ALIGNING SUSTAINABILITY AND CORPORATE STRATEGIES:
The case of hybrid-electric vehicles and Fiat-Chrysler Automobiles
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Thesis presented to Escola de Administração de Empresas de São Paulo of Fundação Getulio Vargas, as a requirement to obtain the title of Master in International Management (MPGI).

Knowledge Field: Management and competitiveness in global companies

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Abstract

This study analyses the integration of environmental sustainability into corporate strategy in the context of the car industry. The implementation of sustainability strategies and the development of hybrid-electric vehicles are investigated with reference to the case of a major player in the industry. Among the applications of electric mobility, which will increase the market presence in the forthcoming years due to stringent regulations and customer preferences, the research focused on hybrid-electric vehicles.

The sustainability strategies of major car manufacturers and the subsequent implications in terms of product development, with a particular attention to hybrid-electric vehicles, were analysed via secondary data. Additionally, primary data was collected about the sustainability strategy of a major player in the industry and used to perform a case study.

The analysis focused on critical drivers and aspects that impact on sustainability strategies aimed at reducing the environmental footprint of the car industry and on the development of hybrid vehicles. The analysis of the data showed that Fiat-Chrysler Automobiles (FCA) had a minor emphasis on electric mobility in terms of sustainability reporting.

The conclusion presents an assessment of FCA’s corporate strategy in terms of environmental sustainability and a framework for HEV development with four different approaches that impact on the sustainability strategy of a carmaker.

**Keywords:** environmental sustainability, electric mobility, hybrid-electric vehicles.
Resumo

Este estudo analisa a integração da sustentabilidade ambiental na estratégia das empresas no contexto da indústria automobilística. A implementação de estratégias de sustentabilidade e o desenvolvimento de veículos híbrido-elétricos são investigados com referência ao caso de um ator principal na indústria. Entre as aplicações de mobilidade eléctrica, que irá aumentar a presença no mercado nos próximos anos devido às regulamentações rigorosas e as preferências dos clientes, a pesquisa está focada em veículos híbrido-elétricos.

As estratégias de sustentabilidade das grandes fabricantes de automóveis e as implicações subsequentes em termos de desenvolvimento de produtos, com uma atenção especial aos veículos elétricos híbridos, foram analisados através de dados secundários. Além disso, os dados primários foram coletados sobre a estratégia de sustentabilidade de um ator importante na indústria e usados para realizar um estudo de caso.

A análise incidiu sobre os fatores críticos e os aspectos que têm impacto sobre as estratégias de sustentabilidade, que visam reduzir o impacto ambiental da indústria automobilística, e sobre o desenvolvimento de veículos híbridos. A análise dos dados mostrou que a Fiat-Chrysler Automobiles (FCA) teve uma ênfase menor na mobilidade eléctrica em termos de relatórios de sustentabilidade.

A conclusão apresenta uma avaliação da estratégia corporativa da FCA, em termos de sustentabilidade ambiental, e apresenta um quadro para o desenvolvimento de veículos híbridos com quatro abordagens diferentes que têm impacto sobre a estratégia de sustentabilidade de uma montadora.

**Palavras-chave:** sustentabilidade ambiental, mobilidade eléctrica, veículos híbrido-elétricos.
List of Abbreviations

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<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>BEV</td>
<td>Battery-Electric Vehicle</td>
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<td>CARB</td>
<td>California Air Resource Board</td>
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<td>EV</td>
<td>Electric Vehicle</td>
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<td>FCV</td>
<td>Fuel Cell Vehicle</td>
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<td>HEV</td>
<td>Hybrid-Electric Vehicle</td>
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<td>ICE</td>
<td>Internal Combustion Engine</td>
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<td>LCA</td>
<td>Life-Cycle Assessment</td>
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<td>LEV</td>
<td>Low-Emissions Vehicle</td>
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<td>PHEV</td>
<td>Plug-in Hybrid-Electric Vehicle</td>
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<td>WCM</td>
<td>World Class Manufacturing</td>
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<td>ZEV</td>
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1. Introduction

Among the major industrial sectors, the automobile industry has a notable economic significance. Being the preeminent thrust of industrial growth in many countries such as the US, Brazil, Germany, France, Italy, Korea and Japan throughout the 20th century, the car industry has a relevant transversal influence on technological development, associated infrastructures and creation of jobs in the abovementioned countries (Pellicelli, 2014; Orsato, 2009; Arthur D. Little, 2009).

The industry has also a significant impact in environmental terms. The size of the sector amplifies the effects associated to the whole life-cycle of its final output: the automobile. Thence, the automobile emerges as the product of one of the most influential economic sectors of the 20th century and “is not just a physical product of technology but it also has economic, environmental, social, cultural, and political dimensions” (Orsato and Wells, 2007: 995).

The focus on the car industry relies in the fact that it represents “the economic sector most emblematic of modern times and of the polluting consequences of modernity” (Orsato and Clegg, 1999: 264). It is a fundamentally global industry dominated by multi-national enterprises that is also a major contributor to environmental damage worldwide, and thence its economic and environmental significance marks it as a crucial case for study.

Acknowledging that the car industry is a manufacturing sector with internationally integrated investments, production and sales, suggests that it is a leading example of an industry that possesses the resources to either reduce or increase global environmental damage (Mikler, 2007). Given this recognition, two contrasting perspectives emerge. The dominant viewpoint is that the industry’s products are a major cause of global environmental damage. On the other hand, there are positive examples of the industry’s efforts to strike a balance between the imperatives of profitability and environmental sustainability. This balance was already anticipated in 1995 by Porter and van der Linde, who launched the proposition that companies with
high environmental standards are more competitive than the laggards. According to Porter and van der Linde (1995b:114) “companies must start to recognise environmental improvements as an economic and competitive opportunity, not as an annoying cost or an inevitable threat”.

The industry’s efforts to reduce its environmental footprint concern both the process of production and its final product – the automobile. There is an extensive body of literature specifically focusing on the development of products and systems that aim at reducing the environmental impact of the car system. Improvements might be related to the choice of materials, innovations in engines and propulsions, and recalibration of size and weight of cars. In particular, studies and researches on the electrification of mobility are constantly growing as long as an increasing number of carmakers moves toward the field of electric mobility and starts selling cars that include a partial or total electrification.

Among the different expressions of electric mobility, hybrid-electric vehicles (HEV)¹ are gaining market share and present several advantages over other options of sustainable mobility, such as battery-electric vehicles (BEV) or fuel cell vehicles (FCV). The hybrid-electric technology is less competence-destroying compared to those of BEVs and FCVs. Moreover, HEVs are characterised by a continued wave of development that led to an actual diffusion of this technology in the market and commercial success (Wesseling et al, 2014).

Innovation, progress and learning on electric technology took place alongside progress and learning on internal combustion engine technology (ICE). Hybrid-electric engines emerged alongside the existing dominant paradigm of gasoline and diesel technology. Hence, the intrinsic link between ICEs and HEVs favours their application.

Nevertheless, major car manufacturers have different approaches and aptitudes toward the development of hybrid systems. Some adopted this technology enthusiastically and leveraged it as a flagship for their sustainability strategies. Other

¹ See Appendix 1 for further details on architectures of Hybrid-Electric Vehicles
groups that did not invested in hybrids in the last decade are now making efforts to catch up. Others are sceptical, postponing investments and introduction of hybrid vehicles.

According to IHS (2013), currently HEVs represent only 2.3% of the total car production worldwide, but their presence is growing; the compounded annual growth rate over the period 2013-2020 is expected to be 14%. Indeed, industry experts seem to agree that HEVs represent the most suitable solution to drastically reduce CO₂ emissions of conventional engines and comply with more stringent regulations expected over the next years.

Also, at the current stage of development, HEVs appear as the most viable and workable solution to pave the way for the diffusion and adoption of electric mobility on a large scale. A shift to electric mobility requires profound changes in the roots of the transportation and car system ranging from infrastructure, to driving behaviour, to progress in the involved technologies. Hybrid-electric vehicles are included in a positive tendency towards electric mobility but, unlike battery-electric or fuel cell vehicles, they don’t rely solely on special recharging infrastructure – still in their early infancy in most countries.

In the corporate perspective of biggest groups, development of hybrids represents hence a threshold in terms of their approach toward environmental sustainability and a possible way of gaining competitive advantage over rivals. Indeed, as Porter noted, “selling poorly performing, unsafe, or environmentally damaging products is not a route to real competitive advantage in sophisticated industry and industry segments, especially in a world where environmental sensitivity and concern for social welfare are rising in all advanced nations” (Porter, 1990: 648). Twenty-five years on, those concerns play a crucial role today and are undoubtedly shaping industry’s dynamics.

Considering the above, the aim of the research is to identify the most relevant trends in the industry and the approach of a major car manufacturer in terms of HEV development.
Instead of framing the wide landscape of corporate sustainability as a whole, this research will mainly focus on environmental sustainability, given the relevant harmful impacts of the car industry on the environment. In particular, it develops a case study aiming at identifying the critical factors influencing the implementation of the sustainability strategy of a big carmaker, operating in different regions with a broad portfolio of brands, and the main drivers of hybrid vehicles development.

Therefore, the present research aims at analysing how firms in the auto industry integrate environmental sustainability into their corporate strategies. The development of hybrid-electric vehicles will be taken as a lens to investigate their attitudes in terms of product development and the approach towards sustainable mobility. Consequently, the study aims at answering the following research question:

“What is the sustainability strategy of FCA regarding electric mobility and the development of HEVs?”

The literature review looks into how corporate sustainability evolves in the car industry, highlighting the variables involved in the development of HEVs. The advantages and drawbacks of the various technologies are analysed in order to understand why they currently represent just niches in the market and their positive impacts in terms of environmental sustainability.

The study is based in two main sources of data. First, it analyses the sustainability strategies of the biggest players via the sustainability reports. Second, it develops a case study based on in-depth interviews of representatives of Fiat-Chrysler Automobiles (FCA), a major player in the industry that adopted a peculiar approach towards HEVs. The analysis of the case allows the identification of the influences on HEV development.

The study is organised in the following chapters. Chapter 2 presents the theoretical background on corporate sustainability and on the applications in the car industry. Chapter 3 explains the methodology and defines the phases in which the analysis is articulated. Chapter 4 contains the analysis of sustainability reports of the biggest car
manufacturers and an analysis of patents related to technology development of hybrid vehicles. Chapter 5 presents the case study on the sustainability strategy of FCA. Chapter 6 presents the discussion of the case study and develops a framework for HEV development. In the conclusion, the key research contributions are presented along with a critical review of the potential of HEVs as the next dominant design. This is followed by limitations and recommendations for future research.
2. Literature Review

2.1. The Evolution of Corporate Sustainability

Nowadays, organisations face increased risks, from more sources and with greater impact. These increased risks also create new opportunities for innovation that can drive financial performance and lead to improved sustainability. Instead of using reactive strategies that only respond to government regulations, industry standards, or consumer protests, companies can become leaders in corporate sustainability by creating proactive strategies, which, in turn, generate opportunities and increased profits (Figge and Hahn, 2012). The opportunity to gain competitive advantage through proactive sustainability strategies emerges from the analysis of remarkable examples in companies such as GE and Toyota (Epstein, 2008).

Leading companies conceive responsiveness to social and environmental concerns as an asset, that produces increased revenues, rather than a liability with associated costs. They recognise an investment in structures and systems, which ensure strong social and environmental performance, as a major enabler of improved process and product quality, improved production efficiency, improved reputation, lower risks, and increased profitability (Epstein, 2008).

Further, executives recognise that long-term economic growth is not possible unless it is sustainable from the social and environmental perspective (Mysen, 2012; Unruh and Ettenson, 2010). A balance between economic progress, social responsibility and environmental protection, also referred to as the “Triple Bottom Line” approach (TBL), can actually lead to competitive advantage (Slaper and Hall, 2011; Sridhar, 2012; Mitchell et al, 2012).

Through a comprehensive assessment of processes and products, companies can more broadly evaluate their impact on the environment and on society, seeking for the intersection between improving social and environmental impacts and increased financial performance in the long run. The evaluation of such impacts is necessary
for an effective decision-making process that positively affects organisational targets and satisfy the needs of multiple stakeholders. In many cases, reducing these impacts increases long-term corporate profitability through higher production yields and improved quality (Epstein, 2008).

The growing interest among the business community concerns the development and implementation of sound, pre-emptive strategies including a significantly increased stakeholder engagement (Mayfield, 2014; Hult, 2011; Ayuso et al, 2011). Indeed, the financial payoff of a proactive sustainability strategy can be substantial and improve the bottom line. However, in order to become a leader in sustainability, it is important to articulate what sustainability is, develop processes to promote sustainability throughout the enterprise, measure performance in sustainability terms, and link this to financial performance. Corporate citizenship is intended by authors as the way companies integrate sustainability principles with everyday business operations and is an important driver for building trust in the organisation and obtaining a “license to operate” within communities (Steger et al, 2007). As a result, an increasing number of companies are proactively publishing their principles and activities related to CSR (Kilian and Hennigs, 2014). A solid, long-lasting and effective sustainability strategy must be representative of and integrated into day-to-day corporate activities. When conceived only as an attempt to provide persuasive public relations, it will not create long-term value and can even become a destructive agent of corporate value (Epstein, 2008).

Marc J. Epstein (2008) identified nine principles of sustainability performance that can be integrated into day-to-day management decisions processes. These guiding principles include ethics, governance, transparency, business relationships, financial returns to investors and lenders, community involvement and economic development, value of product and services, employment practices, and protection of the environment.

In managing corporate sustainability, it is also critical to identify relevant stakeholders and their value. The way in which an organisation defines its stakeholders influences the consideration of stakeholder relations and how stakeholder reactions are
managed. Further, in order to better integrate a broader set of stakeholder concerns into management decisions, an organisation must consider the importance of being accountable. Becoming an accountable organisation requires improvements in terms of corporate governance, improved reporting to a broad audience both internally and externally, and enhanced management systems to drive these improvements through corporate culture and impact the way managers take decisions.

Sustainability has been defined as economic development that meets the needs of present generations without compromising the capability of future generations to meet their own needs (Bruntland, 1985; Elkington, 2006). According to Epstein (2008), in business terms, this encompasses issues of corporate social responsibility and citizenship along with the improved managing of social and environmental impacts and improved stakeholder engagement. These issues have gained considerable attention from the management of both global and local enterprises. Thence, at present the challenge has moved from “whether” to “how” to integrate corporate social, environmental, and economic impacts into management decisions. In fact, managers at all levels are under significant incentive pressures to increase short-term earnings. The debate it is now focused on how to be more socially responsible or sustainable and engage in the relations with stakeholders more effectively. It is about the specific actions that managers can take to deal with the paradox of trying to simultaneously improve both the social and financial side of the equation (Figge and Hahn, 2012).

Currently, leading companies have increasingly acknowledged the critical importance of managing and controlling corporate social and environmental performance and the consequent potential impact on long-term profitability. The impulse for implementing a corporate strategy that integrates the aforementioned impacts may be driven by internal factors, such as the recognition that sustainability can create financial value for the corporation or by commitment of the top management to sustainability as a core value. Often, however, the leading impetus for a sustainability strategy originates from external pressures such as government regulation and customer preferences, to cite a few (Mikler, 2007).
Nevertheless, some companies have not developed yet any coherent sustainability strategy or even any standardised way of managing their negative social and environmental impacts (Epstein, 2008).

On the other side, some have recognised the social and environmental effects of their actions, consequently developed a corporate sustainability statement, and made progress towards the definition of policies that confront the problems. Some companies have effectively developed reactive systems to address the same issues, others instead have been proactive. Leading companies examine the impacts of their products or services, processes, and other activities more broadly and in connection to a wider set of stakeholder concerns.

Therefore, sustainability cannot be managed just as a public relations strategy to pacify concerns of internal and external stakeholders. This approach can be quite risky as “stakeholders expect actions and results to be consistent with rhetoric” (Epstein, 2008: 21). Moreover, performance can be improved and value created only through the identification and the relative measurement of sustainability impacts. This is why sustainability must be integrated into the way a company generally operates, in order to be valuable to the organisation and to its relevant stakeholders. Alongside, firms should not underestimate their ability to turn corporate social responsibility into competitive advantage (Collis et al, 2012). Finally, Epstein also identified four main reasons that explain why sustainability came to the fore as a central debate. Firstly, government regulations and industry codes of conduct are requiring companies to increasingly address sustainability issues. Secondly, gaining a “license to operate” from community relations is of critical importance for corporations to be able to conduct business on an ongoing basis. Thirdly, enhanced revenues and lower costs justify the implementation of sustainability as a good business decision. Lastly, companies incur in societal and moral obligations that lead executives and corporations to include sustainability in their strategies.

Corporations have become more sensitive to CSR-related issues and are seeking to become better “corporate citizens”. As companies seek for ways to improve their performance, determining the best route to integrate environmental and social
improvements into all parts of the organisation still presents challenges (Epstein, 2008). Fundamentally, implementing a sustainability strategy is different than implementing other strategies within an organisation (Windolph et al, 2014). Considering operating targets, the direct link is usually clear and evident. In terms of innovation, the intermediate objective is the delivery of new products and the ultimate goal is embodied in the growth of profit. However, when it comes to sustainability the goal is to simultaneously achieve excellent levels of performance in both social, environmental and financial terms. Managing and measuring this “paradox” generates several challenges. Authors highlight the complexity of implementing proper systems to pursue sustainability and to evaluate the associated impacts on financial performance and the trade-offs that ultimately must be made (Epstein, 2008; Windolph et al, 2014).

Also, the cost of implementation is constantly changing. Even if sustainability is expected to provide positive financial returns, these benefits can only be measured over long time horizons. The unpredictability about how to approach sustainability, the continuously changing emphasis on the implementation of sustainability, and the long time perspective make it difficult to implement sustainability as in the case of other strategic initiatives and, hence, standard approaches often fail (Epstein, 2008). In order to promote the integration of social and environmental impacts into day-to-day management decisions, companies must incorporate measurement and reporting of these impacts into their traditional decision-making processes. Further, these impacts must be measured and reported in financial terms and then integrated into conventional reporting schemes. Translating strategy into action requires appropriate systems and structures that provide managers with information and benchmarks about their current and past performance (Epstein, 2008). Only with such measures and systems managers can make short- and long-term decisions while being aware of the associated risks and opportunities (Mitchell et al, 2012).

Vision and core values are also essential and must embody a commitment to social and environmental concerns that is consistently communicated both in words and actions (Collis et al, 2012). This implies that companies must decide the scope in which they want to integrate these concerns, align the organisation consequently,
and continually reinforce these objectives at all layers of the organisation. Further, they must choose a strategy that is consistent with mission and vision and integrated with products, geography, and customers. Strategy and leadership are minimum requirements for a successful implementation of sustainability strategies (Galpin and Whittington, 2012). The execution of sustainability strategy is just as critical as its formulation.

To sum up, sustainability must be an integral, solid component of corporate strategy. Sustainability strategies must be supported with management control, measurement of performances, and appropriate reward systems. Also, sustainability strategies should be supported with mission, corporate culture and people. Then, managers must integrate sustainability into all strategic and operational decisions. Interpreting sustainability only as compliance and risk avoidance is a partial, inadequate perspective. Instead, managing sustainability performance represents an opportunity for innovation and competitive advantage.

### 2.2. Corporate Sustainability and Competitiveness

Among the three dimensions of corporate sustainability that are expressed in the Triple Bottom Line approach, namely social development, environmental protection, and economic development, in this study environmental protection has the highest relevance, in line with a study of Lin et al (2014), and Kilian and Hennigs (2014), who investigated corporate social responsibility (CSR) and environmental reporting in controversial industries (i.e. industries with high public visibility and political risk). Facca-Miess and Santos (2014), for instance, identified a correlation between corporate sustainability and market value, and between competitive advantage and environmental protection, as one of the three pillars of corporate sustainability.

The relationship between competitiveness and the environment has already been investigated by Porter and van der Linde in 1995. The authors analysed the underlying logic between the environment, resource productivity, innovation, and competitiveness, aiming at creating a framework for environmental improvements
undertaken by companies and the related effects in terms of resource productivity. The authors argued that properly designed environmental standards can lead to innovations that lower the total cost of the product or improve its value. In fact, when regulators set standards in ways that deter innovation, companies react by opposing and delaying regulations instead of innovating to address those regulations and generating competitive advantage. Pollution was identified by the authors as the quintessential expression of inefficiency and economic waste. Pollution in its various forms is a “sign that resources have been used incompletely, inefficiently, or ineffectively” (Porter and van der Linde, 1995a: 122). Therefore, companies must include the opportunity costs of pollution to increase their resource productivity. Accordingly, the cost of addressing environmental concerns and regulations – one side of the trade-off between social benefits and industry private costs – can be minimised, where not eliminated, through innovation that delivers other competitive benefits. In this perspective, regulation is deemed crucial in creating a positive pressure that motivates companies to innovate and to improve their environmental quality. Properly designed environmental standard triggers innovation that may partially or fully offset the costs of complying with them. In other words, the right kind of regulation can enhance competitiveness stimulating companies to embed environmental impacts in the overall process of improving productivity. While the cost of compliance may rise with stringency of regulations, the potential for innovation offsets may rise even faster. Measurement was also already indicated by the authors as a crucial tool to accelerate companies’ progress toward a more competitive environmental approach.

Porter and van der Linde concluded that companies needed a new mindset, becoming more proactive in defining new types of relationships with both regulators and environmentalists. In an increasingly global business environment, companies must seek to improve their resource productivity by producing existing products more efficiently or by making products more valuable to customers. Then, the new paradigm of global competitiveness is the one that “brought environmental improvement and competitiveness together” (Porter and van der Linde, 1995a: 133) stimulating industries to take a new standard as a challenge and respond to it with innovation.
Within the scope of transportation, the environmental impact of motor traffic depends on the stock and usage of motor vehicles, and on environmental damage per vehicles; the latter may be reduced by improved technology of vehicles, but growth in traffic will tend to increase environmental damage. Environmental policies have to ensure that mobility requirements are met without unacceptable environmental damage (Madhavan, 2000).

2.3. Sustainable Mobility

Mobility, especially in urban and metropolitan areas with a large demographic and industrial concentration, is so intense to generate, for those people who live and work there, particular categories of economic and social costs (i.e. the so-called negative externalities) of which a direct and individual responsibility cannot be reconstructed, but that are significantly lowering the quality of life: pollution and congestion (Senn et al, 2011).

Data show that demand for mobility, as a whole, has been steadily growing, both in terms of number of shifts and total distances, and the trend is expected to continue in the coming decades (EnergyLab, 2011). Thus, any attempt to intervene on mobility to reduce congestion and pollution – in order to make life better on a quality level – is part of a complex set of policies that seek to make mobility sustainable in space and time. Attempts are numerous, confirming a widespread awareness of the seriousness of the issue but also highlighting the complexity of the solutions that must be implemented to achieve effective results. Solutions range from commitment of many automakers in developing vehicles driven by energy sources other than gasoline to that of producers of fuel and devices to reduce harmful emissions, to a reorganisation of private and public transport. A route toward sustainable mobility is therefore a major and complex challenge.
2.3.1. From the Current Dominant Design to Electric Mobility

A relevant part of the challenge is related to the peculiarities of the car industry and of its final output: the automobile. Car manufacturers must address economic, environmental and social demands simultaneously in an extremely competitive and inflexible industry marked by overcapacity and market saturation. They have to achieve impressive volumes due to huge investments in manufacturing technologies and margins remains very low. Also, the modern automobile appears to be highly inefficient as a result of its idiosyncratic traits. The technological regime of the modern automobile is best defined by three main characteristics (Orsato and Wells, 2007). First, the “all-steel” car body made possible the mass production of cars but required high capital investments and imposes economies of scale. This production technology negatively affects flexibility of car manufacturers and the car bodies’ weight, which, in turn, causes higher fuel consumptions and emissions. Second, the internal combustion engine (ICE) emerged as the only viable technology for powertrains towards the end of the 19th century and has reigned for more than 100 years. External influences, such as those coming from the petroleum industries, and intrinsic limits of the industry determined the slow pace of development of alternative technologies for power generation fostering, instead, continuous improvements in the efficiency of internal combustion technology. Third, cars are designed to serve a wide array of purposes, ranging from fuel capacity to occupancy and speed. High levels of rivalry in the industry favoured consumers to request a broad variety of models. These led to a proliferation of models and variants given the underlying objective of car manufacturers to increase sales by broadly meeting customers’ needs.

On a wider perspective, the auto industry is under a strong economic pressure and has been driven through a process of restructuring and redefinition of its competitive strategies. Car manufacturers faced pressure to invest in product development but the low profitability that characterises the industry puts pressure on them to cut costs. Imperatives of cost reduction and a combination of low margins with high break-even points highly exposed car manufacturers to market fluctuations and imposed a rationalisation of production systems (Orsato, 2009). Enormous capital investments and the need for synergies and cost savings forced industry players to undertake
processes of mergers and acquisitions. M&A allowed them to reduce risks, obtain resources and access new markets and segments (Chung and Alcacer, 2002). Besides that, given the size of the sector and the extensive environmental footprint in all phases of the automobile’s lifecycle, the industry has been under a persistent pressure to improve its environmental performance. In fact, from the 1990s onward standards and measures on air emissions have continuously intensified and carmakers have responded to the regulatory and market pressure investing in research and development activities. However, the current technological paradigm shaping car design and manufacturing essentially “limits the alternatives available to them” (Orsato and Wells, 2007:1005). Hence, the industry and its final output appear to be both economically and ecologically inefficient, leaving room for sustainable innovations aiming at creating competitive advantage on a large scale.

Among the potential applications of sustainable mobility, electric mobility has gained considerable attention. However, there are still critical obstacles to a rapid diffusion of electric mobility, albeit its relevant benefits for society are evident. Senn et al (2011) identified five factors that might hinder the path toward electric mobility. First, the perception of the business potential is not favouring partnerships that would boost technology development. Second, an intrinsic cultural obstacle can be recognised in the demand, which is influenced by features of the current offering (e.g. high costs, long time of recharging, logistic complexities). Third, public authorities are not resolute and converging enough in their choices on energy policies. Fourth, some players in the mobility industry and in the related markets, such as carmakers and fuel producers, are expressing their opposition. Finally, the industry and the value chain are still characterised by few technical problems that might undermine the economic convenience of adopting alternative solutions in the short and medium term, even though the technologies as such are already available and widely tested. In more general terms, the authors affirm that the biggest obstacle to a prompt diffusion of electric mobility is represented by the need for solutions that allow a simultaneous match of the various interests at stake.

Demand and supply still need to be completely integrated to activate an irreversible process of mobility electrification. On the demand side, at the present stage and
despite a diffuse and growing sensitivity of customers toward the environment, customer willingness to change their mobility behaviour in favour of electric mobility still remains unknown.

The rise of the electric car must overcome the obstacles of cost and comparability to traditional mobility and current low emission vehicles. Cost represents the major problem along with issues of recharging infrastructure and range. Only with an appropriate combination of costs, recharging infrastructure, and range, the perceived drawback of electric vehicles will be removed. In fact, the authors indicate that the environmental driver isn’t sufficient where not sustained through improvements in technology (e.g. range, reliability), in terms of economic convenience (e.g. cost, monetary incentives) and in psychological terms (i.e. the new vehicles must have a “niche” aptitude and be a distinctive element of “lifestyle”). Overall, the biggest challenge concerns the development of batteries with higher resistance and duration, and that will cost around half of the current price. Further developments concern the recharging infrastructure that must be highly standardised and accessible in order to create awareness and faith in the product for a daily, continuous use.

2.3.2. Applications of Electric Mobility

Sustainable and electric mobility trajectories have been intensively researched and analysed in the last decade. Dijk, Orsato and Kemp (2013) identified a series of causes that influence the development of vehicle engine technology. These include changes in fuelling infrastructure, changes in mobility, changes in the global car market, evolution of energy prices, climate policy, and changes in the electricity sector. The authors sustain that electric mobility is benefitting from various developments affecting the car industry and that it has therefore crossed a critical threshold.

The development of electric mobility occurred through the emergence of various systems which sequentially were developed and appeared on the market. Since the early 1990s, three Low Emission Vehicle (LEV) technologies have competed as “sustainable” alternative to the dominant ICE: fuel cell, hybrid-electric, and battery-
electric vehicles (Bakker et al, 2012; Pinkse et al, 2014). Of these, battery-electric vehicles and hydrogen fuel cell vehicles appeared to be “prone to cycles of optimism and pessimism” (Dijk, Orsato and Kemp, 2013: 137).

After brief fluctuating appearances throughout the 20th century, battery-electric vehicles (BEV) re-emerged in the early 1990s thanks to few small companies outside the high volume car industry. Interest in the development of BEV was raised by new regulations imposed by the State of California (USA), favouring the adoption of Zero-Emissions Vehicles (ZEV), and by the ZEV Mandate introduced by the California Air Resource Board (CARB) in light of growing health problems caused by air pollution (Hekkert and van den Hoed, 2007). The ZEV programme challenged the ICE paradigm. A few niche players redesigned the product and processes in order to avoid the imperative of economies of scale, allowing them to be profitable even with few hundreds of vehicles sold. After that, high volume car manufacturers started investments in BEV development and applied the electric traction to existing models.

However, despite being more energy-efficient than conventional ICEs and generating substantial reductions of CO₂ emissions, mass-commercialisation was far because of small technological progress achieved in those years with regard to batteries. In fact, the main intrinsic limit of BEVs was related the high costs and limited lifetime and range of batteries, forming a barrier to market penetration (Budde Christensen et al, 2012; Kley et al, 2011). BEVs appeared only suitable for small cars in urban areas, having a maximum range of 100-200 km. Also, ZEV requirements were gradually watered down after fierce lobbying by vehicle manufacturers arguing that market opportunities for BEVs were low (Hekkert and van der Hoed, 2007). Consequently, the ZEV Mandate was relaxed during the second half of the 1990s and, by the early 2000s, political support for BEVs in the US had faded away. Hence, commercial production of electric vehicles almost stopped by the early 2000s (Yarime et al, 2008). The new ZEV regulation, by fostering the stimulation of new technologies not necessarily achieving zero emissions, offered strong advantage over ICEs and stimulated the development of FCV and HEV technologies.
By the turn of the century, attention shifted to hydrogen fuel cell vehicles (FCV). These vehicles have performance and range comparable to those of ICEs and appear as the only viable solution in the long-run since this technology can be implemented on medium and big sized car and for longer drive (EnergyLab, 2011). Therefore, they can contribute to important decreasing of emissions on a global scale given that vehicles of the cited segment represent more than 50% of the running fleet and 75% of CO₂ emissions (McKinsey, 2010). The technology can further be adopted on heavy means of transport as well. Yet, as in the case of BEVs, costs are still high and range low. Also, fuelling and storage infrastructure need to be improved in terms of safety and economic convenience. Hence, interest in FCVs fell sharply after 2007. Meanwhile, most players of the car industry stayed focused on the development and refinement of the internal combustion engine (ICE) technology. They insisted on incrementally improving efficiency of their ICE engines as the main source of value creation and thus leveraged existing complementary assets as a mean to reinforce their competitive position (Teece, 1986; Amit and Zott, 2001). The authors affirm that patents and new product launches over that period highlight that for many industry players it has not been economically attractive to invest in electric propulsions, deemed non-competitive in terms of costs and not appealing to customers because of range and price – lower the former, almost double that of a conventional car the latter.

However, drastic reductions of emissions can only be achieved through interventions that include a partial or complete electrification of the vehicle or the use of alternative bio-fuels such as hydrogen (Edwards et al, 2007). Hybrid-Electric Vehicles (HEV) allow a considerable reduction of CO₂ emissions, even though not achieving the elimination of the same, and are consequently considered as the only viable solution in the short-medium term for emissions reduction of vehicles on a large scale (Senn et al, 2011).

The application of the hybrid technology by Toyota and Honda represents a successful example of the commercialisation of alternative powertrain technology. The two Japanese firms "saw a business opportunity for the hybrid-electric powertrain technology, independently from regulatory measures" (Dijk, Orsato and
Kemp, 2013: 137). Despite the initial success and good reputation of the Toyota Prius, all the other players in the market remained reluctant to invest in the hybrid technology, insisting on improving efficiency and refining their existing ICE models.

Dijk, Orsato and Kemp (2013) argue that, after 2005, a shift in perception occurred as a consequence of climate change concerns driving the efforts towards electric mobility. Several causes are identified. First is the role of policies and programmes on climate protection that influenced the car industry requiring decreased CO₂ emissions. Second, a renewed interest for BEVs took the scene. Partnership such as the one between Renault-Nissan, a great supporter of EV technology, and Better Place, an infrastructure and service provider, showed a new radical approach to sustainable mobility through a battery swapping system. Third, new collaborations for battery technology development intensified within the supplier network, fostering the generation and sharing of competencies on batteries – the key element to improve performance and enhance the diffusion of BEVs. Fourth, is new investments in recharging infrastructure, an element as much critical as batteries for a wide implementation and commercial success of BEVs. Then, a new market opportunity for BEVs is represented by fleet operators. Especially in city centres, BEVs can be operated and maintained with lower costs compared to vehicles with traditional ICE technology. Also, fleet operators can arrange a network of recharging infrastructure for better use and charge of batteries. Finally, new mobility operators are emerging. These operators provide a wide range of mobility services by revolutionising the concept of car ownership and focusing on the use of the vehicle. For car-sharing companies, such as ZIPcar, and service providers, such as Better Place, electric vehicles are more attractive because of low operating costs and are aligned with range requirements. All the aforementioned elements are sustaining new and further efforts for a sustainable mobility fostering new market entrants and new powertrain diversification strategies of large automakers. The HEV technology, for instance, is now being adopted on a wide range of model, from SUVs to small-medium sized cars and small urban BEVs are already being sold. The authors also identified possible developments that will influence future trajectories of electric mobility. These include fuelling and road infrastructure; changes in mobility patterns that will benefit from inter-modality; the global car manufacturing regime which is changing in its market
size through new geographies (i.e. the emerging countries) and technological focus with emphasis on electric propulsion; energy prices that are expected to grow less than the oil price, favouring more fuel-efficient vehicles; changes in the electricity sector and growth of renewable energies; climate policies and public opinion requiring reduced CO₂ emissions.

2.3.3. Competition and Technology Development

Looking at the competitive environment in which electric vehicle development takes place, some competitive forces, related to each other, and the combination of the same can be identified as a support for LEV development. Wesseling, Faber and Hekker (2014) looked at how the industry structure develops around emerging Low Emission Vehicles (LEV) and focused on competitive forces such as rivalry, dispersion, and the presence of new entrants. In particular, they found that the combination of rivalry and dispersion is positively related to continued LEV development. Presence of new entrants and business model innovation are further analysed by Bohnsack et al (2014) who investigated different pathways undertaken by incumbents and new entrants in the car industry. Bohnsack, Pinkse and Kolk (2014) started from the assumptions that sustainable technologies often do not fit existing production methods, managerial expertise, and customer preferences (Johnson and Suskewicz, 2009) and that the potential benefit of resolving environmental degradation in itself does not seem a sufficient condition to generate widespread customer acceptance (Kley et al, 2011; Siegel, 2009).

Therefore, firms need different business model to transform the specific characteristics of sustainable technologies into new ways of creating economic value (Chesbrough and Rosenbloom, 2002) and overcome the barriers that might hinder market penetration (Johnson and Suskewicz, 2009; Kley et al, 2011). Through business model innovation, sustainable technologies would create new sources of value for customers, in addition to their positive impact for the environment. This is why many entrepreneurial firms entered the industry with innovations in the field of electric mobility, being "less constrained in the evaluation of alternative models" (Chesbrough and Rosenbloom, 2002: 550) and more flexible in pursuing radical
business models from scratch, but lack the resources to sustain a process of experimentation for a longer period of time (Sosna et al, 2010).

Consistently with Dijk, Orsato and Kemp (2013), Wesseling, Faber and Hekker (2014: 154) recognise that LEV development has been characterised by hypes, defined as “periods of increased optimism succeeded by periods of disappointments”. Thus, waves of development are broken due to alternate cycles of disappointment. However, the development of HEV represents an exception. The authors mark this technology as less competence-destroying and highlight that it is included in a continued wave of development that led to an actual diffusion in the market and commercial success. The basic assumptions the authors made is that when an increasing number and higher diversity of firms move into a new trajectory leading to more technological competition, the new technology is more likely to be continuously developed, improving its chances of commercial success. Therefore, there is a positive relation between competition and continued technological development.

While ICEs represent a mature technology that improved over the decades through a process of incremental innovation, LEVs under study are still in an era of ferment, as a transition from a radical innovation to another dominant design. Exploring more in detail the competitive forces that influence technological development, the authors start by analysing rivalry. Rivalry stimulates incremental innovation and plays a crucial role pressuring car makers to invest in LEV technology not to lag behind (Van Den Hoed, 2005). In the case of HEVs, this happened at first with an intense competition mainly between Toyota and Honda (Pohl and Yarime, 2012). After that, other firms entered the field and contributed to further technological development (Chanaron and Teske, 2007; Dijk and Yarime, 2010) supporting continued growth of LEVs. Next, dispersion is also identified as another relevant competitive force in this framework. High volume car manufacturers made the largest contribution to LEV development (Pohl and Yarime, 2012; Frenken et al, 2004; Van Den Hoed, 2005; Oltra and Saint Jean, 2009). However, many other firms throughout the supplier network and the related infrastructure supported LEV development in a wide array of business model combination (Dijk and Yarime, 2010). Finally, new entrants
contributed in particular to the development of competence-destroying technologies (Bohnsack et al, 2014; Tushman and Anderson, 1986), like those embedded in BEVs and FCVs, thanks to lower entry barriers and novel combinations of related technological fields (e.g. Better Place in Israel) through sustainable value innovation in a Schumpeterian fashion (Orsato, 2009). In particular, new entrants and start-up firms like Tesla Motors, Leo Motors, Better Place, and V2Green, to cite a few, focused on the competence-destroying BEV technology while incumbents focused on less competence-destroying technologies, such as those utilised for HEVs. In fact, with the exception of the battery, incumbents could depend on their existing value network (Bohnsack et al, 2014) having vast resources that provide a wide variety of starting points for business model innovation (Helfat and Lieberman, 2002) and allowing experimentation with multiple business models simultaneously (Doz and Kosonen, 2010). The implementation of hybrid technology on existing models allowed them to ride the wave of electric mobility with fairly minor technological adjustments.

In the end, when comparing competitive indicators among different types of LEVs, the authors consider HEV as the only technology that is included in a sustained wave of development due to the interaction of increased rivalry and dispersion. This is not the case for hybrid fuel-cell vehicles, while for battery electric vehicles the dynamic is not certain.

### 2.3.4. Peculiarities of the Next Dominant Design

The internal combustion engine is expected to remain the dominant design in the forthcoming years with established carmakers focusing on efficiency improvements of their traditional gasoline and diesel engines (Arthur D. Little, 2009). But new, low or even zero emissions, powertrain technologies are crucial for the automotive industry to respond to new tightened regulations, increasing energy prices and, as a result, changing customer demand. European and Japanese carmakers have a clear advantage concerning traditional engine technology. There is still enormous efficiency gain potential in this technology and no emerging car manufacturer will be able to rival the triad carmakers (i.e. carmakers from the US, Europe and Japan) on
this competitive advantage (Pellicelli, 2014; Arthur D. Little, 2009). But eventually traditional powertrain technology will disappear and emerging car manufacturers will invest heavily in new technologies as they consider this an opportunity to leapfrog the established competition. Thus, triad carmakers must develop strategies to achieve and protect competitive advantage in the future with new powertrains.

Trying to identify which technology will be embedded in the next dominant design after the internal combustion engine, competitive potential and future growth of HEV must be compared to that of FCV through an understanding of how these technologies fit in the existing technological system underlying the car industry. Hekkert and van den Hoed (2007) compared the development and emergence of the hybrid vehicles to that of the fuel cell vehicles in order to determine whether the HEV technology can become a dominant design. The authors start from the assumption that disruptive innovations deliver a dramatic leap in performance and incumbent firms tend to respond either by ignoring the new technology or by trying to improve the performance of the established technology.

While disruptive and radical innovations are highly imaginative, most technological progress has been made through incremental improvements in the available technology, products and processes. The authors focus on two major technological routes currently proposed by the car industry as a reaction to environmental regulations that require carmakers to increasingly look for technological alternatives. On the one side, the breakthrough route revolves around the fuel cell vehicle (FCV). On the other side, the incremental route features the hybrid-electric vehicle (HEV). The authors also highlight how HEVs played, at first, “a modest role in sustainable mobility” (Hekkert and van den Hoed, 2007: 46), being positioned as an intermediary stage between the dominant design of ICEs and the FCV technology, considered as the embodiment of the future trajectory of sustainable mobility. However, given the good environmental performance and recent commercial success, perspectives on HEV technology changed. Therefore, the authors aim at understanding to what extent HEV might form a competitive threat to FCV and which one of the two will become the new dominant design. They bring together theories of technology dynamics and technological forecasting in order to frame a model in which HEV and
FCV are studied as technological discontinuities. In this perspective, the HEV has already entered the stage of ferment, but the FCV has not yet done so.

The analysis of Hekkert and van den Hoed focuses on the automotive industry, the oil industry, institutional environment, environmental performance, and market performance to understand how well HEVs and FCVs fit with the actors and regulations in the automotive technological system. For instance, HEV technology is compatible both with the current ICE system and the existing infrastructure, while FCVs require changes both in car design and infrastructure. Thus, HEVs experience far fewer barriers than FCVs. Also, FCVs will require large organisational changes from carmakers to develop the technology. The only advantage for the FCV is in terms of emissions while the HEV leads in terms of technical and organisational implementation barriers and keeps the pace in terms of efficiency. Overall, FCVs still require significant improvements to be competitive in terms of performance and costs are still hard to estimate. On the other hand, HEVs are already widely commercialised and compete on drivability with conventional cars.

Finally, the authors gather a series of technological systems indicators and factors influencing the viability of FCV and HEV over time. HEV represents a less radical technological change, it is completely compatible with the current fuel infrastructure, and profited from the trend of regulation standards. Even though, in terms of environmental performance, the FCV technology has been seen as the best option for the future, the authors agree that expectations for FCV are uncertain and costs are likely to stay very high for a long time. Market potential for HEVs has been improving considerably due to significant cost reductions and increases in profitability. In terms of patents, vehicle manufacturers, after firstly shifting attention from BEVs to both HEVs and FCVs, widely focused on HEV programmes mainly. Accordingly, a majority of vehicle manufacturers is currently involved in HEV development, increasing the chances of HEV as a dominant design rather than an intermediary step. A further step to hydrogen FCV will require a simultaneous effort to change both the infrastructure and engine technology, but this is likely to happen only under a very strict regulatory system focusing on non-carbon emissions.
2.3.5. Motives of Environmental Sustainability Across Carmakers

Having framed the relevance of sustainable mobility solutions within the car industry and, among these, the central role played by the hybrid-electric technology, the focus of this study moves to how firms in the industry interpret environmental sustainability and how they integrate those concerns in their corporate strategies.

From the mid-1990s onwards, the industry has taken steps to proactively address questions of environmental sustainability and embed its principles into its business practices.

Three main reasons seem to shape this timeframe. First, international organisations have significantly raised the profile of environmental concerns over this period (Mikler, 2007). Second, Corporate Social Responsibility (CSR) came to the fore as an ideological shift that started in the 1990s and it includes environmental sustainability as one of its main pillars (Lin et al, 2014; Kilian and Hennigs, 2014). Third, a change in how firms do business worldwide can be recognised as they incorporate environmental sustainability concerns in their operations. The extensive body of research on sustainability and the adoption of the Triple Bottom Line approach (TBL) suggest that organizations are increasingly pressured to be accountable for their environmental performance (Slaper and Hall, 2011; Bergenwall et al, 2012; Sridhar, 2012).

In general terms, a blend of rational profit maximising motivations and behaviour based on norms may explain the new car industry’s aptitude. If a shift that sees environmental issues as central to the business interests of the car industry worldwide can be recognised, it is essential to understand what are the drivers underlying these concerns and the consequent reactions of carmakers, given their international economic significance and the resulting political power.

Mikler (2007) moves from the basic assumption that “without the intervention of regulators environmental externalities will never be internalised as firm responsible for them can rationally ignore the cost of them” (Mikler, 2007: 127). The author
considers MNCs as the most important actor shaping the contemporary global economy. The car industry is the archetypal example of an industry dominated by MNCs, truly global in its structures and operations as the international dimension of the product – the car – is embedded in its production. Thus, the author tries to understand how and to what extent the norm of environmental sustainability is being internalised among car manufacturers and how their behaviour has been changing.

Recalling the balance between the imperatives of profitability and environmental sustainability mentioned above, it must be taken into account that the car industry highly influence CO₂ emissions and has a relevant part on environmental damage worldwide. On one side, given the size and consequent economically powerful position, car MNCs have historically put strong political pressure on governments against environmental regulation because of the negative eventual economic impacts (Newell and Paterson, 1998; Bradsher, 2002). On the other side, the author registers that the possibility of the car industry proactively internalising environmental externalities is attractive. In fact, apart from technical developments that also include hybrid systems, the author identifies several initiatives undertaken by car MNCs that might attest a shift to greener strategies. First, initiatives in policy and reporting induce car firms to voluntarily publish annual sustainability report aimed at facilitating corporate transparency. Second, many environmental management systems are increasingly being introduced in order to minimise the environmental impact of production processes. Third, more collaborative agreements and partnerships with NGOs are realised. Fourth, car firms are engaging with the broader public in order to mark their commitment towards sustainability, leveraging on the importance of environmental protection and aiming at changing consumer preferences. Fifth, car firms are also involved in environmental initiatives not directly related to cars’ production and sale but generally focused on the reduction of CO₂ emissions. Finally, sustainable mobility as an overall goal is being included in the corporate strategies of most car firms. The development of HEV technology represent one of the main directions taken.

The author makes another crucial point in the demarcation between exogenous and endogenous factors driving the shift. Exogenous factors work at the level of
international organisations, nation states and consumer preferences. Endogenous factors are relevant at the industry level and to individual firms. For example, state regulations might induce firms to adopt new technologies and powertrains to reduce emissions. The same can be done by the industry players themselves to gain a competitive advantage in anticipation of future regulations. This is exemplified by the voluntary commitments by EU car manufacturers to reduce fleet average CO₂ emissions along with a range of other targets associated with vehicle emissions. These behaviours can further be interpreted as a way of gaining competitive advantage over rivals.

Then, US, European or Japanese firms have “endogenous characteristics that are specific to each of them over and beyond national characteristics” (Mikler, 2007: 146). Therefore, each of them differently approaches environmental sustainable development according to a different set of priorities determined by internal and external stakeholders. Leading car makers from these three countries envisioned the trajectory of electric mobility in different ways and translated it into the technologies they developed, across different market niches and geographies.

Overall, the author indicates that there is a normative change in attitude taking place, rather than just a change in behaviour. In fact, it is in the resource users themselves, those directly causing the environmental damage, in whose hands the solution is most likely to lie. The author concludes that explanations for the industry’s shift in behaviour lie with both exogenous and endogenous factors, with some exogenous factors having effectively been internalised by the industry. Concerns for the environment are among these and are increasingly included as part of successful long-term strategies and approaches to business.
3. Methodology

The route through the applications and the associated challenges in the implementation of electric mobility required an investigation of how and to what extent environmental sustainability is internalised among car manufacturers. Consequently, their approach in terms of product development is analysed with a specific focus on HEVs, given the increasing relevance for sustainability strategies within the boundaries of the car industry.

As it was identified in Chapter 2, hybrid-electric vehicles emerged as the most feasible technology for big car manufacturers to ride the wave of electric mobility at the current stage. Furthermore, HEVs present the features required to become the next dominant design in the coming decades and will pave the way for the diffusion of electric mobility on a large scale in the long run.

Within the major players in the car industry, Fiat-Chrysler Automobiles (FCA) has had a sceptical position in terms of electric mobility. Hence, the problem addressed in this research is the following:

“What is the sustainability strategy of FCA regarding electric mobility and the development of HEVs?”

The research highlights the characteristics of the sustainability strategy implemented by FCA and its focus on affordability and local adaptation as levers of differentiation. Consequently, in terms of product development, the emphasis on hybrid-electric vehicles has been limited. However, a partial shift to electrification of mobility is underway and industry players are adapting their approaches of sustainable mobility consistently. Therefore, FCA must adopt a different strategy that will plausibly entail a greater presence of hybrid vehicles.

The research investigates the field of electric mobility by analysing trends of HEV development specifically because of the potential in the short- and medium-term as a
critical component of carmakers’ sustainability strategies, and as a solution to reduce the environmental impact of the car industry.

The understanding of main drivers and critical success factors in the implementation of hybrid-electric technology is relevant due to the current interest of the industry around this technology and the associated development impulse. HEVs are crossing a crucial threshold and their presence in the market in the forthcoming years will be supported by the imperative of reduction of CO$_2$ emissions, driven mainly by regulations and increasingly by customer preferences.

FCA operates in countries where those drivers will be extremely supportive in terms of hybrid development. Therefore, the transition towards a greater role of electric mobility is relevant in terms of the integration of the motives of environmental sustainability in the corporate strategy of the Group and, subsequently, in terms of sustainable mobility and product development.

**Phase 1: Analysis of Sustainability Reports**

In the middle of the twentieth century there were more than 100 car manufacturers but the continuous consolidation of both producers and major suppliers in the light of overproduction has led to the creation of a number of major groups. Aiming at identifying the dominant industry’s trends in terms of environmental sustainability, I selected the 10 biggest players of the car industry in terms of sales worldwide in 2014. Once selected, I studied their sustainability strategies by performing a content analysis of their CSR and sustainability reports.

Companies commitment to environmental issues and to reduce their harmful impacts play a critical role in such reporting to stakeholders. Annual reports are considered to be the most important and highly credible source of information on corporate activities and performance in various fields. CSR reporting in annual reports is not practiced in a standardised way by companies and remains voluntary and unaudited (Beck et al, 2010). However, sustainability reports are increasingly published by carmakers on a yearly base. In their sustainability reports, carmakers focus on CSR
pillars and proactively publish their CSR-related principles and activities. In more
general terms, being one of the most important sources of information on corporate
activities, corporate annual reports include corporations’ self-reported CSR
performances and provide a means of determining the quality of corporations’
commitment to CSR (Macleod, 2001). Thus, voluntary environmental or social
disclosures provide a proxy for the environmental and social activities of the
company (Brammer and Pavelin, 2008). In the automotive industry, characterised by
public visibility and political risk, CSR and sustainability reporting are even more
critical and significant for stakeholders.

Sustainability reports were analysed in order to understand companies’ approach to
environmental sustainability and in order to identify the relevant trends in the
industry. Since this thesis focuses on the development of hybrid systems, the
analysis is concentrated on product development and innovations in terms of engines
and propulsion systems. Firstly, a content analysis to code development of hybrid-
electric engines and the assigned importance within corporate sustainability reporting
is conducted. In the second step, each of the sustainability strategies is further
analysed to categorise the company’s priority given to the different solutions that are
adopted to reduce environmental footprint and CO$_2$ emissions on the product side.
The results of the content analysis are integrated with a study of patent trends and
top assignees of patents referring to the development of hybrid systems.

**Phase 2: Case Study of Fiat-Chrysler Automobiles**

Once defined the general trends in the industry through the analysis of major players’
behaviour, a case was chosen. Three elements determined the choice of Fiat-
Chrysler Automobile (FCA) as case of analysis. First, the CEO of the group affirmed
that electric and hybrid cars, deemed not economically viable at the actual stage of
development, do not represent the best way to achieve targets imposed to carmakers
by institutions$^2$. Second, the content analysis confirms their position and the minor
emphasis on the role of HEVs, hence testifying the postponement of market
introduction when external factors and conditions would favour their diffusion. Third,

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$^2$ Source: Reuters, 2014
the Group is based in Italy, thus allowing the performing of the case study through direct interviews to company’s members and industry experts.

The performing of the case has been conducted through direct interviews to members of the sustainability teams, in charge of sustainability and CSR reporting in the parent company and in one of its subsidiaries; members of the product engineering; members of the process engineering; other industry experts in order to gather further perspectives on the market and future paths (see Appendix 3 for details on the interviewees). Hence, the case was developed mainly by researching the sustainability strategy of the Group and through two in-depth analysis of the solutions developed for products and processes.

Due to confidentiality reasons, interviews were not recorded. However, the information gathered were used in parallel with secondary data (e.g. corporate communication, industry information, databases) to create the case study.
4. Analysis and Interpretation of Sustainability Reports

This section includes a qualitative and quantitative analysis of the sustainability reports of the biggest players in the car industry. The analysis focuses on electric mobility and on the associated relevance within the scope of sustainability reporting. The results are integrated by an analysis of patents that are related to the development of hybrid technologies.

4.1. Analysis of Sustainability Reports

In a similar fashion to content analysis, I analyzed sustainability reports of 10 biggest carmakers published in 2014 with the support of the analysis program Atlas. Based on the rule that a code which is more frequently mentioned in the reports is weighted more highly, all the codes referring to hybrid and electric vehicles were summed. Consequently, the relative weight and importance was evaluated by the frequency of these specific codes in all the sustainability reports. Results were later processed with Microsoft Office Excel to create a synthetic index of the presence of the codes “hybrid” and “electric” in the reports. This index serves as a proxy for the emphasis given to the development of hybrid and electric cars within the scope of sustainability reporting. For instance, in the case of PSA, that leads the rank, out of 1000 words in the sustainability report 4,75 words refer to hybrid and electric vehicles. As a consequence, the commitment towards electric mobility is evaluated here only in terms of communication to the relevant stakeholders.
Table 4.1. Index of frequency of the codes “hybrid” and “electric”

<table>
<thead>
<tr>
<th>Index</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSA</td>
<td>0.475%</td>
</tr>
<tr>
<td>Honda</td>
<td>0.283%</td>
</tr>
<tr>
<td>Ford</td>
<td>0.268%</td>
</tr>
<tr>
<td>Volkswagen</td>
<td>0.151%</td>
</tr>
<tr>
<td>Toyota</td>
<td>0.151%</td>
</tr>
<tr>
<td>Renault-Nissan</td>
<td>0.130%</td>
</tr>
<tr>
<td>BMW</td>
<td>0.102%</td>
</tr>
<tr>
<td>GM</td>
<td>0.099%</td>
</tr>
<tr>
<td>Hyundai-Kia</td>
<td>0.084%</td>
</tr>
<tr>
<td>FCA</td>
<td>0.051%</td>
</tr>
</tbody>
</table>

Overall, the priority in product development is given to increasing efficiency of conventional ICEs and to the use of alternative fuels in the short term while, in the medium and long term, the focus is on alternative propulsion systems such as HEVs and BEVs. In parallel, all carmakers show big efforts in reducing their environmental footprint along production processes, striving to create “sustainable” value chains. However, some differences among carmakers can be recognised. They have different focus in product development, providing different solutions for the various regions in which they sell their products. Toyota, for example, relies mainly on hybrid versions of its models as a flagship for the group’s commitment to reduce CO₂ emissions. Hybrid vehicles are at the core of its “eco-cars” strategy along with more fuel efficient ICEs. They are also investing in fuel cell technology and marketing their first fuel cell sedan. BMW’s commitment to sustainable mobility is mainly centred on more efficient ICEs and on an increasing number of hybrid and electric vehicles. The strategies of GM and FCA are quite similar. They focus primarily on efficiency of ICEs. They invest in alternative fuels and then in alternative propulsions like HEVs and BEVs. GM’s and FCA’s strategies are also driven by geographies, delivering a variety of options and marketing those in the regions where are deemed most competitive. Ford promotes a “portfolio approach” investing in CO₂ reduction from its current ICEs and already offering on the market a wide range of alternative solutions that include vehicles driven by alternative fuels, BEVs, HEVs and PHEVs. In the future perspective they are investing in the development of fuel cell vehicles as well.
This approach is quite similar to that of Volkswagen that is also highly investing in alternative fuel systems and hybrid and electric vehicles. Hyundai-Kia, in order of priority, is currently investing in more efficient ICES, hybrid and electric vehicles, and fuel cell vehicles. Nissan and Renault are more focused in BEVs and already offer various electric models. PSA is instead more focused on HEVs and postpones the total electrification of its vehicles in the long term. Finally, a similar strategy is implemented by Honda that, in addition, is developing FCVs in the long term perspective.

4.2. Analysis of Patents

I integrated the results of the analysis of strategies, communicated through sustainability reports, with an analysis of the relevant trends from the perspective of technology development. Studies on patents related to hybrid vehicles and applications reveal that the real surge in the activity around this technology happened in the last decade. Patents began to rise during the second half of 1990s and applications broadened since year 2000. A study of Patent Insight Pro has been utilised to identify top assignees of patents on hybrid technologies until 2012. The patent set was created using the commercial patent database PatBase\(^3\) as data source and composing a search query that included “hybrid” or “electric” or “hybrid electric” for drivetrain or powertrain in classes related to engines and vehicles.

\(^3\) Source: https://www.patbase.com/login.asp
Toyota confirms the leadership role in the segment of hybrid-electric vehicles with far more patents assigned than the second Japanese firm, Honda, and than the other industry players. North American producers, General Motors and Ford, follow. European manufacturers until 2012 played a minor role and rely on their components providers, such as Bosch and ZF, for the development of hybrid-electric technologies. The only European manufacturer that ranks among the top 10 assignees is Daimler.
5. Case Study: Fiat-Chrysler Automobiles

The case study is composed of a first, general investigation of the sustainability strategy of the group and of two detailed analysis with focus on organisational processes and World Class Manufacturing on one side and on product development and powertrains on the other side. The present section begins with an introduction of FCA and is followed by the section on the discussion and implications of the most relevant elements presented below.

5.1. FCA – Group Profile

Fiat Chrysler Automobiles (FCA) is an international auto group engaged in industrial activities in the automotive sector, which designs, engineers, manufactures, distributes and sells vehicles, components and production systems. The company's activities are carried out through six reportable segments: four regional mass-market vehicle segments, a global luxury brands segment and a global components segment. The regional mass-market vehicle segment deals with the design, engineering, development, manufacturing, distribution and sale of passenger cars, light commercial vehicles and related parts and services in specific geographic areas, which include NAFTA, LATAM, APAC and EMEA.

Fiat Group has been designing, making and selling vehicles for more than a century and the alliance with Chrysler Group has given birth to a strong and competitive global automaker with annual sales of more than 4.4 million cars and light commercial vehicles and revenues of €87 billion\(^4\). FCA produces in 159 plants around the World and employs more than 225.000 people worldwide.

5.2. FCA’s Sustainability Strategy

Fiat S.p.a. published its first environmental report in 1992. The sustainability strategy, as summarised in the Company’s Sustainability Report, is articulated in 5 main

\(^4\) Data refer to FY 2013
commitments: protect the environment, reduce the impact of production processes, produce increasingly fuel efficient and low emissions vehicles, value diversity in culture and experience, promote sustainability practices by partners and stakeholders.

The group defines its strategy for sustainable mobility as focused on achieving a balance between conventional and alternative technologies that will deliver the greatest benefits for the environment at present, while also ensuring the capability to continuously offer customers affordable products. This includes designing systems and developing new technologies to cut CO₂ emissions and improve vehicle efficiency, as well as projects to address emerging mobility needs and customer-focused initiatives to raise awareness on the impact driving behaviour has on fuel consumption.

As stated in the Group Environmental Guidelines, the company is committed to adopting and developing solutions that are at the same time safe, environmentally-friendly and economically viable. Commitment to reduce CO₂ emissions spans from engines to production plans, transport activities, supplier activities, office-related activities and to eco-responsible driving.

The group's sustainability strategy has been rewarded by important sustainability ratings. In particular, FCA as a listed company has been confirmed in the Dow Jones Sustainability Indices (DJSI). The DJSI, launched in 1999, were the first global indices tracking the financial performance of leading sustainability-driven companies worldwide. The DJSI are among the most prestigious equity indexes, that only admit those companies judged best-in-class in the sustainable management being an integrated assessment of economic, environmental and social criteria with a strong focus on shareholder value. The criteria utilised to determine the performance of the company are: brand management, innovation management, supply chain management, climate strategy, low carbon strategy, operational eco-efficiency, human capital development, labour practice indicators and human rights, talent attraction and retention. FCA received a score of 89/100 compared with an overall average of 61/100 for companies evaluated in the automobiles sector. Also, the
group was named the leader in the CDP Italy 100 Climate Disclosure Leadership Index (CDLI) and Climate Performance Leadership Index (CPLI) for 2013. FCA received the highest score overall for transparency in disclosure (99/100) and the maximum score (A) for its commitment toward reducing carbon emissions.

Deepening the focus into the product offering, environmental sustainability is achieved through a mix of different solutions. The development of engines, in particular, is articulated into three levels. The highest priority is given to increasing efficiency of conventional internal combustion engines. FCA, through its components and services provider, Magneti Marelli, works on continuous innovation of gasoline and diesel engines and on downsizing to reduce CO₂ emissions. A second chapter is represented by the use of alternative fuels such as natural gas and bio-fuels. The group has gained a considerable advantage over competitors in this technology thanks to a wide range of applications of multi-fuel vehicles developed for different markets. In Europe FCA has the leadership in the market of natural gas vehicles with a market share of 67%. They also strongly emphasise the positive impact in terms of CO₂ emissions when compared to gasoline or diesel engine. Furthermore, it stresses the use of biomethane (i.e. a bio-fuel produced from biomass) as a potential renewable source and as an actual opportunity for sustainable mobility since, from a well-to-wheel perspective, biomethane-powered vehicles produce roughly the same CO₂ emissions as an electric vehicle powered by a renewable fuel. Finally, alternative propulsion systems such as hybrid and electric vehicles currently have sporadic applications but are included in the pipeline and are expected to be introduced in the market more extensively starting from 2016.

As Interviewee 1, member of the sustainability team in Italy, explained, FCA’s sustainability strategy has a focus on geographies and, consequently, on customer preferences and peculiarities of the transportation system in the various markets where FCA operates. For example, being the undisputed leader of the market in Brazil for several years, Fiat developed specific flex-fuel models for the Brazilian market. Technologies like the Tetra Fuel system invented by Magneti Marelli allowed Fiat to become a leader in the alternative fuel technology with other big players such as Volkswagen and General Motors moving as followers. Another example is related
to Europe and Italy where FCA has the leadership in the production of natural gas vehicles and other big carmakers lag behind.

Therefore, the priority accorded to product development depends on three variables. First, regions and countries where the technologies are implemented. Second, the timeframe and a consideration of the evolution of market conditions. Third, the current and future development of the same technologies in terms of their potential for environmental impact reduction and compliance with regulations.

The objective of FCA is to offer on the market a variety of propulsion systems that best fit fuelling infrastructure and comply with CO₂ regulations where they are sold. In fact, according to Interviewee 1, as in an efficient energy system the best solution comes from a mix of different sources, the same is true for cars and for the auto industry. At the same time, as repeatedly stated in sustainability reports and corporate communications, all different solutions have to be accessible and affordable for the audience. There is indeed an emphasis on economic viability of the propulsion solutions offered. The focus is on the environmental impact of cars and on the related costs spanned on the long term. This is why, in FCA’s perspective, vehicles propelled by natural gas are more competitive than hybrid vehicles. At the current stage, a comprehensive consideration of the environmental impact and running costs favours the latter option.

Also, when assessing the environmental performance of a car, it must be taken into consideration the performance of the engine plus the energy utilised and harmful impacts generated during the production process. This consideration falls within the adoption of the Life Cycle Assessment methodology (LCA). As explained by Interviewee 2, Sustainability Program Manager at Magneti Marelli, the group is adopting measurements of the overall environmental impact of products on their whole life cycle. Magneti Marelli considers LCA as one solution to the ever-higher environmental expectations of stakeholders and a way to distinguish in the market. This procedure focuses on 5 steps (i.e. extraction, logistics, production, use, recycling) and takes into consideration factors relating to energy and other resources consumed in production, use and recycling, as well as waste generation.
LCA is aimed at improving the environmental impact of the production process and the related spill-over of the product itself. In the next few years, the aim is to gradually involve all business lines of Magneti Marelli, applying LCA to more and more components while they are still being designed. In addition, more employees are expected to be trained to use the tools and methods aimed at consolidating this approach in the company, thus changing the mindset and reducing the impact of products and processes. The higher goal is to become the most environmentally-conscious company in the eyes of its stakeholders. The relevance of the process implemented by Magneti Marelli appears even higher when considering that Magneti Marelli is totally owned by FCA but it sells its products to other several big players of the car industry.

5.3. Organisational Processes: World Class Manufacturing

Environmental sustainability and the commitment to reduce the environmental footprint are firstly achieved through continuous improvements along the process of production. In this perspective, FCA sets sustainability targets closely related to World Class Manufacturing pillars. World Class Manufacturing (WCM) is a system of manufacturing that encompasses all plant processes aiming first and foremost at reducing costs and waste and, in turn, enabling higher standards in environmental performance and efficiency. Environmental stewardship in the company’s perspective moves first of all from the focus on minimising the impact of manufacturing processes. The WCM program worldwide is expected to be extended to 99% of group’s plants by 2020 and currently it accounts for 97% of those. The WCM system in the group’s perspective is aimed at improving production processes to ensure product quality with the final objective of meeting or exceeding customer expectations. WCM is defined in the sustainability report as a “structured, rigorous and integrated methodology covering every aspect of the entire organization, from safety to the environment, from maintenance to logistics and quality”. The projects developed within WCM are designed to achieve the broadest engagement of employees and to systematically reduce losses and waste, ultimately reaching zero accidents, zero waste, zero breakdowns and zero inventories. FCA strongly emphasise WCM as a tool for environmental sustainability. As FCA states in the
sustainability report, “the WCM system reflects our commitment to environmental and sustainability issues, WCM, and in particular the environment pillar, is an integral part of the Group’s Environmental Management System”. This pillar is dedicated to the development of instruments and methods that provide support in reaching targets to curb the environmental impact of plants while aiming to cut waste and optimize energy use. The Energy sub-pillar, included under the Environment pillar, plays a key role in improving energy performance through specific projects targeted at eliminating inefficient energy use.

Moreover, the group is committed to implement WCM within the supplier network. The engagement of plants and suppliers enables the most relevant environmental impacts to be minimised as an integral part of the daily management of production processes along the entire value chain. This entails reducing greenhouse gas emissions, conserving energy and raw materials, and reducing water consumption and waste generation, by maximising reuse and recycling.

As stated by Interviewee 3, WCM coordinator of the FCA plant in Recife, Brazil, WCM was firstly applied to existent plants as a tool to reduce energy consumption, waste and inefficiencies in the light of the Total Quality Management (TQM) system. WCM is now applied proactively in product and process design. This influences, for example, the choice of materials and the assembly process (e.g. shifting from screwed to wedged components), aiming at minimising the related impacts. The production process thus becomes easier and more sustainable from the safety and environmental point of view. Some of the elements analysed in the conception of the process are ergonomics, harmful materials, and containers, to cite a few. The deployment of this process requires a new conception of product development. The marketing function remains the cornerstone in the definition of product specifications but is now jointed by the product engineering in the project conception. The mechanism of linkage between the marketing and the product engineering culminates with the definition of product specifications that are expressively oriented to reduced environmental impact and costs. These product specifications are later transferred to a task force that involves product and process engineering to guide the development. Process engineering, in particular, focuses on reducing production costs through the application of WCM principles.
5.4. Product Development: Powertrains

FCA believes that, at the moment, hybrid and electric solutions cannot compete with conventional ICEs and natural gas vehicles. While other groups have made hybrid and electric technology a flagship of their commitment to environmental sustainability, FCA is more focused on the combination of sustainability and affordability. Also, FCA strongly believes in the offering of a range of solutions specifically conceived for the markets where those are sold. This is why the emphasis is on efficiency of conventional ICEs and engines that run on combinations of traditional and alternative fuels.

In terms of electrification, FCA’s CEO, in May 2014, referring to the Fiat 500e, an electric version of the Fiat 500 sold in North America to comply with EPA standards, affirmed: "Every time I sell one, it costs me $14,000". Marchionne defined BEVs as an intelligent concept but, at the same time, as money losers and a disaster from the financial and commercial point of view. This seems to be the reason why FCA is investing primarily on increasing efficiency of traditional ICEs, where they are actually gaining effective performance improvements and increasingly lower emissions, and on alternative fuel systems. The development of hybrid and electric vehicles is however ongoing and there are several applications in the pipeline that will allow FCA to face future limits on CO₂ emissions.

As confirmed during the investor day in Auburn Hills in May 2014, the overarching driver for powertrain technology change over the next 5 years is CO₂ reduction, driven mainly by regulations but increasingly by customer preference.

For what concerns conventional engines, FCA and the industry in general have made great strides in improving the efficiency of the internal combustion engine. Much more progress will come as gasoline and diesel engine technologies converge. FCA will also start the global roll out of a new small gasoline engine family in 2015, which incorporates these new and emerging technologies. Diesel engines, a Fiat core technology, will increase too outside of Europe. Moreover, compressed natural gas (CNG) can play a significant role in reducing emissions and dependence on oil.
Although widespread usage is not expected to develop in the US primarily due to the lack of a public distribution infrastructure, CNG remains strong in other global markets.

Moving to alternative propulsion systems, FCA believes that the electrification has been “over-blown by the media”. In the company’s perspective, with the exception of a relatively small group of early adopters, the market continues to be primarily driven by regulatory requirements. FCA will launch plug-in hybrid vehicles (PHEV) in 2016 to comply with ZEV requirements and several mild hybrid applications will come to market shortly thereafter. Where the cost of PHEVs will presumably remain high in the forthcoming years, according to industry experts mild hybrids represent instead an adequate compromise between costs and efficiency. Consequently, they are expected to have a broad application in various segments, including small city cars.

Chrysler Group leads the hybrid and electric technology development for FCA. The resources that were previously spread over various electrification development organisations across the group have now been gathered and integrated into the Powertrain and Vehicle Engineering departments. Accordingly, Chrysler Group is developing technologies that can be used in a range of electrified vehicles, including conventional hybrids, plug-in hybrids, fully electrified and range-extended electric vehicles.

Finally, despite the strong regulatory push by CARB’s ZEV mandate, fuel cells still are not conceived as commercially viable for mainstream automobiles. The technology is too expensive and the infrastructure to create and distribute hydrogen with a net CO₂ footprint reduction is not in place. Thus, fuel cell vehicles are not included in the pipeline.

Interviewee 2 also explained that, in the medium to long term, to be effective further improvements must be reconnected to the car itself and to the car system under a broader conception of mobility. Engine development is just one side of the equation. Environmental impacts depend on the car and fuels utilised but also on driver’s behaviour and on system’s infrastructure. Chrysler, for example, is exploring how
electric vehicles might mesh with the energy infrastructure. Through a partnership with NextEnergy the group is evaluating vehicle-to-grid (V2G) technology using all-electric minivans.

In brief, in the group’s perspective effective and affordable solutions come from more efficient conventional engines and from a widespread use of alternative fuels. Electrification doesn’t pay off yet. A broad market introduction has consequently been delayed. Compared to other carmakers, it also plays a minor role in terms of communication to stakeholders on environmental issues. However, developments and test applications are ongoing. Thus, a shift, albeit a gradual one, seems to be accepted by the top management.
6. Discussion and Implications

Corporate sustainability and, with a narrower scope, the environmental pillar can be interpreted as the attempt of enterprises to react to structural changes of the external context. In the car industry especially, the external context is characterised by macro phenomena such as pollution and interest in sustainable development, regulations, standards and certifications.

CSR-related activities are usually governed by top management and increasingly integrated in corporate strategies (Collis et al, 2012). Corporate sustainability stands as the aptitude of a company, and of the top management primarily, to increasingly satisfy the legitimate social, environmental, as well as economic, expectations of internal and external stakeholders through business activities. Thus, sustainability has specific characteristics that depend on sectors, countries and geographic areas in which the company operates, as well as the desired strategic positioning in the various businesses.

The integration of environmental sustainability and corporate strategy within the car industry has even more relevance given the impact of the industry and of its final products on the environment. Consequently, the field is gaining increasing attention from the literature and from car manufacturers. The case study aims at identifying the factors that motivate industry players to combine the imperatives of corporate financial performance and environmental protection. The main drivers and the approach towards sustainable mobility result in the solutions developed and in the systems implemented along the value chain.

FCA’s attention to environmental and social concerns has been anticipatory and proactive. For example, the first environmental report was published in 1992 and the first sustainability report in 2004. In comparison, Toyota first environmental report was published in Europe in 2001 and the first sustainability report in 2007. Moreover, their commitment is certified by sustainability ratings and indices such as the Dow Jones Sustainability Indices and the CDP Climate Disclosure Leadership Index.
Corporate governance is also structured in boards and committees that are specifically in charge of evaluating proposals related to strategic guidelines on sustainability issues.

The approach towards sustainability is systematic and relies on interventions at the corporate level that encourage each business to face environmental problems with the final objective of achieving competitive advantage. These elements contribute to raise the competitive and economic performance of the group through the research of win-win solutions and the creation of shared value.

The attention to the environment is recalled in the mission and results in targets for businesses and for the various layers of the company. FCA monitors the entire value chain to identify partnerships and positive relationships with suppliers in order to create a responsible network. FCA also looks at the whole life cycle of product through LCA assessment to estimate the overall impacts on an extended perspective.

The approach towards sustainability is innovative as well. FCA works on “eco” products and looks for competitive settings where, by conciliating stakeholders expectations and corporate performance, they can achieve stakeholder satisfaction and thus competitive advantage, which, in turn, fosters economic performance. The impact on the corporate strategy depends on transversal projects such as the adoption of the WCM that involves many units and on businesses with a strong environmental value that deliver products featuring reduced harmful impacts as a lever for differentiation. These products, such as those created by Magneti Marelli, can further have positive impacts along the supply chain.

The degree of integration of the sustainability strategy depends lastly on the priorities defined and on the action plan. Given the nature and consequent impact on the environment of the car industry and of its final product, the analysis focused on product development and on hybrid-electric vehicles among the applications of sustainable mobility.
6.1. The Diffusion of Hybrid-Electric Vehicles

Market data on production of HEVs confirm that these vehicles still represent a small niche in the market. Interestingly, IHS in its 2013 report on production of HEVs reduced the forecasts of production and market share presented in the previous releases\(^5\). This is due to a reduction of production in North America, changes in sale trends of the various systems offered (e.g. decrease of mild hybrids in the US and increase of the same in EU), changed strategies of major players such as Renault and GM.

However, IHS indicates a CAGR of 14% for production of HEVs over the period 2013-2020 and a share of almost 5% of worldwide production in 2020.

After 2020, due to increasingly stringent regulations on CO\(_2\) emissions, there will be a more pronounced turning point for HEVs (Arthur D. Little, 2014). Moreover, the hybrid vehicles market by regions is changing. Car manufacturers from the US and the EU will gain market share while Japanese will remain stable in terms of volumes (IHS, 2013). More in detail, in Europe a general change is ongoing and fosters the development of hybrid-electric vehicles. Renault, for instance, which was initially focused mainly on electric vehicles, after optimistic expectations on sales of EVs, is now taking steps toward HEVs. Volkswagen and PSA are also increasing their commitment and investments in hybrid and electric vehicles. Therefore, a change in pace is needed in order to close the gap with other big car manufacturers.

\(^{6}\) See Appendix 2 for further details on IHS releases

6.2. FCA’s Product Development Strategy

In terms of electrification, in the last years FCA had a sceptical position. The top management openly stated its doubts about the actual potential of electric mobility and this was reflected in a minor emphasis on hybrid and electric vehicles, corroborated by the analysis of sustainability reports and development of patents.
An analysis of the technologies under development shows a stronger focus on HEVs, especially with reference to the targets set for 2020. The undisputed driver for technology development will remain regulations on CO₂ emissions. These are crucial to frame future implementation of HEVs. Further, the strategy of product development will be characterised by critical aspects of the technologies involved and of local markets. Mild hybrids will see a growth in the coming years but plug-in hybrids will grow even faster due to their potential of CO₂ reduction in the registration phase (IHS, 2013). In Europe, mild hybrids will play a major role being an effective compromise between costs and CO₂ reduction; plug-in hybrids will also have a growing presence.

The articulation of FCA’s sustainability strategy in terms of products is best defined by three main pillars. Firstly, the company relies heavily on its consolidated expertise and know-how in the production of internal combustion engines (ICE). The wide range of ICEs in the market can be propelled by traditional and alternative fuels, achieving increasingly higher levels of performance and progressively reduced CO₂ emissions. Secondly, FCA over the years has developed technologies that were conceived for specific regions or markets and then transferred across brands and countries. Thirdly, the sustainability strategy of the group has a strong emphasis on affordability and economic viability. FCA aims at offering a wide range of vehicles sustainable throughout their life cycle and accessible to a large number of customers. This has certainly influenced the company’s strategy of product development and its aptitude toward electric mobility. At present, just one electric vehicle is sold in the US to comply with regulations on CO₂ emissions and, except for one specific application in the luxury segment, hybrid vehicles are not included in the current portfolio of the group.

However, authors and industry experts agree that HEVs represent the most viable solution to comply with increasingly stringent regulations in the coming years. The group itself, after having postponed the introduction of hybrid-electric models, is currently investing in these technologies. As for the development of technologies that led to improvements of conventional ICEs, the main driver is represented by regulations on CO₂ reduction. New hybrid models, currently in the pipeline, will in fact
be launched firstly in the US to comply with the ZEV mandate and then extended to other markets. While other carmakers among the biggest 10 in the industry already sell hybrid-electric or electric vehicles, FCA delayed such applications but, as also affirmed by the CEO, a shift to those technologies, especially HEVs, is inevitable.

The approach of FCA toward the development of hybrid-electric vehicles was consistent with the sustainability strategy implemented at corporate level. The emphasis on affordability and economic viability resulted in a minor priority given to electric mobility and is justified by market data on HEVs.

However, at the present stage a transition is clear and it will lead to increasing volumes and market share of hybrid vehicles in the next years. Thus, FCA has to undertake a new path just as much clear to introduce hybrid vehicles and create a solid positioning. FCA is working on mild and plug-in hybrids. The development will also be influenced by characteristics of the demand, infrastructures and regulations in the local markets where those technologies will be implemented.

### 6.3. A Framework for HEV Development

In trying to define how future implementation of hybrid technologies will be integrated in the corporate strategy of the group, I developed a matrix describing possible approaches in different scenarios (see Figure 1). Based on my experience with the study, the development of new technologies in the field of electric mobility and improvements in existing systems will be influenced by two main drivers. On one side, regulations on CO$_2$ reduction with standards imposed for the next years will highly affect changes in powertrain technologies (horizontal axis). On the other side, future pathways of mobility will also be determined by customer preference and their attitude toward electric mobility (vertical axis). The interaction of these two drivers creates four different approaches which are also influenced by geographies, by the mix of different solutions available and by the existing technologies that the group can leverage on. The elements of the four scenarios are determined by an analysis of the most relevant aspects emerged from the case study, of the technologies in the pipeline, and corporate communication.
On the left side of the matrix, regulations are mild and the current mix of engines and systems is perfectly suited to meet imposed standards on CO$_2$ emissions in almost every market. In the case of low customer preference toward hybrid-electric vehicles (Quadrant 1), the current offering of the group fits market demand and expectations with a varied portfolio of solutions: conventional ICEs that run on gasoline or diesel and vehicles propelled by alternative fuels such as natural gas (CNG) or other fuels in different regions (e.g. ethanol in Brazil). In the case of high customer preference for HEVs (Quadrant 2), when this is not coupled with stringent regulations hybrid systems are not intended to be introduced because they are not deemed economically viable and are less competitive than other systems currently offered.

Quadrants 1 and 2 represent FCA’s current approach in many markets and testify the very limited degree of electrification of the group’s current offering.

On the right side of the matrix, regulations on CO$_2$ emissions are more stringent. This is, for example, the scenario of 2020, when all carmakers’ new fleets in the EU are expected to produce, on average, no more than 95 grams of CO$_2$ per kilometre. In
the US, the mandatory level will be 101 g/km in 2025 (Arthur D. Little, 2014). In this scenario, hybrid systems will play a critical role since they can obtain very low figures on emissions and consumption during the registration phase. This is the context in which FCA will inevitably have to introduce hybrid vehicles. However, even in this case customer preference will impact on the modality of adoption of such technology. In the case of low customer preferences and in the timeframe of 2020 (Quadrant 3), conventional engines, propelled by gasoline, diesel or alternative fuels, will still represent the core of FCA production. Nevertheless, plug-in hybrid-electric vehicles (PHEV) will be introduced to comply with regulations in specific markets and will pave the way for several mild hybrid applications. In this perspective, FCA could leverage on the start/stop technology that is already widely applied and favour the implementation of mild hybrids on a large scale. In fact, in the case of high customer acceptance (Quadrant 4), mild HEVs will undertake a process of broad market penetration and applications of PHEVs will be expanded as well. In the latter case, conventional engines and alternative fuel systems will have a decreasing importance but will still represent the majority of the production. BEVs instead, thanks to technology improvements that might lead to superior performance and extended driving range on one side and to lower costs on the other side, could increase their presence across the brands of the group. The core technologies are already under development in conjunction with battery suppliers. However, even in such scenario, BEVs will still represent a very small niche in the market and will certainly not equal sales of HEVs. IHS forecast of BEV production in 2020 is around 1% of total production worldwide⁶.

Quadrant 3 reflects the approach that FCA will presumably have in Europe and in markets such as the US between 2020 and 2025. Quadrant 4 presents the conditions that will facilitate the transition to electric mobility and involves an higher degree of electrification for the group’s fleet. However, this final approach will be, at least initially, limited to few markets in which those conditions are expected to exist and highly influence industry trends.

⁶ Source: IHS, 2013
The portion of engines that includes a partial electrification will be finally determined by the associated costs of development of such technologies. Therefore, FCA must adjust its approach in order to create a balance between regulatory compliance, customer preferences, and sustainability of the strategy that ensures the benefit of the group.

Overall, even in future scenarios, the focus on geographies will outline the implementations of such approaches across different regions and markets according to systems of transportation and infrastructure of each specific country. Also, a crucial element to be taken into consideration concerns the ongoing decrease in oil prices. In fact, as confirmed by a study of Hascic and Johnstone (2011) development of hybrid vehicle technologies is highly fuel-price elastic. Indeed, fuel pricing is likely to have an effect on those technologies that are closer to the market, such as hybrids. The authors estimate that, for a 1% change in fuel price levels, invention in hybrid propulsion will be modified by about 1.8%. Thus, the outcomes of the aforementioned drivers – regulations and customer preference – in terms of hybrid development in the forthcoming years might be altered by trends of fuel price over the same length of time. Moreover, FCA will introduce hybrid vehicles when many other competitors will already have been selling HEVs. This means that the company will have to differentiate its products in order to gain a sustainable competitive advantage. The focus on affordability might be an important driver but could not be sufficient to create a valuable positioning.
Table 6.1. Summary of findings

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<th>Agent</th>
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<tr>
<td>Car industry</td>
<td>• Attention of carmakers to environmental sustainability</td>
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<td></td>
<td>• Potential of HEVs as the next dominant design</td>
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<td>• Interest of European carmakers for HEVs (VW, PSA, Renault)</td>
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<td>Institutions</td>
<td>• Increasingly stringent regulations on CO₂ emissions:</td>
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<td>2020 in EU, 2025 in US</td>
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<td></td>
<td>• Regulations as a critical driver for HEV development</td>
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<td>External context</td>
<td>• Evolution of technologies and infrastructures</td>
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<td>• Characteristics of the demand</td>
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<td>• Trends of oil prices</td>
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<td>FCA</td>
<td>• Finalisation of the merger with Chrysler: wider fleet and different regulations</td>
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<td>• Organisational complexities and challenges</td>
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7. Conclusions and Limitations

Sustainability and, in particular, environmental sustainability is increasingly integrated into corporate strategies of carmakers in the auto industry, giving birth to dedicated sustainability strategies. Within the vast field of environmental sustainability, this thesis has focused on product development and on companies’ efforts toward electric mobility. Among the different applications and ways in which the electrification of mobility emerges, the analysis has been concentrated on hybrid-electric vehicles.

An investigation of development and peculiarities of HEVs determines that hybrid vehicles are expected to become the next dominant design in the coming years and that they represent the most viable solution for a transition toward a new conception of mobility in the long term. Hybrids have several advantages over other exemplifications of electric mobility such as battery-electric vehicles and fuel cell vehicles. First of all, they are the only technology among the three that is included in a continued wave of development while the others are characterised by hypes. Moreover, HEVs are the less competence-destroying technology compared to the other two and don’t require specifically dedicated infrastructure such as special stations for recharging or fuelling. Finally, a positive tendency toward electric mobility favoured their commercial success and nowadays almost all major car manufacturers market hybrid versions of their models.

Given their positive impact in terms of emissions reduction and their relevance as a tool to achieve better environmental performance, especially for major incumbents in the industry, HEV development is taken as a lens to investigate how carmakers integrate environmental sustainability into their corporate strategies and their attitudes in terms of electric mobility and product development. In taking this specific focus, the research did not consider future implementation of other technologies such as battery-electric vehicle and fuel cell vehicles due to the extremely limited sales of the former and to the long-term horizon for an actual market potential of the latter.
Having analysed industry trends through a study of sustainability reports, intended as the main instrument in which companies specify their strategy and impacts in terms of sustainability, a case has been developed. FCA ranks among the 10 biggest car manufacturers worldwide and, while claiming a strong commitment toward environmental sustainability, has placed a minor emphasis on electric mobility and on the development of hybrid systems in the last years.

However, a partial transition to electric mobility will be inevitable in the coming years. The strategy adopted until now is coherent and justified by market data but competitive moves of other industry players testify that a shift is underway and FCA must develop a different approach to deal with the electrification of mobility not to lag behind other car manufacturers. Also, after the finalisation of the merger with Chrysler, FCA has now a wider fleet of vehicles that includes more medium and large sized cars with higher levels of consumption and emissions. Further, FCA is now present in more markets with different regulations. In order to comply with such regulations and develop solutions accordingly, a higher degree of integration of environmental sustainability into the corporate strategy of the group is also required. This implies challenges and organisational complexities.

FCA operates in a low-margin market par excellence. Consequently, targets and objectives are driven by the need to achieve extremely high levels of efficiency and effectiveness through cost reduction that, hence, determines the postponement of huge investments that characterise the industry. Thus, in the last years FCA has not been challenging the HEV technology. However, it has now to engage in the transition toward electric mobility. Moreover, after the merger with Chrysler, the new challenge concerns the integration with the American market, in which conventional approaches are not more exploitable.

In future scenarios driven by increasingly stringent regulations and changed customer preferences, the group must adopt a different approach that will entail a growing presence of HEVs. Regulations and customer preferences are the main drivers but a critical role will also be played by infrastructures and transportation systems of countries where vehicles are sold, trends in oil prices, and developments
in related technologies and systems such as batteries and bio-fuels. FCA will also need to differentiate its product in entering the market as a late-mover. Therefore, it is important to understand how a player of the car industry should react to the combinations of drivers that are shaping industry’s dynamics.

In terms of contributions, this research firstly provides a comprehensive background on hybrid vehicles in a phase of ferment around this technology and gathers several points of view on technology development and on the potentialities of HEVs in the short- and medium-term. Secondly, this study provides a relevant framework for the development of HEVs and the implementation of sustainability strategies that entail some degrees of vehicles electrification along with other conventional technologies. Thirdly, the case helps to identify a set of drivers and relevant factors, which are useful for policy making in order to make HEVs desirable and favour positive approaches of carmakers towards hybrid vehicles. Institutions that impose regulations on CO₂ cannot disregard the role of customer preferences and aspects of the local context such as fuelling infrastructures and trends in oil prices.

Based on this study, I make some recommendations for further research. First of all, this thesis focused on product development and how product development is integrated into corporate strategy to ensure environmental sustainability. In particular, among the outcomes of product development and the expressions of sustainable mobility, the present research analysed hybrid-electric vehicles because of their relevance at the present stage and of the potential as a new dominant design. Further investigations on product development might focus on battery-electric and fuel cell vehicles with reference to a different timeframe and to sustainability strategies of other car manufacturers. BEVs might be investigated in relation to innovative mobility operators or car sharing organisations. FCVs might be investigated with regard to specific countries where the fuelling infrastructures required are being implemented and thus facilitate the assessment of actual chances of success as an alternative to traditional fuels. Nonetheless, production processes are critical as well in the implementation of strategies aimed at reducing the environmental impact of the car industry. All carmakers are carrying out processes with reduced harmful emissions and further studies can focus on the ever-increasing
gains obtained by companies and on the extension of their sustainability strategies along the value chain and the supplier network.
References


Appendices

1. Architectures of Hybrid-Electric Vehicles

a. Mild Hybrid – Parallel

   i. **Flywheel**: Motor is located between Engine and Transmission.
   
   ii. **Belt**: Motor supplies the power to the crankshaft via belt.
   
   iii. **Coaxial Input**: Motor supplies the power to the input shaft of the differential.

b. Full Hybrid – Parallel/Parallel Plug-in

   i. **Axle**: Only the engine turns the front shaft. Only the motor turns the rear shaft.
   
   ii. **Coaxial Input**: Motor supplies the power to the input shaft of the differential.
   
   iii. **Coaxial Output**: Motor supplies the power to the output shaft of the differential.
   
   iv. **Flywheel**: Motor is located between Engine and Transmission.
   
   v. **Flywheel-(2) Axle**: Front section has “Flywheel” architecture, while rear motor(s) provide drive in parallel. If there are 2 motors, architecture is defined as “Flywheel” + “2 Axle”.

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**Engine** M/G **Battery**

**T/M**
c. Full Hybrid – Parallel-Series/Parallel-Series Plug-in

i. **Direct**: Normally, the car is propelled by a motor, and the engine works as generator. (Propelled by M/G-1, Clutch=Off). In specific case, the car is propelled by the engine with a fixed reduction gear, or engine + motor (Clutch=On).

ii. **Power Split**: There is a Power Split (Distribution) Device to combine the Engine Power and Motor Power. One Motor (Generator) works to control the power mixture.

iii. **Direct + Axle**: There is a Power Split (Distribution) Device to combine the Engine Power and Motor Power. One Motor (Generator) works to control the power mixture.

2. **Market Data on HEVs (Source: IHS, 2013)**

a. Hybrid Vehicles Production in million, 2013-2020
b. Total Production of Vehicles by propulsion systems

![Chart showing total production of vehicles by propulsion systems from 2013 to 2020.]

3. Persons interviewed to perform the FCA case study

<table>
<thead>
<tr>
<th>Interviewee</th>
<th>Position and Company</th>
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<tbody>
<tr>
<td>1</td>
<td>Head of Sustainability Team - FCA (Turin, Italy)</td>
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<tr>
<td>2</td>
<td>Sustainability Program Manager - Magneti Marelli</td>
</tr>
<tr>
<td>3</td>
<td>WCM Coordinator - FCA (Recife, Brazil)</td>
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<tr>
<td>4</td>
<td>Director Process Research &amp; Innovation - Centro Ricerche Fiat</td>
</tr>
<tr>
<td>5</td>
<td>Product Portfolio Manager - Magneti Marelli</td>
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<tr>
<td>6</td>
<td>Former VP Purchasing Unit EMEA - FCA</td>
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<tr>
<td>7</td>
<td>CEO - Magneti Marelli</td>
</tr>
<tr>
<td>8</td>
<td>Marketing and Communication Director - Magneti Marelli</td>
</tr>
<tr>
<td>9</td>
<td>Corporate Communication - Magneti Marelli</td>
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