Ecofitting: design directions upgrading cars to zero emissions

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Abstract

This paper presents the design directions for Ecofitting, a sustainable solution for the large UK fleet of internal combustion engine cars that will soon be rendered non-compliant with fast approaching initiatives for Ultra Low Emission Vehicles. Ecofitting circular economy strategy goes beyond just electrification, opening an opportunity for new approaches to automotive design, and to cater for generational shifts in desirability. State-of-the-art, taxonomic and trend mapping research have identified opportunities for retrofitting leading to four proposed design directions inspired and influenced by sustainable practices across other industries, that directly involve the consumer, and provide an alternative approach to the longstanding aesthetic of perfection historically seen in vehicle design.

Keywords—Automotive design; sustainability; retrofitting; electric conversion; ecofitting; electric cars; circular economy; zero emissions.

I. INTRODUCTION

Currently, there is no sustainable solution for the large existing fleet of internal combustion engine cars that will soon be unroadworthy due to non-compliance with advancing clean air initiatives [1]. The UK requirements for Ultra Low Emission Vehicles will create a fleet of 15 million non-compliant ICE cars in the UK [2,3], thus there is a need to extend the life of the current fleet in order to avoid the impact of the end-of-life of millions of cars.

Ecofitting provides an alternative private vehicle offering in addition to the introduction of new low-emission vehicles from OEMs, and proposes a new circular economy strategy to contribute towards zero-emissions in a sustainable manner, by retrofitting this existing fleet of ICE cars. This process involves not just electrification but, importantly, customisation and personalisation of these vehicles to create desirability, promote behavioural change, and long-term ownership. As such, design is at the heart of Ecofitting.

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Converting classic cars to electric is currently a growing trend within small businesses and OEMs, but this project proposes expansion of this trend. Ecofitting extends the potential of retrofitting beyond just classic cars and considers cars from 1980 onwards thereby substantially expanding the potential environmental impact [4].

Looking at UK government targets on clean-air zones and zero-emission vehicle phasing, we identified a timeline and scope within which the context of Ecofitting is most relevant. Currently, only 0.2% of the UK fleet is zero emission[3], and data from the Department for Transport, shows that as of 2019, a fleet of 15.1 million diesel and petrol cars exist currently on the road in the UK that are non-compliant with clean air zones [4]. These cars are the main focus of Ecofitting.

To investigate the feasibility of Ecofitting, this research explores possible designs directions to demonstrate its desirability potential. The 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. The approach included investigating the state-of-the art, behaviour change trends, and trends in automotive design and material culture related to the concept of Ecofitting. A series of design experimentations were conducted to explore possible applications of Ecofitting and visualise possible future design directions.

II. CONTEXT

The project begins analysing a taxonomy of trends of exterior (Fig. 1) [5] 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 [6]. 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 [7] who suggests that taste is changing as response to a context where the relationship between us and the environmental demands more responsibility.

Fig. 1: Exterior car design trends mapping showing main trends between 1980s and today's production and concept cars [5].

According to Walker [7] ‘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 [8] 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.

This project proposes innovation by venturing into alternative approaches, which are well established and explored in architecture (e.g., retrofitting, renovation), more experimental in product design (e.g., upcycling) and more meaningful in traditional craft (e.g., Kintsukuroi) but far less so in vehicle design, whilst concurrently opening vehicle design to more sustainable practices. These design directions are intended to both reflect current changes in, and to cater for new changes and shifts in consumer desirability. Whilst Ecofitting design needs to perform in usability and practicality, it also needs to attract consumers, create satisfaction and personal fulfilment hence the emotional side of design may be more critical to a product’s success than its practical elements, as suggested by Don Norman [9]. Desirability thus becomes a key consideration in the design of vehicles going forward to ensure a longer lasting relationship between consumer and vehicle, encouraging long term ownership, and reducing the culture of excess consumption.

III. STATE-OF-THE-ART AND MAPPING OPPORTUNITIES

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 [10]).
2. *Electric Rustoration:* keeping the rusted or wear our bodywork almost untouched (e.g. 1949 Mercury Coupe EV [11]).
3. *Classic Car Conversion:* fitting classic icons with electric drivetrains (e.g., Lunaz [12]).
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 [13]).
5. *OEM Product Diversion*: OEMs creating electric versions of already established and existing models (e.g., Fiat 500 EV [14]).
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 [15]).
7. *DIY Experimental*: personal research projects or consumers buying individual parts and upgrading the drivetrain to electric themselves [16].
8. *DIY Kit:* consumers buying retrofit kits and upgrading the drivetrain to electric themselves [17].
9. *E-Customising*: traditional customization and tuning applied to electric vehicles conversion to upgrade aesthetics and performance [18].

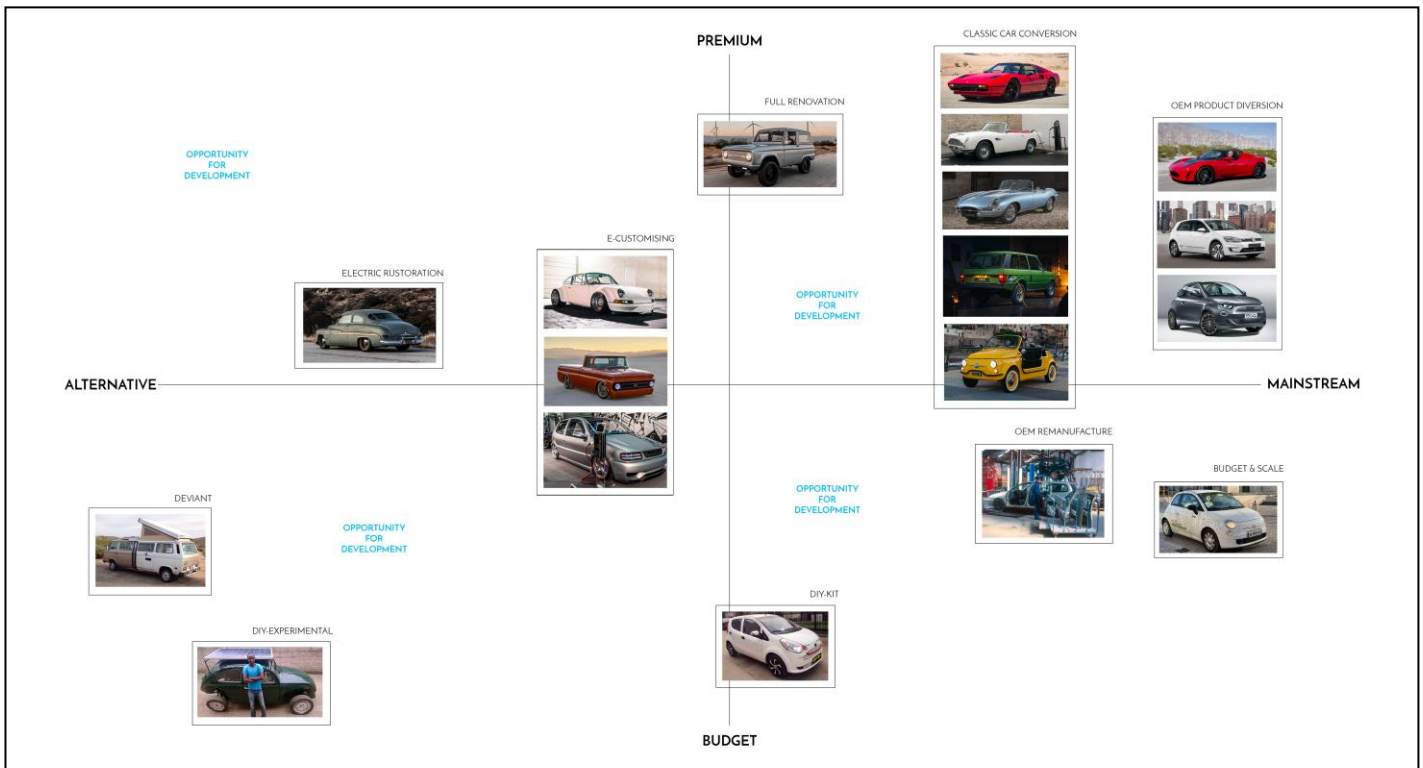

Fig. 2: Chart mapping of opportunities for developing Ecofitting.

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 (Fig. 2). 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. (Figure 3.)

IV. 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:

1. *Metamorphosis:* making products change to adapt to sustainability.
2. *Symbiosis*: a harmonious co-existence of new and old.
3. *Upcycling:* following similar trends in product design, it is a celebration of additions and reduction of waste.
4. *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 synthetises the directions into tangible objects.

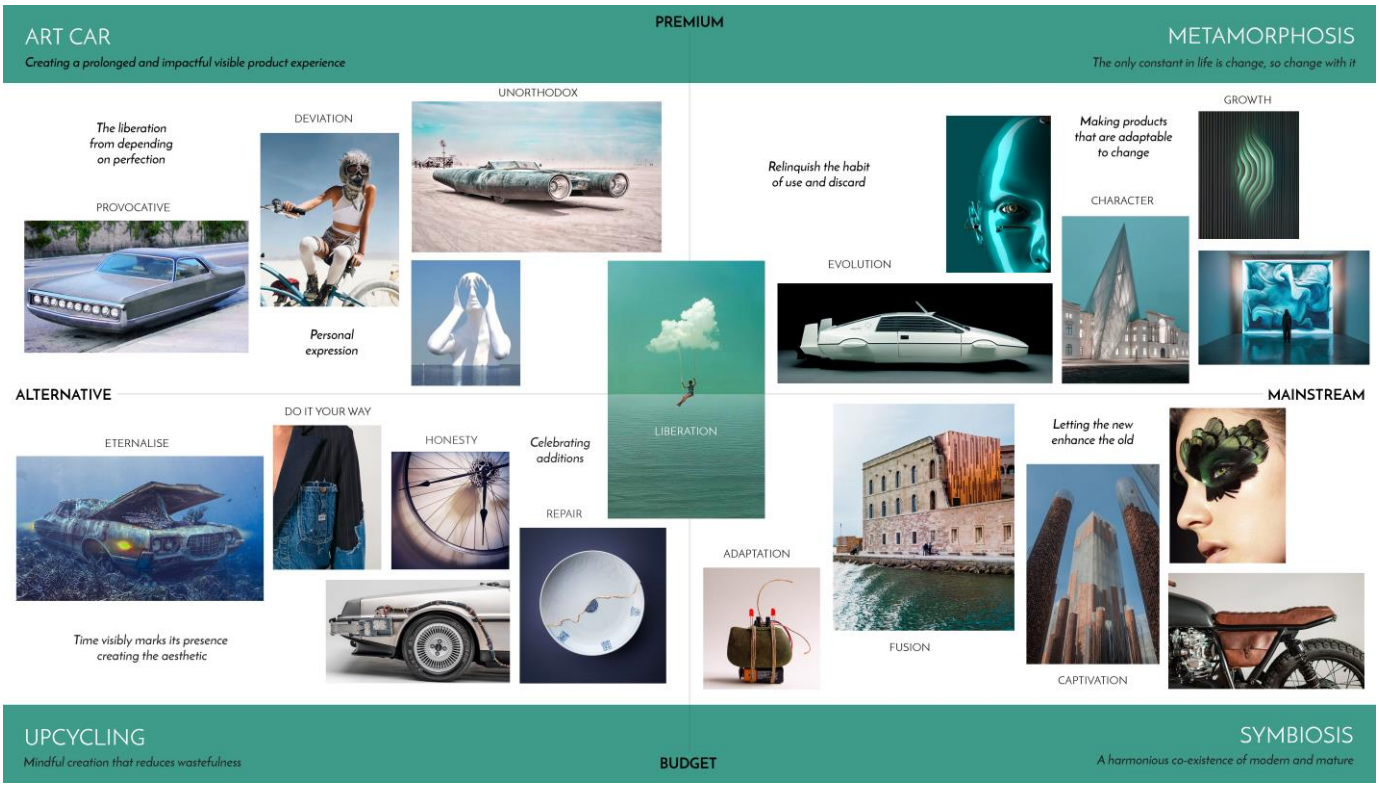

Fig. 3: Mood board for design directions to Ecofitting.

The *Metamorphosis* design (figure 4) 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.

Fig. 4: Metamorphosis MGF

The *Symbiosis* design (figure 5) 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.

Fig. 5: Symbiosis Fiat 500

The *Upcycling* design (figure 6) 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.

Fig. 6: Upcycled Golf

Lastly the *Art Car* (figure 7) 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 Table[16], it utilises moss photovoltaics to generate electricity, not to power the van, but to make a statement about clean energy.

Fig. 7: Art car T5 van.

V. CONCLUSION

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 would allow opportunities for developing automotive design differently, with designers connecting to users to update their cars, and users emotionally reconnecting to their old 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, upholstering) 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.

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 unique selling point 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 (figure 8) 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.

VI. FUTURE RESEARCH

Following the study of its design directions, focus of 2020's CENTS (UKRI) supported project, 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, and for designers to mediate the process of developing Ecofitting vehicles.

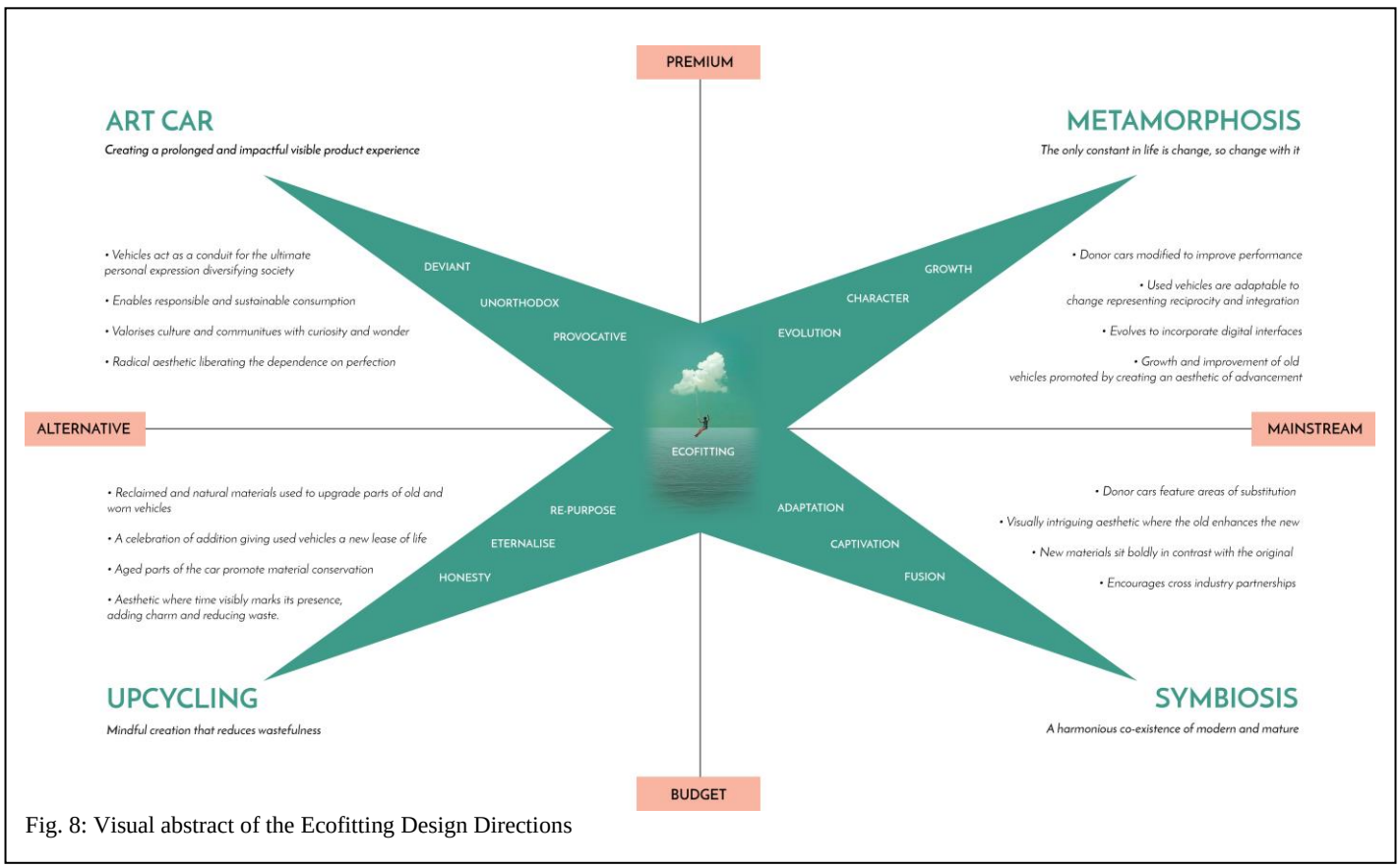

Fig. 8: Visual abstract of the Ecofitting Design Directions

REFERENCES

[1] TRANSPORT FOR LONDON. “ULEZ, Where and When” (https://tfl.gov.uk/modes/driving/ultra-low-emission-zone/ulez-where-and-when#on-this-page-5) Accessed February 2021

[2] DEPARTMENT FOR TRANSPORT. “Vehicle Licensing Statistics: Annual 2018”. (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/800502/vehicle-licensing-statistics-2018.pdf) Accessed February 2021

[3] GOV.UK Cars (VEH02) (https://www.gov.uk/government/statistical-data-sets/veh02-licensed-cars) Accessed February 2021

[4] Mausbach, A.G., Safa, F, Harrow, D. and Diels, C. "Ecofitting Circular Economy: An alternative approach to market, consumption, and design towards zero emissions," *2020 Fifteenth International Conference on Ecological Vehicles and Renewable Energies (EVER)*, Monte-Carlo, Monaco, 2020, pp. 1-9, doi: 10.1109/EVER48776.2020.9242964.

[5] Mausbach, A G., Safa, F., Quinlan, D., Johnson, S., Kennard, A. & Harrow, D. (2019) Prisms: Perspectives on Design for China. Unpublished Research Report. London, IMDC Royal College of Art. In: https://www.rca.ac.uk/research-innovation/projects/prisms-perspectives-on-design-for-china/ (Accessed: 25 March 2021)

[6] Mausbach, A G., Thorpe, C, Safa, F., Diels, C. (2019) Psychology and Desirability in Automotive Design. Unpublished Research Report. London, IMDC Royal College of Art.

[7] Walker, S. (1997) ‘Conscientious Objects - Product Aesthetics in the Context of Sustainability’. Chapter in: van HINTE, Ed. *Eternally Yours - Visions on Product Endurance*. Rotterdam: 010 Publishers.

[8] Datschefski, E. (2001) *The total beauty of sustainable products.* East Sussex: RotoVision

[9] NORMAN, D (2004) Emotional Design – Why we love (or hate) everyday things. New York: Basic Books

[10] Zerolabs (2021) Vehicles. Available at: https://www.zerolabs.com (Accessed: 24 March 2021)

[11] Tudose, S. (2020) ‘Icon’s Tesla-Powered 1949 Mercury Coupe EV Is Coming To Geneva’, *Carscoops*, 26 February. Available at: https://www.carscoops.com/2020/02/icons-tesla-powered-1949-mercury-coupe-ev-is-coming-to-geneva/ (Accessed: 24 March 2021).

[12] Lunaz (2021) Discovery. Available at: https://lunaz.design (accessed: 24 March 2021)

[13] Transition One (2021) Retrofit. Available at: https://transition-one.eu (Accessed: 24 March 2021)

[14] Fiat (2021) New 500. Available at: https://www.fiat.co.uk/500-electric (Accessed: 24 March 2021)

[15] Groupe Renault (2021) News. Available at: https://group.renault.com/en/news-on-air/news/re-factory-the-flins-site-enters-the-circle-of-the-circular-economy/ (Accessed: 24 March 2021)

[16] Bressa, R. (2014) ‘An African student develops a solar and wind-powered car’, *Lifegate*, 29 September. Available at: https://www.lifegate.com/african-student-solar-and-wind-powered-car (Accessed: 24 March 2021)

[17] DIY EV (2021) Products. Available at: https://diyev.com (Accessed: 24 March 2021)

[18] Collins, O. (2020) ‘Car Modifications for Electric Vehicles: What’s Possible?’, *Get Green Now*, 27 December. Available at: https://get-green-now.com/car-modifications-and-electric-vehicles-whats-possible/ (Accessed: 24 March 2021)

[19] Grant, R. Moss table wins international award. Department of Biochemistry, University of Cambridge online publication (https://www.bioc.cam.ac.uk/news/moss-table-wins-international-award) Accessed February 2021