Three possible scenarios for cleaner automobiles

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In a collective book about the automobile firms trajectories at the beginning of the 21st century we have suggested the hypothesis of a possible new revolution of the automobile, that we named the « Second Automobile Revolution » (Freyssenet, 2009), from a reflection about the works realized notably in the framework of the « Sustainable development and automotive industry » program of GERPISA (Jullien, 2008; Calabrese, 2009). Two processes appeared to lead to such revolution. The first arises from the contradiction between a more and more expensive exploitation of oil, a reducing resource, and the increasing needs of the large emerging countries. That fact contributes to increase the oil prices and should make competitive the alternative energies, whatever the fluctuations of the political will of the governments to fight against climate warming and food crises. The second results from the new potentialities of alternative engines requiring the least fossil energies. It could lead to the transformation both of the use of cars and conditions of the mobility and of the production of the whole vehicle. A revolution in the production and in the use of the car would become possible for the first time.

To develop this assumption, after the achievement of the book, we undertook a new work consisting in comparing the current conditions with the conditions that had allowed, at the turning point of the 19th and the 20th century, the emergence of the petrol car (Freyssenet, 2009). The first results of this work were presented during the international colloquium of the GERPISA in June 2009 in Paris (Jullien, 2009; Calabrese, 2010) and they are resumed in the first section of this article. Considering the current effervescence for alternatives motorisations, these results allow us to present, in the second section, the possible scenarios of transformation of the automobile industry.
1. Four main conditions for a car revolution

From the analysis of the historical literature, we can identify four main conditions for the birth of the automobile and of its industry, known under the name of «the Automobile Revolution » (Bardou et al., 1982; Laux, 1992). The first condition was the crisis of the horse-drawn transport system (Tarr, 1969; Barles, Guillerme, 1998; Bouchet, 1993; Garcon, 2003; Kinney, 2004; Turvey, 2005). The second was the emergence of various alternative solutions thanks to innovations coming from other industrial sectors (Chanaron, 1973; Mballa, 1998). The third was the progressive formation of a coalition of economic, politic and social forces which had made prevail the petrol car on the other powertrains, in spite of its uncertainties, its disadvantages and the oppositions which it caused (Mballa, 1998; Frery, 2000; Garcon, 2003; Loubet et al, 2003; Mom, 2004). The fourth was the macro-economic decisions and some public policies that had created the conditions of a broad diffusion, making of the petrol car an universal standard (Boyer, Freyssenet, 2002).

1.1. The crisis of the previous transport system

The comparison with the current situation shows that the first condition for a new automobile revolution is already fulfilled. The petrol car transport system is in crisis since several years. The oil resources are more and more difficult to exploit and their quality is lowering. Even including the potential resources, «oil peak » is very close. In the same time, there are a rise of the costs of use of the cars, a relative profitability drop of car industry and a fall of use value of the automobile because of congestion, pollution, growing costs of the externalities, accidents, etc.

1.2. The emergence of various solutions, thanks to innovations coming from other industrial sectors

The second condition is probably also fulfilling. Some innovations, realized by the food, chemical, electric, electrochemical, electronic and computer industries, allow to solve many problems which had prevented until now the rise of alternative solutions in the car industry: agro-fuels, electronic control system, batteries of which the performances are multiplied by two, alternative sources of electricity, etc.
1.3. The formation of a coalition of economic, politic and social forces to impose one solution

Some coalitions of economic political or social actors are already constituted or are going to be formed to support each one of the different alternative solutions. The different protagonists of these various possible coalitions are, as it was in the past, start-ups or entrepreneurs knowing the market and able to gather the necessary capital, historical producers of means of transport, producers and providers of energies, suppliers of components, distributors, enterprises and institutions owning fleet vehicles (Armies, Mail, government agencies, transport companies, rental or leasing business, etc.), States, ecological associations, political parties, media, etc. We advance the assumption that the emerging countries, whose automobile markets had exploded since ten years, are going to be very important actors, even may be decisive ones, because they will be in position to impose on others, the solution the most appropriated for them: agro-fuels for Brazil, natural gas for Russia, electricity for China and India. These last two countries did not hide their will to create an independent national car industry. Deprived of oil resources, they have interest indeed to avoid the long and expensive acquisition of technologies of the internal combustion engine and to try to become leaders on electric technologies, thanks to their real scientific, technical and industrial competence in this field.

We take then the risk to make a forecast: we consider that the electric car will likely be the vehicle of the « Second Automobile Revolution », in spite of its current uncertainties and its disadvantages. For the following reasons. We know, since « the Automobile Revolution » of the beginning of the XX century, that it is not necessarily the optimal solution which prevails. When the car manufacturers, the Armies, quickly preferred the petrol solution and finally also the States, it was the solution technically most complicated, most dubious, most expensive, most polluting, most uncomfortable, most criticized, most dangerous and least powerful in certain roads or urban configurations (Bardou 1982; Mom, 2004).

It seems that the reason of this incredible paradox was that oil was at that time the only energy easily storable, relatively compact, immediately transportable and distributable on all territories at an acceptable price by many private companies (Mballa, 1998). So it appeared to be the condition of a fast diffusion of the car.

It is thus not the weight, the dimensions and the autonomy of the batteries, which penalized the electric car solution in the past. These problems were reasonably soluble. They
could be effectively solved early, if one had devoted as many financial means than those which were devoted to solve the problems of the internal combustion engine vehicle, much more complicated. The electronic industry found new type of batteries, because it was crucial for itself to increase strongly their autonomy. What really penalized the electric car, it was the absence of electrical networks in all territories. And effectively, the installation and the generalization of coordinated electric networks in the industrialised countries required a long time efforts, and it was fulfilled only more than sixty years latter.

Now the electric infrastructure exists, including in the developing countries, especially in their urban areas. The decentralized solar and wind production of electricity will offer many possibilities to be provided practically everywhere in the future. It is also, frequently, the less expensive energy.

The electric car is an historical opportunity for newcomer car producers, especially for Chinese carmakers, to impose themselves in their national market and also in the international market. They have the intellectual, financial, industrial, political, international and social means to do that. The electric car is also a big opportunity for some suppliers, some car rental companies, etc. to try to control the value chain of the automobile sector.

The electric vehicle allows a completely new car architecture, specially using « engine wheels ». Its parts, less numerous, can be, for the first time, effectively modular, thanks to the standardization of the connexion between them. Only such architectural change is able to respond to the constraints of the urban mobility and to the expectations of many people, and above all, to relaunch the profit and the competition in the car sector. A new profit strategy could be even invented, making compatible volume and innovation profit sources.

The mass production of batteries can contribute to dramatically decrease the price of electric vehicles, much more easy to conceive and to produce than an internal combustion engine car or a hybrid car. The current technical problems of electric vehicle are much less important than the problems of the petrol automobile at its appearance and during several decades.

If such scenario became a reality, then the effects and the impact on the whole car industry, its employees, the countries and the international relations would be considerable. It would be effectively a « revolution ».
1.4. The macro-economic decisions and the public policies for a broad diffusion of a chosen standard

The policies of broad and more egalitarian national income distribution in the industrialized countries after the second world war allowed finally the definitive rise and development of the petrol car industry, more than 50 years after its birth. Today, this condition is not met any more. The wage deregulation and the growth of the inequalities have stopped the average increase of the market of new cars and trucks in the developed countries. The young couples and the middle-classes are increasingly constrained to purchase used vehicles, more polluting and finally more expensive than the new vehicles (Freyssenet, Jetin, 2009; Freyssenet, 2010). The emerging markets, which allowed the worldwide production to increase strongly again, will be able to continue to make it, but only if the concerned countries and the concerned governments adopt new policies of sharing of their national revenue in order to make their income distribution much less uneven than they are today.

2. From an astonishing effervescence, three main scenarios emerge

Since 2009, are the requirements for an automobile revolution reinforced? Or not? We can see an astonishing effervescence: the multiplication of alternative vehicles projects and announcements of next launchings (Table 1); the birth and developing of many start-ups and newcomers, specially for electric vehicles (Table 2); the existence and widespread of ecomobility, even electromobility plans by the States or by the local authorities in many countries; the existence of same support for national champions to help them to become leaders; several changes in their preference for alternatives solutions by some manufacturers and by some countries; the multiplication of the partnerships between manufacturers, startups, equipment suppliers, alternative energies suppliers, manufacturers of batteries, territorial authorities, universities, research centres and States; the creation of research and development groupings of manufacturers; the elaboration of different concurrent standards; the emergence of new experiences or tests of new systems of mobility, etc. (Tables 3 and 4).
From this boiling, three main scenarios emerge for the moment: the scenario of diversity, the scenario of progressiveness and the scenario of rupture.

Table 1

*Number of alternative automobiles in the world by type and condition, from OEM, newcomers and some start-ups (non exhaustive census, October 2010)*

<table>
<thead>
<tr>
<th></th>
<th>Hybrid</th>
<th>Plug-in</th>
<th>Electric</th>
</tr>
</thead>
<tbody>
<tr>
<td>On sale 2010</td>
<td>11</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>Under development</td>
<td>17</td>
<td>17</td>
<td>42</td>
</tr>
<tr>
<td>Project</td>
<td>11</td>
<td>11</td>
<td>42</td>
</tr>
</tbody>
</table>

2.1. The scenario of diversity

In this scenario, the countries will privilege an energy source and a type of engine, because of their own resources or because of their commercial relations with an important producer country. Five great groups of countries could be distinguished.

- The countries oriented towards the agro-fuels, with Brazil as leader because of its resources, of its know-how, of the potential extent of its market, of its commercial relations in strong growth (Amatucci, Spers, 2010).
- The countries privileging natural gas, with Russia like promoter being given its reserves and its weight growing in the provisioning of many European countries and because also of the potential extent of its automobile market.
- The countries which would adopt the plug-in hybrid solutions durably, in particular because of the frequency and the importance of the long ways, because of the preference for the powerful cars and because of the absence of an energy specialization: the United States could be the country of reference, even if the electric option is one of the options retained by the current administration.
- The countries which would prefer the electric car, because of the nuclear or ecological origin of their electricity, because of the frequency and the importance of the short ways, or because of the political will to have quickly a competitive national auto industry. Europe or at least some European countries could represent this option. Japan and Korea also, although for the moment it is not the choice made by these countries. China and In-

dia seems to privilege this orientation
- The last group of countries would be the countries that would conserve the petrol car with improved performances, because of the durably weak price of the gasoline for them, as some countries of the Middle East.

The scenario of diversity is already moving. The countries support generally the kind of motorization that is the most favourable for them. So, some carmakers have or prepare an offer of various motorizations according to the countries or even according to the use or to the customers.

Table 2: Some start-ups, newcomer carmakers, suppliers, assemblers and others producing or developing electric vehicles, in some countries (non exhaustive census, October 2010)

<table>
<thead>
<tr>
<th></th>
<th>Start-ups</th>
<th>Suppliers</th>
<th>Newcomers carmakers</th>
<th>Assemblers and others</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>Tesla, Zap, Fisker, Think, Phoenix, Segway</td>
<td></td>
<td></td>
<td>Miles Electric, GEM</td>
</tr>
<tr>
<td>Canada</td>
<td>Nemo</td>
<td>Magna</td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>Venturi</td>
<td>Bollore, SVE Dassault, Michelin</td>
<td></td>
<td>Heuliez, FAM, Aixam, Lumineo</td>
</tr>
<tr>
<td>Germany</td>
<td>E-Wolf, Ruf, Innovative, Streetscooter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>Micro-Vett K-Way Motus</td>
<td></td>
<td></td>
<td>Tazzari, Biro, Effedi, Pininfarina</td>
</tr>
<tr>
<td>Suisse</td>
<td>Protoscar, Rinspeed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>Stevens Vehicules, Lightning, Nice car, Murray, Smith Electric</td>
<td>GK</td>
<td></td>
<td>Lotus</td>
</tr>
<tr>
<td>Suede</td>
<td>Koenigsegg EV adapt</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>Sim-Drive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>Reva</td>
<td>Tata, Mahindra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>Eagle</td>
<td>BYD, Geely, Chery, Tianjin Qingyuan, Beijing Auto, Chana, Foton, Hafei, Lifan, Zotye</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The problem of this scenario is its cost for the international manufacturers or suppliers. To offer, to develop and to improve all the types of engines and to be able to sell them everywhere requires considerable means. The economies of scale would strongly decrease. The automobile producers, privileging the volume and the limited diversity as sources of profit (Boyer, Freyssenet, 2002), would be seriously affected. Some of them are convinced that it is necessary to grow again by mergers or by acquisitions, or to multiply again the co-operations, as do Volkswagen and PSA. Could that ways be sufficient? It is possible to imagine the emergence of regional manufacturers or manufacturers specialized only in one type of engine? Fiat had until now selected the agro-fuels and the natural gas, taking into account its South American and Eastern-European anchoring (Stocchetti, Volpato, 2010). But its alliance with Chrysler could change this incipient specialization.

Table 3:
*Alternative energies national preference for cleaner cars ... until mid 2010*

<table>
<thead>
<tr>
<th>Agro-fuels</th>
<th>Natural gas</th>
<th>Plug-in hybrid</th>
<th>Electric vehicles</th>
<th>Only objectives of pollutant reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brazil</td>
<td>Russia</td>
<td>USA</td>
<td>China, India, India, Italy</td>
<td>Japan, Germany, European Union</td>
</tr>
<tr>
<td>Sweden</td>
<td>Russia</td>
<td>USA</td>
<td>China, India, India, Italy</td>
<td>Japan, Germany, European Union</td>
</tr>
</tbody>
</table>

2.2 The scenario of progressiveness

It is the scenario of the progressive transition from the petrol vehicles to agrofuels or natural gas vehicles, then to the hybrid vehicles, then to the plug-in hybrids, then to the electric cars with batteries, finally to electric automobiles with fuel cells. Many people consider that this scenario is the reasonable and realistic scenario, as one can read in many articles and newspapers. It seems reasonable, because the successive motorizations could be adopted as their technical improvement and as the amortization of investments.
It seems realistic, because in any event the world car fleet could not be renewed at a stretch, and because the inversion of the proportions of the various motorizations will be necessarily progressive (Chanaron, Teske, 2007). The scenario of the progressive transition was the scenario privileged until recently by the German manufacturers, and also by Ford, PSA, Toyota, Honda, Mazda and Hyundai. According to them, the market of the electric car was very limited in short term. Taking in account this scenario, the German government, the Japanese government and the European Union had adopted a "technological neutrality". For them, the governments must decide only objectives of fuel consumption and gas pollution reduction, the manufacturers have to propose the solutions which they consider the best, and finally the markets will choose (Tables 3 and 4).

Table 4:
Five (changing!) strategies: priority to...

<table>
<thead>
<tr>
<th>less car-fuels: gas, agrofuel</th>
<th>hybrid versus plug-in hybrid</th>
<th>hybrid versus all types of engine</th>
<th>plug-in hybrid versus electric vehicle</th>
<th>electric vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fiat</td>
<td>Toyota</td>
<td>Ford</td>
<td>GM Mitsubishi</td>
<td>Renault, Nissan</td>
</tr>
<tr>
<td>Volvo</td>
<td>Honda</td>
<td>PSA</td>
<td>BYD</td>
<td>Chrysler</td>
</tr>
<tr>
<td></td>
<td>Mazda</td>
<td>Volkswagen</td>
<td>Chery</td>
<td>Geely, Tianjin</td>
</tr>
<tr>
<td></td>
<td>Hyundai</td>
<td>Daimler</td>
<td></td>
<td>Qingyuan, Bei-</td>
</tr>
<tr>
<td></td>
<td>Porsche</td>
<td>BMW</td>
<td></td>
<td>Auto, Chana,</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Foton, Hafei,</td>
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<td></td>
<td>Lifan, Zotye,</td>
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<td></td>
<td>Tata, Mahindra</td>
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<td>ups</td>
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</tbody>
</table>

But since few months, the speeches and the acts of the German car manufacturers and also of PSA are changing. Finally PSA launched in October 2010 clones of the i-Miev electric car of Mitsubishi, its new ally, and the electric versions of its two small commercial vehicles. Volkswagen has just announced the launching of a plug-in hybrid and a full electric Golf for 2013 and an electric taxicab named Milan. Daimler has just tied partnerships with the American start-up Tesla, with the Chinese newcomer BYD and with Renault-Nissan. The position of the German government and the European Union also evolved, recognizing the importance of the electromobility and the need to set up a network to recharge the batteries, to standardize the plugs and to install an electronic billing system. Hyundai has just launched a city car, the electric iLO, produced in India. Toyota, Mazda and Honda seem to conserve the same position. Honda has even reaffirmed recent-
ly that it does not believe in the success of electric car, preferring to continue its search for fuel cells, the only radical innovation for it. The Japanese carmakers prepare however standards for recharge plugs, and they would like the other countries adopt these standards.

The scenario of progressiveness implies for it success that the oil prices will not increase too quickly, that the climatic urgency and the pressure of the governments and of the ecologists will not be too strong, finally that scenario assumes that the performances of the batteries will progress slowly. In contrary case, the manufacturers that will have already electric car in their range could quickly take market shares. A new automobile network could be set up, without the manufacturers having chosen the progressiveness scenario. Right now, many cities, areas, countries, public institutions or enterprises, private service firms want to buy electric cars for themselves and propose to the population some financial advantages linked particularly to the electric car purchase. The volume of these purchases could cause the drop of the price of the electric cars and of the batteries. In this case, the transition between the various motorizations could be reduced, and the amount of the required investments would rise quickly and could not be bearable, including for great automobile groups.

2.3 The scenario of the rupture

It is the scenario of the electric car or of the electric car with a small auxiliary petrol engine. The carbon assessment "well to wheel" of the electric vehicle can be the best or the worst of the solutions, according to the origin of electricity (Figure 1).

Nevertheless, the supporters of this scenario put forward several reasons. According to them, the electrical production starting from fossil energies will necessarily regress. The current batteries offer a sufficient autonomy for the large majority of the displacements carried out as well by the service companies as by the private individuals, in many countries. Many territorial authorities and countries want to quickly reduce pollution and the dependence to oil for financial and geopolitical reasons. They are ready to create the infrastructural and the financial conditions for the takeoff of the electric vehicles. Thus an opportunity exists to leave the vicious circle "high price / weak demand".

The experience gained by the carmakers that would have made the first step could be decisive for the continuation. The performances of the batteries should in addition increase substantially and quickly taking into account the financial and scientific means used in many countries by many actors (Beaume, Midler, 2009). But, if there were only these considerations and perspectives to start this scenario, its future would be still very dubious. The fundamental fact for its future is that neither China, nor India will be able to continue their « automobilisation » with the petrol engine, included hybrid. On other hand, they have the means to become electric car producers and exporters and to precede the historical car countries and car manufacturers. The last declarations and the adopted plans, in particular by China, do not make mystery of the will to reach that point. Other new actors: the manufacturers of batteries, the manufacturers of tires, the suppliers of electronic equipments, even the car rental companies, etc. have also interest with this scenario, not only to develop their business, but also to eventually take the control of the value of the new car chain, and even to become themselves carmakers, etc. At last a growing number of States and Armies can have to prefer the electric solution, if their financial and strategic dependence with oil became unbearable.

Figure 1
« Well to wheel » C02 emission, according to the type of engine, the energy and the country

![Graph: C02 emissions for different vehicle types]

Source: French Institute of Petroleum
This scenario is clearly privileged until now by Renault-Nissan, numerous Chinese carmakers, Tata and Mahindra, many start-ups, small assemblers, sport cars producers and several equipment suppliers. Start-ups occupy niches market: city-car, small utilities, sporting cars. They sell their know-how to historical manufacturers that took delay in this field, or tie partnerships with them like Tesla with Daimler and Toyota, or even they sale themselves, as recently Reva to Mahindra. Some other actors dream to become carmakers as Bollore-Pininfarina, Heuliez, etc. Renault and Nissan consider that the electric car market will exist really only if it is created: what implies the immediate installation of the infrastructures to recharge or to exchange the batteries, a diversified offer of four models going of the quadricycle to the family car. It implies also to have some government aids to erase the overcost of the electric vehicle during the first years. Renault and Nissan tied for that numerous partnerships, so much with territorial authorities, providers of electricity, manufacturers of batteries, car rental companies etc., and they used one's influence with the States. But these carmakers decided to replace only the petrol engine by an electrical motor, without changing of the current automobile architecture. Renault, of which the profits come from its innovating models, is in its role when it bets on the electric car. It isn't in when it refuse to exploit, at least for the moment, the freedom of design, of production and of use that the electric vehicle can aloud. It could regret its refusal. A radical innovation is accepted much better when it offers new functionalities and possibilities.

**Conclusion**

In one year, the quivering observed towards the alternative motorizations could be the start of at least three scenarios. The consequences of these three scenarios on the geography, the structure, the economy and the sociology of the world car industry are completely different. In the first scenario, each car producer will be able to find its regional niche. In the second, only most powerful carmakers will survive. In the third, the newcomers and the innovating enterprises will have the possibility of engage a true « Second Automobile Revolution ». The winning scenario will prevail, after confused and nevertheless rough fights, not because of its technical superiority or of its best environmental performances, but initially because of energy geopolicies and of firm profit strategies. For these reasons, the third scenario, which appears today most random, could impose in the next years, as the improbable petrol car scenario imposed one century ago.
References


http://freyssenet.com/?q=node/1166


http://freyssenet.com/?q=node/1467.


Biographical note