# Editorial

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**Abstract:** The papers included in this special issue have been selected from the contributions presented at the 16th GERPISA international conference 'The automobile industry and sustainable development: concepts and doctrines, public policies and company strategies'. The automobile industry is facing a new economic, technological and political environment. The potential scarcity of future energy resources and escalating fears about climate change have become powerful forces for change in the industry, even if the regulatory impact of the policy response to these issues as yet remains unclear.

**Keywords:** automotive industry; sustainable development; alternative fuel vehicle; public policies.

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## 1 Introduction

The papers included in this special issue have been selected from the contributions presented at the 16th GERPISA international conference 'The automobile industry and sustainable development: concepts and doctrines, public policies and company strategies'. The conference was held in Moncalieri (Turin), Italy and hosted by Ceris-Cnr in June 2008.

The conference was structured in 5 plenary sessions and 25 parallel sessions. On the whole, 81 contributions were presented. Most of the slides and papers can be downloaded from www.gerpisa.univ-evry.fr.

The conference can be considered the first step in GERPISA's Fifth International Research Program for the period 2008–2011. As Jullien (2008) confirmed, the research is moving the international network into new territory, but it should mobilise the competencies built up over the past 25 years. The question of how the automobile industry is integrating the demands of sustainable development is fundamentally tied to the question of how this activity is positioned in societies that produce and/or use automobiles. In particular, the scale on which the position of the automobile is currently being renegotiated in society requires us to return to the question of politics, states and the importance of regulation and taxation, as these issues are likely to play a major role in determining outcomes for automobile firms and regions. This can be summarised in three major areas:

1 The automobile industry presents a level of unity and continuity that reflects a sectoral community made up of competition and imitation. This lends credibility to the sectoral approach to research in order to identify key trends that concern all firms in the sector. Sustainable development has become one of these trends.

2 Trade-offs need to be made and, because firms have specific historical trajectories – *i.e.*, are not occupying the same competitive space – they will make different trade-offs and the members of the community thus co-exist with a large diversity in its practices in relation to production and production policies. There are many reasons to consider that this principle also applies to the forms of interpretation by firms of the requirements of sustainable development.

3 The strategies adopted by firms need to be interpreted more broadly than in terms of competitive analysis. In addition to evaluating their sustainability in terms of performance, we must add an analysis of their capacity to gain a long-term position in an increasingly global social, political and economic landscape. The sustainable development strategies that are being developed in automobile firms today clearly need to be evaluated on this dimension.

## 2 The state of the art

The papers presented in this special issue are dedicated to the innovation design and sustainable development in the automobile industry.

Finding new methods of propulsion for automobiles is currently a subject of intense debate due to the worsening of urban pollution. The development of sustainable propulsion technologies is a hot topic for public opinion, and consequently local and national governments. This is particularly relevant in this period of trouble for the automotive industry.

Nevertheless, most of the considerations related to the development and placed on the market of alternative fuel vehicles undoubtedly depends on fuel prices. In July 2008 petrol reached an all-time peak at about $150, and five months later it was 75% less.

A high price variability does not help car makers' strategies in improving zero-emission vehicles in their product plan. That is, if fuel prices do not rise too dramatically, customers will tend to downsize but stay with conventional vehicles, but if fuel prices rise sharply and remain high and other conditions are met (battery prices come down, public utilities provide a suitable recharging infrastructure, and the EU sticks to its 95 g/km $C0_2$ emissions target for 2020), the future of alternative fuel vehicles will be much brighter.

For this reason, all automobile manufacturers are committed to not only improving the internal combustion engine, both in the gasoline and diesel versions (see the paper of Berggren *et al.* in this special issue), but also to finding alternative methods of propulsion and any system that can reduce emissions: driver assistance, start and stop feature, dual clutch transmission, braking regeneration, downsizing, weight reduction, direct injection and turbocharge, roll resistance, LED headlamp, aerodynamics, mission control, electrification, $CO_2$ sequestration and so on.

Since the 1990s, the main source of innovation in the automobile industry has been largely connected to environmental issues in an effort to reduce pollutants (fine particulates and sulphur, carbon and nitrogen oxides), reduce Greenhouse Gases (GHGs, mainly carbon dioxide) and replace hydrocarbons with recyclable and renewable fuels.

In the last decade, the improving performance of batteries, from nickel-hydride to lithium ion or polymer technology, revived the purely electric-driven cars and maybe discredits Fréry's (2000) myth of the electric vehicle as 'eternally emerging' technology. Electric vehicles are not considered technologically less efficient any more (please see the papers of Aggeri *et al.* and Beaume and Midler in this special issue) and seem to be a strategic move to reshape troubled European coachbuilders.[1] On the contrary, biofuels are suffering drawbacks concerning both the impact on agricultural products' prices and potential unhealthy aftereffects.

It is now possible to buy electric, natural gas and hybrid vehicles on the market. The next goal is to drive a vehicle that is completely powered by hydrogen, either directly or by means of fuel cells. At the moment, there is nothing on the market other than the Honda Fcx Clarity, 200 cars of which are targeted to be produced in the next three years and that one can rent at only $600 per month.

The mass availability of environmentally friendly cars presents not only an opportunity for manufacturers, but also for citisens and workers. This opportunity does not come without its own set of obstacles, however, such as the need to convert the fuel distribution network and to define common standards. There is not even a consensus on a comparison of energy costs for these different methods of propulsion. Some experts feel that the main problem at the moment is urban pollution, which can be immediately resolved by using compressed natural gas vehicles; on the other hand, if the entire production cycle is considered, some studies conclude that hybrid autos are more ecological than hydrogen vehicles. Yet others are of the opinion that future developments in traditional engines, together with the use of biological or synthetic fuels, will lead to a reduction in fuel consumption by 30%–40% and to the use of renewable sources of energy.

The technological scenario is therefore anything but clearly defined. Only the expertise acquired thus far on natural gas technology could be considered in any way consolidated. There is still much room for improvement in the other methods of propulsion. To summarise, the methods of propulsion are still in different phases of R&D. Compressed natural gas vehicles are in the precompetitive research phase – many models are available but they still need to be perfected; hybrid vehicles are in the industrial research phase, even though Toyota Prius is a success model all over the world and other manufacturers are planning to mass-produce hybrid cars in a few years and are currently testing new types such as the hyperdrives; lastly, fuel cell technology is still in the basic research phase – the few prototypes that have been built serve more as research laboratories rather than vehicles similar to the ones actually in use, to the extent that universities and research centres play the most significant role in this area.

Nonetheless, these different types of propulsion are not being developed independently, but rather they are following a technological trajectory that comprises a flow of related innovations. The endothermic motor is used on both compressed natural gas and hybrid vehicles and on hydrogen vehicles without fuel cells; methane storage systems for hydrogen cars can be used both on the vehicle and at distribution points; storage batteries are common to the electric, hybrid and fuel cell vehicles; power electronic systems are often common to all the alternative methods of propulsion; and since fuel cells are essentially energy generators, they can also be put to use in other industrial sectors.

This is an important issue not only because it requires a consistent flow of investment, but also because the decision on which technological solution to adopt and the timelines for development have not even been defined yet. Moreover, car manufacturers have to focus on the organisation of innovative design activities around the issue of eco-innovation as a complement to the established R&D processes (see the paper of Elmquist and Segrestin in this special issue).

The various options all have different costs and opportunities, as well as different industrial repercussions:

- Recent studies show that the potential for the further improvement of existing engines, catalyst technology and power train control systems is still large and will probably be sufficient to meet possible new emission standards in the next five to eight years (see the paper of Dijk and Montalvo in this special issue). This means it should not be necessary for manufacturers to introduce hybrid or fuel cell propulsion technology from the viewpoint of meeting future emission standards. On the other hand, some technologies have simply fallen out of fashion because they are too expensive. The electromagnetic valvetrain is one example. At first, it was hailed as a breakthrough, but now it has lost its momentum because of high costs. Cylinder deactivation and controlled auto-ignition are promising, but they are not widely used because they are difficult to mass-produce despite their proven fuel efficiency.
- The price and performance of compressed natural gas vehicles are comparable to traditional cars. They greatly reduce local pollution, they cost less to operate if governments keep excises down and there is a great deal of technical expertise in this area, but these cars do require a corresponding distribution network (less for liquefied petroleum gas than methane).
- The change to lithium ion has to consider the fact that these batteries account for up to 30% of the total future cost of electric vehicles. Car makers have a long way to go in making electric vehicles affordable. The companies need to keep the price gap between electric vehicles and similar nonelectric cars to less than $9,000.
- Hybrid vehicles with nickel-metal hydride batteries have reduced the difference from similar nonelectric cars to a few thousand euros. But cars equipped with more expensive lithium-ion batteries have yet to reach the mass market. According to industry insiders, the real gap could be substantially higher. Emissions, greenhouse gases and noise will be reduced, operating costs will depend on battery maintenance

and are not yet quantifiable, and there is no need for a new distribution network, but the electronic management systems and the optimisation of the entire system, particularly the batteries, all have room for improvement.

The scenario for hydrogen cars cannot be easily hypothesised since there is no standard technology in place, the existing alternative options are not economically feasible and currently none of these is without some environmental impact (with the exception of the production of hydrogen (which is not found in nature) by solar energy or new hydroelectric, aeolian and geothermal plants). In addition, the catalytic action of fuel cells is obtained by using platinum, a rare natural resource with a very inelastic curve (the cost of platinum is approximately 5,000 euros for any fuel cell vehicle). Nevertheless, the impact of fuel cell technology will radically shift the focus of propulsion construction away from mechanical technology to chemical/electrotechnical technology, from the removal technology of endothermal motors to shearing/deformation for the stacks, from mechanical transmissions to transmissions with synchronised/electronically regulated electric motors, from mechanical repairs to electrical repairs. In fact, the components used for the new methods of propulsion will include electrodes and electrolytes for fuel cells, reformers, on-board hydrogen fuel tanks, new types of transmissions, electric motors, batteries, electronic systems, on-board software, *etc.* As mentioned earlier, some of these technologies are common to both methane and hybrid cars.

The new frontier has been detected in the solar car using photovoltaic panels. Some car makers, like Toyota and Fiat, are investing in prototypes quite different from the demonstration vehicles and engineering exercises we are used to seeing. For example, the Fiat Phylla concept is designed to use solar panels and a hydrogen fuel cell to send power to each of its four wheels.[2] The project involved many different agencies, including the Piedmont Region, which sponsored and funded the undertaking. In 2010 the first fleet should be delivered.

Currently, the percentage of sales in Europe of new, low-emission cars is infinitesimal and concentrated mainly on natural gas and liquefied petroleum gas cars. The USA and Japan have a similar pattern of sales but the cars are more differentiated (ethanol, methanol and hybrid cars are also available).

France and Great Britain each play a major role in building alternative cars, but the remaining countries in Europe contribute practically nothing. It is also important to note that France and Great Britain have focused their efforts on completely different technologies in accordance with their own specific needs and energy structures. Italy has chosen to specialise mainly on the methane car (see the paper of Nadin *et al.* in this special issue), France is focusing on the electric car, while Great Britain has opted for the liquefied petroleum gas car.

As for the European Union, steps towards finding alternative methods of propulsion have taken the usual path, with the institution of regulatory requirements that increasingly restrict the sale of polluting vehicles, the placing of specific limits on emissions (the next deadline is 2009–2011 with the Euro 5 standards) and the provision of direct support for basic research – thus focusing on fuel cells (see the paper of Dijk and Montalvo in this special issue). The commitment of member countries in this area has thus far been disorganised, limited and fragmented. It is estimated that the public funding allocated to these programmes amounts to 50–60 million euros per year, approximately one-third of US funding and a quarter of Japanese funding.

Even if the long-term objective is to build a hydrogen auto with fuel cell technology, this option should not detract attention from the other types of alternative propulsion because the timeline for introducing fuel cell technology is still largely undefined and its success still very uncertain (the launch date has been postponed every year; 20 years ago we had the same hopes for electric cars), and also because some of the components needed to develop fuel cells are also used in compressed natural gas cars, especially the hybrid ones.

It is not by chance that the Americans have decided not to focus solely on fuel cell technology. Since 1993, projects have been developed specifically for hybrid cars, co-financed equally by the US government and separately by the three national manufacturers. These support programmes were unified in 2000, so Ford, General Motors and DaimlerChrysler have started to develop projects together. In the last years, US manufacturers have launched a few hybrid models, but with smaller commercial success than current market leaders Toyota and Honda (see the paper of Berggren *et al.* in this special issue).

Even though European manufacturers have developed prototypes with hybrid methods of propulsion, in some cases with national public support only, they are not inclined to produce these vehicles at the moment (with the exception of commercial niche vehicles). The main obstacle is the additional costs and the unwillingness to sell at a loss, unlike their US and Japanese counterparts. The European Union may intervene by instituting regulatory requirements (in some countries hybrid cars are comparable to traditional cars and subject to circulation restrictions), by means of technology (improving the cost and efficiency of some parts), or by supporting demand in order to reduce the price differential with traditional cars.

They can similarly intervene for compressed natural gas technology, again by instituting regulations (exploiting the environmental and safety benefits as opposed to traditional vehicles), through technology (improving the energy performance, and incorporating compressed natural gas into hybrid cars) and by supporting demand (by not adjusting excises in particular and by promoting the conversion of cars already in circulation). The fundamental issue mainly involves increasing the distribution network, which is scarce in Italy and almost nonexistent in other European countries. This will break the vicious circle between methane distributors, who do not want to increase the network due to the lack of demand, and the consumers, who are not willing to buy methane cars due to the lack of supply points. In addition, the methane distribution network can easily be converted to supply hydrogen, which is one of the main factors that could slow down the widespread diffusion of fuel cell cars.

## 3 Trade-offs and synergies

As far as public policies are concerned, it is useful to recall what Jullien (2008) mentioned in proposing a new framework to enrich the scientific, political and managerial understanding of sustainable development issues for the automotive industry and in particular the list of potential trade-offs and possible synergies about sustainable development issues.

The public debate between those who see ecological regulation as a job killer and those who stress its employment-creation potential is one example. The relation between ecological innovation and employment is an important, but not the only, arena of trade-offs and synergies. If we take ecological sustainability as the starting point, it is possible to see several areas of potential trade-offs or synergies:

- ecological innovation–employment – Technological innovations aiming at improving ecological sustainability have effects on the value chain and can cause employment losses in some parts of the automobile industry and in other industries linked to automobile production. However, they can also create new products and employment (*e.g.*, fuel cells). Cross-industry effects have to be taken into consideration. The change to regenerative fuels creates new growth opportunities for agriculture in both industrialised and developing countries, but it also implies some dangers (*e.g.*, negative social effects through increasing corn prices).
- ecological innovation–regional development – Ecological innovations can change the competences required in the development and production of automobiles and cause a restructuring of value chains and automobile production regions. Do traditional automobile regions profit from the orientation on ecological sustainability due to their technological capabilities? How can regional policy create synergies between ecological innovation and regional development?
- ecological innovation–innovation costs – Ecological innovations require high investment and high innovation capability of OEMs as well as of suppliers. It is an important question whether the OEM-supplier networks support such innovations and if the power asymmetries and the cost pressure of OEMs on suppliers do not represent an innovation barrier. OEMs can shift the burden of innovation costs to suppliers or they can develop a more cooperative division of labour.
- ecological innovation–consumers' demand – The ecological sustainability can collide with the consumers' preferences for size, speed and price (SUVs and premium cars on the one hand, and low-cost vehicles on the other hand), though there are activities designed for and signs of a change of preferences. Thus, the companies have to solve conflicts between ecological goals and product policy requirements. They can choose an active approach aiming at developing new markets or remain passive.
- ecological innovation–functional requirements – The ecological goal of emission reduction (*e.g.*, use of light materials, reduction of weight) can collide with the requirements for safety. However, there are also potential synergies. The development of sensors and electronics pushed by safety regulations can also help in the development of ecological innovations.
- ecological innovation–relocation and international division of labour – Since the 1990s, there has been an intense discussion about the relocation of production from industrialised countries (Western Europe, USA) to low-wage countries (Eastern Europe, China). The costs of ecological innovation can increase the cost pressure and relocation to low-wage countries. Another aspect is the development of competences needed for 'green' cars: Will the traditional industrialised regions profit from their technological experiences and will the newly industrialising countries develop the

competences needed for ecologically sustainable products? Ecological regulations in the triad countries also have the effect of raising market-entry barriers for car producers from low cost countries like China or India, which do not have the required technological capabilities. How will the producers outside the Triad react?

Even if this list does not provide an exhaustive overview on all areas of trade-offs or synergies related to sustainable development in the automobile industry, it shows that most of them have a complex character and (with a few exceptions) cannot be reduced to technological problems. Actually, the actors in the automobile industry are confronted with a variety of trade-offs within companies, within the industry and between different industries, which they have to manage concurrently and (in the best case) turn into synergies. They do this on the basis of the given company productive models, which are the results of the trajectories of the companies in the past. Product technology issues have to be seen in relation to product policy, the supply chain, and labour and financing issues in order to get a comprehensive view of the trade-off and synergy problematic. The interaction of different processes means that the solution to one particular trade-off can produce new conflicts and problems in another area, thus generating a fragile process of readjustment and the ongoing formulation of compromises.

So, clearly, trade-offs will have to be made. Firms will do this, each probably in its own manner. Public policies will have to be coordinated as ranked objectives that will influence these trade-offs in the way specified by this hierarchy. To achieve our purposes, it will be necessary to take a deeper look at the trade-offs identified in such cases, in relationship to the synergies that could either be implied by them or arise from them. This is the purpose behind the present proposals and the goals of our research.

## 4 The contents of this special issue

The six papers presented in this special issue are dedicated to the innovation design and sustainable development in the automobile industry and cover all the best emerging choices between alternative fuel vehicles.

Two papers are dedicated to the comparison of hybrid electric vehicles with other vehicles: with electric vehicles, in the paper of Aggeri *et al.*, and with the internal combustion engine, in the paper of Berggren *et al.* The contribution of Beaume and Midler pays attention only to electric vehicles. Hydrogen vehicle technology is the focus of Dijk and Montalvo's paper.

The paper of Nadin *et al.* takes into account natural gas vehicles and tests if the buying pattern follows rational or irrational intentions. The paper of Elmquist and Segrestin is focused on alternative design strategies to combine environmental and economic sustainability.

More specifically, the paper of Aggeri *et al.* aims at discussing some learning mechanisms that car manufacturers have used to develop their capabilities around electric vehicles and hybrid electric vehicles. They highlight that, in this kind of broad innovation field, more advanced mechanisms might be needed for automotive firms aspiring to take the lead, such as market experiments and exploratory partnerships.

They also argue that, in the context of electrification, new mechanisms for learning, instruments, tests and experiments are being deployed in the automotive industry and overall learning strategies are necessary to guide the many learning mechanisms activated. The paper contributes to an increased understanding of how automotive companies deal with disruptive innovation.

The aim of their paper is to discuss how companies can build innovative capabilities in disruptive contexts through highlighting some of the mechanisms used in various projects. The paper is based on an interview with different car manufacturers and a case study of a hybrid electric vehicle project. Three different approaches to learning on electric vehicles and hybrid electric vehicles has been briefly taken into account, via examples from Toyota, Volvo Cars and Renault. These examples have been selected because they highlight different learning mechanisms on how companies can build new competencies in this field.

Similarly, the paper of Berggren *et al.* pays attention to the real-world competition between fuel-saving technologies unfolding in the marketplace and concentrates on the two most important ones (according to the authors): the 'new' gasoline hybrid electric vehicle versus the 'old' diesel power train. These technological options are related to the strategies of significant Japanese and European manufacturers, and to the evolution of the European and US markets.

The paper attempts to capture three different components of the innovativeness of auto makers: technological inventive competence; product development competence, and industrialisation and marketing competence. A central finding is that, although the advent of a new technological challenger, the hybrid power train, has increased R&D spending and technological competition within the automotive industry significantly, there is no evidence that it will replace the evolving diesel systems in the foreseeable future. In a more long-term view, a technological synthesis of the competing technologies of today will be a major possibility, with a very significant potential to contribute more to GHG reductions. However, the competitiveness of technological trajectories must be distinguished from the fate of the firms engaged in these technologies. The paper ends with a discussion of the two major innovation strategies pursued by leading Japanese and European manufacturers and the key factors which will influence the outcome of this contest.

On the other hand, the paper of Beaume and Midler reports the first outputs from an action research done at Renault which was started at the end of 2007. The research is focused on an ambitious programme aimed at addressing the challenges related to a mass-market roll-out of electric vehicles. In the paper, the authors introduce a theoretical framework to enlighten management on complex and radical innovation. It is based on four theoretical clusters: value-driven strategies, usage-driven design, innovative design theory and co-innovation partnerships.

The theoretical framework is used to highlight the deceptive history of 'eternally emerging' electric vehicle technology, and to improve the understanding of past failed attempts to mass-market electric vehicles. They then describe the case of the Renault programme on electric vehicles, and demonstrate that the case reveals new innovative design practices that overcome the pitfalls of the previous attempts. The success of this initiative is still uncertain. It still faces the question of the social acceptance of such a radical innovation; it is still very dependent upon changes in the business and political environment; and it will have to face a rising level of competition both from electric vehicle competitors and plug-in vehicles, or other kinds of improved vehicles.

Moreover, the paper firstly enriches the design theories, showing how a company can manage the renewal process of a dominant design. Secondly, it analyses the question of user integration within the design process, and proves that the company has managed a double process: simultaneously enlarging the scope of usage from product to service and the definition of the user, because the stakeholders in electric vehicles are involved. Last but not least, it deals with the question of innovation strategy, and proves that such an innovative context as electric vehicles have forces OEMs to test new strategies, including new cooperation patterns and programme-led innovation management.

Dijk and Montalvo pay attention to hydrogen vehicle technology and how car firms appreciate investments in ultra-low emission vehicles. In contrast to studies that examine aggregated patterns on the market, such as sales levels, new launches, patents issued and revealed concept cars, their paper is focused on individual car firms and analyses business considerations, with the aim to support policy design issues.

The paper reports on the drivers and barriers for car manufacturers regarding the development of hydrogen engine technology. A social-psychological approach is followed through a questionnaire survey to identify barriers and drivers at the firm level. The study reveals that different firms deal differently with hydrogen vehicle developments. Broadly, three groups of firms can be distinguished: one group of uncertain firms, a second group of unwilling firms and another of optimistic firms.

Secondly, the paper explores the implications for sustainable development policy making and discusses the options of environmental innovation policy makers. Since the level of technological and organisational capabilities has a high correlation with the willingness to engage in hydrogen technology development, sustainable development policy should currently be focused on supporting R&D. From an integrated perspective, the development of ultra-low-emission vehicles and the incremental innovation of internal combustion engines compete. Based on a preliminary sustainability assessment, the authors conclude that policy makers aiming at sustainable development have good reasons to support ultra-low emission vehicles in general, and hydrogen technology in particular.

The contribution of Nadin *et al.* is aimed at understanding how values, awareness, ascribed responsibility and personal norms contribute, as a whole, to create a pro-environmental behaviour intention in the attitude of a customer. They have designed and deployed a research with the intention to understand if natural gas vehicle motorists nurture a pro-environmental behaviour intention and if this has contributed to the choice of their new car or the conversion of the old one. The paper tests if, besides cutting down on operational cost and overcoming traffic restrictions, social and personal responsibility decisions are key drivers for motorists as well.

The results of the study show that, in contrast with common belief, cost saving is not the main driver that influences people to buy and drive a natural gas vehicle. So the decision of purchasing a natural gas vehicle is more often a consciousness choice that depends marginally on cost-saving reasons. That is, a more efficient policy could consist in developing communication actions to support the moral and psychological value of this pro-environmental behaviour in terms of responsibility and consciousness:

buying and driving a natural gas vehicle is neither something for marginal or poor people, nor a choice for greedy people motivated by the desire to save money, but an 'eco-cool' decision.

Finally, the paper of Elmquist and Segrestin is based on a collaborative research study with a European car manufacturer where design theory was used to set up an experiment on cars that combine environmental and economical sustainability. The case contributes to an improved understanding of the challenges of eco-innovation and provides an example of how the automotive industry can foster the innovative capability of its established R&D processes.

Based on the design theory framework, their paper aims at providing an example of how innovative design activities can be organised around the issue of eco-innovation in the automotive industry as a complement to the established R&D processes. It draws on an empirical experiment with a European automotive firm, which was looking for new ways to expand its eco-offer in an innovative way. The experiment was set up to deliberately renew the design alternatives of environmental offers: it aimed at renewing the attributes of the products to take the environment into account, while still being sustainable and profitable.

Two main arguments result from this experiment. First, the paper confirms that eco-innovation can be addressed in both a rule-based and an innovative design regime. This case study shows that efforts within the rule-based regime primarily resulted in improvements on known parameters, while the experiment explored more innovative offers in a more innovative way. For sustainable development, companies need to be proficient in working with product development both in the rule-based design regime, where they already excel, and in an innovative design regime, where managerial techniques are still being developed. Second, this paper argues that there are three additional tasks that managers need to perform in an innovative design regime: identify the missing knowledge, design valuation criteria and build design strategies where products and competencies are expanded in a sustainable but innovative way. The paper of Elmquist and Segrestin thus contributes to an improved understanding of the actual management practices that support eco-innovation in the automotive industry. But there may well be other methods that enable the same result. In that respect, the paper provides some proposals which it would be worthwhile to develop further.

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## Notes

1 In fact, Pininfarina, Karmann, Valvet and Heuliez have announced plans to build electric cars.

2 The Phylla prototype is a 2 + 2 seater sub-A-segment urban car that captures solar energy in order to power electric motors that drive all four of its wheels. Four individual electric motors, one mounted in each wheel, get their electrons courtesy of on-board lithium-based batteries (either lithium ion or lithium polymer), which store power generated from the car's solar cells. The dimensions of the vehicle are height: 1980 mm, length: 2995 mm and width: 1618 mm. It comes with 142 l (2 + 2 seats) and 584 l (2 seats) of luggage space capacity. An aluminum-intensive frame adds up to a very light weight of just 750 kg, so those batteries are capable of providing a range of up to 220 km. Acceleration is measured at 6 sec from standstill to 50 km/h and 130 km/h as its maximum speed.