ASPECTS REGARDING ECO-INNOVATION PRACTICE AND TRENDS FOR A SUSTAINABLE AUTOMOTIVE INDUSTRY

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Abstract - Eco-innovation of products, processes and management has a significant positive impact on the circular economy of companies in the automotive and auto parts industry, but, the barriers to innovation may emerge from systemic failures that hinder the flow of knowledge and technology, and reduce the overall efficiency of the system-wide R&D and innovation effort. The potential market and systemic failures suggest that policies for innovation will only be successful if they enhance the performance of the system as a whole, targeting weak links between elements that can hurt performance.

Keywords: Eco-innovation, Circular economy, Automotive industry, Sustenability.

1. Introduction

Breakthroughs in computing, sensors, mobile connectivity, artificial intelligence, robotics, 3D printing, and advanced materials are transforming manufacturing and production systems. New business models, based on platforms and developing an ability to offer new services rather than simply delivering products, will change the ways that manufacturing companies operate. Policy-makers and business leaders need to develop new related approaches and work together, in order to build innovative production systems that truly benefit everyone [1].

2. Eco-Innovation

According to the OECD's report [2] eco-innovation represents a "key pre-requisite for sustainable development" at macro level as it brings positive synergetic effects on economic, social and environmental conditions of a country. International organizations, research institutes, academia, etc. are continuously emphasizing the importance of eco-innovation, highlighting the role of the public and private sectors to create enabling conditions.

Eco-innovation refers to all forms of innovation – technological and non-technological – that create business opportunities and benefit the environment by preventing or reducing their impact, or by optimizing the use of resources. Eco-innovation is closely linked to the way we use our natural resources, to how we produce and consume, and also to the concepts of eco-efficiency and eco-industries. It encourages a shift among manufacturing firms from "end-of-pipe" solutions to "closed-loop" approaches that minimize material and energy flows by changing products and production methods – bringing a competitive advantage across many businesses and sectors [3].

Eco-innovation is the development and application of a business model, shaped by a new business strategy that incorporates sustainability throughout all business operations based on lifecycle thinking, in cooperation with partners across the value chain. It entails a coordinated set of modifications or new solutions to products (goods /services), processes, market approach and organizational structure which leads to a company's enhanced performance and competitiveness [4].

A conceptual model of eco-innovation that is based on this definition is shown in Figure 1 below:

Figure 1: Conceptual model of eco-innovation
[source: www.unep.org/eco-innovation]

The evolution of risks, regulations and legislative constraints as well as market dynamics are factors that contribute to the stimulation of innovation, as summarized in Figure 2. Increasing business

pressures are creating favorable conditions for eco-innovation. [5].

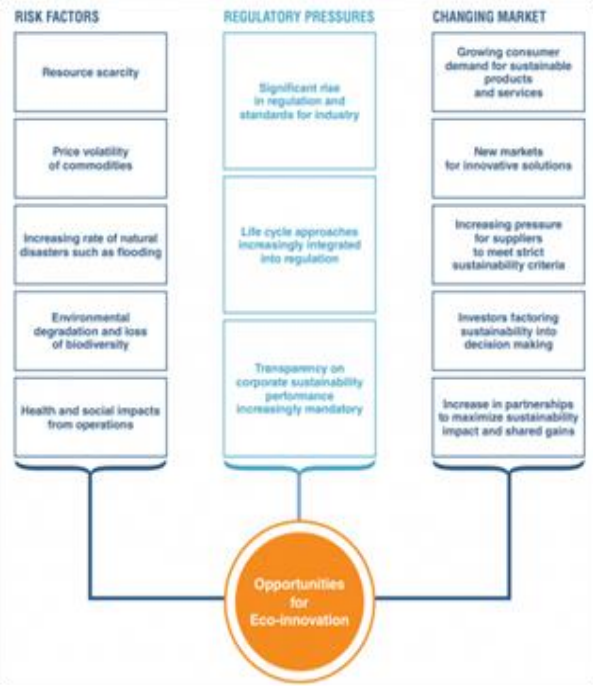

Figure 2: Opportunities for eco-innovation [https://www.unep.org/eco-innovation]

3. The Circular Economy and its Influence on the Car Industry

The rapid increase in the use of electric vehicles with the associated advantages and disadvantages highlights the need for more than the gradual elimination of the combustion engine to drastically reduce carbon emissions so it will be essential to use circular economy strategies to transform products, as well as adapting the way these products are used.

In actual context of the automotive industry, circular economy are part of four strategic ways: decarbonising energy usage, establishing circular material flows, extending and optimising product lifetime and improving capacity utilisation during vehicle usage and producers such as Renault, Volvo, PSA, Daimler, BMW, Volkswagen have already set ambitious targets towards carbon neutrality and aligned their business strategies with an ever-accelerating push for electrifying their products [6].

Original equipment manufacturers are heavily investing in electrification, closing material loops, and developing new service offerings and mobility solutions. investors and regulators are pushing to go further.

Cars are increasingly bought online and flexibly subscribed to for shorter time periods, revenue streams are shifting towards the use phase and the drive towards circularity is slowly picking up speed. Already most automotive materials are recyclable. cars are built to last and to be repaired. These are all important aspects of circularity. The value chain needs to be fundamentally reimagined to minimise lifetime carbon emissions and resource consumption.

The "Circular Car", as a strategic concept, adopts a circular flow in the whole product lifecycle: reduction, recovery, repair, renovation, reuse, and recycling of all components. These processes are a part of the value chain, and the reason is to increase value and the circularity of materials. A circular car maximizes value to society, the environment and the economy while efficiently using resources and public goods. Its value is measured in terms of its ability to provide mobility, and its efficiency is measured in terms of carbon emissions, non-circular resource consumption and use of public goods, such as space or clean air [7].

The definition focuses on the relevant variables [1]: energy, materials, lifetime, and use (see Figure 3). Energy is used efficiently (per km of movement) and renewable; lifetime of the vehicle and components is optimized for resource efficiency (by emphasizing efficient design, modularity, purpose-built vehicles, reuse, repair, remanufacturing, etc.). Materials are used without waste (reduced, reused, recycled and/or renewed). Use rates are optimized (accounting for resiliency requirements).

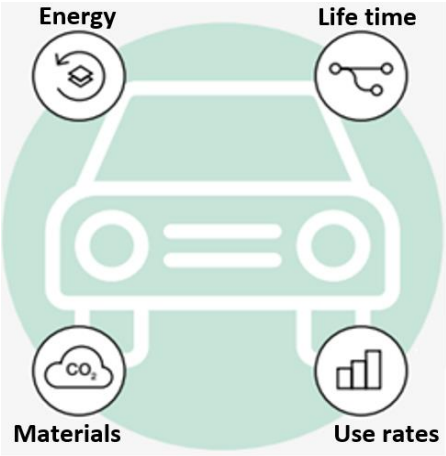

Figure 3: Circular car [https://www3.weforum.org/docs/WEF_A_policy_research_agenda_for_automotive_circularity_2020.pdf]

Accenture proposes a taxonomy with five levels of circularity based on two primary measures (carbon and resource efficiency) to evaluate and improve the circularity of cars [8]. The proposed levels range from single owner use and disposal (Level 0) to an aspirational goal of an automobility ecosystem that has net positive impacts (Level 5). The levels describe vehicles that are part of an increasingly circular automobility system. Each level can be determined based on the characteristics of both the product and its use, so the producer and the owner of the car are responsible for achieving circularity.

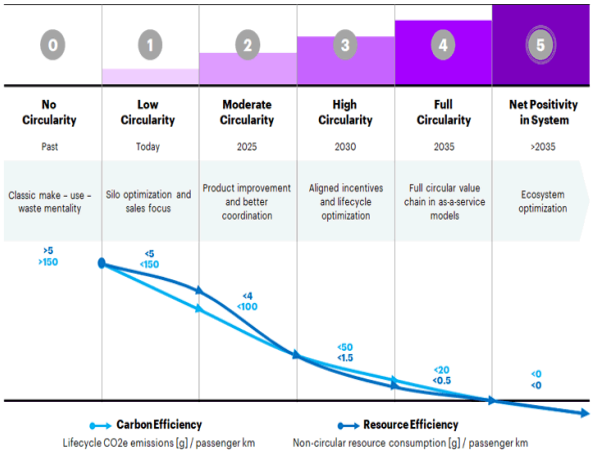

Figure 4: Five levels of circularity
[Source: WEF & Accenture, Raising Ambitions: A new roadmap for the automotive circular economy, 2020]

4. Evolution and Perspectives in the Automotive Industry

Environmental protection is one of the basic pillars of the carmaker's sustainability and the automotive industry has the opportunity to shape this fundamental restructuring. When devising strategies and business models, companies should not only consider direct product purchasers but all users and groups affected by transport issues. The automobile changed from a technical to a social commodity: it guarantees the personal mobility and social participation, shapes the cities and landscapes, and structures the temporal and spatial thinking.

This is why it have to rethink the whole automotive industry – with the focus on the use rather than the production of vehicles, in order to make the lives of individual users more enjoyable, more efficient and safer. The car of the future is electrified, autonomous, shared, connected and yearly updated: "eascy" [9].

Five of the top 20 companies with the highest R&D investment are vehicle manufacturers, but they do not feature among the 10 most innovative enterprises. Between 2020 and 2025 the industry will have to find ways of compensating for falling margins and rising investment. Manufacturers and suppliers should put users at the heart of their business model and offer them "eascy" mobility solutions. Implications will be the rapid redistribution of investment in research and development. Decisions regarding the long-term structure will be made between 2020 and 2025 and an illustrative representation of the mobility of the future is given in the figure 5.

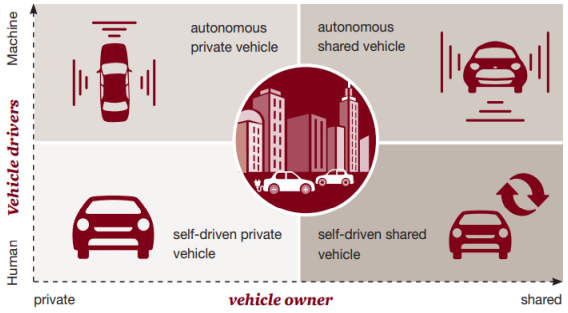

Figure 5: Manifestation of the mobility of the future [9]

Environmental strategic visions and plans of automotive companies are generally based on the following key objectives [10]: non-waste production technologies; reduction of emissions throughout the life cycle; reduction in fuel consumption and alternative sources of propulsion; replacement of non-recyclable materials; reducing the consumption of energy and water in the production process.

Even the actual production processes are more sophisticated, the environmental impacts are formed in the following three main stages: inputs, operations, products [11].

The figure 6 shows the interaction between bussines facility and the environment and the impact it may have on the environment throughout the 'lifecycle' of the products that it produces.

Inputs are materials or intermediate products used to manufacture the products, operations are processes to turn inputs into products and activities necessary to operate the production processes (e.g. facility operation, transport of inputs and products, business travel, staff commuting and other overheads) and products represent products manufactured and their use and treatment at the end of their lifetime.

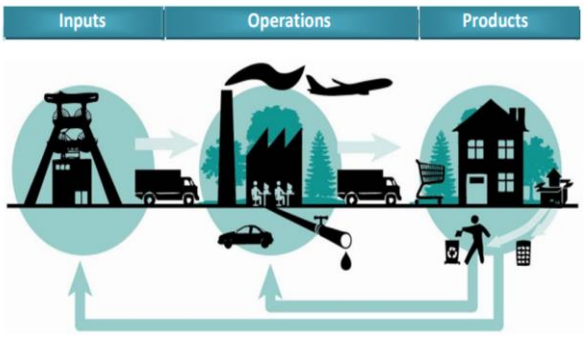

Figure 6: Basic relationships between manufacturing and the environment
[source: The OECD Sustainable Manufacturing Toolkit, 2011]

Sustainability stimulates innovation, on the one hand, new industries and services emerge, on the other hand, existing industries integrate sustainability concerns into the development of their products and services, such as the electric car [12], which is one of the solutions success in the automotive industry.

Increasing standards are emerging for OEMs and dealers, increasing the complexity of the sales process, and multi-party coordination is needed. Today's customers have high expectations for their cars, so the following main factors are identified for the next years [13]: Key factors are expected to double - While vehicle performance, design and price will remain important, five other factors will become critical for a positive customer experience.

New factors critical for a positive CX- dealer/repair shop accessibility; staff expertise; connected vehicle and advanced systems; data privacy and protection; sustainability and responsibility. Digital experience - A majority of customers (62% – 65%) expect online, virtual, and real-time response experiences from their automotive original equipment manufacturers and dealers.

Eco-innovation of products, processes and management has a significant positive impact on the circular economy of companies in the automotive and auto parts industry [14]. But, the barriers to innovation may emerge from systemic failures that hinder the flow of knowledge and technology, and reduce the overall efficiency of the system-wide R&D and innovation effort. The potential market and systemic failures suggest that policies for innovation will only be successful if they enhance the performance of the system as a whole, targeting weak links between elements that can hurt performance [15]. Car manufacturers are constantly adapting to environmental changes and customer requirements and are adopting the most innovative solutions in this transformation. An example is the factory of the future Audi Neckarsulm (figure 7), the first Volkswagen Group car factory that uses RFID technology to identify vehicles throughout the production process and connect processes across all systems.

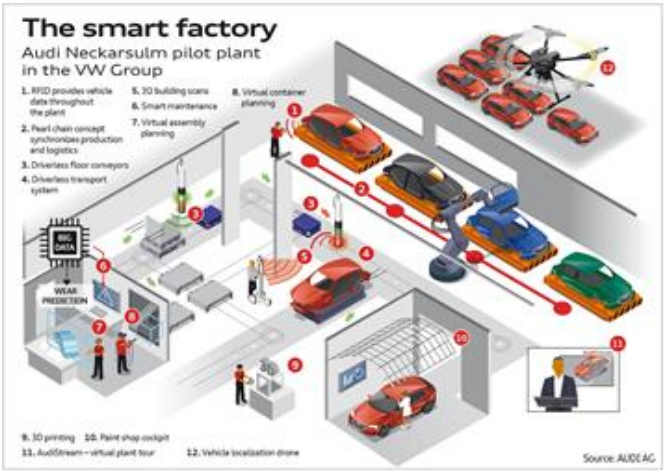

Figure 7: The smart factory - Audi Neckarsulm pilot plant in the VW Group [Source: AUDI AG]

Digital solutions for vehicle production and supply chain will be tested and developed for later use in series production, through factory elements: 1. RFID provides vehicle data throughout the plant; 2. Pearl chain concept synchronizes production and logistics; 3. Driverless floor conveyors; 4. Driverless transport system; 5. 3D building scans; 6. Smart maintenance; 7. Virtual assembly planning; 8. Virtual container planning; 9. 3D printing; 10. Paint shop cockpit; 11. AudiStream – virtual plant tour; 12. Vehicle localization drone.

The trend in the context of the circular economy is interdisciplinary collaboration between research, industry and IT and thus meet the needs of automation and digitization of the automotive industry.

5. EU Directives and Strategies regarding Eco-Innovation

The European Green Deal is the European Union's answer to the climate crisis and continuing resource exploitation. It lays out solutions for transitions to a fundamental transformation of the economic systems, operating within our planetary boundaries and aligned with a 1.5°C scenario.

In its 2020 Strategy for Sustainable and Smart Mobility [16], the European Commission has set an intermediate target of at least 30 million zero-emission vehicles by 2030, as well as the 2050 target for zero-emission vehicles to be most of the fleet, which is a significant increase from the approximately 2 million electric vehicles currently registered in the EU.

The European Commission set up the Eco-innovation Action Plan as a commitment of the Europe 2020 Innovation Union Flagship Initiative.

It focuses on the specific bottlenecks, challenges and opportunities for achieving environmental objectives through innovation. The plan includes seven targeted actions on both the demand and supply sides, on research and industry and on policy and financial instruments. The measures are undertaken by the European Commission, national and regional authorities, industries and research organisations.

Current key priorities are mobilising finance and other actions to promote market opportunities for businesses involved in environmental technologies. This includes establishing credible verification of environmental performance to increase confidence in eco-technologies. Building on the experiences of the "Eco-Innovation Scoreboard", the Commission will monitor and review measures taken by Member States and the EU. In March 2022, the European Commission presented its proposal for an Ecodesign for Sustainable Products Regulation along with the Ecodesign & Energy Labelling Working Plan 2022-2024 [17].

The automotive industry is at the center of this new paradigm, generating over 7% of Europe's GDP. The Circular Cars Initiative EU policy action roadmap provides a compelling synthesis of the policy ideas that will inform and inspire EU-level policy-making. System interlinkages, structural and political lock-ins, as well as questions on economic and social effects need to be considered [18].

6. Conclusions

The circular economy is interconnected with climate policy objectives and the development of sustainable mobility systems is aligned with global climate commitments. The transition to electric vehicles is likely to be more sustainable if it is approached from both a climate and a circular economy perspective.

Stimulating innovation and addressing the availability and use of resources are on the current agenda of car manufacturers.

Eco-innovation can provide environmental, economic and social benefits, create an advantageous situation and improve the sustainable performance of the automotive industry.

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