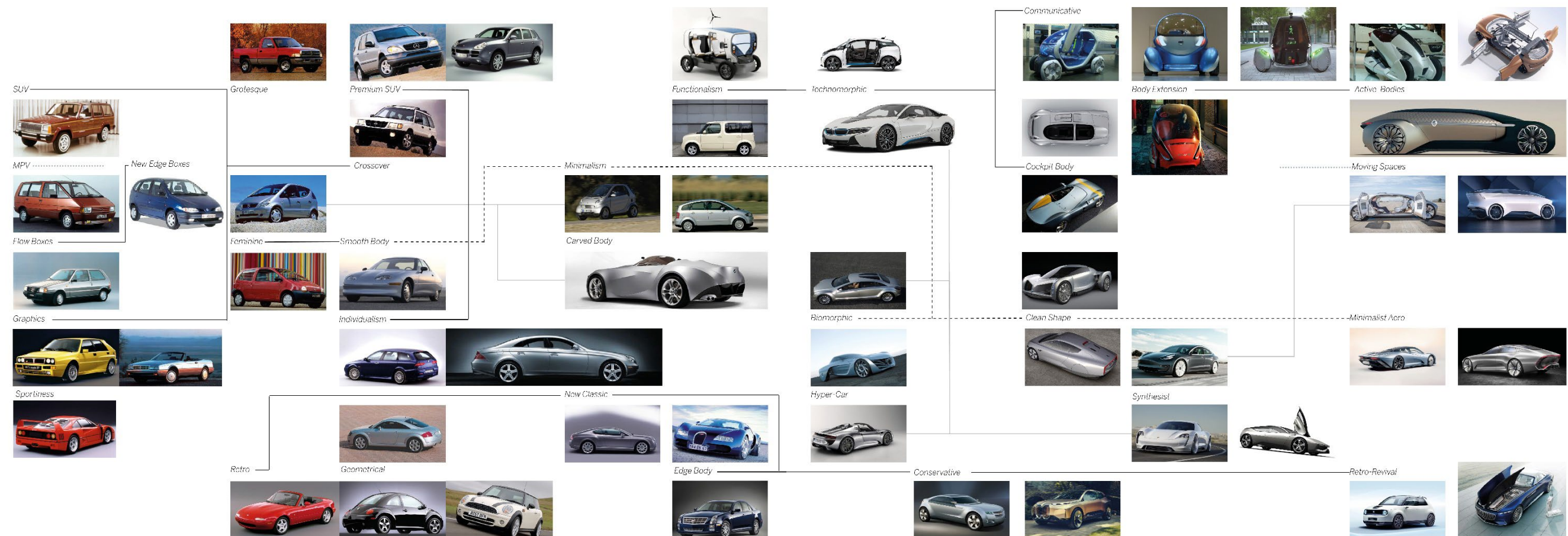


Figure 4. Car exterior design evolution in the last 40 years. For reference and larger images search from *Car Design Taxonomy* on the IMDC website.

3.2.3. The car interior from Carriages to Moving Spaces

Looking at interiors, from the origins of the car to today's concept cars, it is noticeable that it evolved from a *Carriage* interior, crafted like luxury interior design on *Limousines*, or cleaner and more functional as products gained scale, to an ergonomic or driver centered design which consolidates in many trends. Significantly, from the 1970s the use of plastic changed the aesthetics and the possibilities of shape and safety standards. In the 1990s the design came closer to product design with room for the *Playful* trend, with toy-like language. At the same time, *Retro* and *New Classic* trends extended to the interior the same nostalgic ideas which inspired exterior design development. And while *Retro-Revival* brings back colors of the past, the instrument panels also point to a cleaner and plain surface, like *Luxury Performance* used to have. The difference is that in the past, it looked like it was possible to fit a new instrument in the wood or metal panel, simply cutting a space for it. Now, the clean and plain surfaces are a long sleek screen, where new apps can be downloaded. Another interesting change with new technologies is the exploration of interiors developed like *Lounges* and *Moving Spaces* coming with autonomy. It indicates a desire to develop car interior like architectural spaces, more personalized and customized.

3.2.4. The aesthetic of perfection

Another aspect which is possible to identify through the Taxonomy, is the similarities between the trends of a specific period. This can be observed in the proportion of vehicles bodies, surface treatment and reflection of the technology on elements like body panels, wheels, tires, lights etc. More significantly, car design has developed an aesthetic of perfection, in terms of product development, which is represented by the sleekness of surfaces, the varnishing of the paints, the thinness of the joint between panels of metal or plastic, the cleanness of the glass, the shininess of the chromes, the sharpness of the edges, or even the noise of the closing doors or the smells in the interior. All these characteristics point to a product perfection which requires high-level maintenance and soaring environmental costs to keep it in immaculate condition. It leaves little space for personal intervention, or to portrait the life of the product and the experiences that the user had with them. Ecofitting can represent an alternative approach to aesthetics, incorporating real life interventions, and imperfections, considering aging a part of the object. This could also be aligned to the values and tastes of younger generations, as investigated in the next section.

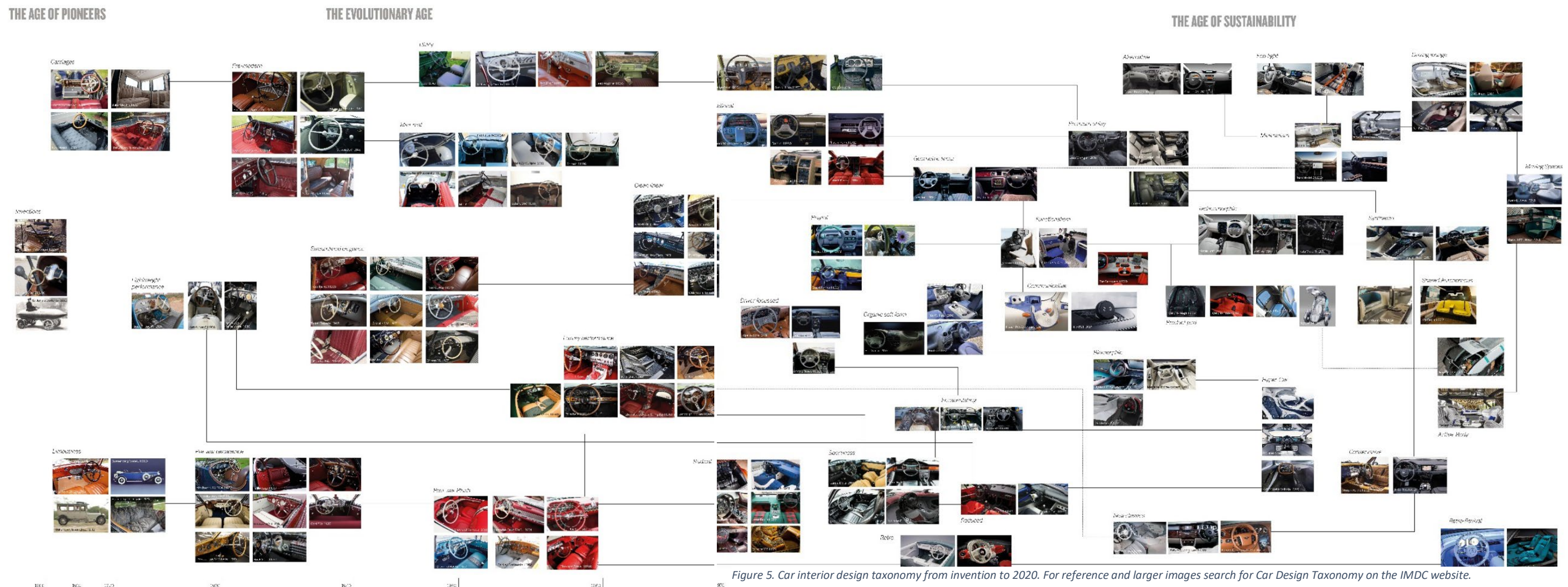


Figure 5. Car interior design taxonomy from invention to 2020. For reference and larger images search for Car Design Taxonomy on the IMDC website.

3.3. Changes in Behaviour and Attitudes

Research recently compiled at the Royal College of Art provides a view into changing behaviour and attitudes over the past 20 years, which studies links to current lifestyle, consumption, taste, and branding, and the relationship between these and material culture focusing on rising trends in architecture, fashion and mobility spanning the next 20 years. This research investigates the Generation Z, which will be the next generation of consumers.

The research shows a shift towards a regard for people in the public eye who have a purpose- like standing up against injustice, rebelling, and speaking out (Malala Yousafzai, Greta Thunberg and Emma Watson). Increasing support is observed for societies marginalised, as recently seen in the Black Lives Matter movement, and legalisation of same sex marriage across 16 European countries. Gender fluidity is gaining prominence with a focus on not being defined, as well as a movement supporting self-authenticity and body confidence. Further attitude and lifestyle changes include a huge drive towards healthy living, exercise, and environmental awareness, with the popularity of Yoga, running and extreme sports, and an introduction of a plastic straw ban and plastic bag charges in the UK.

In parallel to the success of reality TV 'everyday' celebrities, the rise of the 'influencer' who through the use, popularity and the widespread reach of social media, are a lucrative commodity and marketing tool, asserting influence on the desire and successful sale of products. Gen-Z has harboured a preference to buy more from those they trust, and the everyday relatability and constant availability of influencers to engage with their fans makes this possible. An increased propensity to trust the opinions and reviews of real people over companies, and platforms that share real life experiences and advice have proved successful, causing businesses relying on trust and sharing like TripAdvisor and Airbnb to gain major traction.

The domination of technology brands (Apple, Google, Amazon) and a rise in the popularity of philosophy driven brands connecting via compelling storytelling, authenticity and an apparent ethical message (Tesla, Whole Foods, Airbnb and Nike) mean that consumers now expect to be at the centre of the brand, want to be inspired, and see a commitment to excellence and social responsibility. With the help of AI, consumers are at the core of the service, and individuals are the market target.

Social networking apps such as Facebook, Instagram, YouTube and Snapchat dominate the way we connect and share, and the demand for constant seamless connection has inspired services that evolve to the mobility and automotive sectors. The innovation of new products is often largely driven by emerging technology and/or the demand for connectivity and products such as the Dyson vacuum cleaner, Amazon Kindle, Fitbit, iPod, iPhone and iPad are reflecting the embracing of new technologies on the success of sales figures. The popularity of products such as the GoPro and personal drones illustrate the desire to capture and share life experiences, showing how new products are influencing lifestyle and habits.

Fashion has seen a rise in casualwear, stylish comfort, and clothes that are not defined by gender. Luxury brands continue to be aspirational and desired for quality and exclusivity, but a trend of major luxury fashion sportswear is also evident. There has been an increase in the use of sustainable and recycled materials and major fashion labels are dropping the use of real fur. Fast fashion brands like Primark are being increasingly scrutinized regarding worker conditions and pay, thus a corresponding transparency regarding the philosophy and conduct of a brand is expected.

Diversity and inclusivity are evident in the design of everyday products like make-up and underwear to include all skin colours and appeal to a wider audience, as well as the arrival of 'modest fashion', a multibillion-dollar market catering for covered-up fashion.

In a long-term ongoing process, architecture is becoming more environmentally conscious with building that assimilate wind turbines or vertical forests in their design causing sustainable architecture to change the aesthetic of buildings. Clean, geometric architectural styles are developing, as a new interpretation of less-is-more, which focuses on energy reduction. Advances in engineering are allowing more organic and radical shapes and silhouettes that break away from convention, to contribute to a new aesthetic as seen in Frank Gehry, Santiago Calatrava and Zaha Hadid's designs, and Structural Expressionism is also defining a new sci-fi-like skyline to European cities. The high-spending spectacular architecture of the big design studios is clearly a representation of the world economy before the 2008 crisis. Almost in opposition to these practices, the Venice Architecture Biennale has explored more socially conscious themes: "How we live together" (2021), "Reporting from the front" (2016), "Common Ground" (2012), "People meet in Architecture" (2010), "Out there: Architecture Beyond Building" (2008).

Following the social and environmental focus, and the opportunities of new technologies, efforts have been implemented in cities to create space for pedestrians, and city design is responding to accommodate new forms of mobility with cycle hire schemes, cycle lanes, electric car charging points, sharing cars and other small, shared mobility devices. The London Congestion Charge and Ultra Low Emission Zone, and the planned ban on polluting cars from central Madrid illustrate the importance of improving air quality and reducing congestion in inner cities.

The analysis of these observations in multiple contexts identified changes in behaviours and attitudes which encapsulate the parallel shifts across these multiple industries. These trends were 'Social and environmental responsibility', 'Trust and sharing', 'I, me, mine', 'Non-conformity and inclusion', and the 'Flexible healthy living' (Mausbach et al, 2019). Given these insights, a concept such as Ecofitting may likely appeal to upcoming generations as it may relate to those wanting to be more socially and environmentally responsible, those who wish to have a channel for individual expression and non-conformity, and those wishing to participate in inclusion and building of communities. Moreover, it indicates that the context and values on which design is based have gone through significant shift, one that the automotive industry is failing to capture, and it continues to produce, design, and operate like it used to do in the 1950s. New habits, families, people, taste, conscience, ethics, communities, and environment demand alternatives to business and usual.

4. Ecofitting-related State-of-the-Art

Although Ecofitting is a new concept, it reflects, extends or it is influenced by existing activities in industry, design, culture, and behaviours. It can be said that Ecofitting has been growing from a niche passion project speciality to businesses specialising in the craft, and OEMs upgrading the drivetrains of their own iconic vehicles. In a climate where stringent emission standards are being enforced, and the landscape, options, and infrastructure for electric vehicles is still developing, Ecofitting serves as an alternative financial and sustainable option towards the path of zero emissions which can include many actors and align with many trends.

The alternative nature of Ecofitting takes in consideration that the proposed circular economy activity is distinct from the mainstream automotive industry. Nonetheless, it is supported by a landscape of stakeholders whose activities are linked to Ecofitting, like restoration, conversion to electrics, and others. In this section, we look at the trends encompassing retrofitting, restoration and conservation, customisation and tuning, car culture and material culture, communities and lifestyle, which can inform Ecofitting and indicate in which context and direction it should be developed.



Figure 6. Conversion of a classic Porsche 911.

4.1. Car Conservation

4.1.1. Restoration



Restoration is a common practice for vehicles and other man-made objects. The aim is to bring the object back to its original condition. In many cases the aesthetic of the object is the focus of the restoration, and as it becomes historical or treasured artifact to be contemplated. In other cases, it is expected that the restored object would be brought back to original working condition. Although there are cars simply sitting at museums displays, it is expected that a restored car would be able to function. Thus, a restored car must have all its systems working, from body shells restoration to painting, panel and metal work (picture above), trimming, mechanical or electrical work, and ideally back to factory specification using original factory parts. The trend of completely restoring old vehicles back to their former glory is expertly carried out by many companies and independent professionals, and configure an important activity related to car culture.

Restored cars are kept by car enthusiasts, some then entered classic car concours, some participated on owners' clubs, some simply like them for a Sunday drive (see section 3.4). Restoring cars has been a hobby, especially for men, according to data collected at the 2019 Practical Classics Classic Car & Restoration Show (2019), which had 28,500 visitors in the UK, 95% were men and average 52 years old. The visitors also own two cars, one of which is a project car, and they usually spend 11 hours per week working on their cars in the summer and 8 hours per week in the winter. Moreover, 64% of the visitors were members of a classic club and 79% use to go to events or show their cars in events. This demonstrate the car restores, or collectors, are deeply involved with it.



In the UK there are lots of companies specialized on restoring cars, and it is not rare to see classic cars sharing the roads with the latest industry models. While restoring a popular car, like the original Mini (pictures above) will have the advantage of easy finding parts or garages specialised on the model, like the London Mini Centre Ltd, in Putney, some recovers require hunting for parts around the world or even manufacturing new ones.

The recently discovered one off Aston Martin Bulldog (picture below) was brought to Classic Motor Cars in Shropshire, for a full restoration. One-offs or concept cars present the extra difficulty of not have spares parts and much information to be restored. Nevertheless, the new owner's plan for the Aston Martin Bulldog is to restore it to original colours and trim, and to repair the engine so the car would be able to reach close to 200 miles per hour as it did in 1981.



4.1.2. Preservation

A different approach to conservation of cars is to preserve them on the current condition and not to interfere on the traces of time.

Giugiaro design Porsche Tapiro concept car of 1970 was later sold and used on roads, like many other concept cars of the past. Then the car was victim of vandalism and was burnt and permanently damaged (Flatsixes, 2009). Nevertheless, it was not restored, but it was placed in pedestal as a sculpture at Italdesign studio in Turin (picture on the left).

The idea of preserving the car as an object of historic record, brings it closer to a museum artefact. Actually, the London Science Museum used to display a crashed McLaren formula 1 car. While the Tapiro and the McLaren at the Science Museums are not functioning cars, some vehicles have the aesthetic untouched, but are kept on using conditions. That is the case of the Porsche 911 RSR (picture on the left), winner of the 24 hours of Le Mans race in 2018. The car was not even cleaned after the race, to better remember the important achievement of the occasion.

Some car enthusiasts also are bringing the *Preservation* approach to their collection. The 1928 Ford Model A (picture on the left) is on the same condition it was bought in 2001, after being left alone for decades (McNessor, 2008). After some consideration, the new owner decided not to repaint the car, or make big changes on its characteristics, but to take advantage of the fact that the car still original finishing on interior and exterior.

The *Preservation* trend gained momentum with the critic on “over-restored” cars, which end looking fake. Very popular on Instagram, nevertheless, the rusty cars are still not seen as the favourites on concours’ d’elegance (McNessor, 2008).



4.1.3. Extension of Life

In some parts of the World, conserving history becomes a necessity because of the lack of availability of newer products. Although nowadays automotive manufacturing is present in more than 60 countries around the world (Wikipedia 2020.1, OICA 2017); some regions, like Central America, do not have local production, and some countries, for political or economic reasons, don't have wide access to new vehicles. There are also regional differences inside countries, between cities, and cities and countryside. In Brazil, which produces more than 2 million vehicles per year, it is quite common to see original VW Beetles and Camper Vans, especially in the countryside.



One of the most interesting cases of Extension of Life is Cuba. American cars were imported into Cuba from the early 20th century for about 50 years but after the Cuban Revolution, the U.S. embargo meant that Fidel Castro banned the import of American cars and mechanical parts. Cuba has since become a living museum for classic cars with classic American cars kept running with parts never intended for them. It is estimated there around 60,000 classic American cars in Cuba many of which are often family heirlooms, passed down from generation to generation. Since Cuba lacks replacement parts and often the necessary tools for repair and restoration, the locals have become creative and crafty in their approach to fixing engines and exhaust systems, with their ingenuity keeping these glorious cars on the road.



4.2. Car Retrofitting

4.2.1. Classic Cars Conversion

Fitting beloved classic icons with an electric drivetrain has been a popular trend to give classics a sustainable future. It has been the focus of companies like Electric Classic Cars, Lunaz Design, and Garage Italia, additionally, and some OEMs have also experimented in that direction.

The trend is not limited to expensive, luxury and sportscars. Classic Minis and Fiat 500 are between the favourites to electric conversion. When owned by Fiat heir Lapo Elkann, Garage Italia, has created a 1960s Fiat 500 Jolly Spiaggina Icon-e (Bird,2019). Aston Martin Works transformed a DB6 with an electric powertrain that is fully reversible, hence the tailpipes remain. The £200,000 cost for the conversion is expected to be reduced if 10% of the 3000 identified eligible cars would be converted (Duff, 2020). The DB6 chosen has the same powertrain 'cassette' that also works for the DB4, DB5 and the DBS increasing the number of cars available to convert. The motor and battery pack were designed to deliver a similar acceleration and power as the original engine and is of a similar weight to preserve the handling and feel of driving a classic car. Thus, it is not intended to be faster but to prolong the life of the vehicle, and for it to feel as authentic as possible whilst being environmentally responsible. The reversible concept means that the old engine is stored in case the driver wishes to reinstate it, complete in a rally or concours, or it can be mounted in a glass case as a show piece (Aston Martin Lagonda 2018).

Jaguar Classic have created the Concept Zero, combining E-type's design with electric power. The 1968 Series 1.5 Jaguar E-type once electrified does 0-60mph in 5.5 seconds aiming to deliver a dynamic experience with enhanced performance through electrification. The lithium-ion battery pack has the same dimensions, and similar weight, to the XK six-cylinder engine used in the original E-type and sits in the same location as the XK engine meaning the car's structure, suspension and brakes have not changed, thus drives, handles, rides and brakes like an original E-type, and a conventional engine could be reinstalled at any point. The new drivetrain also works across Jaguar's other iconic models of that period, including the E-type, XK120, Mk2 and XJ6. Lunaz is an automotive engineering company that aims to establish a new tradition of classic car ownership by converting classic cars to electric drivetrains securing them for future generations to use.



4.2.2. Full Renovation

Like what happens with the Restomod, a mix of restoration and modernisation of cars, some businesses have identified the opportunity to realise a full renovation of the vehicles while converting them to an electric powertrain. This trend shows an opportunity for design development in parallel to the electric conversion engineering, California's Zero Labs Automotive take vintage vehicles and remake them as premium electric. The company specialises in off-road vehicles, like the Land Rover Defender, and the Ford Bronco (figure above), which are given a well finished and contemporary interior, with use of leather, brushed metal, and wood. In the exterior, the Bronco also got updated front lights and grill. The company focus on delivering "authentic, high-end custom, modernised versions of classic vehicles to be driven well into tomorrow world" (Zerolabs, 2020).



1. Custom-built starting with a vintage 4x4



Authentic 1966-77 First Generation Ford Bronco 4x4



Authentic 1971-1985 Landrover Series III 5 door 109 Wagon

2. Modern Electric Vehicle



2.0 Chassis Full Battery Electric
300-600HP, 18,000 RPM
85-100kWh Performance Platform

3. Premium Off-Roader



Custom Engineered
(IFS) independent front suspension and
(IRS) independent rear suspension

4. Modern Luxury Vehicle



Classic and modern Interior
Refined Luxury Car



Rolls-Royce build Quality"
— TopGear



Premium Classic Electric Vehicle

4.2.3. Electric Reborn

Different from retrofitted cars, Electric Reborn cars are new vehicles high-end, using pre-existent parts, manufacturing machinery or design, While the premium market focus of this kind of company will not do much to popularise electric conversion, they show that Ecofitting is also an opportunity to improve performance and comfort. Based in London, the British company Charge Cars works with engineers from McLaren Automotive, JLR and Formula 1, to deliver high performance electric car version of classic Mustang. At the same time the company claims to preserve the iconic design of the vehicles they work with. In the case, officially licensed shells of classic 1960s Ford Mustangs, which have only few discreet modifications on the exterior. The paint, wheels and colours are customised, and the grill, headlights and taillights are updated. The interior, in the other hand, receives a new design, incorporating premium materials and digital interfaces, but keeping a Retro aesthetics. The prices of exclusivity start at £300,000. (Charge Cars, 2020).



4.2.4. Electric Rustoration



An alternative approach to cars converted into electric, which also produces surprising aesthetic, is the trend named here *Electric Rustoration*. In addition to the electric drivetrain, the renovation is completed with a mix of customisation, updated elements, but keeping the rusted bodywork almost untouched. Comparing to the full renovation, this approach reduces even more the ecological impact of the new electric car.

While maintaining the cars in their natural condition, it makes a statement about its age and past.

The 1949 Mercury Coupe converted by Jonathon Ward, had little touches on the exterior aesthetic, like the chrome of the bumper and the headlights, which accentuated the corrosion of the body. Under the hood however it was upgraded with Tesla battery, laid out in a way it would resemble a V8. The lowered suspension also denotes that it is more a personal approach than a pure preservation.

Wales based Electric Classic Cars has also supported a customer to convert into electric a 1971 Karmann Ghia, keeping the rusted bodywork. The car also features new wheels and headlights.



4.2.5. E-Customising



Aligned with the ideas behind Car Customisation (see section 3.3), more than sustainability, E-customising has the potential to present as many schools or variations to the practice of EV conversion as it happens with ICE. The possibilities with retrofitting are attracting the attention of events like SEMA (Specialty Equipment Market Association) held in Los Angeles since 1963, when it was associated to the group of suppliers and manufacturers of parts and equipment to the Hot Rod community and Custom Culture.

OEMs are also getting involved and GM presented at the 2019 SEMA the concept E-10. It was basically a hot rod EV conversion of a 1962 Chevrolet C-10. "The E-10's Connect & Cruise concept propulsion system is composed of a double stack of Chevrolet Performance concept electric crate motors (eCrate), two 400-volt batteries and a conventional SuperMatic 4L75-E automatic transmission" (Chevrolet, 2019). The layout of the motors is carefully done to mirror a traditional V8. Moreover, the E-10 shows, colours, equipment and suspension which identifies it with customising, being very different from the Classic Car Conversion focus on maintaining originality.

Performance has always been a key element of customisation, and with retrofitting there is opportunity to achieve better performance than the original cars. Rauh-Welt Begriff's Porsche 911 E-RWB incorporate drivetrain from Tesla Model S Performance. Two electric motors delivering 563 HP (Mihalascu, 2019). Aesthetic customisations included ivory paint, chrome trim, BBS RS wheels, Momo Indy Heritage steering wheel. The traditional aesthetics leave little space for sustainability.

3.2.6. Budget and Scale



higher value, for newer and more common vehicles it becomes strategic. Then repetition, sharing parts and reduction of costs become a defining aspect of the design. As seen before, JLR and Aston Martin plan to scale up the solution of electric drivetrain to different vehicles, Electric Classic cars, sells copies of the bespoke parts they create, developing an online portfolio. In other cases, companies seek partnerships with OEMs to supply drivetrains. VW has started to provide kits to the Germany company eClassics to convert original Beetles and Campervans (O'Kane, 2019).

The France based Transition-One converts smaller ICE vehicles into electric and connected. The process takes 4-hours, costing €5,000. Clients can test drive the Fiat 500 or Renault Twingo first before opting for the government approved retrofit, where all elements specific to the heat engine (gasoline or diesel) are extracted and replaced with a 100% electric engine block and batteries. For city cars, the range is 100 km, and the top speed is 110 km/h. The retrofit warranty is for 2 years (unlimited mileage) with a battery warranty of 5 years (or 100,000 km). The cars eligible for conversion or retrofit at Transition One are Renault Twingo II, Fiat 500, Toyota Aygo, Citroën C1, Peugeot 107, Mini, Volkswagen Polo, Renault Clio 3, Peugeot 207, Citroën C3, Dacia Sandero, and LCVs (Renault Kangoo, Citroën Berlingo, Peugeot Partner). The service is open to individuals, but Transition-One are also looking for Europe wide partners such as automobile fleet managers, garages, auto centres, body shops, dealerships, or subsidiaries of automotive manufacturers that are looking to develop a new activity. (Transition-One, 2020)



4.2.7. OEM Products Diversion



Converting classic ICE cars is not the focus of OEMs. The focus is the production of new EV. Some models, like the Porsche Taycan, Jaguar I-Pace or VW ID3, are new designs created to be exclusively electric. Nevertheless, OEMs are also adapting some their existing vehicles with an electric version, a *diversion* on the design development that gives an option of electric powertrain to very stablish products.

The Volkswagen e-Golf features 144 miles of range and charges to 80% capacity in 45 minutes. You can choose between five driving modes depending on the severity of braking and how much energy you want to recover (VW UK, 2020). The only noticeable difference from petrol, Diesel and hybrid models are the wheels and small touches on trim.

Built on an electric platform, and mostly the same bodywork, the Fiat 500e come with up to 199 miles of range and comes with a fast charger and a home charging wall box. It also features level 2 autonomy, a longer wheelbase for more internal space, and sustainable leather alternative materials used on the seats and dashboard (FIAT UK, 2020).

There are clear benefits for *Product Diversion* strategy like building on a renamed product and sharing parts, and it creates a quick route to the acceptance of EVs. For retrofitting, it opens the possibility for easily converting the fleet of ICE on the road into zero emission, with support and the latest technology from the original equipment manufacturers.



4.2.8. OEM Re-Manufactured

In November 2020, Renault announced the conversion of the Flins plant into a “Re-Factory” dedicated to retrofitting and Circular Economy, as stated in the corporate video. The Renault Group claims that in the future it is necessary to have vehicles capable of doing 1 million miles (Groupe Renault, 2020). Renault aims to reinvent the company and develop “accessible, sustainable, carbon-free mobility solution for everyone”. Renault’s statement acknowledges the problem of cost of new EVs, which creates a challenge for mainstream brands producing popular cars. The cost of the electric Zoe is £27k after the £3k grant, close to two times the price of a Clio hybrid.

The RE-Factory is a circular economy initiative by the French OEM, which is open to start-ups and partnerships. The site is organised in 4 activities centres: “Re-Trofit, Re-Energy, Re-Cycle and Re-Start”. It aims for a “negative carbon balance by 2030”, and “European ambition of zero impact by 2050”. (Groupe Renault, 2020)

Re-Trofit is focused on extending life of vehicles. Renault points out that the second-hand market is booming due to cultural change and ecological awareness. The key to the success of the business is the management of the flow of reuse of parts and materials on the same site. Renault objective is to develop an attractive offer for conversion, focused primarily on commercial vehicles and professional costumers, then mobility providers in a second stage. The facility will provide prototyping and 3D printers for additive manufacture of unavailable parts. A technology which is also used by Porsche for the same reason.

Re-Energy is focused on production, storage and management of energy, and EVs battery lifecycle. The factory will remanufacture batteries and prepare then to a second life, to portable and mobile storage systems. The aim is to create storage solutions to cope with the intermittence of the clean energy supply. Since 2011, Renault has provided second-life batteries to 17 countries where they have been used in mobility and grid solutions. At the end of their life, the batteries are recycled by partner industries, like Renault’s subsidiary Indra. (Groupe Renault, 2020)

Re-Cycle is focused on increasing the recycled materials incorporated to vehicles, which is currently circa 30% in European Renaults. In order to achieve this, a dismantling line will be installed from 2024, targeting 10,000 vehicles per year. The activity will be based in circular economy partnerships, and include the Choisy-Le-Roi plant, which since 1949 works in reconditioning engines, and remanufacture of vehicle parts. (Groupe Renault, 2020).

Re-Start is focused on the development of skills, research, and innovation. The unit will host an incubator, education, and training activities. The aim is to support research, partnerships, inclusion and promote access to employment in a circular economy. Flins factory Global Training Centre started in 2010, focused on industrial techniques, and it will develop new modules focused on the activities of the Re-Factory.

The Re-Factory paves a way to Ecofitting OEM Re-Manufacturing, covering issues of environmental, economic, and socio-ethic sustainability – which are subjects of the Sustainable Design Analysis chapter. Nevertheless, there are little references to how the subjective sustainability has been considered. In automotive design terms, there is need to develop the aesthetic principles of the activity too.



4.2.9. DIY Experimental, Deviant and Kit

The challenge to convert internal combustion engine vehicles to electric has tempted many cars and technologies aficionados. While the DIY culture has embraced the electric power due to its relative simplicity, Guide, publications, lots of You Tube videos and kits are available for those who want to retrofit, recreate and revolutionise their own vehicle.

A senior engineering at Obagemi Awolowo University in Nigeria has spent a year retrofitting a Volkswagen Beetle into electric, also incorporating wind and solar generation in the vehicle. Using free scraped parts donated by friends and family, the overall cost was under US\$6,000.00 (EVH News, 2020). A case of **DIY Experimental**, more interested on investigating the technological possibilities than a design evolution.

The **DIY Deviant** is focused on transforming radically the vehicles, in aesthetics and experience. The North American software developer Jim Belosic fitted a 1981 Honda Accord with the powertrain of a Tesla Model S P85 and batteries of Chevrolet Volt to create a 500+ horsepower car (Berman, 2019). As happens on many electric car conversions, the motivation sometimes is more about improving performance than reducing environmental impact.

The DIY mentality has extended to companies capitalising in the opportunity to provide **DIY Kit** for individuals to convert their own cars. DIYEV (2019) refers to itself as a multi-disciplinary EV component developer whose engineers have developed a new kind of all electric drivetrain and battery module system for small, medium and large trucks and buses that are easy to use, install, maintain and understand. The products on offer consist of several “Electric motor drivetrain kits that are designed to just bolt to the existing (ICE) engine mounts with all the wiring and programming ready to go out of the box. The battery packs are all modular making them easy to place anywhere on the vehicle- the more battery modules you add the more distance you can travel” (DIYEV,2019). DIYEV also has programs to teach people how to build and or repair your own Electric Vehicle, with the aim of educating citizens on the ins and outs of electric vehicles.



CONVERT IT!

Convert ANY Classic Car into an Electric Vehicle (For Fun or Profit!)

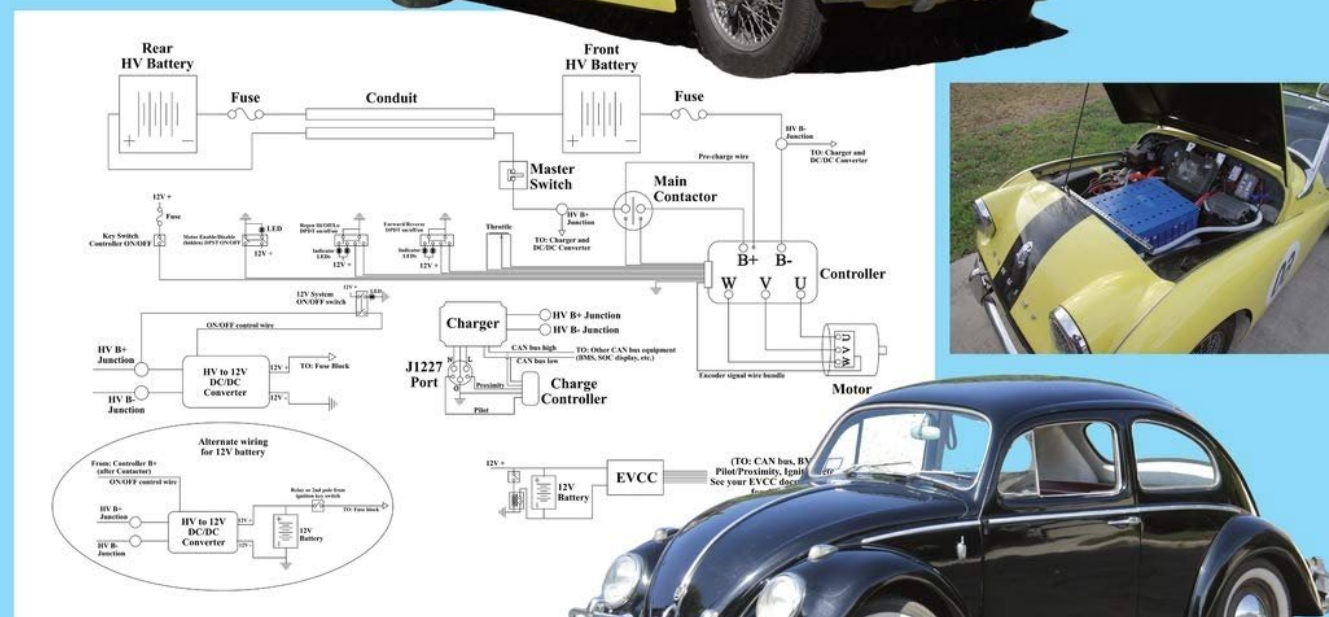
2021 Edition, By Ron Toms



Dirty, Noisy, Smelly



Quiet, Clean, Reliable



4.3. Car Customising

4.3.1. Change of Use

Changing the use of a vehicle to a specific job, task or function can require specialised work and design. Commercial vehicles are usually expected to be customised, and sometimes have open architecture, boxes or flat beds,

With food-trucks becoming a strong movement in the last decades, vintage vehicles, like the Piaggio Ape, the Citroen HY (picture on the right), VW Camper Vans, 1960s Fords and Bedfords are favourite targets to the transformation.

Another trend which gained momentum in the last decade is camper cars. VW has re-edited the California and many other followed. To use camper cars for a weekend escape has become as interesting space while cars are progressively less useful in cities. And living in vehicles is changing from a last option condition, without comforts – like the Lady in the Van (picture on the right) to a design idea for autonomous vehicles with flexible electric platforms.

Today's passenger cars, in the other hand, have a less flexible layout. However, passenger cars have traditionally been transformed, for sport use, leisure, and business. In addition, a specialist customisation is a desired trend for those wanting a vehicle like no one else has. Over the course of 10 months every piece of a 1984 Porsche 911 (picture on the right) was pulled apart, re-built or reimagined. Function over aesthetic was important, aiming to be large in stature but with muted details that help it blend it rather than stand out. With rally suspension, additional lights, and larger tyres, this shows an interesting direction, when SUVs and off-rovers are still popular.



4.3.2. Luxury Customisation



The trend of *Luxury Customisation* has seen companies like Mansory, a luxury German car modification firm founded by a tuner and working on luxury cars, supercars, luxury SUVs and custom bikes, flourish with demand from high end vehicle owners. Mansory works on vehicles spanning Aston Martin, Audi, BMW, Bentley, Bugatti, Ferrari, Maserati, Rolls-Royce, Tesla, Lamborghini and Porsche (images above). They are renowned for their expertise in carbon fibre design and construction and are notable for outlandish body modifications, light weight alloy wheels and bespoke interior modifications, as well as offering armoured and special protection vehicles.



It is not only the exterior that Luxury Customisation companies explores, but the modifications on the interior are also key to define the status of the vehicle. The Chelsea Truck Company work with off-road vehicles which in some cases have not luxury in their original form. That is the case of the conversions turning standard Defenders and Jeeps and old G-Wagons into luxury trucks. The concept of luxury is related to the extensive use of leather, which OEMs are pushing to reduce, in the case of new EVs. Chelsea Truck Company uses their own parts and other suppliers too. In addition to fitting accessories and changing trim, they also do more radical transformations, adding extra axle to make a 6 wheel-drive Defender, and in the other end, they sell fashion and lifestyle items, like watches, clothes, and baseball caps (Chelsea Truck Company 2020).

4.3.3. Personalisation

From personal touches to an artform in itself, personalisation is an ongoing trend for customers to set themselves apart from others.

A wide range of accessories exists to feed the trend of personalisation of vehicles.

For car interiors from gearstick embellishments, seat covers, personalised car mats, vent charms and steering wheel covers. This trend aligns to other in fashion and lifestyle, from accessorising jackets with badges and laptops with stickers. The exterior personalisation includes stickers, mouldings, trim, extra lights, reflectors, wheels and others. They can be bought from petrol stations to the internet, and mostly can be fitted by the owners.

More sophisticated, filming the car exterior can create a bespoke personal look. Companies like 3M make car wraps allowing customers to reimagine and transform their vehicles instead of repainting, which is reversible and can even protect your original paintwork from damage and abrasions. A range of different colours and finishes are available to completely transform and customise a vehicle.



4.3.4. Performance Tuning

As mentioned before, the Myth of Speed has been a key symbolic aspect that directs the automotive desirability (Mausbach et al, 2019). An obsession with going faster, or equipping vehicles for racing capabilities, the long-lasting trend of *Performance Tuning* expand from OEM programs to small garages. sees suspension upgrades, turbochargers, superchargers, engine tuning and the addition of sports seats as all popular and legal modifications to enhance car performance.



Some companies Performance and Tuning company have a racing background, like Abarth, which was incorporated to Fiat in 1971 (Wikipedia 2, 2020). The it has become an internal program, for branding and engineering proposes, like AMG to Mercedes-Benz and BMW M program.

BMW costumer can also look for the Alpina customised models. The company's BMW line-up focuses on higher end luxury, performance and torque, with particular styling, badging and colour options to differentiate them from the basic models. Alpina develops its models in partnership with BMW and with the parent company approval. It is now also working with hybrid models, but still not with BMW's electric line-up.

Companies like DTE Systems are developing *Performance Tuning* to EVs. A "PedalBox" system does the so-called chip-tuning to deliver 3 user modes to the Tesla Model S: City, Sport and Sport-Plus. The chip-tuning aimed to deliver faster acceleration "for a guaranteed push of adrenaline" (DTE Systems, 2020),

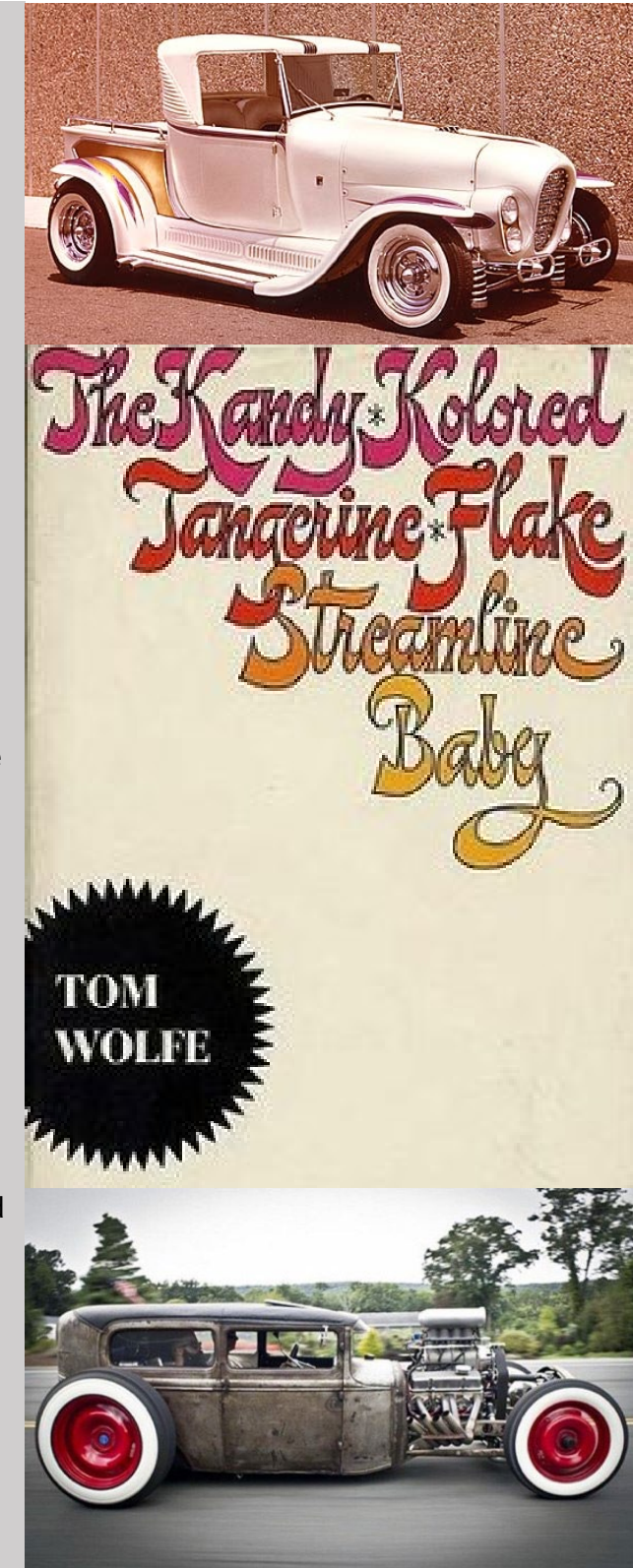
4.3.5. Custom Culture

There are several trends of car customising: (clockwise from top left) Custom Cars (or Kustom), Hot Rods, Lowriders, Stanced, Rat Rods, Funny Cars, Hi-Risers, Bosozoku, to name a few. Mostly they are substantially modified cars in mechanics and aesthetics, configure a particular community of owners and admires, with their own language jargons, habits, and events.



The Custom Car scene became popular in the 1960s and it was narrated by Tom Wolfe in "The Kandy-Kolored Tangerine-Flake Streamline Baby". Wolfe (1963) explains that in the post-World War II United States, "massive infusions of money in every level of society" gave the opportunity to people to "build monuments to their own style". Wolfe also advocated that customizers were more creative, or closer to artists, than the designers of the big Detroit manufactures.

Similar to Custom Cars, but considered a different trend, the Hot Rods are generally classic or modern American cars that are rebuilt or modified for performance and to impress with noise and looks. They are often individually designed and constructed using components of other cars and have generated an entire attitude and lifestyle with meeting and events. The trend started in the 1920s – when *Hot* apparently denominated a stolen car in the Prohibition era (Wikipedia 3, 2020). The big difference from Hot Rods and Rat Rods is the unfinished surfaces, or rusted metal. A common saying in the Custom car scene is that a Rat Rod is a Hot Rod that someone did not have enough money to finish. Nevertheless, it presents an interesting aesthetic contrast between the very shining chrome section – usually the engine, and the rusted metal of the body. Funny cars are usually prepared to drag races, and not legal to road use. Hi-Rise are cars with very high ground clearance, big wheels, usually featuring contrasting low-profile tires. It became well known through the MTV show *Pimp My Ride*.



Lowriders are customised cars with lowered bodies originating from Los Angeles. They are commonly fitted with hydraulic systems that allow for height adjustable suspension and painted in bright and colourful designs to be eye-catching. Originally started by Mexican American youths the purpose was the redesign the cars to go against their intended purpose and create a cultural and political statement.



4.3.6. Restomods and Replicas

Restomod refers to car restoration combined with a level of modifications. Usually, it aims to improve some aspects related to aesthetics or performance while keeping a link to the original vehicle. The term Restomod has been used for many different approaches, from customisation to technology updates. Hence, EV conversions are sometimes referred to as Restomods. Indeed, Top Gear's 2020 list of 20 best Restomods featured a few Retrofitted cars, including the Electric Reborn Totem Alfa Romeo Giulia GT and Classic Car Conversions like the RWB MG B and the Swindow Powertrain Mini (Pattni, 2020).

The Automobili Amos Lancia Delta Futurista, is a renovated design based on the Giorgetto Giugiaro original Lancia Delta. It features new lights, carbon fibre parts, personalised colours and interiors, and radically eliminates the rear doors. Amos Lancia explores the mains features for updates in technology and aesthetics in Restomods to refresh the Lancia Delta (AA, 2022).



Some of the so-called Restomods are replicas, since they are based mostly on new components, and with a level of modernisation. Replicas have always been present as niche automotive industry, and at some point, joined by major manufactures for projects like the Ford GT. Now, both OEMs and niche industries are looking at the opportunities to produce Replicas with electric powertrains.



An example of against-the-grain styling and aesthetic, Japanese Bosozone started as a reaction against post-war conservatism with motorbike gangs carrying out heavy and intimidating modifications on two wheels, the culture and aggressive styling aesthetic spread to cars, with wild body kits, lighting, and exhausts that push the boundaries of extreme. In Japan, two main trends stand out, the heavily modified cars and the supercars – specially Lamborghinis, with multi-coloured lights and reflective surfaces.



4.4. Communities and Lifestyle

4.4.1. Owners and Admires Groups and Clubs

The common passion of a particular product or activity tend to bring people together, and this has become significant in car culture. From institutional to more independent groups, there are automobile clubs, owners' clubs organised, supported, or acknowledged by OEMs, motorsport supports and admires groups. In common, they show the enduring and deep relationship between people and their vehicles, which are more than a mobility tool, but an emotional and cultural connection.

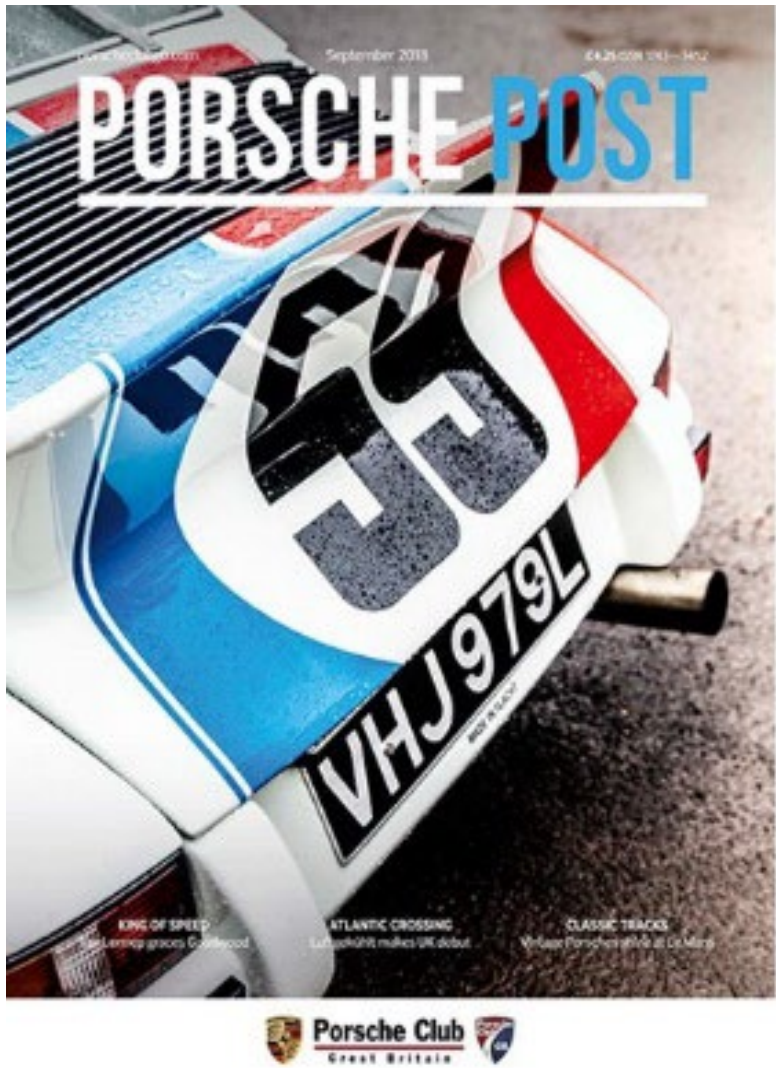


The Royal Automobile Club is an example being a private members club and the UK's oldest motoring organisation. With automotive events, historic cars displayed in the rotunda and hosting the annual London to Brighton Veteran car run, it is regarded as the spiritual home of motoring clubs in the UK.



Owners' clubs are another form of gathering of automobiles enthusiasts. They can organise events, connect owners, produce publications and some can help on maintenance of vehicles and preservation of the brands heritage. The MG car club was formed in 1930 by MG owners and has 50,000 members (MGCC, 2020). Its activities include car meetings, car tours and track days. The club was set up to bring MG owners and enthusiasts together creating a social community.

Official car clubs set up by OEMs such as Porsche, offer model specific sub-groups, vehicle valuations, exclusive track days, discounts, forums, factory visits and clubhouse access for an annual membership fee. The connection between motorsport and passion for selected car companies is clear. Motorsport also make the cars naturally modified to purpose, both aesthetically and mechanically. Some of these interventions are brought to production models. Porsche often sells special editions of its cars including racing inspiring looks and performance.



The world of motorcycles has on Harley Davidson an example of how a product has shaped a lifestyle. The iconic motorcycle brand that has evolved into a lifestyle representing freedom, rebellion, and adventure, with an unapologetically loud and muscular motorcycles that garner a loyal following. Owners and enthusiasts meet for communal bike rallies and social events, and the brand has extended into clothing and apparel. The fans of the brand extend forward than the owners' group, which is called HOG. The acronym also refers to the piglets, a racing mascot in the 1920s (Panhead, 2017).



In the side of cars, an interesting case is Ferrari. Being at the same time, a traditional motorsport team and a car company, the admiration of the fans goes across both sides, although they are two different companies. Ferrari S.p.A, founded in 1947 by Enzo Ferrari, created in 2006 the Scuderia Ferrari Club, a not-for-profit consortium to coordinate the activities of the many fans of Scuderia Ferrari. The Scuderia Ferrari Club (2016) has identified over 150 officially recognised Clubs in 16 nations. Ferrari's F1 team fans, know as "Tifosi" are considered the most fanatic followers in the world of motorsport. Capitalising on that, and the fame of the brand, Ferrari's franchised products expands from clothing and toys to the Ferrari World Park in Abu Dhabi.

4.4.2. Hubs and Venues

Every group must have a place to meet, and these places can become central for a particular culture, like seen at the Café Racers. Car enthusiasts congregate in public spaces, but also in venues planned for the purpose. Caffeine and Machine (bellow) in Warwickshire, is one of these places where car enthusiast go to get together and share their passion.

Extending from just a place to gather and appreciate cars, a trend of businesses combining this with eateries and stores is forming. The Duke of London (right) is a family run classic and supercar hub offering sales, restoration, storage, servicing, and detailing. Combining a pub and a pizzeria, they host regular events for car lovers including drive-in cinemas and car meets creating a community following.



The Bike Shed is a similar space but for lovers of two-wheel bikes, who according to its website (Bike Shed, 2020) are looking for an escape from the virtual and digital world to indulge in an authentic analogue experience centred around motorcycle culture. The experience offers dining, clothing, accessories, a barbershop, sales, and events. Events in the venue display bikes from companies from different part of Europe.



4.4.3. Classic Cars and Motorsport Events

Classic Car and Motorsport events join car collectors, enthusiasts, racing drivers and the public in the celebration of car culture and sport. While classic car shows, like the London Classic Car Show (bellow) are more focused on trade and restoration, Concours d'Elegance emphasises design and conservation of cars, and Classic Motorsport events are more focused on entertainment and fun.



Car racing has been around for as long as cars themselves and the need to relive its golden era is pertinent in the Goodwood Festival of Speed, an annual event featuring historic motor racing vehicles in a hill climb with 150,000 attendees (Goodwood 2020). The event features an annual motor sculpture, races, car launches and a supercar paddock. The Goodwood Revival is a 3-day event featuring cars that would have competed at the circuit between 1948-1966. Attendees arrive in period clothing which strives along with other events to recreate the 1950s and 1960s era of motorsport.

Concours d'Elegance, meaning competition of style, are worldwide events where prestigious vehicles are exhibited and judged. Dating back to the 17th Century where aristocrats would parade their horse drawn carriages, today motor cars undergo rigorous judging to determine the most well-preserved vehicles in mint condition. Often featuring rare, unique, and unusual vehicles, they are set in beautiful venues like Villa d'Este, Pebble Beach, Hampton Court Place and Blenheim Palace. Lately, concours have been the stage for OEMs to launch concept cars, to link the prestigious past to present and future of brands. BMW has been the sponsor of the Italian concours since 2006, releasing a series of *Retro* homages and lately, *Retro-Revival* EVs (Zoltan, 2015).



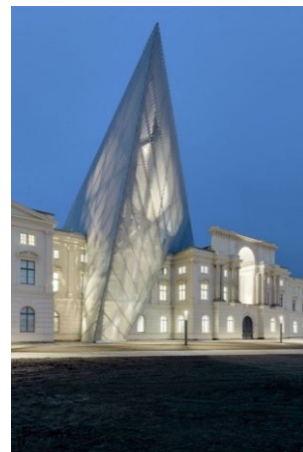
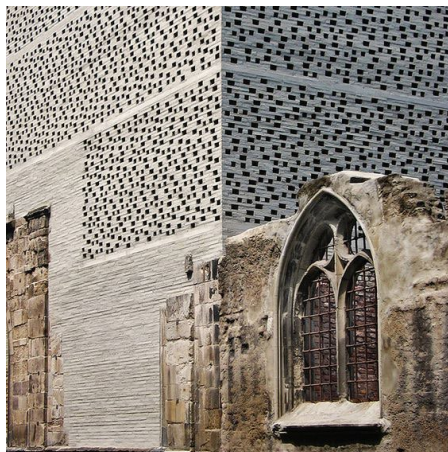
4.5. Expanded Material Culture

4.5.1. Architecture



Being an antique form of material culture, architecture has a long experience on dealing with pre-existing buildings. The discipline of conservation is well developed in architecture, to keep cultural heritage. But at the same time, as building can last for centuries, different architectural approaches can be taken to historic buildings. Paris Louvre Museum renovation, by the Chinese- American architect I. M. Pei became a landmark on how new and contemporary architecture could intervene in historic and listed buildings.

With the aim of preserving a relic, architecture has successfully created hybrid buildings that utilise the foundations of old buildings, whilst transforming or extending onto that a modern and often contrasting aesthetic extension. This approach keeps clearly identifiable which parts and elements of the building are new, and which are old, avoiding faking or hiding the renovated, instead, making the most of the contrasts in aesthetic.



4.5.2. Art

According to Deyan Sudjic (2008), “perhaps the divide between art and design is not as sharp as is sometimes suggested”. While creating an aesthetic, the pursuit of the designer is not so different of the one of the artists. Soon after invention, cars were recognized as an object, if not of art, at least worth of being celebrate and preserved for its cultural and aesthetic values.

In 1951, the significance of the relationship between car design and art was exposed by the exhibition ‘Eight Automobiles’ at the New York Museum of Modern Art, curated by Arthur Drexler (picture on top right). The architect Philip Johnson head of the museum’s Architecture and Design department stated on the catalogue: ‘An automobile is a familiar twentieth-century artefact and is no less worthy of being judge for its visual appeal than a building or a chair. Automobiles are hollow, rolling sculptures, and the refinements of their design are fascinating” (Margolius 2000),

Being such an omnipresent object in the Twentieth Century culture, there are many crossings between car and art, especially pop and contemporary art. In the 1960s trend of painting cars transformed cars in canvas. Celebrities like John Lennon would have his Rolls-Royce colorfully painted. The car sits at the Royal B.C. Museum in Canada. A form of expression which was common on the hippie culture, and is mixed with the image its favorite vehicles, the VW Camper Van (pictures on the right).

Also using the car as a canvas between design and art, BMW commissioned the Art Cars to artists, like Andy Warhol, Roy Lichtenstein (picture on the bottom right), Alexander Calder, Jeff Koons and others, to paint some selected cars (Wikipedia 5, 2020). The BMW Art Cars, produced from 1975 to 2017 are celebrate in car culture, but did not originate a popular trend. Despite of their beauty, consumers still prefer a single-colored object.



In many art forms, there are expressions of protest the dominance of the car. And although the meaning of The Long-Term Parking, by Arman, 1982, is open to interpretation, it is interesting to note which are the cars selected in the “accumulation” sculpture (Vintage Everyday, 2018), and how all the car turn classless and modest. It also makes one question about the destiny of old or disposed cars.



The Cadillac Ranch, by the art group Ant Farm, of 1974 is an interesting example. Although the idea behind the piece is quite uncompromised, it is interesting that the piece itself is open to intervention of anyone. People are invited to participate with graffiti, writings. More recently, cars were painted all in black by an artist to support the Black Lives Matter movement (Wikipedia 6, 2020).



Distant from cars, but also interesting as a new vision of mobility and aesthetics from art forms, the kinetic sculptures of Theo Jansen – the Strandbeests - do not have wheels, but legs. They inspire a vision of sustainability, harnessing wind energy to create movement.



A cultural and social event which links an artistic interpretation of cars with alternative lifestyle and art is the Burning Man festival. Described as a ‘global quantum kaleidoscope of possibility’ (Burning Man, 2020), the festival attracts tens of thousands of people to gather annually in Nevada’s Black Rock Desert to create a temporary city (picture top right) dedicated to community, art, self-reliance, and self-expression.



Dubbed the crucible of creativity, the festival explodes with art, fashion, sculpture, and mutant vehicles (picture above). The very particular avant-garde aesthetic of the festival is intended to be experimental and subvert institutional values, encourage expression, with the artists encouraged to challenge status quo norms, to embody anti-commodification, marketing, and bureaucracy, and instead spiritually awakening, falling into a bracket of ‘outsider art’. The philosophy stands to contrast from the ‘economy of scarcity’, ceaseless competition of resources, accreditation, and validation, to utilising volunteer aid to create communities, and harbouring collaboration between artists creating a populist movement. A ban on city wide motorised vehicles proliferates ‘mobile art’ only - ingenious art cars from motorized couches to lamp stands. The aim is to be radically accessible to all, interactive and anti-hierarchic, the very opposite of modern-day mass marketing and manufacture.



4.5.3. Fashion



Upcycled clothing takes old, takes worn out or damaged materials and transforms them into new pieces. The trend that has been around far longer than the recent movements of sustainability and socially responsible shopping and consumption and continues to be a channel to the creativity of designers (pictures above).

Recycled materials for clothing are also becoming popular with brands like Adidas using recycled ocean plastic to make trainers (picture below left). The Brazilian brand Osklen, has been working since 1999 on alternative materials and sustainable strategies. Osklen's 2018 collection ASAP (As Sustainable As Possible) uses recycled cotton and recycled soles for new shoes (Marques et al, 2018)(picture below centre). Osklen has built its image as forward thinking and responsible fashion and had achieved international success and become a reference brand for the Brazilian conscious consumer.

It has also been a successful fashion, especially for street style and jeans wear, to make clothes looking worn, giving it more character and producing an alternative look. The distressed and stone washed denim started in the 1970s and it is produced by many types of brands, including luxury houses like Dolce & Gabbana (picture below right).



4.5.4. TV

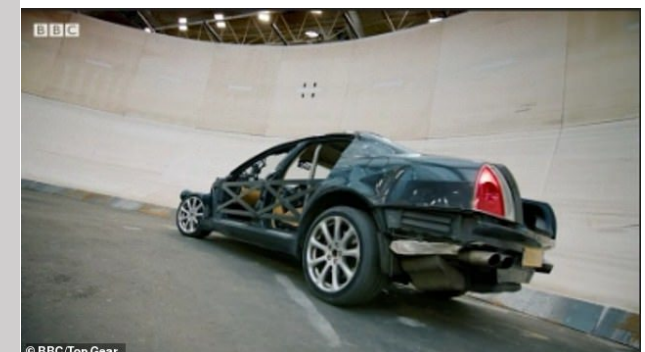
With TV serving as a large scale means to both represent and influence the population, motoring shows in the UK represent the interest that exists in cars, its trade and restoration, from the technical challenges to the storytelling and sense of achievement on automotive restoration projects,

Wheeler Dealers is a restoration and trade show broadcasted since 2003. It shows cars – usually vintage cars - being restored and trade. The show goal is to create value on old cars, and to extend the life of (as the presenters of the show say), iconic cars. To make it more attractive to buyers, sometimes the cars the restored cars receive visual and mechanical updates.

The restoration shows got a retrofitting twin with Vintage Voltage. The show started on UK TV in 2020, showing the activities of Electric Classic Cars, a garage specialised in electric conversion in Wales. The show was sponsored by Octopus, an electricity company. The TV show promotes the activity of conversion to electric to a wider public, nevertheless, the cars done at the show are usually classics and high-cost projects, focused on high performance and using Tesla power units and batteries.

One of the most popular shows about cars in the UK is Top Gear, produced since 2002. The program has a comedy and journalism mixed, which started with the original cast of Jeremy Clarkson, and continues until the date. The show usually shows the cast, and BBC producers re-creating on top of existing vehicles. The 2020 season showed write-offs cars being repaired in an alternative way, and presented the idea of a Maserati Quattroporte, without doors, and a Mad Max movie look.

There are also TV shows about custom cars and bikes, presenting the personalisation process.



4.5.5. Cinema

Since its inception cinema has provided the ultimate form of escapism for spectators, and a playground for futurist ideas for its creators. Cinema has a history of influencing future automotive aesthetics or the visions of people about the future. With respect to cars there is a trend of retro-additive aesthetic in future vehicles, like seen in the Fifth Element. There is also an additive aesthetic which is more purist and creates a sleek vision of the future, like seen in I-Robot. Another additive aesthetic shows attachment and addition on top of vehicles, in a raw manner, like seen in the De Lorean turned into a time machine in Back to the Future.

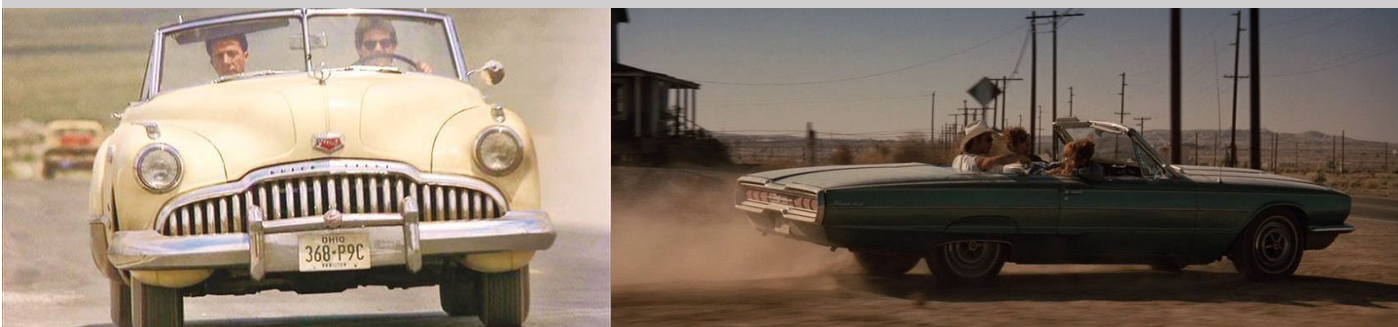


Personalised and custom cars are also present on cinema. George Lucas 1973's movie American Graffiti (image above) portrait the youth in the USA living around their cars, and custom cars, the street races and drive-ins as the 1950's lifestyle.

In a more modern version, the Fast & Furious movie series (image bottom right), created by Gary Scott Thompson, shows adventures of gangs of performance tuned cars. The franchising extended to toys (picture below) and gaming (right), promoting a different aesthetic and vintage cars to young generations.



In the other hand, cinema also often celebrates the cars of the past, which are protagonist in many road movies, like Rain Man (Barry Levinson, 1988) and Telma & Louise (Ridley Scott, 1991). While using vintage or classic cars, the movies play with the present time reference and become more timeless. Moreover, cinema interest confirms the value of cars beyond programmed obsolescence.

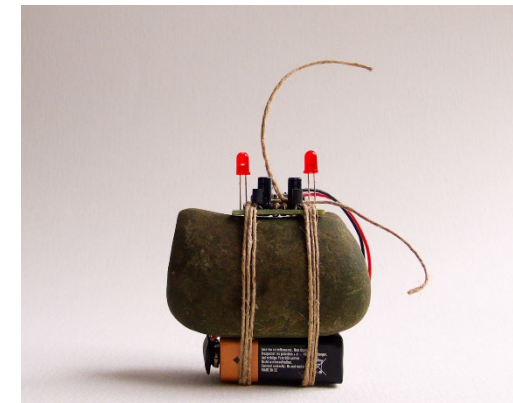


4.5.6. Design and Craft

Between many approaches to design, for Ecofitting is interesting to observe trends in re-use and recycle. In contrast to traditional recycling where the initial product needs to be broken down first to be reused, product upcycling sees creative innovation from a different angle, the challenge being not to create something new, but to take something old and repurpose it in an aesthetically acceptable way into having a new function, whilst still retaining its old spirit, and creating better environmental value- a trend valuable to the concept of Ecofitting. This movement is practised on smaller scales but also features in the work of notable industrial designers such as Gae Aulenti and Ingo Maurer, and it extends to the works of Stuart Walker.



Walker's works extend from the theory and books which are largely referenced on this research, and design experimentation, where theory is transformed in tangible objects – and tangible objects inform theory. Walker's designs experiments with re-purposing of discarded objects, raw combinations of electrics and electronics with natural materials, influences of local craft, symbolism, and evolving upgradable objects bridging these issues.



Additionally, it is interesting to observe how the processes of maintenance and repair is done in different types of craft. Sometimes, the resultant aesthetic will reflect this. Traditional craftsmanship and traditional philosophies - like Kinsukuroi [24], show the scars of the repaired ceramic. The approach incorporates the damage as part of the history told by the object and preserves the resources sustainably.



4.5.7. Café Racer Motorcycles



An example of how a community can create an aesthetic and product trend is the *Café Racers*. The name originated in the 1960s from the bikers who used to do quick runs between cafés in the UK: the and the Busy Bee in Watford and the Ace Café (picture on the left), in Stonebridge, London (Wikipedia 4, 2020). *Café Racers* are powerful but lightweight motorcycles optimised for handling and speed, with bodywork recalling the 1960s grand prix racing motorcycles. They feature a minimalist aesthetic with low mounted handlebars, prominent seats, and elongated fuel tanks.

Café Racers can be vintage or contemporary; Triumph explores the style with the Thruxton, delivering timeless product. In addition, there are concepts and electric bikes following the trend. Built over a Honda 125cc Cafe Racer, the Honda Electric Cafe Racer (middle right), was designed in Spain by Pablo Baranoff Dorn (Hemsworth, 2019). The trend has got attention from product and automotive designers. Sacha Lakic (picture below), designer of electric cars for Venturi and founder of Blacktrack Motors customizer, stated that “modern bikes are too clean, too perfect, too plastic” (Boruslawski, 2016).



4.6. Conclusions and Insights

The study of trends which inform the State-of-the-Art of Ecofitting was based on observing a wider scope of activities, products and cultural expressions that help to identify how Ecofitting can develop. The study indicates consonances in material culture demonstrating a new space to be explored by automotive design, representing alternatives to the Aesthetic of Perfection (section 2.2.4). It also helps to build the design philosophy of Ecofitting, and which questions are needed to investigate through further research and design experimentation, the feasibility of Ecofitting as an alternative strategy for market, design, and industry, towards zero emission.

The Ecofitting design philosophy is configuring as a contrast to mainstream automotive design, marketing strategies, and current business plans for major automakers. As such it is not intended as a replacement, but more to exist as an adjunct and occupy a parallel space alongside that is currently unfilled as a large-scale economy for EVs. The study points out the extend of the activities and culture related to Car Conservation (section 3.1) which can be aligned to practices of Ecofitting, giving it an immediate growth in scale. In opposition, the business-as-usual practices of car industry should reduce their intensity to lower the impact on the environment. Ecofitting can help to support mobility demands while extending the life of the current fleet.

Looking at Car Conservation (3.1) we identified different approaches to it, which reflect pathways to aesthetics, technology, or production. While Restoration (3.1.1) focus on bringing cars back to as close as the original standards as possible, Preservation (3.1.2) doesn't try to hide the signs of the past, which builds an interesting point to sustainability and long-term ownership. Embracing the worn and damaged in the object, there is less need for repair or discard. In addition, Extension of Life (3.1.3) acknowledge the efforts to keep vehicles on the road, and the way that this builds a strong cultural and emotional connection to cars. Thus, supporting the idea of long-term ownership as meaningful and opposite to an unpersonal and ephemeral consumption.

Observing the activities of Car Conservation (3.1) in parallel to the current Car Retrofitting ones (3.2) raises the following points. Classic Cars Conversion (3.2.1) reflects most of the principles of Restoration, apart from the conversion of the powertrain to electric. The market for this activity is clear, as the focus of the businesses developing it now, it aims strictly to change the powertrain conserving the aesthetic. Nevertheless, as seen on the section Identifying the Fleet (1.3), classic cars should not be the focus of Ecofitting, due to its minor impact and not been restricted to use on the road, according to current ULEZ's rules. And while it is expected that the Classic Car Conversion model will be a continuing trend, its challenges are more to engineer than design. Additionally, newer models, including those build after 1980, are progressively being considered *classics*, *modern classics*, or *vintage*, and are already focus of trade business like KGF Classic Cars (KGF, 2020). This trend is also positive to Ecofitting, meaning that the aimed fleet is increasingly becoming more significant for people and culture, and retaining market value, and more often cars after 1980 will be turned electric.

Retrofitting also have their equivalent to Preservation. Named here Electric Rustoration (3.2.2), the trend to take classic cars, convert to electric but not doing much to their worn bodies makes a radical statement about aesthetics of sustainability. The trend is also highly influenced by Rat Rods, Lowriders, and other forms of Custom Culture (3.3.5). The multitude of trends of Car Customising, and their creativity and engagement as tribes are interesting elements to be considered for Ecofitting. It shows a diversity which is not acknowledged by official automotive marketing and design, and cultural area to explore.

Refined and sophisticated, Full Renovation (3.2.1) is a significant trend of Ecofitting, considering that it incorporates design strategically to EV conversion. It can be argued that its design principles also create an *aesthetic of perfection* (2.2.4), positioning it closer to current car design standards, or the *official automotive design* practice. At the same time, the examples analysed are easily acceptable by the public used to mainstream or high-end products.

All the above-mentioned retrofitting activities are part of a smaller scale industry, individual focused. This acknowledges the slower speed of production possible on electric car conversions. Although, as seen on the section Budget and Scale (3.2.6), there are efforts to make conversions faster and cheaper. Mostly the activities of restoring, personalising and customising are tailored, and might be more significant to people if Ecofitting is also personalised. Additionally, the DIY trends (3.2.9) points out that conversion opens opportunities to people to work on the production of their own electric car. Ecofitting DIY is a low-cost option, being possible to convert a car from as little as £900 (Briscoe, 2020). The cost of Ecofitting can vary a lot, depending on the starting doner-vehicle, and the performance aimed. Therefore, there is also the opportunity to develop solutions around user needs, and with less redundancy than a mainstream automotive industry product.

From the mainstream automotive industry side, two different market strategies are observed: OEM Product Diversion (3.2.7) and OEM Re-Manufactured (3.2.8). The Product diversion acknowledges that conversion is possible, and platforms can be adapted to multiple uses. The first Tesla model, the Roadster, produced between 2008 and 2012, and famously sent to space in 2017, was an OEM Product Diversion since it was based on a Lotus Elise. OEM Re-Factory, introduced by Renault, focuses on establishing a circle economy strategy, and provide lower electrification solutions. There is big difference in the care of aesthetics and desirability on both industry strategies, which can make the Re-Factory less desirable than other EV products from the industry. There is a risk of repeating the history of failure of other ecological vehicles, like the GM EV1, is subjective aspects of design are not well-developed.



Figure 7. Tesla Roadster sent into space in 2018.

Looking at Car Customising (3.3) we observed many different activities that support long-term ownership, and also possibilities for design exploration which are not the common route of car design. The research indicates that while creating alternatives to mainstream car design, which will be represented by the new electric vehicle models from OEMs, there are possibilities of expression of individual taste and authorial design. This will open possibilities for more small and medium businesses to be part of a circular economy and democratise economic opportunities. Although most of the trends do not focus on sustainable practices, they support long-term ownership. To fully integrate those business in Ecofitting, it is needed a review on their production and design approaches.

Customising, nevertheless, expands to create a group identity. Which are beyond the production of design from OEMs and reflection of popular culture, as identified by Tom Wolfe in the sixties (Wolfe, 1966). Furthermore, Communities and Lifestyle (3.4) looks at the value of design and objects (car and motorcycles – where included as examples) as congregating groups of people, and becoming cultural references, with enduring presence and significance. The research observed the dimension of Owners and Admiring Groups and Automobile Clubs (3.4.1), Hubs and Venues for car enthusiasts (3.4.2) and Classic Motorsport Events (3.4.3). While they consolidate as important cultural references, and some grow in size and attendance, the industry is seeing the decay of the Motor Show, and a possible end after the 2020 pandemic with the selling of Geneva and cancelling of many other events (BBC 2020-1).

The State-of-the-art research also observed references on Expanded Material Culture (3.5) to make parallels and compare automotive design – and Ecofitting - practices, with architecture, fashion, and product design. It also observes possible crossings between Ecofitting and Art, Cinema and TV. In Architecture (3.5.1) is possible to observe a well-developed philosophy and practices of retrofitting and blending old and new construction, and at the same time, it indicates the need to observe case by case, object by object, and each different user needs and expectation, which points towards a designer led process of retrofitting in cars, like an architect-led process in building.

Fashion (3.5.3), Product Design and Craft (3.5.6) points towards a consumer behaviour change which is ignored by the official automotive design, and the straightforward incorporation of re-using, recycling and remanufacturing, which are aesthetic expressive and at the same time producing honest and authorial objects.

Moreover, the research observed the value given to classic car in cinema (3.5.5) and television (3.5.4), and how modified cars inform aesthetic of the future in the cinema. In addition, the inclusion of a show about the conversion of car to electric indicates that Ecofitting is gaining momentum. Finally, at the Art section (3.5.2), the research observed critical views about the car can indicated the opportunity for a paradigm shift on automotive design. Significantly, how different the vehicles produced at the Burning Man Festival are, reflects the changes in context, tastes and habits which are challenging the industry, the immense distance between the future generation of consumer and the official automotive design, and the need to find an alternative automotive design aesthetic.

The sheer diversity of the trends observed in the State-of-the-art research is inspiring, and the positive effect they have had on influencing wider culture and community shows their value. In some instances, these trends have arisen directly from the deep love and passion for particular objects, with a resulting desire to celebrate them. Extension of life, Restoration, Preservation, Classic Car Clubs, and Classic Motorsport events, exist comfortably in parallel to Ecofitting's philosophy of continuing to use products for longer lifecycles.



Figure 9. 2021 Ford F-100 Illuminator concept.



Figure 10. Totem Automobile GT Electric



Figure 8. Electric Classic Cars Baja.

Nostalgic trends mean a relatively conformable space for OEMs, which are working on the one side on new Retro Revival EVs, and on the other, some are starting to realise the potential of supporting Ecofitting. Ford has unveiled the F-100 Illuminator concept offering the powertrain of the Mustang Mach-E to retrofit a 1978 pick-up.

Small manufactures are also sensing the opportunity to produce Electric Reborn replicas (3.2.3), like the Totem Automobile (Alfa Romeo) GT Electric. Nevertheless, while replicas are mainly new builds, they are not the ideal strategies to reduce environmental impacts. Still, they support the development of alternative industries, practices, and consumption, and with that, Ecofitting.

With other trends, it is the need to split from the norm, to stand out, and almost rebel against the status quo that has driven the birth of an alternative aesthetic, like seen on the Electric Classic Cars Baja. This is a concept that Ecofitting promotes by providing an almost DIY approach involving owners/users to customise design and upgrades, which may drive the birth of a unique set of aesthetics.

Lastly, some of these trends arise from the want and wish to create community and belonging, like Café racers (3.5.7) and the multitude of Hubs and venues opening to cater for this. Concurrently, Ecofitting can appeal on an ethical level to people wishing to make the world a better place, to foster more responsible consumption. Thereby connecting with others of the same mindset, creating or

communities of environmentally conscious people. From research into the changing lifestyle, values, and attitudes of upcoming generations, it was identified their personal investment into industries, products, and companies that promote responsibility, transparency and exist to add value and positive change. Ecofitting shall observe these aspects and follow similar values.

In the next section, we analyse how Environmental, Economic, Socio-ethical and Subject Sustainability aspects can be observed in Ecofitting, in comparison to the traditional industry and current EV strategies, and how it can also direct its designs.

5. Sustainable Design Analysis of Ecofitting

Sustainable Design Orienting toolkit

The aim of this chapter is to produce a holistic analysis of Ecofitting's sustainable design strategy. As mentioned in the Introduction, Ecofitting is analysed here as a design proposal in the context of sustainability, using design methods to investigate its potential. More specifically, being a sustainable design concept, tools for sustainable design were also adopted to evaluate the proposal. To study its sustainability credentials, the starting point was the Sustainability Design Orienting toolkit (SDO), developed at the Politecnico di Milano by Dr Carlo Vezzoli, with Ursula Tischner and others, and its user guide created by Hussain Indorewala and Daniel Metcalfe (2009). The SDO investigates the Environmental, Economic and Socio-ethical dimensions of sustainability, questioning a series of issues related to product and service design, and respective externalities, relating to a *triple bottom line for sustainability*.

Following Stuart Walker suggestion to consider the Personal Meaning as well, the SDO toolkit was reviewed to include a fourth section, amplifying the concept to a *quadruple bottom line for sustainability*. Repeating the same structure as the Environmental, Economic and Socio-Ethical dimensions, we have added a Subjective Dimension. Six criteria were defined, with references to the aspects discussed by Walker (2014, 2017), Faude-Luke (2002), Papanek (1984), Manzini (1998), Sovacool (2018), Hassenzahl (2010) and others. As in the original toolkit, a checklist was added to each one of the six criteria. Additionally, a review was made in the original questions of the toolkit. The questions were also reworked referencing the UN Sustainability Goals (UN, 2020).

In this Design Analysis the toolkit is used to compare ICE-based automotive industry and products, with EV-automotive industry and products and Ecofitting circular economy and products. The study is divided in four parts or bottom lines, according to the updated toolkit. The first and second sections relate to more functional, tangible, or quantifiable issues, and include the Environmental Sustainability and Economic Sustainability. The third and fourth sections, relate to more symbolic, intangible, or qualitative issues, and include the Socio-ethical and the Subjective Sustainability.

The four bottom lines are studied using six different criteria per each. To analyse each criterium, there is a checklist which is answered to inform the comparison between ICE, EV and Ecofitting. The answers are given relating to present and short-term context, or long term, when specified. Following the checklist, a review is written, and it is signalled a scale of improvement for the specific criterium. The level zero of the scale of improvement is the current state of the automotive industry and products, which is predominantly ICE-based. Therefore, on most of the criteria, ICE will have a no improvement and receive an equal signal (=). In the case of long-term questions, ICE can improve or worsen. Improvements can be medium or high, receiving one or two plus signals (+) respectively. Worsening receives the minus sign (-). Then, the grade signs are transferred to a Radar per each criterion.

In the following section, we use the tool to compare Ecofitting to ICE car industry and the plans for electric cars, as they are presented today. The objective is to observe how Ecofitting, as a circular economy proposal, can differentiate to the current strategies of automotive industry and to help to identify its high and low points, design implications, and inform the feasibility study and the development of the design experimentation.

5.1. Environmental Sustainability

Introduction

Environmental Sustainability looks at issues related to the materiality, efficiency of systems and products, and externalities that affect the environment and life. In this analysis, Environmental issues are considered often functional, tangible, and quantifiable. Nevertheless, because this study is mostly a conceptual analysis, it will not deliver data like a life Cycle Analysis, but a comparison between ICE, EVs and Ecofitting.

It considers this dimension of sustainability practical issues and related to Practical Meaning. Practical Meaning is characterized by: that is sense based and provable; instrumental thinking; intellect and reasoning; quantitative methods; evidence-based methods; analytical thinking; logic and efficiency. Relates to physical sciences, mathematics, engineering, technology, innovation.

The Environmental Sustainability should directly tackle the following UN Sustainable development goals: *Good Health and Well-Being (goal 3), Clean Water and Sanitation (goal 6), Affordable and Clean Energy (goal 7), Industry, Innovation, and Infrastructure (goal 9), Reduce Inequalities (goal 10), Sustainable Cities and Communities (goal 11), Responsible Consumption and Production (goal 12), Climate Action (goal 13), Life Bellow Water (goal 14), Life on Land (goal 15), Partnerships (goal 17).*

Summary

In the Environmental Sustainability analysis, Ecofitting has showed better results than mainstream EVs and ICEs, in every criterium. The results of the analysis can be seen in the following radar.

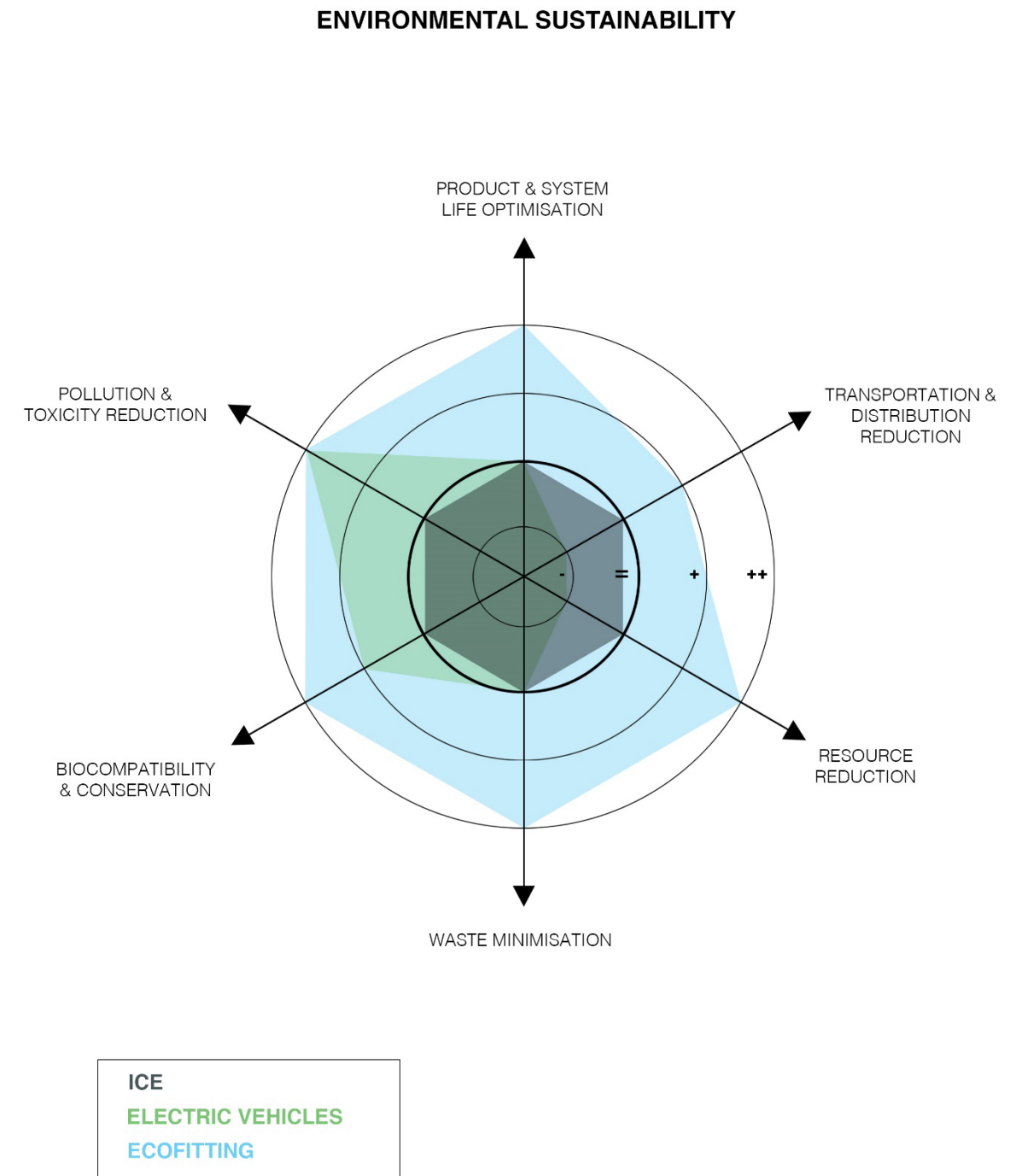
Ecofitting's better results included criteria which are significantly difficult for EVs now: Resource Reduction and Transportation and Distribution Reduction. Looking at the perspective of the replacement of the ICE for electric cars, it is strategic to put in place a strategy to reduce the impact of transportation and use of resources. Ecofitting shall also make a more significant use of biomaterials, to increase the biocompatibility of the system.

A considerable improvement of Ecofitting is on minimisation of waste and on the optimisation of the product and system. Although now the conversion of cars is mainly happening on small scale, the objective of Ecofitting is to expand this activity, therefore the environmental impact of electrification of private mobility will be reduced.

The Environmental Sustainability analysis indicates that Ecofitting Circular Economy concept is a worthwhile strategy towards zero-emissions sustainability.

In the following sections, the criteria of the analysis are detailed following the toolkit method.

Radar



5.1.1. Biocompatibility and Conservation

Checklist:

- A. *Is all energy produced from fossil fuels? Is all the energy produced from renewable sources?*

There is a clear route for both EV and Ecofitting to be based on renewable energy sources. There is option to use biofuels on ICE, nevertheless, that will still produce emissions.

- B. *Does the system use mainly depleting and/or non-renewable material for the production processes? Does it use biomaterials?*

The most significant new issue of electrification is the dependence on non-renewable materials for batteries. The use of biomaterials is not largely explored in car design, which are mainly focused on costs, durability, and strength. There are opportunities to Ecofitting to use more natural material in interior and exterior.

- C. *Does the system use locally grown materials?*

The use of natural materials, especially wood, and leather, are common on high end products, but not necessarily it favours local production.

- D. *Is the product and system prepared to respond to changes and disturbances in natural and manmade contexts?*

The car industry showed a dependence on a worldwide logistics of supplier and little resilience, during the 2020 crisis. A local re-manufacturing on Ecofitting can allow the industry to respond to global crisis, transferring responsibilities for local scale. In term of energy use, and dependence on infrastructure, electrification will create challenges.

Review:

Biocompatibility and conservation are not favoured in the automotive industry, and on the design of its products. The scale of production and standards of design do not are highly compromised and dependant on a techno-ecology. There is opportunity to develop Ecofitting as an industry that would incorporate locally grown materials, biomaterials instead of non-renewable materials. This could, nevertheless, restrict the scale of growth of Ecofitting.

Scale of improvement:

ICE =
EV +
ECOFITTING ++

5.1.2. Resource reduction

Checklist:

- A. *Is the system consuming high quantities of natural resources? Is the system absorbing high quantities of consumables?*

Although there have been great improvements on manufacturing process, the car industry consumes large amounts of materials, which are incorporated in the products, and this is not going to change much with EVs. Actually, EVs are heavier. Conversion of existing cars to electric is an option to reduce consumption while re-using highly engineered part of the vehicles, as structure, body, and glass.

- B. *Is the system consuming high quantities of energy?*

The consumption of energy to produce new cars is high, and it is even higher for hybrids and electric vehicles, the option to retrofit would reduce the consumption of energy while reducing manufacturing processes.

- C. *Are the extension of life of the products and system facilitated?*

The extension of life of vehicles is facilitated by the network of suppliers of parts and repair and maintenance shops. Nevertheless, the changing of emission regulations turn vehicles redundant. Moreover, the industry stimulates a continuing acquisition of new cars. The change to shift of the industry from ICE to EV anticipates end-of-life.

- D. *Is the extension of life of materials promoted in the system?*

The extension of life of materials is promoted through systematic recycling, nevertheless, that depends on uncertain end-of-life of vehicles.

Review:

The automotive industry has been focusing on developing recycling systems, which are, nevertheless, dependant on a control of the end-of-life of vehicles, which is difficult to enforce. At the same time, premature recycling would mean spending of high quantities of energy. Ecofitting proposes to reuse most of the vehicles while remanufacturing them as electric, this would mean a reduction on resources and promoting responsible consumer behaviour, which could reflect on future new vehicles and a wider change of habits

Scale of improvement:

ICE =
EV -
ECOFITTING ++

5.1.3. Transportation and distribution reduction

Checklist:

- A. Are there any excessive transportation of goods, semi-finished products, or by-products?

There is an excessive transport of new vehicles, both as import and export. “The UK automotive sector is truly global, with products exported to some 160 markets. Exports accounted for 81.5% of all car production in 2018, while imports accounted for 87.9% of new car registrations.” (SMMT, 2019)

- B. Are the transportation means in services fully used or shared?

(Not observed)

- C. Is there any excessive transportation of materials and resources to run the system or product?

The automotive industry is dependant of a worldwide logistics to produce. The change to electric is creating a world dependence on raw materials for battery production which are concentrated on specific parts of the world. Ecofitting can create opportunities to incorporate local manufacturing, and local materials.

- D. Are maintenance and upgrade developed locally or highly dependent of long-distance transport?

In theory, maintenance and upgrade of cars can be developed locally, but it depends on centralized production of part or imports. Ecofitting promotes the development of parts in SME, through 3D printing and other technologies.

Review:

In the globalised economy, import and export of vehicles and parts, as much as semi-finished vehicles, became common. Whilst this has opened alternatives for consumers and helped to improve the standards in a global level, this also creates a high ecological footprint. A focus on local production can help the industry to meet local emission targets. Ecofitting can help to reduce transportation, nevertheless it will still depend on the same logistics for battery components.

Scale of improvement:

ICE =
EV -
ECOFITTING +

5.1.4. Product and System life optimisation

Checklist:

- A. Do parts of the system and products tend to be technological or culturally/aesthetically obsolete?

Electrification is making the fossil fuel, and combustion engine systems obsolete, moreover the new emission standards and ULEZ will make 15 million cars redundant. Culturally, there is little change in how cars are used and perceived, also meaning that it continues to become obsolete following fashion cycles in style. The technology obsolescence recently occurs more due to improvements in communication systems, or to attend changes in safety and environmental standards.

- B. Is the system individually used, when it could be shared in some of its parts?

Cars can be shared, have shared use, or be used individually, independently of the energy source.

- C. Do some parts of the system/product tend to be wear out more easily (than others)?

Looking at the automobile, there are parts which wear out easily, but won't change with electric or Ecofitting – like tyres. There are also body parts of the vehicles – bumpers, side-panels, seats – which are subject to faster depreciation. EVs will additionally have the battery pack life span as a weak point.

- D. Does the system favour maintaining and upgrading services?

Cars are subject to systematic maintenance, but upgrades are not favoured since the main focus of the industry is selling new vehicles.

Review:

Although the focus of automotive industry has been on selling new cars, instead of upgrading, there is an opportunity with Ecofitting – that would probably require the acknowledgment of car conversion as part of the electrification promoted by the OEMs – and include it on industry's statistics. Ecofitting can also optimise the life of the car replacing the worn parts of bodies and interior and making significant changes in aesthetics to create attractive cars. Ecofitting can help to develop a modular architecture that considers the possibilities of easy replacement of batteries. Therefore, Ecofitting should incorporate upgrading in aesthetics and technology.

Scale of improvement:

ICE =
EV =
ECOFITTING ++

5.1.5. Pollution and Toxicity reduction

Checklist:

- A. Are the processed resources toxic or potentially toxic during production and distribution?

One of the worst problems of oil dependence is the accidents in transport and production. Similarly, all the activities depending on mining are also dangerous for people and environment. Most of them would affect EV the same way as ICE. The first has the additional problem of battery production, which will also affect Ecofitting.

- B. Are the processed resources toxic or potentially toxic for people?

Although there have been advances in technology, the fossil fuel engine is potentially dangerous for health. Electrification represents a big advance.

- C. Are the processed resources toxic, polluting or damaging to the environment in the long term?

The burning fossil fuels is responsible for greenhouse gases and damaging the environment in long term. Additionally, there are other form of pollution from disposal, use of landfills, which can be reduced by re-using the vehicles, or extending their life.

- D. Are the products, subproducts, packing or infrastructure toxic or potentially toxic during after service time?

Although there is a systematic control of disposal and recycling to eliminate the risk of intoxication after service time, the replacement of the fleet from ICE to electric will create more challenges, due to the loss of value of the ICE vehicles.

Review:

The shift to electric is necessary and widely beneficial for reducing pollution, environmental damage, and health problems. Ecofitting will support the change to electric and also reduce the risks of uncontrolled disposal and export of outdated technology and cars to places where there is less control in environmental and health standards. Purposely designed EVs will be the more efficient vehicles and collaborate in large scale to the reduction of pollution.

Scale of improvement:

ICE =
EV ++
ECOFITTING ++

Footnotes:

A 2000 study by M.A. Weiss et al., entitled On The Road In 2020: A life-cycle analysis of new automobile technologies revealed that 75 percent of a car's lifetime carbon emissions stem from the fuel it burns, not its production. A further 19 percent of that is production and transportation of the fuel, leaving just 6 percent for the car's manufacture. However these figures vary and a more recent Volkswagen study suggests that with vehicle efficiency rising steadily, 68 percent of the car's lifetime emissions came from driving it, while the manufacturing process accounts for a higher 22 percent, although this was for an ultra high-efficiency model. Thus as cars become more fuel efficient and towards zero emission, the car's lifetime energy use from its production will account for a greater proportion of its lifetime environmental impact than its propulsion. (Roberts, C, 2019)

5.1.6. Waste minimization

Checklist:

- A. Do the production, packing and support products produce big quantities of landfill waste?

The industry has achieved good improvements to reduce landfill waste.

- B. Does the system produce high quantities of landfill waste at the end of service-life of products and parts?

There is a high quantity parts of vehicles on waste. Significantly, tyres, which are estimated to take 80 years to decompose, and are pushed to recycling. The disposal of vehicles is heavy on land use.

- C. Does the system facilitate dismantling and disassembly?

Surrounding and support activities, of automotive industry have developed systems of dismantling and disassembly. Nevertheless, disassembly is not the focus of the mainstream industry. Ecofitting will develop disassembly for remanufacturing vehicles as EVs, create more value in the chain.

- D. Does the system use biodegradable materials?

The use of biodegradable materials is no favoured on current automotive design standards.

Review:

Ecofitting is an alternative strategy to minimise waste, while reusing most of the vehicles which are going to become redundant due to new emission standards. Additionally, Ecofitting can incorporate more biodegradable materials than the usual standards of automotive industry. With electric cars, the industry is also pushing to use more biodegradables materials in interiors.

Scale of improvement:

ICE =
EV =
ECOFITTING ++

Note:

Full list of references available in the end of the document.

5.2. Economic Sustainability

Introduction

Economic Sustainability also looks at issues related to the materiality, efficiency of systems and products, but through a financial perspective. More importantly, in this study, the wider consequences of the economic activity, how it includes people, show benefits are shared and how inequalities are reduced are prioritised in the economic model. In this analysis, Economic issues are considered then more functional and tangible than just a monetary quantity. This study will not deliver data on profit or expending. It considers this dimension of sustainability practical issues, or means to something, and is related to Economic Means.

Economic Means is characterized by: financial viability, but not as an end in itself. The focus is on inclusion and sustainable development. It is sense based and provable; but should be observed holistically to promote sustainable development. Relates to physical and social sciences, mathematics, economics engineering, technology.

The Economic Sustainability should directly tackle the following UN Sustainable development goals: *No Poverty (goal 1)*, *Good Health and Well-Being (goal 3)*, *Decent Work and Economic Growth (goal 8)*, *Industry, Innovation, and Infrastructure (goal 9)*, *Reduce Inequalities (goal 10)*, *Sustainable Cities and Communities (goal 11)*, *Responsible Consumption and Production (goal 12)*, *People, Justice and Strong Institutions (goal 16)*, *Partnerships (goal 17)*.

Summary

In the Economic Sustainability analysis, Ecofitting has showed better results than mainstream EVs and ICEs, in most of the criteria. The results of the analysis can be seen in the following radar.

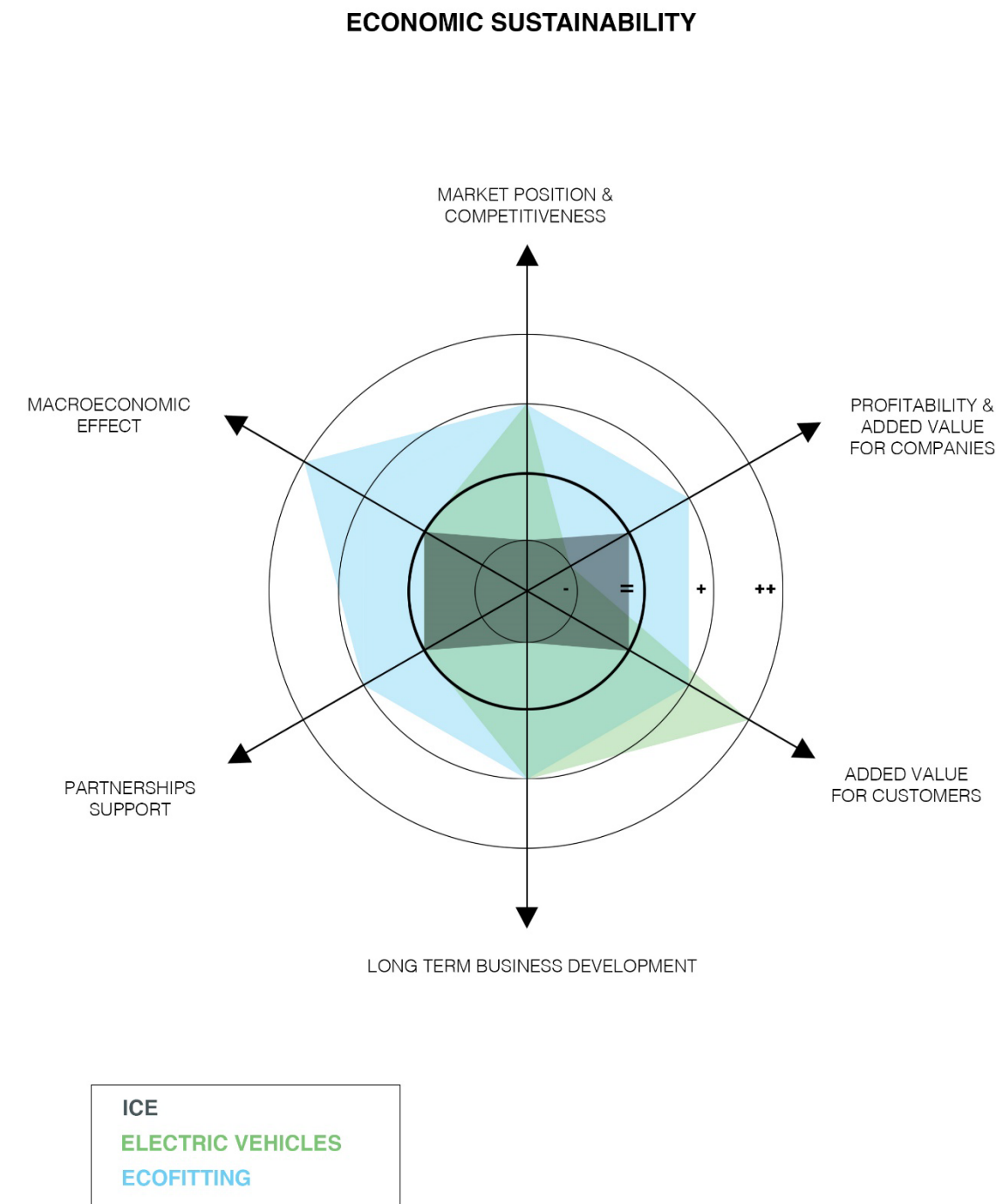
It is expected that Ecofitting will have a better result on profitability and added value for companies, that is significantly difficult for EVs now. While supporting long-term ownership, Ecofitting improves customer fidelity and deliver services more continuously. Additionally, the circular economy concept supports partnerships and creates a positive macroeconomic effect, while creating jobs and reducing the financial cost of environmental damage.

A challenge for Ecofitting is to match the added value for costumers. Theoretically, purposely designed EVs will perform better than adapted cars and have the support of the mainstream automotive industry strategies for marketing, maintenance, and benefit from government incentives.

The Economic Sustainability analysis indicates that Ecofitting Circular Economy concept is a worthwhile strategy towards a new sustainable economy model.

In the following sections, the criteria of the analysis are detailed following the toolkit method.

Radar



5.2.1. Market position and competitiveness

Checklist:

- A. Are the products of the system in a weak or strong market position?

ICE cars still dominate the market, but they are experiencing a decrease in demand, especially due to the decline in diesel cars registration, which is consequence of the implementation and plans of Clean Air Zones. EVs represent a small percentage of the market, and electric conversion is not developed on scale, both depend on improvements on infrastructure for charging.

- B. Are there possibilities to improve market position? Are there possible threats to market position?

The EV market is increasing and between 40-60% of the European consumer are considering buying an electric car. The perspectives for ICE cars are not positive, due to the UK commitment to become carbon neutral by 2050 and the expansion of clear air zones. The lack of charging infrastructure is a threat to EV and Ecofitting. The reliability of the system and products threatens EVs and specially, Ecofitting. (Vilchez and all, 2019).

- C. Is there an intense competition in the market for products of the system?

There is an intense competition in the market for ICE cars. In the other hand, while the industry is focusing on launching new electric vehicles, there is also the competition of new companies to automotive production, likes of Tesla. While the demand for electric conversion is low, it does not represent a threat to automotive industry or create an intense competition inside Ecofitting.

- D. Are there lower cost offers for delivering the same service or function?

On the whole alternatives such as cycling, walking and sharing services work out cheaper than the cost of car ownership but are not able to cater for every type of journey or the privacy guaranteed from a private vehicle. The total cost of ownership is lower for Electric vehicles. The cost of Ecofitting could also vary according to level of vehicle but can start as a lower investment. (Hertzke and all, 2019) (Cross, 2024)

Review:

Automotive industry is highly competitive and the EV alternative produced by the same industry will faces similar challenges, and dispute broadly the same consumer. Ecofitting could focus on developing products which would reach consumer not aligned to current mainstream design.

Scale of improvement:

ICE - EV + ECOFITTING +

5.2.2. Profitability and added value for companies

Checklist:

- A. Is the profitability of the system low or high for companies and partners?

Most OEMs do not make a profit from EVs in the small to midsize segments, when compared to ICE. (Baik and all, 2019)

- B. Are there opportunities to create more value in the whole system or value chain?

The principles to create more value pursued by automotive industry are through adding comfort, performance, and status to the products. There are opportunities to develop principles of long-term ownership to create more value.

- C. Does the system allow long-term fidelity of costumers?

The Automotive industry uses online and direct market campaigns, offers deals including part exchange, to keep costumers at the brand. Financing is progressively moving form ownership to pay for the use, favouring fidelity. Ecofitting will incorporate updates as part of strategy to long term fidelity.

- D. Are there possibilities of lowering costs through reduction of processes, use energy or material?

The research investigates the possibilities of reducing processes, energy through the conversion of ICE into electric. Electrification itself is expected to simplify the systems of the automobiles, and as consequence, the production processes. The transition to electric demands high investment from OEMS. (Baik and all, 2019)

Review:

The Automotive industry investments to produce EVs are currently high with low pay offs, the bill can end either on the shareholders, taxpayers or consumers. Ecofitting can represent a lower cost investment and better profit ratio. The downside is the scale and speed of conversions; therefore, standards, modularity and shared systems are necessary to be developed. Looking at the automotive dealerships' profits, half of it goes on maintenance services and parts, a quarter on sales of new vehicles, and another quarter on sales of used vehicles. That indicates that remanufacture can become a profitable activity.

Scale of improvement:

ICE = EV - ECOFITTING +

5.2.3. Added value for customers

Checklist:

A. Do the products of the system perform efficiently their functions?

The ICE car has over a century of development and performs well their functions (apart from the issues pointed out in the other parts of the research). Currently one of the largest drivers preventing consumers investing in electric cars is range anxiety. EVs also suffer from failure on charging systems. Otherwise, EVs have better performance and more internal space. The latter is more challenging to Ecofitting, which has also greater compromises than EVs.

B. Is the cost benefit good for costumer and final user of the system?

The cost benefit for electric is increasingly getting better than ICE. While there are high-cost conversions, Ecofitting aims to expand to costs which are lower than a new EV.

C. Does the system offer long-term tangible savings for the costumer?

The perspectives for ICE are to lose value in long-term due to the current and further restrictions on use. On EVs, battery technology is constantly advancing but that means costly upgrades once the customer has already invested financially in a high-priced product to start with, and a better option arrives. The principle of Ecofitting is to reduce the material and vehicles losses on the existing fleets.

D. Are the products of the system keeping the value invested by the costumer?

Currently huge depreciation of EVs do not protect customer investment. Electric vehicles depreciate by approximately 60% after three years, 10% more than their fuel guzzling counterparts (Lightfoot, 2019). Converting an existing car means less upfront investment but it is currently unknown if Ecofitting will change the value of car after conversion. Ecofitting extends life and usability of current investment. (Hensley and all, 2018).

Review:

While ICEs are progressively becoming a risk to own, EVs are the safer option. Ecofitting can start from a lower cap, and be an advantage on long term, if applying continuous updates.

Scale of improvement:

ICE =
EV ++
ECOFITTING +

5.2.4. Long term business development

Checklist:

A. Is the acceptability of the offer of the system secure for the long term?

The acceptability of ICE offer in the long term is not secure. EV are the alternative the industry is seeking to continue business, nevertheless, that is also not safe as private transport cannot be favoured in future city planning. Ecofitting can become more interesting when cars are older.

B. Are there any major risks to the business from external sources?

Automotive industry is adapting and facing the transitions to shared, autonomous, and electric. They all represent shifts on the way the business used to be made. Additionally, there are threats on the demand of raw material to batteries. (Hensley and all 2018).

C. Are the products of the system threatened by technological or fashion changes?

The automotive industry has introduced the model-year concept and continuously used fashion and aesthetic changes to create demand for new cars, those were sometimes combined with technological advances. For EVs, the advances on battery technology can make the cars outdated quickly. Ecofitting proposes upgrades in technology and aesthetics to be the rule.

D. Is the system financial background strong, stable, and self-sustainable?

The financial background of automotive industry is strong, nevertheless, it has succumbed to Global crisis in 2008 and struggled again in the COVID-19 crisis. The industry operates with subsidies from government to open factories and create jobs, Ecofitting will depend on more fragile structure of stakeholders to be developed. (Jones, 2020)

Review:

In the long term, the automotive industry will have to shift from ICE to EV, Nevertheless, it will continue the common practices of marketing and politics. The principle of Ecofitting is to understand cars as upgradable platform in the long term. The principle should influence in the longer term, the design of new EVs, but the source of vehicles to conversion is also limited.

Scale of improvement:

ICE -
EV +
ECOFITTING +

5.2.5. Partnership's support

Checklist:

A. Are strategic partnership and cooperation possible in the system?

Yes. There are many examples of partnerships between big OEMs, specially focusing on reducing the costs of new model's development. The same policy is happening to EV platforms. There is also cooperation from OEMs on conversions to electric.

B. Does the system make use of existing manufacturing and marketing capacities?

While the automotive industry has well established infrastructure of marketing and manufacturing, there will be many changes needed to adapt to EV production. While Ecofitting looks at the repurposing of maintenance and customising networks to create a manufacturing capability.

C. Does the system encourage sharing of products?

Shared used is not prioritised by the automotive industry.

D. Do the system favour partnerships to end-of-life management, closed-loops recycling, remanufacture, re-use or retrofit?

While the automotive industry focuses on recycling, Ecofitting is based on partnerships to allow retrofit or remanufacture.

Review:

Supporting partnerships is essential for the success of Ecofitting, which will rely on electrification technology shared with mainstream industry, and small business. This will create an opportunity to the OEMs to extend their partnerships to cover the costs of the transition to EVs

Scale of improvement:

ICE =
EV =
ECOFITTING +

Note:

Full list of references available in the end of the document.

5.2.6. Macroeconomic effect

Checklist:

A. Are there problems on a macroeconomic level, monopolistic structures or rebound effects or encourage the development of fair trade?

The industry has evolved in the direction of big conglomerates (VW, FCA – PSA), which operate in an open market competition. It is difficult for smaller business to thrive, and many small manufacturers are absorbed by bigger groups which have more access to consumer and suppliers.

B. Does the system create shared economic benefits to the development of communities or concentrates financial gain?

The automotive industry generates shared economic benefits. Nevertheless, the number of jobs created is not highly significant anymore. Ecofitting will be structured in a circular economy model, aiming to share benefits

C. Does the system create costs of environmental impact?

Considering all stages of the system, it produces costs. There are efforts to make EV production, also ICE, production carbon neutral. Ecofitting can significantly reduce the costs by reusing cars.

D. Does the system support job opportunities and inclusion of people on sustainable economic development?

Although, according to the Society of Motor Manufacturers and Traders, 186,000 people are employed directly in the industry in the UK, recent closure of plants shows that at the least there is an 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.

Review:

Ecofitting is an alternative strategy to support the transition to zero carbon. It is meant to create opportunities for small business, garages, design studios, customizers and etc, sharing economic benefits in a wider landscape of stakeholders. The activity will help to reduce the environmental impact of the private mobility system. At the same time, it can create mobility solutions that are less dependent of an international network of suppliers.

Scale of improvement:

ICE = EV = ECOFITTING ++

5.3. Socio-Ethical Sustainability

Introduction

Socio-ethical Sustainability looks at issues related to communities, society, and people, considering the collective and shared contexts. It investigates ethical issues and the relationship to work and externalities of consumption habits.

The Socio-ethical dimension deals with qualitative issues and it is related to Social Meaning. Social Meaning is characterized by: concerns of justice, peace, charity, compassion, and the moral compass that informs our social relationships. It is represented by disciplines such as social sciences, politics, law philosophy, economics, as well as the applied arts such as design and fashion.

The socio-ethic sustainability should tackle directly the following UN Sustainable development goals: *Good Health and Well-Being (goal 3), Quality Education (goal 4), Gender Equality (goal 5), Decent Work and Economic Growth (goal 8), Industry, Innovation, and Infrastructure (goal 9), Reduce Inequalities (goal 10), Sustainable Cities and Communities (goal 11), Responsible Consumption and Production (goal 12), Climate Action (goal 13), People, Justice and Strong Institutions (goal 16), Partnerships (goal 17).*

Summary

In the Socio-Ethic Sustainability analysis, Ecofitting has showed better results than mainstream EVs and ICEs, on all criteria. The results of the analysis can be seen in the following radar.

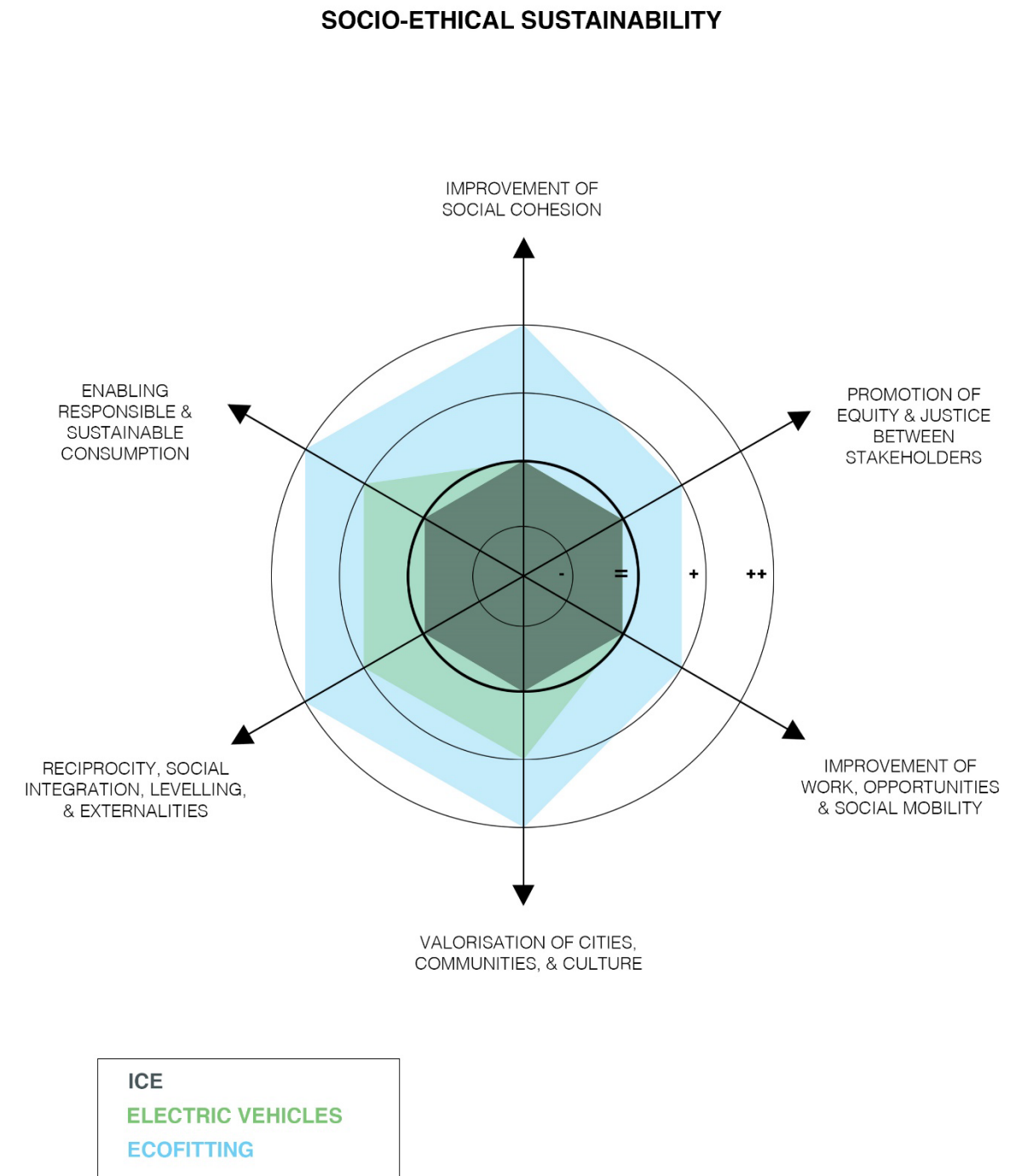
While EVs industry and product show improvements on sustainable consumption, reciprocity, social integration, externalities, and valorisation of cities, when compared to ICE's, Ecofitting can bring even more improvements. Ecofitting advantages lies on the long-term ownership, respect for local culture and the integration of people in the system. Therefore, Ecofitting shall focus on developing the design related to place.

Ecofitting Circular Economy also enables improvement in issues EVs will not promote change, like social cohesion, promotion of equity between stakeholders, improvement of work opportunities and social mobility.

The Socio-Ethic Sustainability analysis indicates that Ecofitting Circular Economy concept is a worthwhile strategy towards a more respectful and egalitarian society.

In the following sections, the criteria of the analysis are detailed following the toolkit method.

Radar



5.3.1. Cities, communities, and culture valorisation

Checklist:

A. *Does the system improve the quality of public and private spaces of the city?*

Cars take a lot of city space, private and public, making no distinctions between ICE, EV or Ecofitting on direct impacts. On the other hand, the ICE externalities, pollution of air and sound, are a worse problem to the quality of the cities, EV are expected to lower the level of pollution in the city. Ecofitting, in addition, since it is based on the current fleet of vehicles, does not increase of numbers of cars in the cities - specifically when considering context where ICE and EV will still share the urban spaces.

B. *Does the system have a positive impact on social well-being of the local community?*

The extension of the use of public spaces of the city, and the externalities caused by the cars, have a negative impact on the local community social well-being, when there is an unbalanced dispute for space and attention. Although private cars are extensions of private spaces, they also serve the users to exercise their mobility needs related to social life.

C. *Does the system respect or support local cultural values and identities?*

Most of the industry products are developed with little or no connection to local cultural values - it can be argued that Retro cars, New Classics (e.g.) have a cultural legacy, at least, in terms of car design. Same can be argued about Ecofitting and preserving identity of old cars.

D. *Does the system favour the long-term building of culture and community?*

Ecofitting transfers activities to local communities, which will have the backing to develop craft and technology, at the same time it is an opportunity to build on the local culture and traditions. Ecofitting circular economy includes local dealerships, garages, and business in a new sector of activity. In the other hand, with electrification, many businesses must adapt to a new activity and there is risk of losing skills and culture of doing.

Review:

Cars have a conflicting relationship to cities and communities. In the one side it provides benefits, and research indicates that even driving can generate wellbeing (Harmer and Mausbach, 2020). In the other hand as a private appropriation of public space, the automobiles in the streets has long been object of criticism, which is just worsen by the acknowledgment of its externalities, health, and environmental impacts. At the same time, as an object on the public realm, cars become part of the urban landscape. A question remains if that object connects to the local culture and identity.

New EV factories from big OMEs are not being welcome as they don´t seem to create benefit to communities. In Grünheide, Germany, people 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 (Chazan, 2020). Ecofitting can develop a new relationship between the automobile and communities, if conceived as circular economy activity, focusing on inclusion instead of prioritising profit. Nurturing local business can in long-term help building of local culture and community. Moreover, joining such a movement also helps to inspire change, opportunity, and

creates inclusion and new communities similar to the many car clubs and affiliations we have seen over the years.

Scale of improvement:

ICE =
EV +
ECOFITTING ++

5.3.2. Social cohesion improvement

Checklist:

- A. *Is the production system creating or favouring any form of intragender, intra-cultural, intra-generational exclusion or discrimination?*

The automotive industry is an environment traditionally dominated by white male. A parallel activity, as Ecofitting, can be more open to less favoured groups.

- B. *Do the system and product offer inclusive access to all, regardless of income, gender or background?*

The possibility to buy cars are related to a minimum income. Higher prices might make it more difficult for EVs. Also, it can be argued that cars are not designed to be inclusive as "closed-products" they hardly accept adaptations to people with disabilities (e.g.). Ecofitting would incorporate more openly and widely adaptations, being also more aesthetically inclusive.

- C. *Is the system creating opportunities to people to participate on sustainable initiatives?*

The transition of the automotive industry to EV is creating opportunities for many stakeholders to participate on sustainable initiatives, especially when considering that the industry is also focusing on turning the production carbon neutral. With Ecofitting, the opportunity expands to others, who can also take the lead and innovate.

- D. *Is the system creating opportunities to people to support each other?*

The proposal of Ecofitting as a circular economy initiative focuses on collaboration rather than competition. Extending the concept, it can help to generate more social cohesion as people will aim common good.

Review:

The research indicates that cars become a strong cultural reference which also originated many forms of social gatherings: around sports, car clubs, touring, collection, customising tribes etc. Nevertheless, those groups rarely aim to create a common gain to society, not disregarding the pleasure focus and connection of that with wellbeing. Ecofitting can generate a more cohesive group, which would learn, cultivate, and share values and common aims. Therefore, its circular economy is essential to create social cohesion in a form the automotive industry does not.

Scale of improvement:

ICE = EV = ECOFITTING ++

5.3.3. Promotes equity and justice between stakeholders

Checklist:

- A. *Are there critical (geographic, political, social) implications on the supplying system?*

The automotive industry operates in critical geographic distance between production, suppliers, and raw material sources. Trade deals have political implications and create social instability.

- B. *Are there any unjust unethical relations with suppliers, subcontractors, sub-suppliers and between the partnerships?*

There are concerns about unjust and unethical work relations in the raw material supply for batteries to electric vehicles. The ICE, and oil economy, have created historical problems between countries, leading to war on extreme cases.

- C. *Is the equity of benefits and sustainability promoted or safeguard in the relationship between stakeholders and governments?*

Since the activities of OEMs is regarded as beneficial to create jobs and economic growth, it has been questionably favoured by governments. While EV industry is supposed to promote sustainability, looking the economic growth of Tesla and its owners, it is creating an uneven concentration of wealth.

- D. *Is there knowledge exchange to develop partnerships to climate action or environmental good?*

This can be exemplified by the joint development of vehicles platforms, in ICE and EV cases. Nevertheless, it can't be said that the industry is highly active to create environmental good or responding to climate change.

Review:

Ecofitting can promote the participation of communities in production. In the UK there is a tradition of craftsmanship and engineering, which is also supported by premium brands, like Bentley and Aston Martin. which work with local workforce. However, this can hardly be replicated to mainstream EVs, as it can on Ecofitting. In a circular economy this can help to leverage benefits. Ecofitting can democratise the relationship to stakeholders and also make a closer relationship between who makes and who buys and uses the vehicles, which may lead to more efficient products.

Scale of improvement:

ICE = EV = ECOFITTING +

5.3.4. Work, opportunities, and social mobility improvement

Checklist:

A. Are there any problems with health and safety?

There are a variety of hazards in automotive industry from: manual handling, being hit or trapped between objects, slips, trips, falls, exposure to noise and vibrations and others. Most of these can be transferred to EV production, and it this will simplify the process it will also reduce the risks. Ecofitting will have more challenges, specially is the processes are not repeated often.

B. Is there social mobility in the system?

Ecofitting circular economy creates opportunities for independent professionals and businesses to develop new initiatives and change their social position.

C. Are there any problems with workload, inadequate wages, or profit distribution?

The main problem for automotive industry has been the jobs cut. As mentioned before, profit concentrates on after sales services. There is also a great concentration of wealth on shareholders.

D. Does the system favour the development of new sustainable industry?

Ecofitting favours sustainable industries to develop once it incorporates sustainable material and processes. EV is a sustainable development from ICE, and it support the development of an industry and supply chain which are necessary for Ecofitting as well.

Review:

Proposing a new circular economy means the creation of jobs not previously in existence and expanding the opportunities for small and medium business. Ecofitting can help replace the demand for jobs lost on automotive industry. At the same time, when based on independent business working on partnerships, it can also favour more social mobility. The new industry needs to work its health and safety standards, as well as the product standards, for fair competition and just work conditions.

Scale of improvement:

ICE =

EV =

ECOFITTING +

5.3.5. Responsible and sustainable consumption enabling

Checklist:

A. Are the system and products delivering relevant benefits for society that justifies itself?

It can be said that the car, either electric, fuel combustion or retrofitted, is regarded as relevant as its popularity remains. The benefits of the industry as it operates now are more questionable, but it is still necessary to provide the products. Ecofitting can deliver relevant benefits to society in the production and design level too.

B. Are there options of products and service delivering the benefits in a sustainable way?

There are options, from cycling, walking, public transport etc. Nevertheless, they have limited function delivery when comparing to cars in is arena. EVs are a more sustainable option as Ecofitting.

C. Is the client/final user able to acknowledge clearly and easily the social sustainability along the whole product chain? Is the client/final user able to understand the responsible/behaviour by the supply chain?

Unless it searches for information on OEMs website, there is little reference to sustainability.

D. Is the system creating distracting elements to entice the consumption?

Automotive Industry uses marketing and design to entice consumption of new cars. Facelifts on cars are an example of process to distract consumers and create consumption on fashion cycles. Ecofitting aims to integrate styling upgrades in vehicles to stimulate long term ownership.

E. Is the system promoting the extension of life of the products?

Cars are developed to last, and there are possibilities of repairs and systematic maintenance. There are also possibilities for updates in the products, from accessories, to like the Porsche Classic Infotainment systems, or major changes on the powertrain, like proposed on Ecofitting.

Review:

The shift from ICE to EV enables more sustainable consumption, due to the change of powertrains. Additionally, the speed of new technology development means software updates on vehicles are necessary, specially on EVs. Nevertheless, there is more to explore to make cars attractive for longer. Ecofitting proposes to incorporate update on style and usability to vehicles, which are going to be understood as long-lasting platforms. This can be transferred as a principle to new EVs and other products.

Scale of improvement:

ICE =

EV +

ECOFITTING ++

5.3.6. Reciprocity, social integration, levelling, and externalities

Checklist:

A. Does the system support levelling of benefits in the community?

Ecofitting can support the spread of benefits in communities, while making a new industry to personalisation, updates, and conversion of vehicles as part a circular economy.

B. Does the system propose solutions to people with weaker social status or lower income?

The portfolio of car industry is wide and there are also options on used cars markets for people to acquire personal mobility. Nevertheless, it is not a mobility solution with universal access due to its relatively high cost of ownership. The shift to electric is, at least through its transition period, making it even more restricted to higher income.

C. Are there opportunities to develop new skills and knowledge to work sustainably?

Electrification of automotive industry is an opportunity to learn new skills and work sustainably. Ecofitting proposes to expand this to smaller business and garages, which will need to adapt to a new age.

D. Does the system promote conscious actions towards the environment?

Electrification is forcing the industry to promote more conscious actions towards the environment, which is sometime contradictory to actions of the industry itself. The industry still does not widely support sharing cars and the use of other more sustainable mobility modes. Ecofitting will add the long-term ownership concept.

Review:

Electrification is an important step forward to automotive industry; it will reduce the externalities and be less damaging for using cars. Nevertheless, it does not address the opportunities of social integration in a circular economy, which is essential due to the high number of vehicles which need to be replaced. Ecofitting can also make possible to lower income groups to acquire, or update to electric.

Scale of improvement:

ICE =
EV +
ECOFITTING ++

Footnotes:

Whilst computers and smartphones have long benefitted from a continuous development cycle, this open-endedness and modifiability is not so often seen in cars. Traditionally cars are sold as finished and complete products. Buyers do not expect new cars to improve or change once they are rolled out of the dealer’s premises. Only occasional maintenance, software updates or repairs are carried out to keep the vehicle functional. To stay competitive, car makers introduce new models to market every four to seven years and these models are refreshed with minor functional and cosmetic changes around halfway through their life cycle. But the status quo is being challenged by the Californian car company Tesla. Much like your smartphone, Tesla releases frequent software updates to improve and change the functionality of the cars they design and manufacture, thereby modifying cars continuously after the point of sale. A product traditionally considered to be finished and complete, can become open-ended and continuously “in the making” if a company decides to adopt the modifiable character of digitally controlled components and functionality. This brings upon novel avenues and challenges for innovation and product management practices and marketing messages can be tailored to emphasise the promise of continuous innovation and improvement instead of focusing on the finished goods. This also offers more choice to the consumer. They may decide to purchase a product where the specification is fully known at the point of purchase, or, alternatively, to buy into a stream of updates, which not only enables new features and improves existing functionality but requires them to maintain and learn new features and settings (10).

Although introduced by Tesla on new products, Ecofitting also taps into this philosophy of upgrading but with the added benefit of using an existing product whose life cycle will be extended using this new form of purchasing and consumption.

Possibility of engaging the government to incentivise the scheme:

In a bid to encourage drivers to take the road to zero emissions, a discount on the price of a brand new low-emission vehicle is available through a grant the government gives to vehicle dealerships and manufacturers, as well as money off the cost of installing a charger at home through the Electric Vehicle Homecharge Scheme (11). Similarly, in order to encourage waste reduction it may be possible to engage the UK governments on similar incentives to help people from all income brackets to make sustainability a priority.

The ‘Right to repair’

A recent trend that is gaining traction especially across more unexpected luxury and high end markets is the trend of repairing instead of replacing. A recent surge in specialist teams and businesses promoting the delicate and dedicated restoration of well loved but work luxury items such as handbags and shoes, is helping to encourage a more sustainable attitude to apparel. One of the most prominent department stores in the UK, Selfridges in Oxford Street, London has recently opened ‘The Restory’, a specialist department offering a multitude of services from cleaning, re-edging, colour restoration, re-stitching, leather restoration, lining, strap and zip repairs, and even custom refashioning to extend the product life cycle (12). Following on from this, Ecofitting also channels a similar philosophy which is already seen in diligent classic car restoration, but now has the scope to extend beyond priceless icons on the road to be much more inclusive across the full range of budgets and cars.

Note:

Full list of references available in the end of the document.

5.4. Subjective Sustainability

Introduction

Subjective Sustainability looks at issues related to aesthetics, meanings, personal experiences with products, values, and wellbeing. It deals with symbolic and intangible aspects of design, which are essential for its conceptualisation. In this analysis, Subjective issues are considered qualitative and related to context. The analysis provides a comparison between ICE, EVs and Ecofitting, and helps to position the aesthetic principles of Ecofitting.

In the State-of-the-Art chapter, becomes clear the diversity of outputs possible within Ecofitting. All outputs will share the principle of extending the lifecycle of the object, therefore some of the original object will be kept as a base platform. In addition, the research will investigate which design director will be more adequate for sustainability, reflecting its values and then aligning to the expectation of the user. While a Ecofitting design will have to perform in usability and practicality it will also need to attract consumers, create satisfaction and personal fulfilment. Don Norman (2004) argues that “the emotional side of design may be more critical to a product’s success than its practical elements”.

In the research, Subjective Sustainability is the proposed fourth pillar of the Sustainable Design Analysis, added to the original SDO, and it relates to Practical Meaning, described by Stuart Walker (2014). Personal Meaning characterized by: the interior life and addressing perennial questions about being itself, life’s purpose and ultimate value cannot be pursued through rationalization or proved via empirical methods. It is represented by disciplines such as arts, poetry, music, and literature.

The Subjective Sustainability should directly tackle the following UN Sustainable development goals: *Good Health and Well-Being (goal 3)*, *Quality Education (goal 4)*, *Sustainable Cities and Communities (goal 11)*, *Responsible Consumption and Production (goal 12)*, *Climate Action (goal 13)*, *People, Justice and Strong Institutions (goal 16)*.

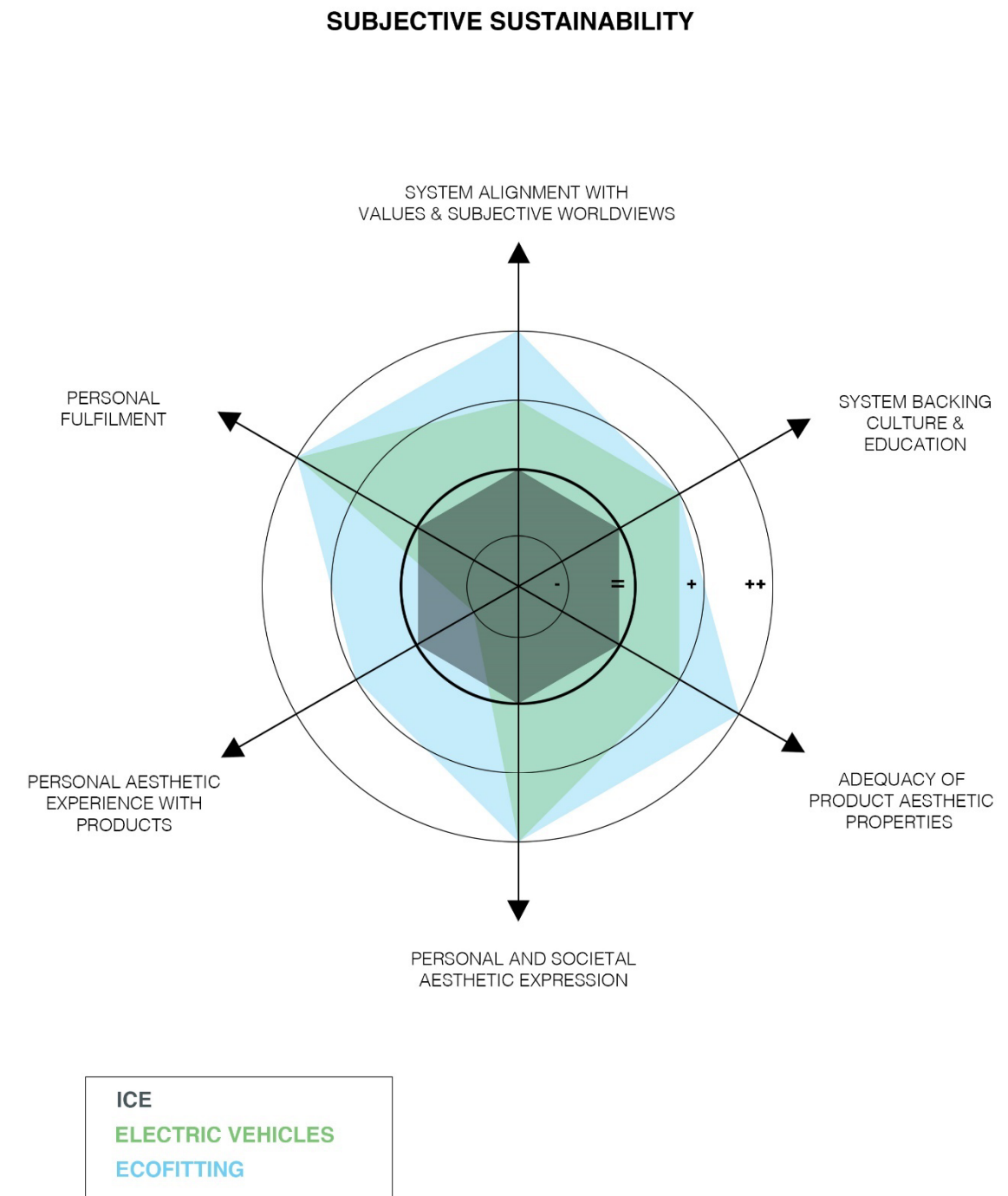
Summary

In the Subjective Sustainability analysis, Ecofitting has showed better results than mainstream EVs and ICEs on most of the criteria. EVs has matched Ecofitting on three criteria. The results of the analysis can be seen in the following radar.

While based on existing cars, Ecofitting can respond better to the personal aesthetic experience with products, which has been a historic challenge for EVs. In the other hand, Ecofitting can focus on developing a more radical aesthetic for sustainability, and highly personalised products, using factor less explored by mainstream industry to create desirability. The Subjective Sustainability analysis indicates to which direction Ecofitting shall be developed to be an alternative strategy towards a more sustainable consumption.

In the following sections, the criteria of the analysis are detailed following the toolkit method.

Radar



5.4.1. System alignment with basis of values, and subjective worldviews

Checklist:

A. Does the system connect to an essence for existing and a search for deeper values?

Looking at the private car as a mobility system, it connects to a sense of freedom and with pleasure, which can be considered essential to exist. It also nurtures possibilities of people encounters, but it is still focused on superficial consumerism.

B. Does the system encourage imagination or spiritual experiences?

The activities surrounding design and producing, maintaining cars, and motorsport, are inspiring to a lot of people. In some cases, where highly localized of object of national pride, there is a connection to traditional beliefs or passion.

C. Does the system promote principles of rightness, truth, and goodness?

The automotive industry has promoted consumerism and pleasure, regardless of the principles. At the same time there is a concern to deliver a practical mobility solution.

D. Does the system adhere to principles of empathy and reciprocity?

There is not a perceived sense of empathy and reciprocity from the activities of automotive industry. The transition to electric position the companies more aligned to public empathy. As a circular economy, Ecofitting will be a system embedded in the community and therefore, more align with its principles.

Review:

An analysis of the automobile, as a system, must also consider in addition to designing, producing and regular use, the activities related to car culture: motorsport, car clubs, touring, those give a different dimension of the subjective worldviews about the automobile as a system. Our relationship to the system, not only to the car as an object, is emotionally driven and related to images of freedom and pleasure. While electrification changes the focus, a bit towards rightness and goodness, Ecofitting should be as system based on principles of empathy and reciprocity, more than individuality and lust.

Scale of improvement:

ICE =
EV +
ECOFITTING ++

5.4.2. System backing of culture and education

Checklist:

A. Does the system promote development of knowledge?

The industry drives the development of knowledge through the advances in technology and production managing. The industry also supports the development of academic research and sponsor students. Electrification brings new challenges for development of knowledge, with Ecofitting this could also be more democratised.

B. Does the system encourage reflection and questioning of habits?

The transition to electric encourages the questioning of habits. Nevertheless, there is still little questioning about sharing. While the automotive industry wants the continuity of habits of consumption with EVs, Ecofitting questions it too.

C. Does the system consider local culture and heritage?

The automotive industry considers its own design heritage, but that has little or no connection with local culture. The production follows international standards, and it is rare the examples of transference of local craftsmanship skills. Ecofitting is an opportunity to properly address a relationship to local culture and heritage.

D. Does the system help to build a sense of belonging and permanency?

The research indicates that car clubs, customising, admires and owners' groups, are forms of building a sense of belonging. Nevertheless, those are parallel to the industry activities. It was also identified that a sense of permanency is attained through long lasting designs – which are repeated generation after generation, through retro designs, but not much through promoting long term ownership.

Review:

Ecofitting circular economy concept creates a different level of backing culture and education, while decentralising the production and opportunities. This is a space to explore both in technology and aesthetics areas. Ecofitting envisages the insertion of local craftsmanship in the development of electrification.

Scale of improvement:

ICE =
EV +
ECOFITTING +

Footnotes:

<https://www.morgan-motor.com/craftsmanship/>

5.4.3. Products aesthetic properties adequacy

Checklist:

A. Do the products of the system have moderate aesthetic properties?

The research on automotive design identified *Functionalism*, *Clean Shape*, *Minimalist Aero*, and *Synthesist* trends are having moderate aesthetic properties. It is a significant change coming with electric cars. At the same time, there has been an exaggerated development on graphics and textures to substitute traditional elements of ICE, like font grills.

B. Do the products of the system have elegant aesthetic properties?

The car industry is careful to develop products with attention to form, proportion, expression, and details. There are subtle changes in proportion with electric vehicles which are starting to appear, as is the case of the VW ID3, or BMW i3, which have short overhangs and are quite tall. Moreover, opposite to what is expected in the future, many electric cars are big and heavy, clearly not finding its most elegant form yet.

C. Are the aesthetics of the product of the system congruent with its sustainable meaning?

Not all the new EVs are coming with an aesthetic which is congruent with its sustainable profile. Some new cars, like the KIA E-Niro, follow closely their ICE equivalent. There are undefined areas, like the *Eco-Brutalism*, represented now by the Tesla Cybertruck, which has an aggressive character unsuitable to sustainability. *Eco-Brutalism* could, nevertheless, mean roughness and honesty.

Biomorphic and *Technomorphic* designs, developed by Mercedes-Benz and BMW respectively, are congruent to two different approach to sustainable design proposed by Manzini and Vezzoli (2002).

From the already existing Ecofitting trends identifies in the research, *Full Renovation*, *Classic Car Conversion*, *Budget and Scale*, *DIY*, *Product Diversion*, and *Electric Rustoration*, Just the last one present an expression more congruent to sustainability.

D. Does the aesthetic of the products of the system facilitate the understanding of its utility?

The understanding of car utility is less relevant than the efforts to produce a product with unsuitable or unnecessary utility, just to achieve a desired aesthetic or character. The SUV is the most popular case of this misinterpretation of form and function.

Although the conversion to electric does not make too much difference on the understanding of its utility, it is interesting to note that there is a lot of car bot on Ecofitting and EVs to the design of the charging system elements.

E. Are the aesthetic properties of the product of the system long-lasting or not ephemeral or transient?

The aesthetic properties of the cars are both long lasting and ephemeral. They are long lasting while the identity of some products are kept through decades, making a connection between products of the past and today, like the Porsche 911 or the Mini; or through the repetition of details and proportions, like VW Golfs, BMWs or Mercedes. At the same, the speed of change in models makes surface treatment, form, materials, and details quick look outdated. The ZeroLab Bronco, on Ecofitting's *Full Renovation* trend combined identity and novelty to make old, fashionable.

Review:

While Ecofitting is based on the existing ICE fleet, it is expected that those selected to be donner vehicles have an aesthetic value, or an emotional connection with the owner. There is an opportunity to develop an aesthetic which is less mainstream and more aligned to principles of sustainability.

The same diversity which can be identified on EV or ICE cars is expected to Ecofitting. Additionally, Ecofitting can create an alternative to the *Aesthetic of Perfection*, discussed earlier in the research. Aesthetic properties can incorporate aging, rust, imperfections, re-used materials, and elements and upscale. Ecofitting can also incorporate natural materials and local craftsmanship – something that is seen in premium brands like Bentley, but in an honest and straightforward version.

Scale of improvement:

ICE =

EV +

ECOFITTING ++

5.4.4. Personal and societal aesthetic expression

Checklist:

- A. Does the system promote personal image congruent with sustainable behaviour?

In one side, EVs are perpetuating the traditional images of the car, related to power, speed, individuality, status. Inevitably, Ecofitting can also repeat this while reusing existent cars, with previous associated character. Nevertheless, the Ecofitting, and classic cars in general, have an image of preservation and respect with is congruent to sustainable behaviour.

- B. Does the system promote personal identity expression?

Although the car is a form of personal expression, it does not reflect much of personal identity. Instead, it associated the personal identity to the image of the particular car. *Someone is a BMW driver*, means a person incorporates a stablished identity. Ecofitting, due to this unitary scale, can promote personal identity expression like mainstream car industry is not able to deliver.

- C. Does the system aesthetic encourage empathy?

Car design has shifted from more empathetic designs, like the *Soft Shells*, and *Minicars* of the 1950s, *Playful*, *Smooth Bodies* of the 1990s, to more aggressive trends. With EVs, the car design is starting a movement in a direction of more gentle designs.

- D. Does the system promote humble personal expression and societal status?

As car design became less about the function and more about the status and individual expression, the space for simple and efficient mobility tool was replaced by a race to more luxury and more power. Cars which were loved for their honesty and simplicity, nevertheless, could not deliver the ideal profit to industry. Additionally, while enticing the consumer to buy new cars in short cycles, the industry promotes a societal stratification, between owners of new, and owners of old cars.

Review:

Progressively, car became a form of personal expression in society. It is expected that the sustainable car will reflect a change to more empathetic, honest, and humble aesthetic expression, which should change the ways car are used, shared, and discarded. Ecofitting shall regard cars as useful tool and culturally valuable objects, instead of instruments of ensuring power and social oppression.

Scale of improvement:

ICE = EV ++ ECOFITTING ++

5.4.5. Personal aesthetic experience with products

Checklist:

- A. Does the experience with the products promote subjective well-being for the user? (independent / competent / connected / popular / stimulated / secure)

The myths of the automobile (Mausbach, 2010) can be linked to subjective well being: *Myth of Freedom* to independent and competent, *Myth of Speed* to popular and stimulated, *Myth of Comfort* to secure and connected. Previous research indicated that driving cars is seen by some as positive experience (Harmer et al, 2020), nevertheless, the reality of driving in cities changes the perception. Driving an electric car can be positive while enhancing these factors in a favourable context., the same can be for Ecofitting.

- B. Does the experience with products stimulate one's interaction with a natural or physical dimension?

Cars have clearly a visceral appeal, and that has been mastered in the case of the ICE. There are less options on EVs to please all tastes, but Ecofitting can fill that hole. A general complain about EVs is the loss of pleasure for driving, especially because of the absence of sound when compared to ICE.

- C. Does the experience with the products stimulate one's spiritual dimension and imagination?

Formula 1 racing driver Ayrton Senna famously stated that his driving experience once took him to "well beyond his conscious understanding" (Donaldson, 2020). The experience of driving can be stimulating for many people. The car is an avatar and an escape. Nevertheless, owning and driving a car have lost importance in the last decade.

- D. Does the experience with the products stimulate one's ethical consciousness and sustainable behaviour?

All the criticism against the car, since the 1960s, have put the car on o ethical crossroad, for which, the EVs appears to be conscious way out. Ecofitting will follow and add the respect for culture heritage and people's history with objects. EVs are currently one big step forward for people to adopt a sustainable behaviour.

Review:

Our aesthetic experience with the cars has been influenced by its symbolic images, the *Myths of Speed, Comfort, and Freedom* (Mausbach, 2010). Although it has been more visceral than reflective, or profound, the awareness of the climate crises is changing people's perception. The electric car is a conscious option, nevertheless, it has struggle to deliver personal aesthetic experience the same way as the ICE cars used to, because people are still tied to symbols and natural experiences of the past. As context move, the reign of ICE loses power, but until that point, Ecofitting can be a solution which will fit better the expectations of many consumer, and car enthusiasts who feel out of place at the moment. Additionally, Ecofitting is protecting objects – which are adored – from becoming redundant.

Scale of improvement:

ICE = EV - ECOFITTING +

5.4.6. Personal Fulfilment

Checklist:

- A. *Do the system and products add to one’s sense of reality, life purpose and achievement? (awareness)*

Owner a car used to be a key milestone on people’s life. While younger generations do not feel the same way, it is still a considerable achievement as an acquisition, which reflects mindset of fulfilment been related to financial success. In one side, an evolved mind would care less for it, but it cannot be denied that there are people who will are not prepare emotionally and financially to give them away or change to an EV. For an ecological conscious mind, electrification means connecting car to the reality of environmental and health needs and owning something connect to their beliefs.

- B. *Do the system and products collaborate to inner development and transformation? (evolution)*

Change on attitudes and behaviours are not isolated actions, but every step in the direction of an education of ourselves to be more sustainable collaborates of our evolution as a whole person. While our mobility choice is a significant part of our ecological footprint, the decisions made about it have big impact - also symbolically. Owing a retrofitted car, or an electric car is a public statement, which means a commitment of a person towards sustainability.

- C. *Do the system and products collaborate to build a sense of belonging and harmony in ourselves in our dealings with others and nature? (integration)*

Electrification builds a sense o respecting nature, while not polluting the environment and abandoning the use of limited resources. There is little use of biomaterials on cars, EV or ICE, that could make it fell as in more harmony with nature. Ecofitting can make use of more natural materials to effectively make the cars more sustainable and can also connect to local culture and craftsmanship.

- D. *Are the system and products relevant for life in long term? (importance)*

To change the pattern of ownership to long term will bring more importance to each car. A car that you keep, update, and make it as yours, will be more relevant in the longer term. This movement can be followed by the new EVs, which could be design as an updateable platform, with solidity and qualities to be relevant for longer period. Now, due to the fast speed of technology, new ICE seems irrelevant and EVs momentary.

Review:

In the relationship between people and cars, there are values that can collaborate to personal fulfilment. The climate crisis created a tension between what you love and what you can have. While there is an urgency to be sustainable there are also aspects of people happiness which needs to be considered. A sustainable car will bring people closer to nature, and reduce the social conflicts surrounding car production and use. EVs can be a solution to many. Ecofitting can be an alternative for those who do not have access to new cars, or simply do not want their vehicles to be scrapped.

Scale of improvement:

ICE =
EV ++
ECOFITTING ++

Note:

Full list of references available in the end of the document.

5.5. Insights and Conclusions

The current context of the automotive industry was studied from the perspective of environmental, economic, socio-ethical and subjective sustainability, in order to determine how Ecofitting might fit into the current on-changing landscape and serve to improve it.

From the view of subjective sustainability, there are many ways in which Ecofitting is relevant. The study indicated that people have a stronger moral connection to sustainability than a financial one, thus a more effective strategy for behaviour change is not only financial incentive, but also one which aligns with a higher agenda of doing good, something which Ecofitting embodies more effectively than the reduction of costs.

It is important to put on the perspective that the costs and benefits considered for the achievement of sustainable targets are determined by the unsustainable dominant economic model. Therefore, the benefits of reducing waste and extending the use of products whose manufacture and use is responsible for a large carbon footprint are more significant to long term than a short view financial analysis may indicate.

From a cultural standpoint there are multiple benefits from a proposed ecosystem like Ecofitting, from supporting culture and education by enabling the development of a new discipline and skillset benefitting design, engineering, and mechanics, to representing local styles or cultures in the design and aesthetic that develops. Those who invest in such vehicle also benefit from a sense of belonging to a community, tribe, and generation of change, belonging to something bigger and being a part of a catalyst for positive change.

There has long been a conflict between automotive aesthetics and sustainability, and traditionally, green design with respect to cars has not associated well with beauty. Ecofitting presents a chance to create a new aesthetic and way of representing an electric future. This aesthetic will likely develop as the result of exploration, and may well go against the grain, the standard of accredited opinion, and be a purer form of individual self-expression rather than mass market aesthetics, much like the philosophy seen in the Burning Man festival art and design pieces. This approach and collaborative attitude may lead to a more community-based design that is inclusive, fresh, and inspiring. Ecofitting presents an opportunity to explore how sustainability can directly challenge aesthetic conventions and social norms to produce design that is engaging and representative of its underlying philosophy. Also contrary to the mainstream, Ecofitting must focus on applying natural materials, local craftsmanship and reflect local culture.

Where once owning a car used to equate with personal fulfilment, now actively contributing to building a better world is replacing this, thus creating a value driven reason for car ownership and use is more aligned with a future perspective. Therefore, not only Ecofitting must develop long-term ownership as an instrument to climate action.

In terms of economic sustainability, the global car market has been consistently shrinking over the past few years with car registrations dropping, certainly compounded also by the global pandemic of Covid-19. However, interest and registrations of zero emission vehicles is on the up and also reflects a positive sales trend. Increased supply and a larger range of new EV models is expected, as is an increase in charging points and city infrastructure to support this. 2030 will now see the sales ban of petrol and diesel vehicles in the UK, with many cities imposing clean air restricted areas making this the ideal time for Ecofitting to become commonplace and add to the urgency of development of charging infrastructure and services, which is significant for the success of electrification.

Currently the high cost of initial investment for the majority of EV's in the UK makes it an inaccessible option for all income brackets even though the total cost of ownership is less compared to ICE vehicles over time. If the cost of Ecofitting, especially for smaller and lower cost cars could be kept competitive, this could be a viable option to encourage far more consumers across all salary brackets into a more sustainable choice of transport. Once prices begin to equalise between EVs and ICE cars, consumers will have more of a choice, but until then Ecofitting could stand as an alternative option. Currently EVs depreciate much quicker than ICE cars due the rapidly changing battery technology, thus including a system that is easily upgradable will allow better value for customers as the design enables quick changes and upgrades.

EV's are currently having a negative impact on OEM profit margins, mainly due to battery costs, and collaboration may be a wise strategy to keep costs down. Furthermore, the added threats of competitors from outside the traditional industry players, as well as the Far East tech titans dominating battery technology are creating a different monopoly. As the tide is turning, Ecofitting presents an additional revenue stream for OEMs with fleets of unsellable cars, chassis and bodies that may otherwise meet an early demise. Renault Re-factory is the first mainstream move on this direction. In the UK, the aftermarket economy is a large part of the automotive sector and is currently both franchised and independent, but holds a potential space for Ecofitting to thrive, connecting with wider automotive players to benefit all parties.

It is noteworthy also to bear in mind that car purchasing itself is undergoing a shift brought about largely by Tesla, with online purchasing and customisation providing an opportunity for innovation and deviation from traditional practices. How Ecofitting could benefit from this new process is to be investigated. The internet could certainly benefit the circular economy by linking the actors on the Ecofitting landscape and facilitating the development of conversion projects. Platforms can be develop facilitating the business of conversion and personalisation, as well as circular economy.

The marketing strategy for products that have a refresh cycle of 4 years may well stand to slow especially with the onset of Covid-19, making it a good time to introduce a new way of thinking with regards to extension of vehicle life, and challenging us to change how we think about design. Design should not just serve to create a new shape, but to create a meaningful and engaging object that owners do not wish to discard so easily thereby lengthening the product cycle by choice. Ecofitting is also a laboratory of ideas on technology, design, business, and marketing that will support the development of a more sustainable automotive industry, and long-life products.

Given the economic challenges brought about both by the general EV landscape and the global financial strain and production challenges following from a pandemic, this may be the ideal time for strategic partnerships with stakeholders and government leaders to ease the burden on issues such as recent shortages in battery-cell production leading to long waiting periods for some EVs in Europe.

Electric vehicles stand to create a severe impact on employment and the economy as EVs are simpler machines to manufacture and keep on the road and therefore need less servicing. However, servicing and maintenance currently provides almost half of dealership income thus a significant drop in revenue is expected in the future. Taking up Ecofitting as a new service could help mitigate this not only for dealerships but also keep and create jobs for garages who might otherwise be out of work with the minimal scheduled maintenance of EVs.

Environmentally, despite reducing harmful air pollution by converting to zero emissions, the manufacture of EVs still uses a lot of energy and can generate more carbon emissions than the manufacture of ICE cars, considering factories, parts, and the very electricity on which EVs are run being generated from non-renewable sources. Thus, although the intention of EVs represent a cleaner choice compared to ICE vehicles, the very production of new vehicles and the long supply

chain, shipment, and logistics involved still make the Ecofitting of an existing vehicle a sounder option in terms of overall carbon footprint. Waste minimisation is widely being implemented by OEMs, but Ecofitting allows the choice and responsibility to reduce waste to fall directly into the hands of the consumer making them a vital part of the sustainability cycle.

From a socio-ethical perspective of sustainability and indeed the global pandemic, supports a trend of buying more of what is needed and less of what is hedonistically wanted, with consumers being more mindful of consumption in general. This coupled with the 'right to repair' trend seen in luxury fashion items recently, which has seen services to restore instead of replace flourish, extending this to the automotive industry seems like a natural progression.

Ecofitting is not just a solution for the right now, but also a solution for the future generations. A recent McKinsey revealed four core Gen Z behaviours, all anchored in one key element: the generation's search for truth. Gen Zs mobilise themselves for causes they are passionate about, they avoid labels and value individual expression, they profoundly believe in the efficacy of dialogue to improve the world and solve conflicts, and they make decisions and relate to institutions in a highly analytical and pragmatic way. Such behaviours influence their relationships with brands and the way they view consumption.

As it stands to appeal to those who hold transparency and sustainability as priorities, Ecofitting offers a sound ethical alternative to current non sustainable means of private transport, with the intention of being more accessible, affordable, to improve upon current carbon footprint from manufacture, and to encourage inclusivity, individual expression, and a closeness to nature and culture.

6. Design Experimentation

This project applied a range of design research methods to investigate responsible ways of managing fleets of non-compliant vehicles and developing alternatives to make people embrace the transition to EVs. To investigate the feasibility of Ecofitting, this research explores possible design directions to demonstrate its desirability potential. A series of design experimentations were conducted to explore possible applications of Ecofitting and visualise possible future design directions.

The project begins analysing a taxonomy of trends of exterior and interior car design over the decades in identifying references and previous aesthetic and functional approaches. This taxonomic research then identified trends going forward influencing the current development of car designs. The endurance of designs referencing the past is a noticeable aspect of the exterior design taxonomy, and the desire for more personalisation and customisation is pertinent in interior design, in particular with regards to autonomous vehicle concepts. Across the board, despite of variations in styling, car design seems to have developed an aesthetic of perfection related to traditional paradigms of perceived quality.

Aiming to understand how desirability will evolve in the future, IMDC research on European Gen-Z consumers founded out a tendency for more disruptive consumer behaviour trends, which deviates from the mainstream automotive design standards (Mausbach et al 2019). Possibly as a consequence of this, newer generations are more interested in alternatives to traditional models of cars and mobility than previously. The research also indicates that the next generation is likely to look beyond purely the physical beauty and practical aspects of products, and to invest additionally in meaning and ethical value. This is supported by Stuart Walker (1997) who suggests that taste is changing as response to a context where the relationship between us and the environmental demands more responsibility.

According to Walker (1997) 'the aesthetic experience involves beauty, taste, sensory response and contemplation. And 'taste' is culture-, time- and place-dependent. Therefore, as societies and cultures change, and as their knowledge and understanding evolve, so tastes change'. Datschefski (2001) further explains that 'it's no longer enough that a product is pretty on the outside, cheap and available'. Referring to the context of sustainability which has a strong influence on how car design will change, Datschefski proposes that beauty must be total, therefore, reaching values, meanings and physicality. With Ecofitting, there is an opportunity to venture into alternative areas of design that cater for this, which are currently not explored in depth in car design.

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.

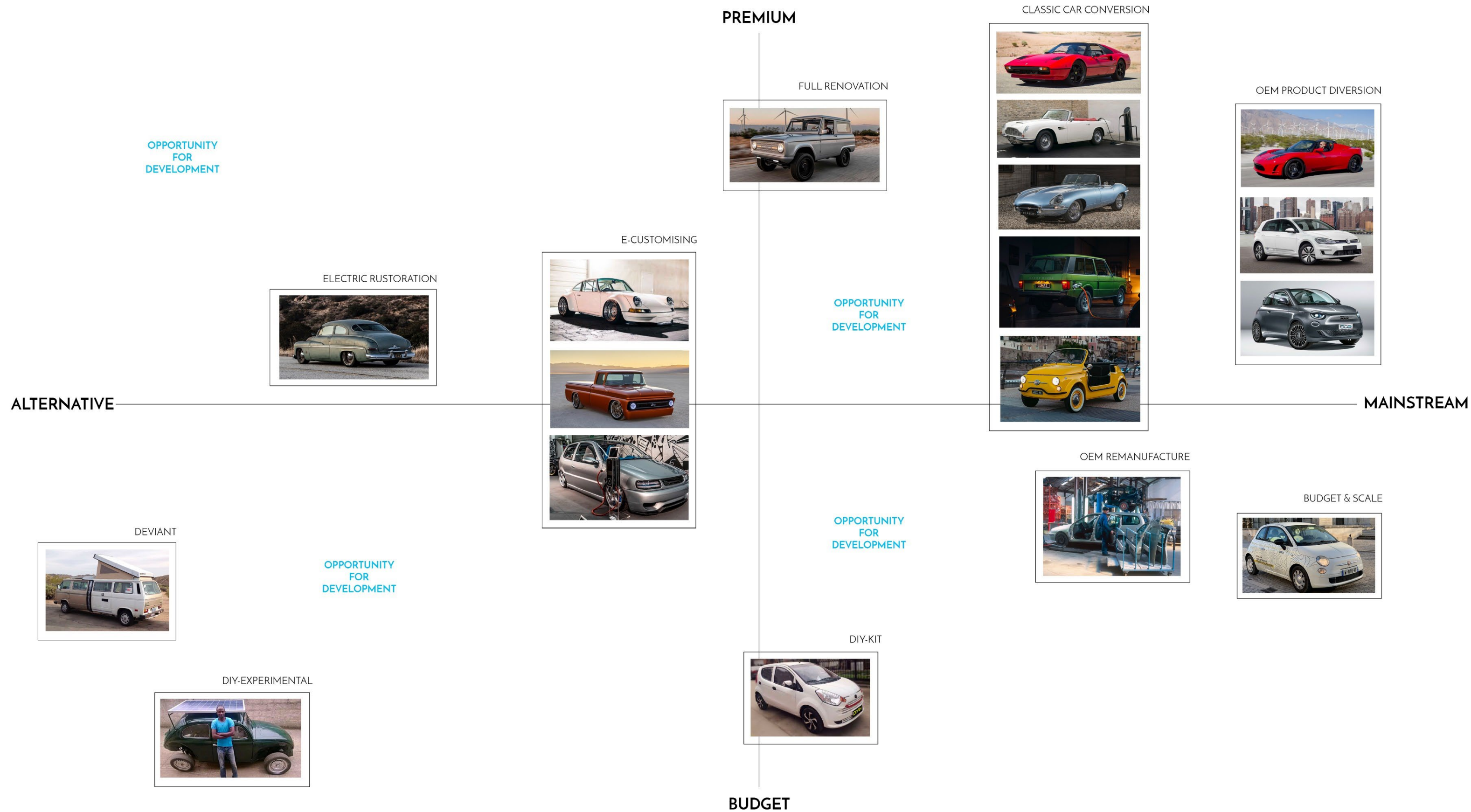
6.1. Design Strategy

The state-of-the-art research identified different areas of car conservation – from Car Restoration, Car Preservation, and Extension of Life as practices that lend support to the development of Ecofitting. The trends observed within Car Retrofitting were named and described as:

1. Full Renovation: complete aesthetic refit during conversion (e.g., Zero Lab Bronco).
2. Electric Rustoration: keeping the rusted or wear our bodywork almost untouched (e.g. 1949 Mercury Coupe EV).
3. Classic Car Conversion: fitting classic icons with electric drivetrains (e.g., Lunaz).
4. Budget and Scale: promotes large scale repetition and sharing of EV conversion parts to reduce cost and reach more users (e.g., Transition One).
5. OEM Product Diversion: OEMs creating electric versions of already established and existing models (e.g., Fiat 500 EV).
6. OEM Re-Manufacture: OEMs taking back their old ICE cars and retrofitting them internally for resale and extension of life (e.g., Renault Re-Factory).
7. DIY Experimental: personal research projects or consumers buying individual parts and upgrading the drivetrain to electric themselves.
8. DIY Kit: consumers buying retrofit kits and upgrading the drivetrain to electric themselves.
9. E-Customising: traditional customization and tuning applied to electric vehicles conversion to upgrade aesthetics and performance.

These trends were classified and positioned in a chart to identify opportunities for development for Ecofitting. Plotting current retrofitting examples along an axis of budget to premium, and another encompassing mainstream to alternative design, enabled a visual representation of the current context in which Ecofitting could exist with respect to design directions (see images on the following pages). The aim was to identify spaces for alternative approaches to automotive design, which would align with the aspirations of new generations, and to consumers who are not attracted to current OEM product aesthetics.

The State-Of-The-Art research also observed wider material culture, outside the automotive industry inspiring the future of Ecofitting design possibilities. This included looking at behaviour trends and cultural expressions related to cars, owners and automobile clubs, cultural festivals, and classic motorsport. These cultural expressions support long-term ownership of cars. In material culture, the contrasting use of worn and new materials is seen in Cafe racers, and the preservation of beautiful objects by making the repair a feature as seen in Kintsukuroi, and the evolution and imaginative adaptation of vehicles seen in film are all reference points for influencing Ecofitting design. Some of those references appears on the mood board for design directions to Ecofitting.



ART CAR

Creating a prolonged and impactful visible product experience

PREMIUM

METAMORPHOSIS

The only constant in life is change, so change with it

*The liberation
from depending
on perfection*

PROVOCATIVE



DEVIATION



*Personal
expression*

UNORTHODOX



*Relinquish the habit
of use and discard*

EVOLUTION



*Making products
that are adaptable
to change*

CHARACTER



GROWTH



ALTERNATIVE

ETERNALISE



*Time visibly marks its presence
creating the aesthetic*

DO IT YOUR WAY



HONESTY



*Celebrating
additions*

REPAIR



LIBERATION



ADAPTATION



FUSION



*Letting the new
enhance the old*

CAPTIVATION



MAINSTREAM

UPCYCLING

Mindful creation that reduces wastefulness

BUDGET

SYMBIOSIS

A harmonious co-existence of modern and mature

ART CAR

Creating a prolonged and impactful visible product experience

- Vehicles act as a conduit for the ultimate personal expression diversifying society
- Enables responsible and sustainable consumption
- Valorises culture and communities with curiosity and wonder
- Radical aesthetic liberating the dependence on perfection

METAMORPHOSIS

The only constant in life is change, so change with it

- Donor cars modified to improve performance
- Used vehicles are adaptable to change representing reciprocity and integration
- Evolves to incorporate digital interfaces
- Growth and improvement of old vehicles promoted by creating an aesthetic of advancement

PREMIUM

ECOFITTING

BUDGET

MAINSTREAM

ALTERNATIVE

- Reclaimed and natural materials used to upgrade parts of old and worn vehicles
- A celebration of addition giving used vehicles a new lease of life
- Aged parts of the car promote material conservation
- Aesthetic where time visibly marks its presence, adding charm and reducing waste.

- Donor cars feature areas of substitution
- Visually intriguing aesthetic where the old enhances the new
- New materials sit boldly in contrast with the original
- Encourages cross industry partnerships

UPCYCLING

Mindful creation that reduces wastefulness

SYMBIOSIS

A harmonious co-existence of modern and mature

DEVIANT

UNORTHODOX

PROVOCATIVE

GROWTH

CHARACTER

EVOLUTION

RE-PURPOSE

ETERNALISE

HONESTY

ADAPTATION

CAPTIVATION

FUSION

6.2. Design Directions

Looking at the opportunities to expand Ecofitting, four design directions were set inspired by the material culture and behaviour trends observed in the research (Fig. 3). These design directions were named and described as:

Metamorphosis: making products change to adapt to sustainability.

Symbiosis: a harmonious co-existence of new and old.

Upcycling: following similar trends in product design, it is a celebration of additions and reduction of waste.

Art Car: the ultimate in provocative personal expression liberated from the aesthetic perfection.

Following this, four corresponding design experiments were developed focusing on delivering efficient, cheaper, more sustainable, and expressive solutions. The design experimentation process creates new insights and synthesises the directions into tangible objects. The design experiments are shown in the following pages.

6.2.1. Metamorphosis

The Metamorphosis design takes a MG-F and applies principles of evolution, growth and building character to inspire relinquishing the habit of use and discard. Streamlining the front, rear, and side panels to increase aerodynamic efficiency whilst also modifying the character and soul of the vehicle helps to visually identify this as an Ecofitted vehicle.

6.2.2. Symbiosis

The Symbiosis design uses a Fiat 500 as the donor car, exploring sustainable fabric and materials for exterior panels and showcases options for additional revenue streams for OEMs with fleets of existing unsellable cars in the near future. Symbiosis proposes a design language that is representative of sustainability and can deliver cost-effective solutions.

6.2.3. Upcycling

The *Upcycling* design presents an opportunity to explore how sustainability can directly challenge aesthetic conventions, social norms and be an instrument to climate action. In the exemplar, it takes a Mk2 VW Golf and applies principles of honesty, repair, and eternalisation by applying natural materials to the exterior, reflecting local craftsmanship culture.

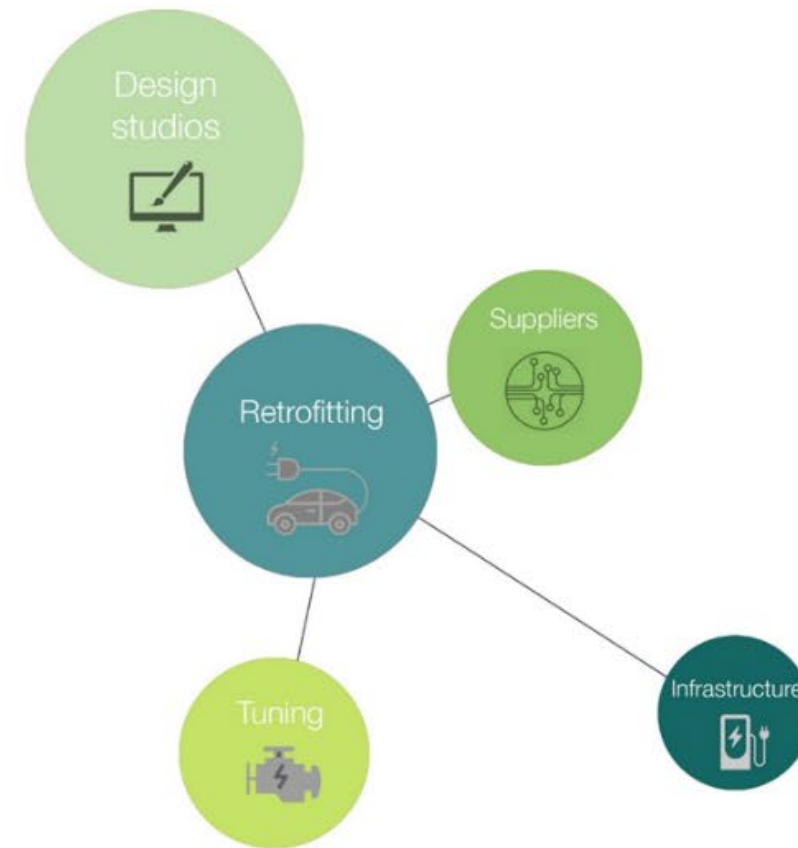
6.2.4. Art Car

Lastly the Art Car design channels the sense of unorthodox deviation to create an unusual and unexpected expression using a VW T5 donor van. Intended as a form of captivating personal expression and inspired by the Moss Table¹⁶, it utilises moss photovoltaics to generate electricity, not to power the van, but to make a statement about clean energy.

METAMORPHOSIS



METAMORPHOSIS



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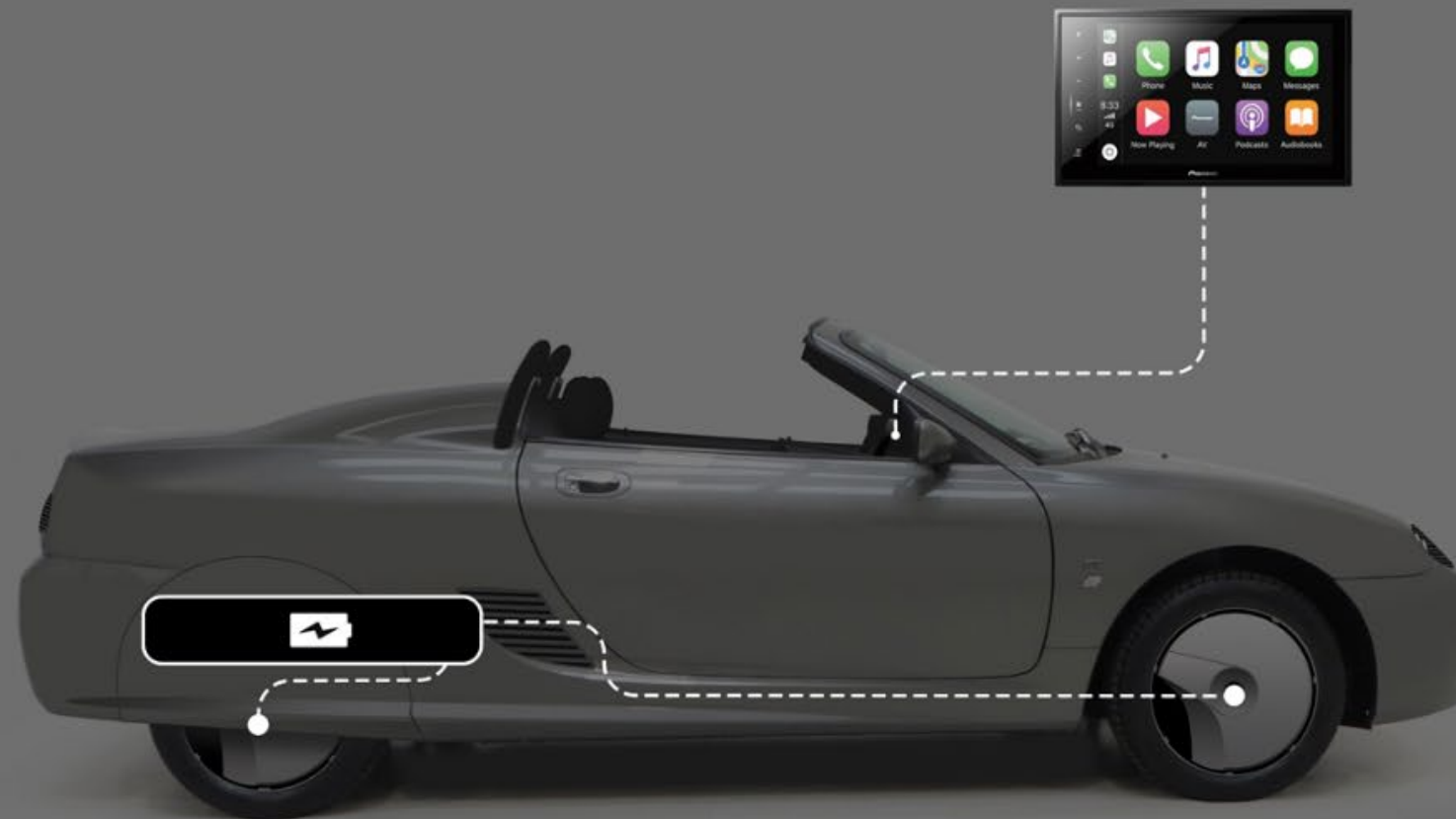
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Worcestershire



01905673578

View details

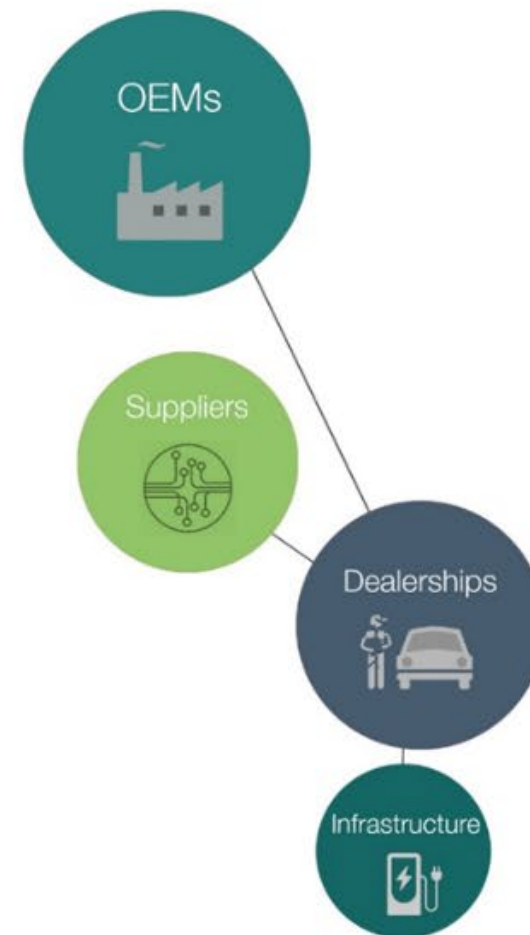
METAMORPHOSIS



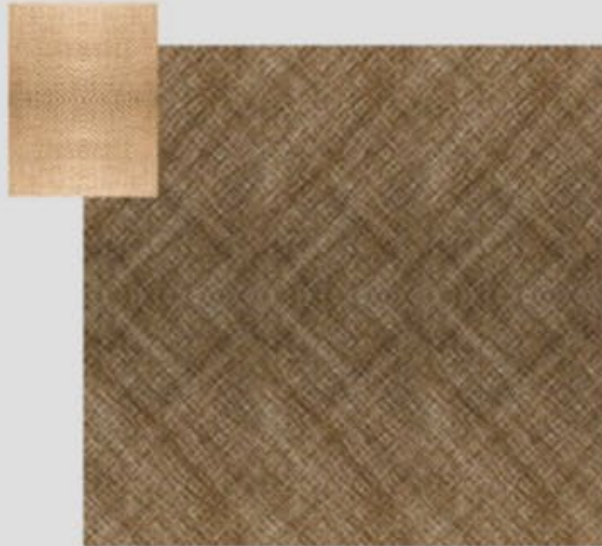
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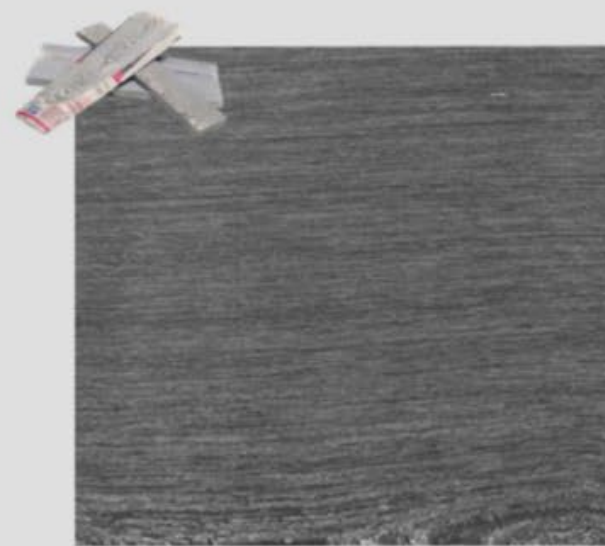
SYMBIOSIS



SYMBIOSIS



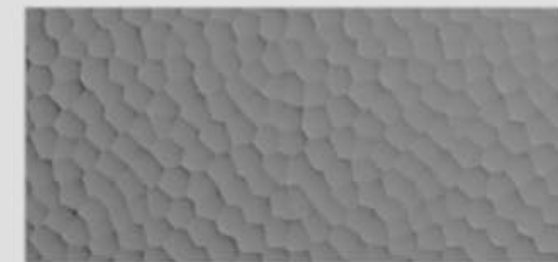
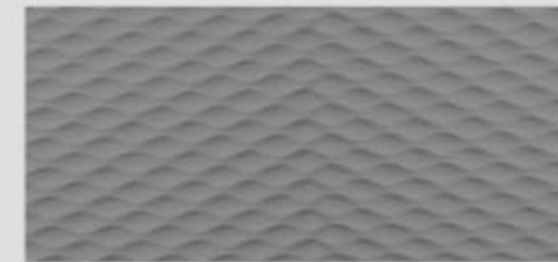
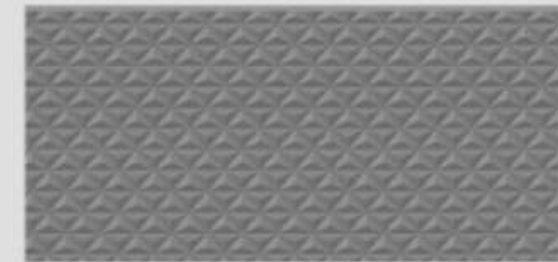
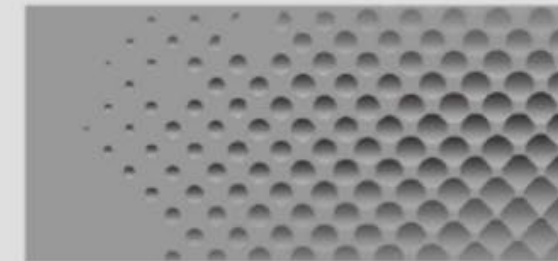
Bcomp



Newspaper Wood



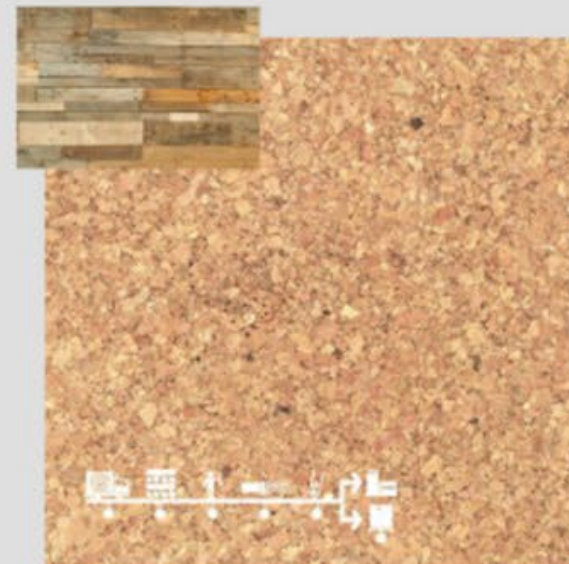
Weymann Fabric



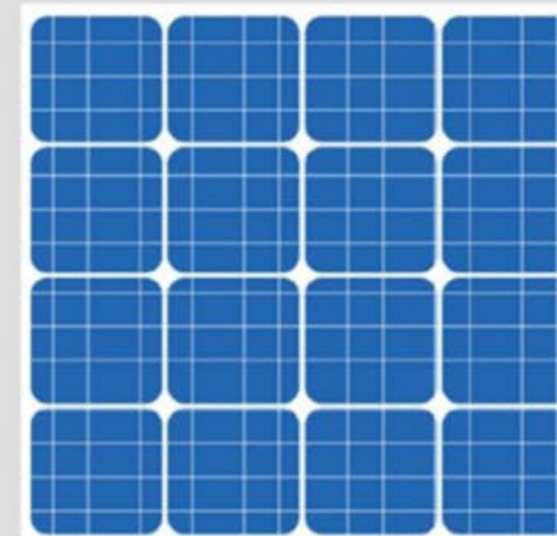
Patterns



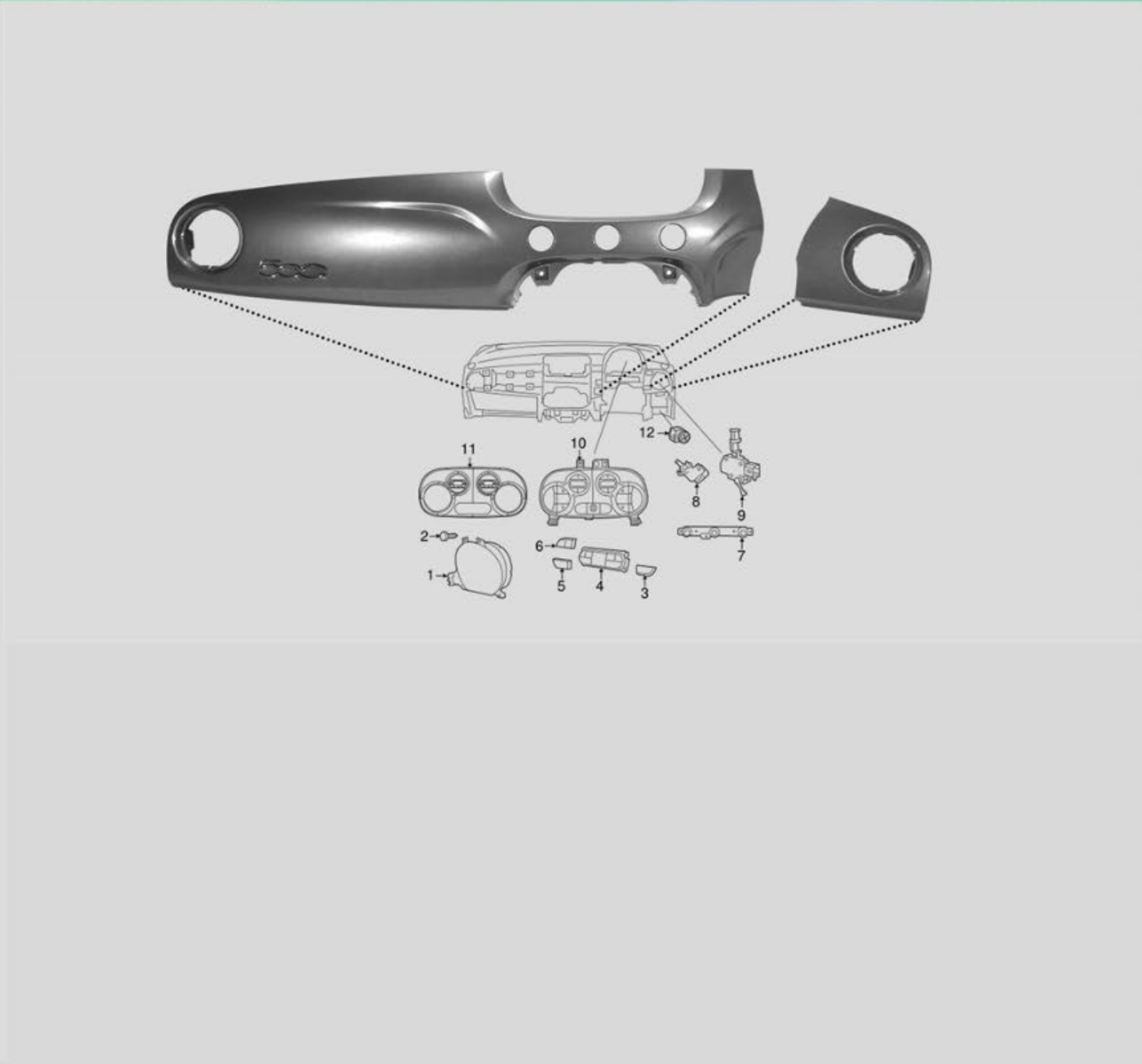
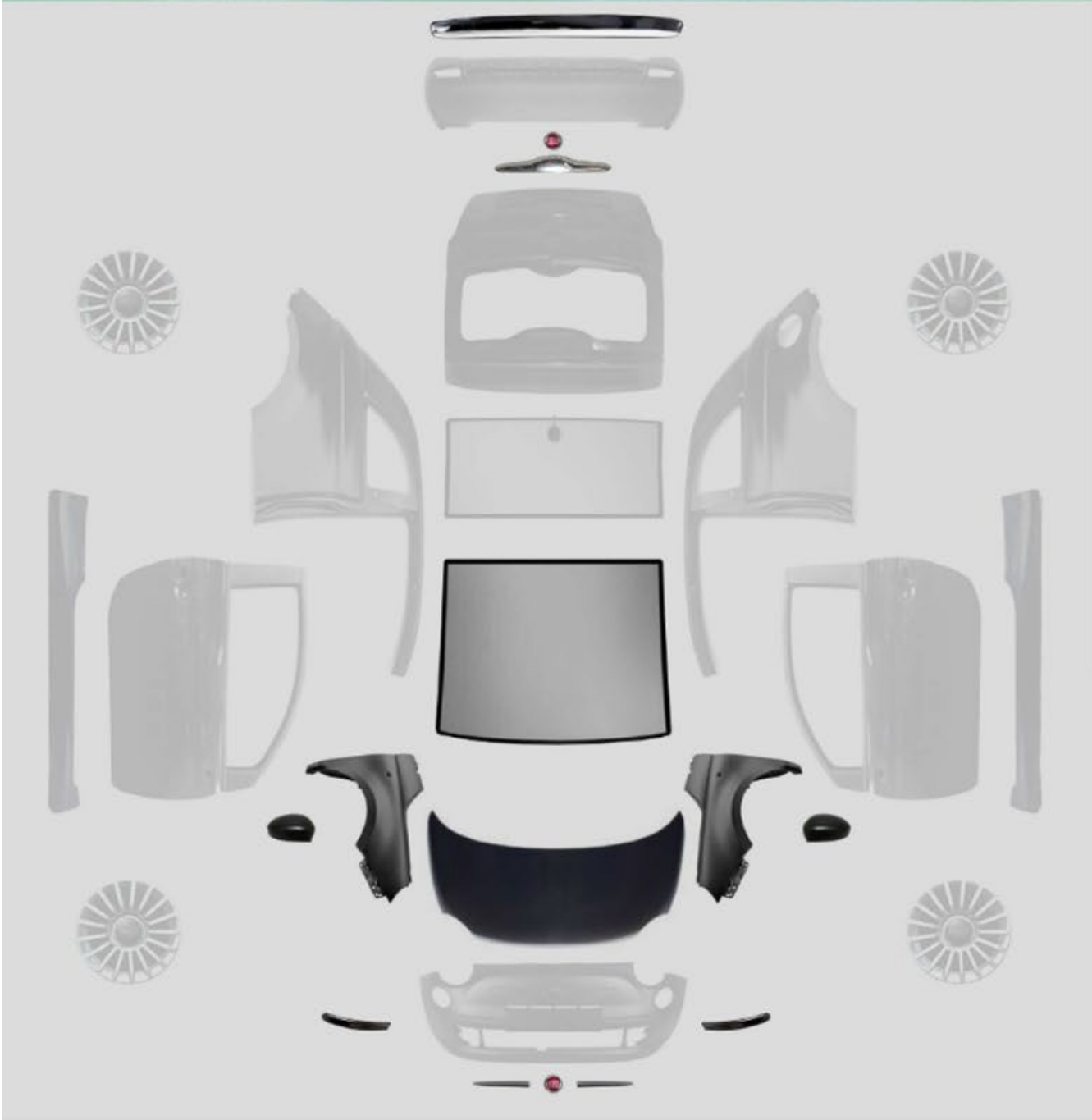
**Recycled 3D Printed Plastic
by Zero Waste Lab**



Recycled Wood



Solar Panels



SYMBIOSIS



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1986 Golf Mk2 GTI 1.8 Engine Unfinished project Car with Alloys."

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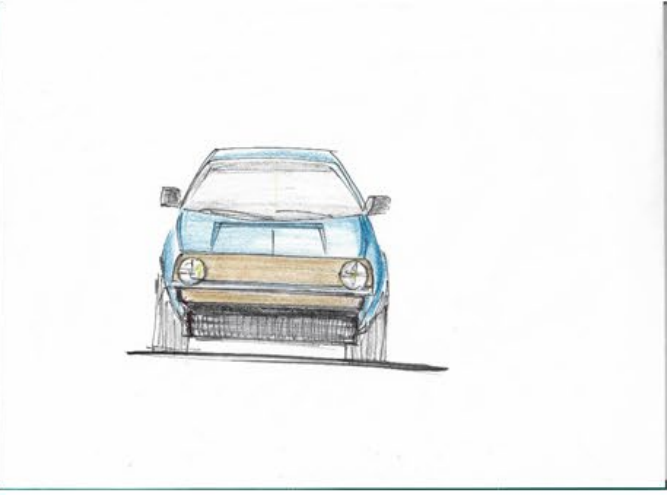
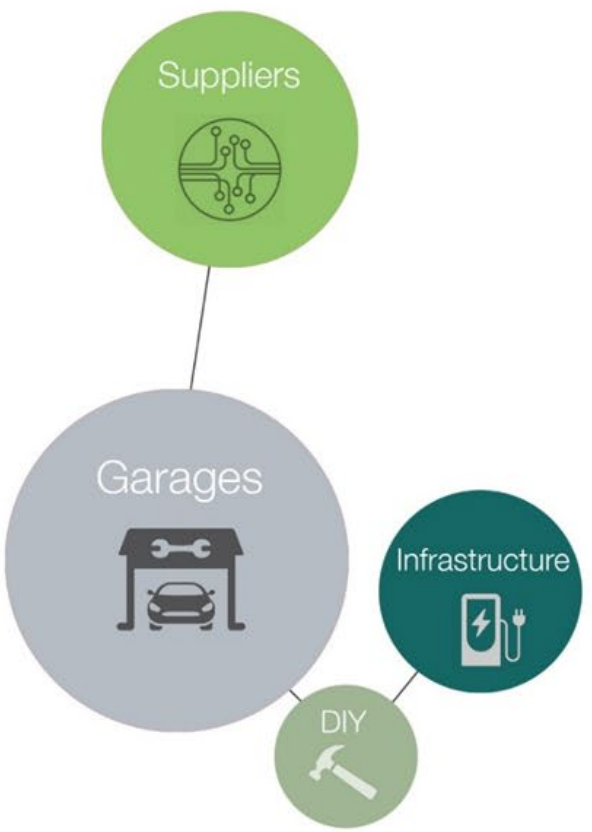
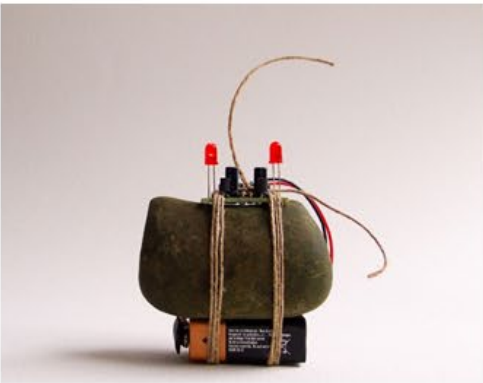
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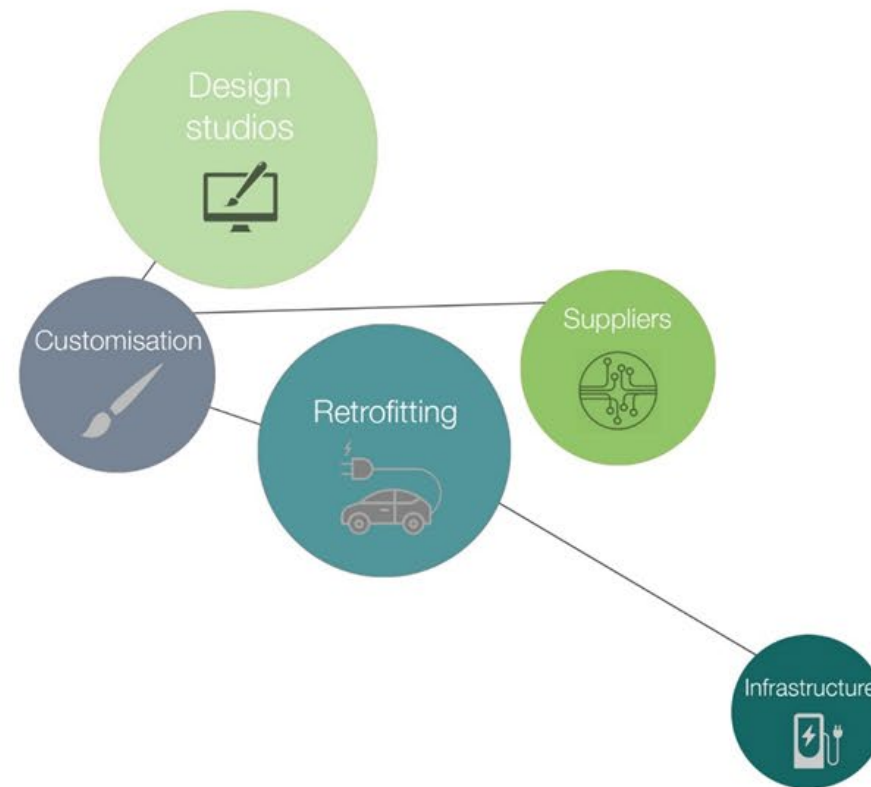
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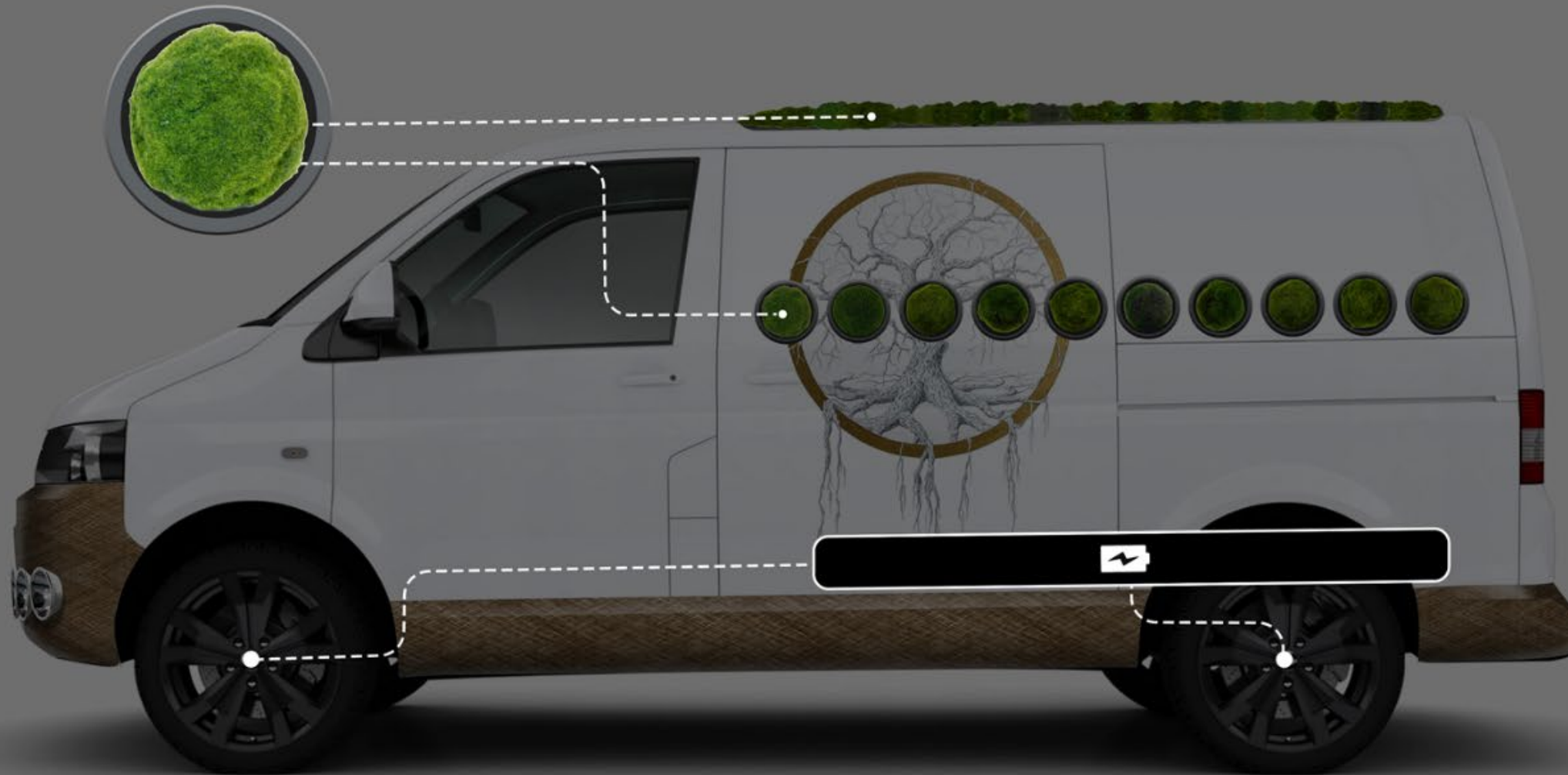
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ART CAR



ART CAR



ART CAR



7. Conclusions and Future Research

Ecofitting study presented the development of design directions to expand the trends of converting ICE cars to electric as an additional strategy to zero-emission mobility. The feasibility studies identified a stakeholder's landscape showing different activities which can collaborate to Ecofitting; produced state-of-the-art research identifying material culture trends which suggests an alternative approach to automotive design, more aligned to the expectations of new generations; classified current trends of Ecofitting; compared ICE, EV and Ecofitting strategies through a sustainable design perspective; and produced design experimentation to visualize the possibilities to expand Ecofitting. The design experimentation project uses design to investigate responsible ways of dealing with the fleet of non-compliant vehicles; and developing alternatives to make people embrace the transition to EVs. Four design directions were explored to expand the retrofiting activity and impact the transition to zero emissions, following a focus on UN Sustainable goals of climate action and responsible consumption and production.

Ecofitting changes the perspective of retrofiting by focusing on cars from 1980 to the complaint fleet. Therefore, addressing a more significant impact in the environment.

Looking at the opportunities to expand Ecofitting The project findings indicate that there are promising opportunities for developing automotive design differently. Car design has developed an aesthetic of perfection, which is represented by the sleekness of surfaces, reducing shut gaps between metal or plastic panels, the shininess of the chrome, sharpness of edges, and even tuning the noise of closing doors. These are costly to maintain not and do not represent the entire spectrum of taste of the newer generations. This study therefore identifies an opportunity for Ecofitting to develop a more environmentally conscious aesthetic to sit in parallel amongst existing car design aesthetics. Ecofitting innovates while venturing in alternative areas of design, which are not explored in dept in car design, but it is well respected in architecture, more experimental in product design and more meaningful in traditional craft. At the same time, opens car design to more sustainable practices.

Ecofitting would allow opportunities for developing automotive design differently, with designers connecting to users to update their cars, and users emotionally reconnecting to their own cars. There are opportunities for alternative suppliers to become part of an entirely new automotive industry ecosystem and contribute to providing more sustainable solutions. There are options to develop new products to be incorporated as usability and technology updates (interfaces, powertrain, bodywork, upholstery) and a concurrent need to develop an online platform to facilitate Ecofitting and inform responsible consumer choices on upgrades. It proposes understanding vehicles as platforms that can be updated and customized promoting long-term ownership and changing the way new cars will be designed in future.

The Symbiosis design suggests that Ecofitting presents an additional revenue stream for OEMs with fleets of unsellable cars. As a new business model, it facilitates conversion, upgrading and personalisation, helps support dealerships, and keep and create jobs. It has the potential to reconfigure the economy around it and reduce environmental impact for disposal, manufacturing, distribution, and product use. Promoting long-term ownership is the main goal of Ecofitting, and requires a shift in how we understand, consume, and use cars to bring it to fruition. Refurbishing and reusing cars can become as common a practice as the refurbishing of homes and is an interesting area for design to evolve into. The four design directions developed in the project demonstrate that Ecofitting is an effective sustainable solution which respects the emotional and cultural values of cars, develops a socially responsible material culture, promotes long-term ownership of vehicles, and can alter how we design cars in the future.

7.1. Key Findings

Car design has developed an aesthetic of perfection, which is represented by the sleekness of surfaces, thinness of the joint between panels of metal or plastic, the shininess of the chromes, sharpness of edges, or even the noise of closing doors. These are not aligned with the taste of new generations and are too costly to maintain. This creates an opportunity to Ecofitting to develop a more environmentally conscious aesthetic.

The Sustainable Design Orienting toolkit analysis highlighted Ecofitting's benefits related to long-term ownership, waste and resource reduction, local production and wider distribution of opportunities, promotion of local culture, communities and responsible consumption, promotion of an aesthetic of sustainability, valorisation of personal identity and deeper values.

7.2. Design Evaluation

Dr Mausbach and Dr Safa presented Ecofitting in an RCA-based design forum to automotive, product and fashion design experts. Key points pointed out by the panel included:

- The Symbiosis approach as interesting to OEMs, especially for the case of cars already with existing EV versions (such as the Symbiosis Fiat 500)
- Explore in more detail the full carbon footprint involved in the different Ecofitting design directions.
- Explore how policies can support Ecofitting.
- The Symbiosis as a design language that is representative of sustainability and can deliver cost-effective solutions.
- Refurbishing of cars to become a practice similar to refurbishing homes as an interesting area for design to evolve towards.

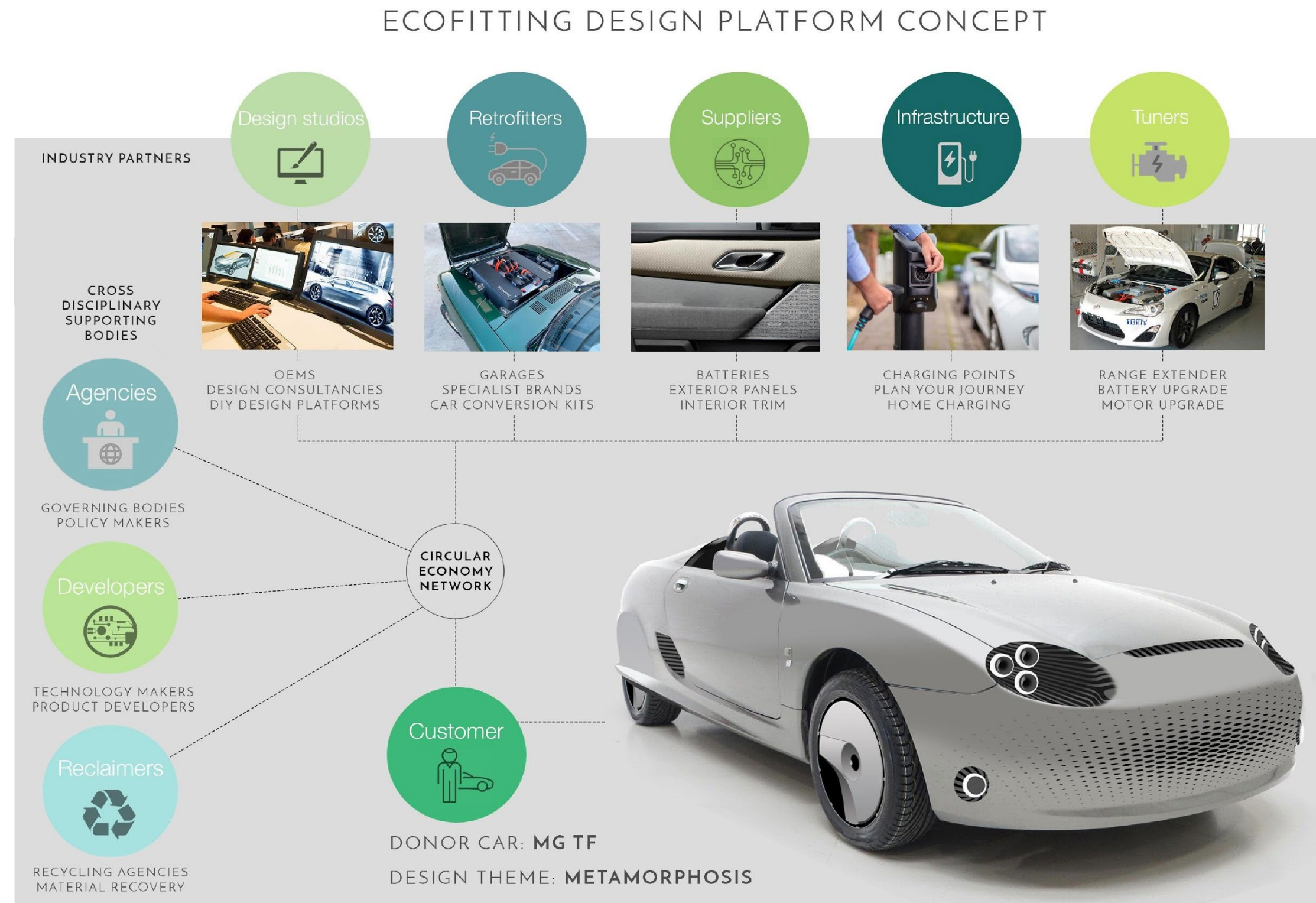
7.3. Next Steps

Ecofitting is focused on the challenge of protecting the environment, the Sustainable Goals of climate action, responsible consumption, and production. It is aligned with the focus of KTN on sustainability, and specifically, the area of Low Emission Vehicles in the Transport sector.

Following its key findings, the next stage is the development of a digital platform to facilitate the spread of knowledge and information, to connect industry partners to consumers and researchers on circular economy, to configure Ecofitting cars, and for designers to mediate the process of developing the vehicles.

The Ecofitting platform objectives are:

- Inform and inspire consumers/collaborators on the purpose and opportunities within Ecofitting.
- Enable contributors and stakeholders to connect and engage with potential consumers and each other.
- Provide a place for consumers to configure, visualise and develop their own Ecofitting projects.
- Inform conscious decisions about sustainability on Ecofitting.
- Create the Ecofitting Car Configurator website.



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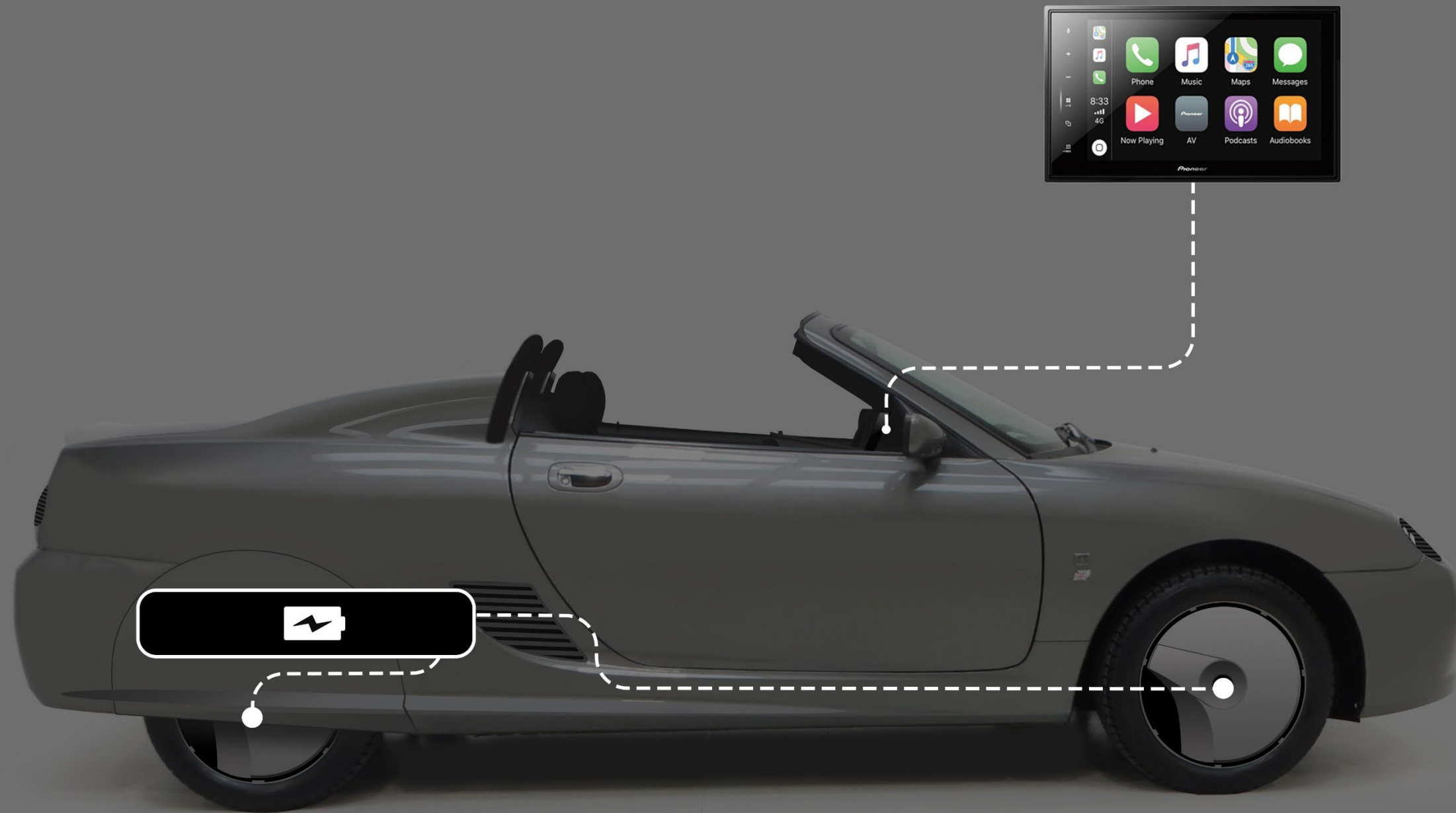
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